UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 7

In the matter of:	)	
Moran Beef, Inc.	)	DOCKET NO. CWA-07-2010-0080
Pottawattamie County, Iowa,	)	COMPLAINANT'S SUPPLEMENTAL PREHEARING EXCHANGE
Respondent.	)	

Pursuant to 40 C.F.R. § 22.19 of the "Consolidated Rules of Practice Governing the Administrative Assessment of Civil Penalties," 40 C.F.R. Part 22 (CROP) and the Presiding Officer's Order of August 26, 2010, Complainant United States Environmental Protection Agency (EPA) submits this Supplemental Prehearing Exchange.

WITNESS

Wayne Gieselman. Mr. Gieselman is the Division Administrator for the Iowa Department of Natural Resources. EPA reserves the right to call Mr. Gieselman as a rebuttal witness to address efforts by IDNR to inform producers about discrepancies between state and federal regulations for concentrated animal feeding operations (CAFOs) and producers' awareness of the differences. Among other things, Mr. Gieselman may be called to testify regarding his attendance at a public hearing on or around March 13, 2006, in which respondent's consultant and engineer raised concerns about the regulatory status of animal feeding operations. Mr. Gieselman's summary of the hearing statements are attached as Complainant's Exhibit No. 39.

EXHIBITS

For purposes of the list of documents below, "Complainant's Exhibit" is abbreviated as "C___." The documents themselves are labeled "Complainant's Ex. No. XX"

C24 Map showing Moran Beef, Inc. open lot and confinement barn with sample locations and results, March 15, 2011

C25 Map showing Moran Beef, Inc. confinement barn with sample locations and results, March 15, 2011

C26 Iowa Manure Matters - Odor and Nutrient Management, Iowa State University Extension (Winter 2005). *CAFO Determinations – Review the Federal Requirements*, Gene Tinker, Iowa Department of Natural Resources

C27 Iowa Department of Natural Resources (October 7, 2008). *Compliance Steps for Combined CAFOs* [Factsheet]

C28 Iowa Department of Natural Resources. *FAQs for Combined Open Lot and Confinement Animal Feeding Operations* [website posting]

C29 Iowa Manure Matters - Odor and Nutrient Management, Iowa State University Extension (Fall 2006). *New Fact Sheet Series Regarding Manure Management is Available,* Angela Rieck-Hinz, Department of Agronomy, Iowa State University and Alison Smith, Iowa Pork Producer's Association. *And,* Iowa Manure Manager Series, Iowa State University Extension (Vol. 9, 2008). *Summary of Regulation for Building or Expanding Open Lot and Confined Beef and Dairy Operations with less than 1,000 Animal Units*, Angela Rieck-Hinz, Extension Program Specialist, Iowa State University

C30 Economic Benefit Report by Jonathan Shefftz, revised March 18, 2011 to include Respondent's wastewater control expenditures

C31 Receipts for construction of wastewater controls submitted by Respondent March 9, 2011

C32 Memorandum from Michael F. Davis to Trevor Urban (March 8, 2011), titled "Modified Data Transmittal for ASR #4705" (showing revised results for Total Kjeldahl Nitrogen and Total Phosphorous for the October 30, 2009 Sampling Inspection)

C33 EPA CWA Section 308 Request for Information issued to Respondent, January 21, 2011

C34 Moran Beef, Inc. response to EPA's January 21, 2011 Request for Information, February 7, 2011.

C35 Memorandum from Joe Heafner to File (March 16, 2011) titled "Addendum to Inspection Report dated September 23, 2010"

C36 Aerial photograph of Moran Beef, Inc., showing unnamed tributary (March 10, 2011)

C37 Aerial photograph of Moran Beef, Inc., showing confinement barn and unnamed tributary (March 10, 2011)

C38 Dr. Huggins' supporting documentation

C39 Summary of hearing on "bad advice" bill, compiled by Wayne Gieselman

RESPECTFULLY SUBMITTED this 18 day of March, 2011.

Chris Muehlberger
Assistant Regional Counsel
Region 7

CERTIFICATE OF SERVICE

I hereby certify that copies of the Prehearing Exchange in the Matter of Moran Beef, Inc., Docket No. CWA-07-2010-0080, were sent to the following persons in the manner indicated:

A true and correct copy by United Parcel Service to:

Sybil Anderson (original plus two copies)
Headquarters Hearing Clerk
EPA Office of Administrative Law Judges
1099 14th Street NW
Suite 350, Franklin Court
Washington, DC 20005

A true and correct copy by first class mail to:

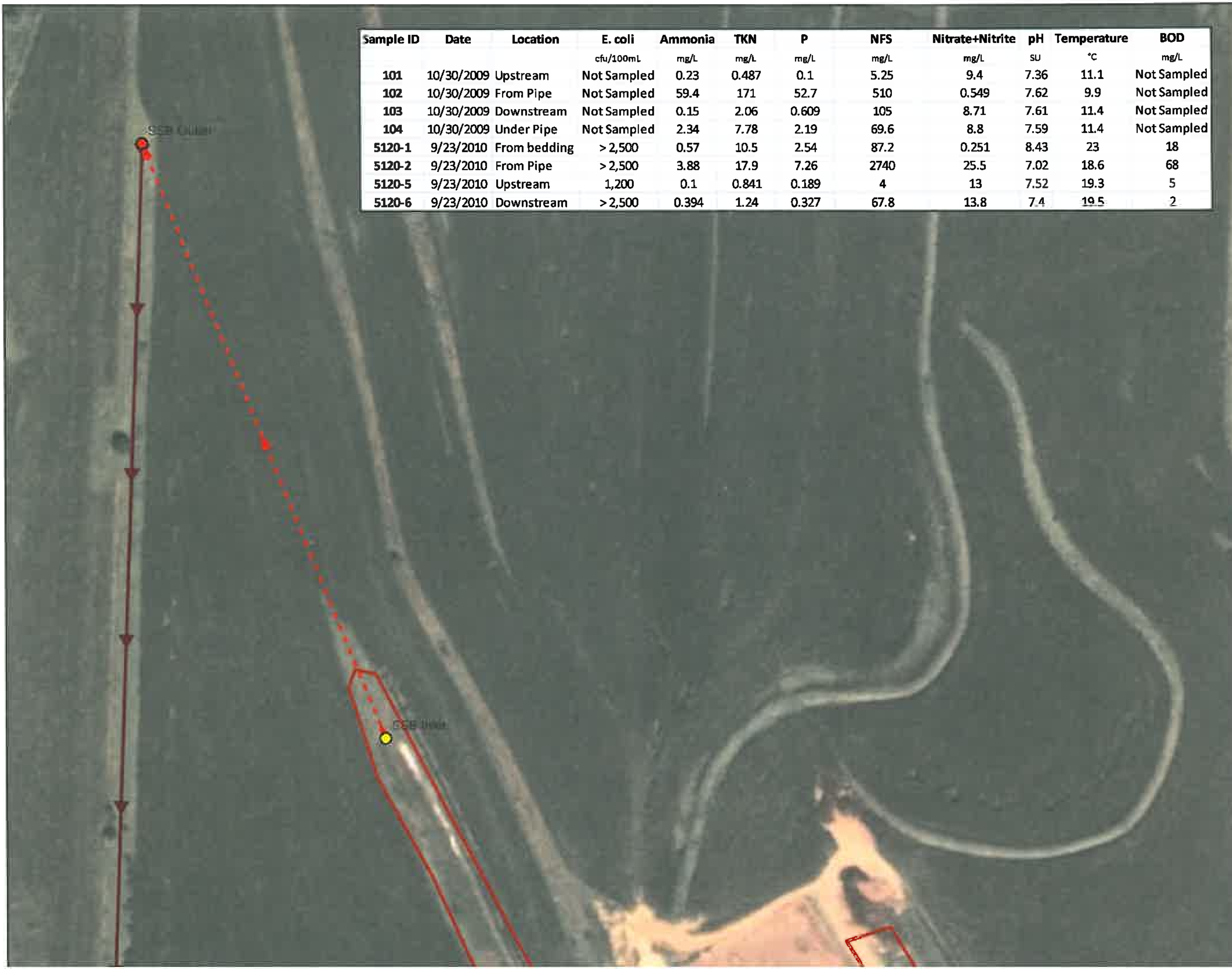
Eldon McAfee
Beving, Swanson & Forrest, P.C.
321 E. Walnut St., Suite 200
Des Moines, IA 50309

Dated: March 18, 2011

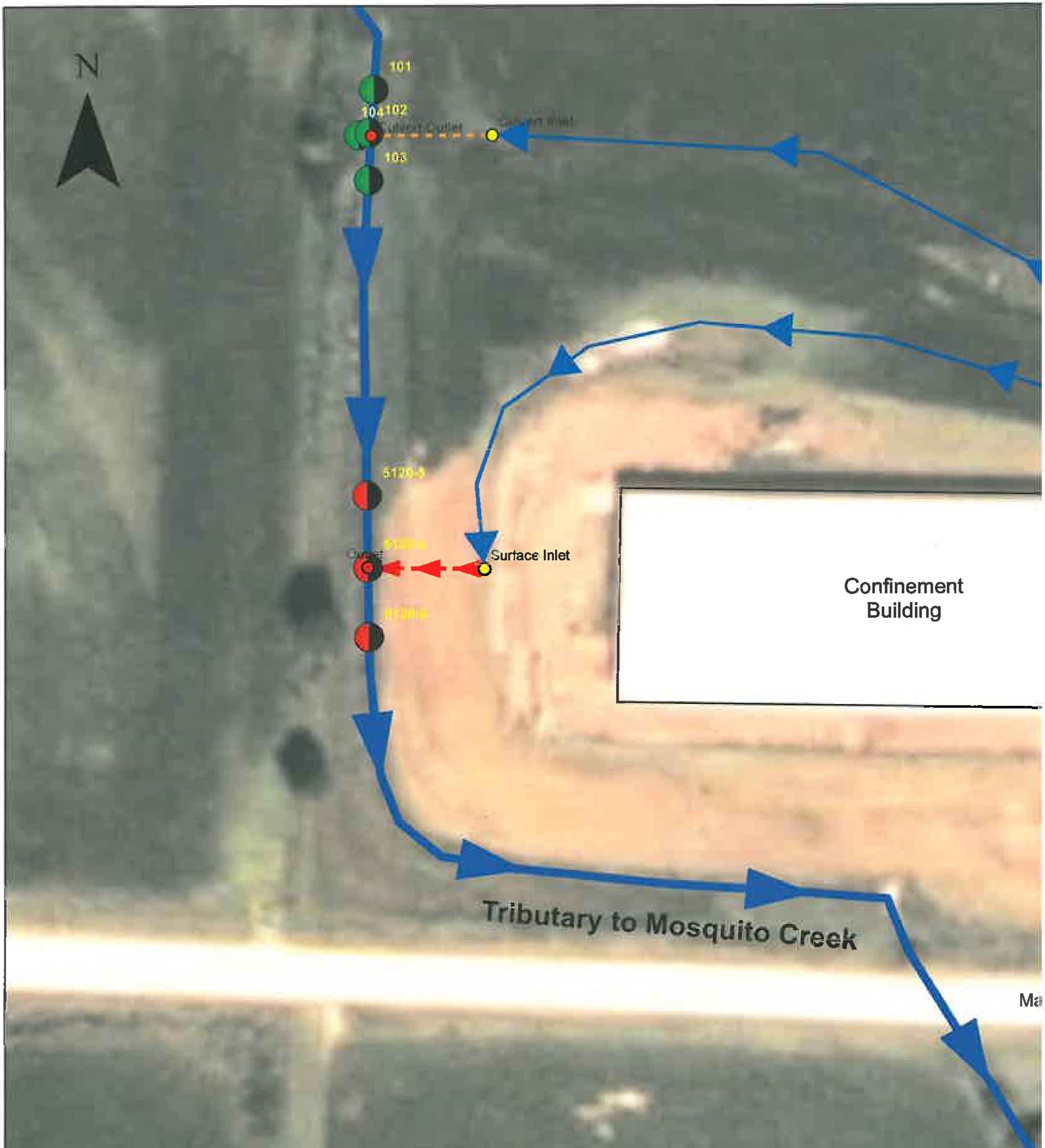
____

COMPLAINANT'S
EX. NO. 24

Sample ID	Date	Location	E. coli	Ammonia	TKN	P	NFS	Nitrate+Nitrite	pH	Temperature	BOD
			cfu/100mL	mg/L	mg/L	mg/L	mg/L	mg/L	SU	°C	mg/L
101	10/30/2009	Upstream	Not Sampled	0.23	0.487	0.1	5.25	9.4	7.36	11.1	Not Sampled
102	10/30/2009	From Pipe	Not Sampled	59.4	171	52.7	510	0.549	7.62	9.9	Not Sampled
103	10/30/2009	Downstream	Not Sampled	0.15	2.06	0.609	105	8.71	7.61	11.4	Not Sampled
104	10/30/2009	Under Pipe	Not Sampled	2.34	7.78	2.19	69.6	8.8	7.59	11.4	Not Sampled
5120-1	9/23/2010	From bedding	> 2,500	0.57	10.5	2.54	87.2	0.251	8.43	23	18
5120-2	9/23/2010	From Pipe	> 2,500	3.88	17.9	7.26	2740	25.5	7.02	18.6	68
5120-5	9/23/2010	Upstream	1,200	0.1	0.841	0.189	4	13	7.52	19.3	5
5120-6	9/23/2010	Downstream	> 2,500	0.394	1.24	0.327	67.8	13.8	7.4	19.5	2



COMPLAINANT'S
EX. NO. 25



Moran Beef, Inc.

Underwood, Iowa

0 25 50 100 Yards

COMPLAINANT'S
EX. NO. 26

Iowa Manure Matters -
Odor *and* Nutrient Management

IOWA STATE UNIVERSITY
University Extension

Winter 2005

Commercial Applicator Training 2006 CAFO Determinations - Review the Federal Requirements 2006 Confinement Site Manure Applicator Workshops Newsletter Survey DNR Schedules Tests for Manure Applicators

Home Page

Previous IssuesFeedbackSubscribeCredits

CAFO Determinations - Review the Federal Requirements

PRINT VERSION (pdf)

By Gene Tinker, Iowa Department of Natural Resources

A livestock feeding operation can be a concentrated animal feeding operation (CAFO) based on 1) size (1,000 animal units or larger), 2) size and management or location (300 to 999 animal units with a direct discharge to a water of the United States or a water of the U.S. running through the operation), or 3) designation as a CAFO due to a significant contribution of manure or process wastewater to waters of the U.S.

CAFO determination for an animal feeding operation is important because it determines how the facility may operate. In Iowa confinement operations are no discharge systems, so having a CAFO determination normally isn't an issue. But for open feedlot operations the CAFO determination impacts whether the operation can have a legal discharge. Open feedlots that are determined to be CAFOs cannot have a discharge of any type without a NPDES permit, which specifies when a discharge is allowed.

A number of open feedlot operations have attempted to avoid the CAFO determination by decreasing the animal numbers in the open feedlot to less than 1,000 head and adding feeding capacity in confinement. The open feedlot law passed in the 2005 legislative session, House File 805, states that animal capacity for confinement feeding operation shall not be combined with animal capacity of open feedlot operations when determining if the operation is a CAFO. This is in direct conflict with EPA's CAFO regulations (effective April 14, 2003) that combine open feedlot and confinement structures housing the same type of livestock. The recent court ruling on the EPA CAFO regulations has no bearing on determining when an operation is a CAFO.

Complainant's Ex. No. 26

COMPLAINANT'S
EX. NO. 27

Compliance Steps for Combined CAFOs[1]

Required to apply for an NPDES[2] permit by December 31, 2008

After you have determined that your animal feeding operation is a combined CAFO[1], follow these 5 steps and deadlines:

Step 1: Develop a Nutrient Management Plan (NMP). You will need:

- A phosphorous (P) Index for each manure application field.
- The RUSLE2 and the P-Index are available at http://www.ia.nrcs.usda.gov/.
- Prepare an NMP on DNR Form No. 542-2021.
- The NMP requires Public Notice. Use DNR Form 542-1553.

Note: all forms can be found at http://www.iowadnr.gov/afo/forms.html, or call 515-281-8941.

Step 2: No later than **December 31, 2008**, submit all of the following:

1. NPDES[2] permit application on DNR Form 542-4001.
2. NPDES[2] application fee on DNR Form 542-1250. Make check payable to Iowa DNR.
3. NMP on DNR Form No. 542-2021.
4. Completed compliance schedule for a combined CAFO[1] (see page 2 for an example.)
5. Mail items 1-4 to the following address:

Iowa DNR
AFO Program
502 East 9th Street
Des Moines, IA 50319-0034

Note: all forms can be found at http://www.iowadnr.gov/afo/forms.html, or call 515-281-8941

Step 3: Next, follow the Pre-Construction Requirements of the Open Feedlot Construction Application Manual, posted in http://www.iowadnr.gov/afo/open2.html. This includes, but is not limited to, the following:

a) Hire a professional engineer licensed in the state of Iowa.
b) Schedule a site visit with the professional engineer you have hired.
c) Have your professional engineer prepare preliminary design work.
d) Request and schedule a Pre-Application Meeting (PAM) with the DNR. You have 2 options:
   - E-mail the pre-design work to: AFOengineer@dnr.iowa.gov
   - Or, mail it to Iowa DNR - AFO Program (see address in Step 2)
e) At the pre-application meeting, discuss with DNR your proposed manure and runoff control structures.
f) Submit the manure and runoff controls final design along with your construction permit application as instructed in your pre-application meeting with DNR.

Step 4: Once DNR receives your manure and runoff controls final design and corresponding construction permit application, the DNR will make a determination to approve or disapprove your application. Accordingly, the DNR will issue a construction permit or denial letter.

Step 5: Depending on the DNR's determination made on step 4, the following will occur:

- If DNR issues a construction permit for your manure and runoff controls, your NPDES[2] permit may be issued, thereafter, provided that you comply with the NPDES[2] permit requirements.
- If your application for your manure and runoff controls is denied, and DNR issues a denial letter, your NPDES[2] permit will not be issued. You will need to re-start the process.
- **CAVEAT**: Your NPDES[2] permit will not be issued, until all these five compliance steps are completed.
- If you have any questions, contact the DNR – AFO Program at (515) 281-8941.

1. CAFO = Concentrated Animal Feeding Operation as defined in rule 567 IAC 65.100(455B,459,459A). You must combine same type of animals, in confinement buildings and open lot pens that are under common ownership or management. To calculate the animal capacity of the operation or combined operation, use DNR Form 542-1427 (Table 1, on page 2 of the form.) If the combined animal capacity meets the large CAFO or medium CAFO definitions, your operation is a CAFO. A CAFO also includes a designated CAFO. Also see DNR Form 542-1427 (page 7) for instructions on how to download the open feedlot rules.
2. NPDES permit as defined in rule 567 IAC 65.100(455B,459,459A). See DNR Form 542-1427 (page 7) for instructions on how to download the open feedlot rules.

Producer's compliance schedule for combined CAFO[1]:

1) On behalf of:

Facility ID No. ____________ (if known)

A) Name of operation: ______________________

Location: ____ ____ ____ ____ ____ ____

(1/4 1/4) (1/4) (Section) (Tier & Range) (Name of Township) (County)

B) Owner information:

Name: __________________ Title: __________________

Address: __________________

Telephone: ______________ **Fax:** ______________ **e-mail:** ______________

We are submitting the following information:

- ☐ 1. NPDES[2] permit application on DNR Form 542-4001
- ☐ 2. NPDES[2] application fee on DNR Form 542-1250. Make check payable to Iowa DNR
- ☐ 3. NMP on DNR Form No. 542-2021
- ☐ 4. This compliance schedule for a combined CAFO[1] (completed and signed)

Mail these forms and fee as explained on Step 2, page 1.

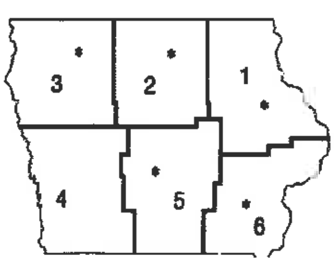
2) In addition, the pre-design work will be submitted to DNR no later than: ______________________

(E-mail or mail this pre-design work to the AFO Program as explained on Step 3, page 1)

Signature of owner: ______________________________ Date: ______________

DNR Contact Information:

- If you have questions about combining animals housed in confinement buildings and open lots, or if you are not sure if your combined operation is a CAFO[1], contact Ken Hessenius at (712) 262-4177.
- If you have questions about this compliance schedule, forms, permit application for NPDES[2] or construction, or to obtain a copy of the needed forms, call the DNR-AFO Program at (515) 281-8941.
- For questions regarding the NMP, P-Index or soil sampling, contact the corresponding DNR Field Office:



Field Office 1 909 West Main, Suite 4 Manchester, IA 52057 (563) 927-2640	Field Office 3 1900 N. Grand Avenue Spencer, IA 51301 (712) 262-4177	Field Office 5 401 SW 7th, Suite 1 Des Moines, IA 50309 (515) 725-0168
Field Office 2 2300 15th St SW Mason City, IA 50401 (641) 424-4073	Field Office 4 1401 Sunnyside Lane Atlantic, IA 50022 (712) 243-1934	Field Office 6 1023 W. Madison Washington, IA 52353 (319) 653-2135

COMPLAINANT'S
EX. NO. 28

FAQs for Combined Open Lot and Confinement Animal Feeding Operations

Q. Most of my 690 dairy cows are under a roof (in a confinement), but I keep the dry cows outside (open lot). Most of the time there are about 70 dry cows outside. Do I have to add those 70 to the 690?

A. Yes, mature dairy cows are all one animal type as defined by the U.S. Environmental Protection Agency. So, you would include any cow that has had a calf, whether dry or milked. Thus, you would have to add 70 + 690 to equal 760 mature dairy cows. Since the number of dairy cows is equal to or more than 700, you would need to apply for an NPDES permit or make a change in operation so that you don't need a permit.

Q. What if I have 500 mature dairy cows inside, 40 dry cows outside, 400 replacement heifers inside and 500 dairy steers outside? Do I need an NPDES permit?

A. No, you would not. You would add your mature dairy cows that are in indoor and outdoor housing together (500 + 40 = 540). Since this is less than 700, you would not be a large CAFO and in most cases would not need to apply for an NPDES permit for your mature dairy cows.

The replacement heifers and dairy steers are considered a different type of cattle and should be added together (400 + 500 = 900). Since there are less than 1,000 "other cattle," your operation would not be a large CAFO and would not need a permit.

In explanation, neither of these situations would combine enough animals of the same type in indoor and outdoor housing to require an NPDES permit (700 mature dairy cattle or 1,000 head of other cattle). However, if the facility discharges, proposes to discharge, has a man-made conveyance carrying runoff out of the building or has a stream running through it, an NPDES permit may be needed. Producers in these situations would be wise to visit with their local DNR field office to determine if an NPDES permit is required.

Also, in the example of other cattle above, if you had an additional 120 calves in calf huts, that would make your other cattle more than 1,000 head (400 + 500 + 120 = 1,020) and you would need an NPDES permit.

Check the DNR web site for a fact sheet on NPDES requirements and a table giving animal types and numbers that require a permit.

Q. What if I have 800 head of beef cattle and 2,400 head of finishing swine in confinement? Do I need an NPDES permit?

A. No, you would not. Beef cattle and swine are different animal types. Also, because the animals, cattle and swine, are all in confinement (under a roof), state law prohibits any discharges. Another reason that an NPDES permit would not be required.

However, if the facility discharges, proposes to discharge, has a man-made conveyance carrying runoff out of the building or has a stream running through it, an NPDES permit may be needed. Producers in these situations would be wise to visit with their local DNR field office to determine if an NPDES permit is required.

Also, in this example, if you added 100 finishing swine outside, you would need to add the swine together (2400 +100 = 2500 head) to determine that you would need the NPDES permit.

Q. What happens if I do not get my NPDES application form and nutrient management plan completed by Dec. 31, 2008?

A. Persons not in compliance are subject to potential enforcement action from the DNR or EPA.

Q. I have only a few animals outside, but I have 1,200 beef cattle. What happens if my open feedlot area does not have a discharge?

There are very few open feedlots in Iowa that do not have a discharge, simply because we have plentiful rainfall that is likely to co-mingle with manure, bedding, feedstuff or silage products and run off the lot into a stream or drainage ditch. It is up to the producer to determine if the lot has a discharge. However, producers should understand that if they take the position that there is no discharge, the U.S. Environmental Protection Agency or the Iowa DNR can still check to see if there is evidence of a discharge. There are also models, such as the Soil Plant Air Water (SPAW) Hydrology Tool, to determine if runoff would occur given the particular specifics of the operation including soil types and crop rotations. Producers who decide they do not need an NPDES permit because their operation does not discharge and then have a discharge could receive federal or state penalties both for having the discharge and for not having the required NPDES permit.

Q. My operation has a confinement housing 750 head of beef cattle and a manure management plan (MMP) which renews every year. I also have an open feedlot of 600 head of beef cattle that discharges (1,350 head total). If I decide to keep the open feedlot, how long will I have to construct a containment system so that I am in compliance?

A. The important issue here is to get the NPDES application form, nutrient management plan (NMP), compliance schedule and fees in by Dec. 31, 2008. If you can't make that deadline, document when and who you contacted for soil sampling and the NMP development. Send that information in by Dec. 31, along with the contact information for an engineer and a schedule of when you will be submitting pre-plans, final plans and completing construction. A Compliance Schedule (form 542-0190) can help producers with planning and scheduling. DNR's initial target is to have all producers who need the permits in compliance by December of 2009, including completing any needed construction or alternative method of compliance. The important thing for producers who need permits but don't have them is to make continual progress towards obtaining the permit and completing any required construction.

Q. Will an open feedlot have to be totally contained?

A. Yes, depending on the definition of total containment. For example, in Iowa, for cattle, you must be able to store the runoff from a 5.5-inch rainfall received within 24 hours (25-year, 24-hour storm event) in addition to the runoff received between periods of land application as specified in Division II of Chapter 65 of the Iowa Administrative Code. An NPDES permit is a permit to discharge under very specific circumstances. This means the operation must be properly designed, constructed, operated and maintained. Discharges due to poor management (such as not emptying a basin) would not be allowed.

Q. **Where can I find design criteria or the effluent limitation guidelines for my combined operation?**

A. For more information on what is required, see state regulations in Division II of Chapter 65 of the Iowa Administrative Code or consult with a design engineer. Chapter 5 of the U.S. Environmental Protection Agency's Producers Compliance Guide for CAFOs may also contain some helpful information.

Q. So I need an NPDES permit, what forms and attachments should be used when I have some animals in confinement with an existing manure management plan?

A. If you have an existing confinement with a manure management plan (MMP), then you can continue to use that form (542- 4000) and the shorter annual updates (542-8162) for the confinement portion of the operation. You would also need a nutrient management plan (NMP) form (542-2021) for the open feedlot and any other animals not covered by the MMP. In both the MMP and NMP, you would need to keep records of actual application rates and fields.

You will also need the NPDES application form (542-4001), the NPDES fee form (542-1250) and the compliance schedule (542-0190). Before you begin construction, you will also need to apply for a Construction Permit (form 542-1427). Other forms such as a storm water permit, floodplain permit or water use withdrawal permit may be needed. All forms can be found on the DNR forms page.

Q. Can manure plans be combined into one?

A. It's up to the producer. You may keep the confinement portion of the operation covered by an existing manure management plan (MMP) which offers the convenience of using the short forms for three years out of four and allows producers to keep records of any changes in application rates and fields without filing a new MMP each time a field changes. If you continue to use the MMP, there is a spot on the nutrient management plan form to indicate that the confinement animals are covered under an existing MMP.

In this case, only the open feedlot portions would need to be covered with a nutrient management plan (NMP). Or, a producer could choose to cover the entire operation under a nutrient management plan (NMP). It's your choice. However, compliance fees are due each year for the confined animals.

Q. Will silage effluent have to be contained?

A. Yes, silage effluent is considered part of manure and process wastewater under state rules and must be contained. (See manure definitions in Chapter 65 of the Iowa Administrative Code on pp. 7 and 57) It's also important to contain the runoff from feed and feed stocks because it has high organic matter content which can rob waters of oxygen when the runoff reaches a stream. The resulting low oxygen conditions can cause poor water quality in streams and in extreme conditions can cause a fish kill.

Q. Will a manure management plan (MMP) be required with an NPDES application?

A. Not unless you are already required to submit a manure management plan (MMP) for the confinement portion of the combined operation. Otherwise, no, the federal rules under the U.S. Environmental Protection Agency require facilities that need an NPDES application to file a nutrient management plan or NMP. While many requirements of an NMP and MMP are similar, the NMP also asks producers to document their management practices for handling dead animals, chemicals, maintaining clean water and more. Following the NMP also becomes part of the NPDES permit. (See questions on NMPs and MMPs above.)

Q. Is the application sent to DNR field offices or Des Moines?

A. The NPDES application form along with the NMP and/or MMP, documentation of public notice, compliance schedule and fee should be sent to the DNR's Des Moines office at 502 East Ninth St., Des Moines 50319.

COMPLAINANT'S
EX. NO. 29

skip to: page content | links on this page | site navigation | footer (site information)

Iowa Manure Matters -

Odor and Nutrient Management

IOWA STATE UNIVERSITY
University Extension

Fall 2006

New Fact Sheet Series Regarding Manure Management is Available

PRINT VERSION (pdf)

By Angela Rieck-Hinz, Department of Agronomy, ISU; Alison Smith, Iowa Pork Producer's Association

Month	Fact Sheet Title/Topic
July	Introduction to the Iowa Manure Manager Series
August	Land Application
September	Neighbor Relations
October	Agronomics of Manure vs. Commercial Fertilizer
November	Winter Application of Manure
December	Manure Stockpiling
January	Financial and Technical Assistance for Producers
February	Regulations/Compliance
March	Small Animal Feeding Operations
April	Manure and Organic Agricultural Production
May	What Crop Producers Need to Know About Using Manure

A new series of fact sheets for Iowa crop and livestock producers titled the "Iowa Manure Manager Series" is currently being developed, with the first fact sheet available in early July. This series of fact sheets is being developed by the members of the Iowa Manure Management Action Group (IMMAG) in response to the continued need to provide information on regulations, best management practices, neighbor relations and sources of additional information for people producing or applying manure as crop nutrients.

Topics for each of the 11 facts sheets were identified by the members of IMMAG and are listed below. The fact sheets will be available through the IMMAG Web page and will be distributed by the members of IMMAG through their respective newsletters, magazines, producer mailings and the popular press. Anyone wanting hard copies of the fact sheets will be able to print the material from the Web at :

Complainant's Ex. No. 29

http://extension.agron.iastate.edu/immag/pubsimms.html.

Members of IMMAG and additional contributors include: Natural Resources Conservation Service, Iowa Department of Natural Resources, Iowa Pork Producer's Association, Iowa Cattlemen's Association, Iowa Turkey Federation, Iowa Poultry Association, Iowa State Dairy Association, Iowa Corn Grower's Association, Iowa Soybean Association, Agribusiness Association of Iowa, Iowa Commercial Nutrient Applicators Association, Iowa Farm Bureau Federation, Coalition to Support Iowa's Farmers, Iowa Department of Agriculture and Land Stewardship-Division of Soil Conservation, Conservation Districts of Iowa, Iowa Environmental Council, Iowa Pork Industry Center, Iowa Beef Center, Iowa State University Extension and the Iowa State University College of Agriculture.

Iowa Manure Manager Series

Volume 9

Summary of Regulation for Building or Expanding Open Lot and Confined Beef and Dairy Operations with less than 1,000 Animal Units

Iowa law requires that all manure from an animal feeding operation be handled, stored and land applied so that it does not cause surface or groundwater pollution. Confinement feeding operations must retain all manure between periods of land application. Open feedlots that have not been designated as a Concentrated Animal Feeding Operation (CAFO) must remove settleable solids from effluent prior to discharge into a water of the state. Even if settleable solids have been removed, when open feedlot effluent reaches a water of the state it must not cause sludge, floating debris, toxic conditions or objectionable odor or color (general water quality criteria). Reference: Iowa Administrative Code (IAC) [567] Chapter 61 and 65.

Multiple Feeding Operations on Your Farm

State law says animal feeding operations that are under the same ownership or management, and are adjacent or use the same area or system for disposal of manure or open feedlot effluent will be considered one operation. Therefore, it is crucial to determine if multiple building sites in your operation meet this determination and subsequently require you to have the appropriate manure or nutrient management plan and meet the appropriate construction permit requirements.

Although this fact sheet is written to address issues for facilities smaller than 1,000 animal units, recent legislative changes may affect your operation and how to determine the size of your facility and in particular whether or not your operation is defined as a CAFO.

Effective December 31, 2008, all animals of the same category, as defined by federal law, are counted together, regardless of housing type, to determine if the animal feeding operation meets the definition of a CAFO. If the operation is determined to be a CAFO, it could potentially need to have an NPDES permit. This permit would need to be applied for on or by December 31, 2008.

In the past Iowa law did not combine animals of one species across housing types. For example, when determining facility size, confined animals were not counted with open lot animals. This is still true for Iowa's regulatory requirements such as construction permits and manure management plans. However, EPA rules and as of December 31, 2008, state law (for the purpose of determining CAFO status as part of the federal NPDES Permit program) combine open feedlot and confinement facilities housing the same category of livestock. To determine "categories" of livestock as defined federally please see http://cfpub.epa.gov/npdes/afo/compliance.cfm. If you have more than one animal type on your farm, you count all animals of each type separately. However, if one type of animal meets the CAFO definition on your farm, but the other animal types do not, all the manure, effluent and process wastewater from all animal types on the farm will be regulated under the CAFO NPDES permit.

Contributors

- Natural Resource Conservation Service
- Agribusiness Assoc. of Iowa
- Iowa Farm Bureau Federation
- Iowa Poultry Association
- Iowa Turkey Federation
- Iowa Pork Industry Center
- Iowa Beef Center
- Iowa Pork Producers Assoc.
- Iowa Department of Natural Resources
- Iowa Cattlemen's Association
- Division of Soil Conservation, Iowa Department of Agriculture and Land Stewardship
- Iowa State Dairy Association
- Iowa Commercial Nutrient Applicators Association
- Coalition to Support Iowa's Farmers
- Iowa Corn Growers Association
- Iowa Soybean Association
- Iowa State University, University Extension
- Iowa State University, College of Agriculture

Regulation	Confinement Feeding Operation	Open Lots
Definition	A confinement feeding operation confines animals to areas that are totally roofed. Confinement feeding operations in Iowa are not allowed to discharge manure to a water of the state.	An open feedlot is unroofed or partially roofed with no vegetation or residue ground cover while the animals are confined. Open feedlots in Iowa are required to remove all settleable solids from open feedlot effluent before discharge into water of the state. Even if the settleable solids are removed Iowa law prohibits discharges which violate Iowa's water quality standards. See 567 IAC 61.3. http://www.legis.state.ia.us/ACO/IAChtml/567.htm#rule_567_61_3
Manure or Nutrient Management Plan	**Yes**, Manure Management Plan if more than 500 animal units http://www.iowadnr.gov/afo/mmp.html **Yes**, if applying for a low interest loan – the manure management plan can be developed with funds from the loan. For more information on low interest loans see: http://www.iowaagriculture.gov/FieldServices/localWaterProtection.asp	**No**, unless designated by DNR as a CAFO. If a CAFO and required to have NPDES Permit see: http://www.iowadnr.gov/afo/nmp_producer.html **Yes**, if applying for a low interest loan – the manure management plan can be developed with funds from the loan. For more information on low interest loans see: http://www.iowaagriculture.gov/FieldServices/localWaterProtection.asp
Manure Applicator Certification Required	**Yes**, if more than 500 animal units http://www.iowadnr.gov/afo/appcert.html	**No**. Not required of the producer. If using commercial applicators, the commercial applicator must be certified. http://www.iowadnr.gov/afo/appcert.html
Separation Distanced for Land Application of Manure	**Yes**, see Tables 1, 2 and 3 (if more than 500 animal unit capacity) or Tables 2 and 3 (if under 500 animal units capacity) of DNR 113. http://www.iowadnr.gov/afo/files/sepdstb4.pdf DNR Form 117 High Quality Water Resources http://www.iowadnr.gov/afo/files/hqwr2.pdf Required to Report Manure Spills to (515) 281-8694	**Yes**, see Table 2 of DNR 113 http://www.iowadnr.gov/afo/files/sepdstb4.pdf DNR Form 117 High Quality Water Resources http://www.iowadnr.gov/afo/files/hqwr2.pdf Required to Report Manure Spills to (515) 281-8694

Regulation	Confinement Feeding Operation	Open Lots
Stockpiling Manure	**No**. All manure must be retained between periods of manure disposal. See 567 (IAC) 65.2 http://www.legis.state.ia.us/ACO/IAChtml/567.htm#rule_567_65_2 Exceptions apply to manure sold under Iowa Code Chapter 200A	**Yes**, but subject to requirements in Iowa Code 459A.403 http://nxtsearch.legis.state.ia.us/NXT/gateway.dll?f=templates&fn=default.htm
Separation Distances for Construction or Expansion	**Yes.** http://www.iowadnr.gov/afo/files/distreq.doc	**Yes.** All feedlots, runoff control basins and settling basins built or expanded after March 20, 1996 are required to meet minimum separation distances from wells. See 567 Iowa Administrative Code (IAC) 65.108 http://www.legis.state.ia.us/ACO/IAChtml/567.htm#rule_567_65_108
Master Matrix	Required if the site needs a construction permit and the county where the site is located requires the Master Matrix. See Construction Requirements for Confined Animals. http://www.iowadnr.gov/afo/matrix.html	**No.**
Storm Water Discharge Permit	**Yes**, for information see: http://www.iowadnr.gov/water/stormwater/index.html DNR Form 542-1415 http://www.iowadnr.gov/afo/forms/5421415.pdf	**Yes**, for information see: http://www.iowadnr.gov/water/stormwater/index.html DNR Form 542-1415 http://www.iowadnr.gov/afo/forms/5421415.pdf
Water Use Permits	**For information**: http://www.iowadnr.gov/water/wse/allocation.html DNR Form 542-3106 http://www.iowadnr.gov/afo/forms/5423106.pdf	**For information**: http://www.iowadnr.gov/water/wse/allocation.html DNR Form 542-3106 http://www.iowadnr.gov/afo/forms/5423106.pdf

Regulation	Confinement Feeding Operation	Open Lots
Construction Requirements	Summary of Preconstruction Requirements prior to building, modifying or expanding a Confinement Feeding Operation. http://www.iowadnr.gov/afo/files/summary.pdf **500 animal units or less** Unformed storage requires construction permit. http://www.iowadnr.gov/afo/forms/5421428.doc Formed storage does not require a construction permit, but preconstruction requirements must be met. http://www.iowadnr.gov/afo/specreq_small.html **501 to 999 animal units – Unformed Storage** A construction permit is required prior to building, modifying or expanding all sizes of operations that use unformed storage. http://www.iowadnr.gov/afo/specreq.html http://www.iowadnr.gov/afo/forms/5421428.doc **501-999 animal units – Formed Storage** A construction permit is not required for building, modifying or expanding a confinement feeding operation with a proposed animal unit capacity from 501 to 999 animal units that uses formed storage. However, pre-construction requirements and design standards must be met before construction begins. http://www.iowadnr.gov/afo/specreq_non.html And an MMP must be submitted to the DNR 30 days prior to the beginning of construction.	If your operation is less than 1,000 animal units, but you have been designated a CAFO see DNR Form 542-1427 Open Feedlot Construction Permit Application Form http://www.iowadnr.gov/afo/forms/5421427.pdf **Open Feedlot Construction Permit Manual** http://www.iowadnr.gov/afo/files/open_permit-man.pdf For facilities with less than 1,000 animal units (non-CAFO), there are no construction requirements, unless the open feedlot is a designated CAFO. However you are not allowed to discharge open feedlot effluent unless all settleable solids have been removed nor are you allowed to cause a violation of state water quality standards. No direct discharge from an animal feeding operation is allowed to a publicly-owned lake, a sinkhole or an agricultural drainage well. This fact sheet is intended to be a summary and is not inclusive of all regulations that apply to livestock operations. Please contact your local DNR Field Office if you have questions or concerns related to your livestock operation. For assistance in determining the type and size of livestock operations you operate defined by state and federal rules, please see IMMS Vol 1, *Introduction to the Iowa Manure Manager Series.* Written by Angela Rieck-Hinz, Extension Program Specialist, Iowa State University

COMPLAINANT'S
EX. NO. 30

Supplemental
EXPERT OPINION
on
Economic Benefit
***In the matter of*:**
Moran Beef, Incorporated

prepared for:
U.S. Environmental Protection Agency

prepared on:
March 18, 2011

prepared by:
Jonathan S. Shefftz

d/b/a JShefftz Consulting
14 Moody Field Road
Amherst MA 01002

under subcontract to:
Industrial Economics, Incorporated
2067 Massachusetts Avenue
Cambridge MA 02140

Supplemental Expert Opinion of Jonathan S. Shefftz
Economic Benefit of Noncompliance
March 18, 2011

1. Summary of Opinion

I have been asked by the U.S. Environmental Protection Agency ("EPA") to provide an expert opinion regarding the economic benefit that Respondent Moran Beef, Incorporated may have gained because of alleged environmental noncompliance at its open cattle feedlot located in Iowa's Pottawattamie County. This supplemental report provides additional calculations based on new information received since my prior September 29, 2010 expert report and is designed to be read on its own without reference to my initial report.

My opinion is that Respondent has gained an economic benefit of approximately $5,200 to $18,400, with the range dependent on the final net cost of compliance. The upper-end of the range, $18,400, corresponds to standardized cost estimates for the compliance measures. The lower-end of the range, $5,200, corresponds to submitted invoices net of anticipated government funding. A middle figure, $9,800, corresponds to submitted invoices but without any government funding.

I may revise my opinion as additional information becomes available to me or upon the reconsideration of existing information.

2. Basis for Opinion

My opinion is based broadly on my expertise in economic and financial analysis. I hold both undergraduate and graduate degrees with a focus on economics in various contexts. My experience with economic benefit calculation dates back to 1992, encompassing expert witness casework, computer model development, training of state and federal agency staff, as well as involvement in federal agency public comment and peer review processes.

More specifically, I have been involved with the periodic revisions and modifications to the U.S. Environmental Protection Agency's "BEN" economic benefit computer model since 1992, first as an employee of Industrial Economics, Incorporated ("IEc") and since April 2006 as a subcontractor to IEc. Both federal and state environmental enforcement staff use the BEN model to develop their economic benefit results for penalty determinations. In 1998, I managed IEc's development (under contract to U.S. EPA) of an entirely new version of the model for the Windows operating system. Since then, I have continued to work on all aspects of IEc's support to EPA on the BEN model, encompassing researching relevant tax code changes, implementing new features, supervising a helpline that assists EPA and state environmental agencies, managing academic peer reviews, developing training course materials, and even typing in individual formulas. I have also published articles on the subject matter (both concerning the BEN model, and related economic benefit issues).

Specifically for this case, I have reviewed compliance-related information provided to me by U.S. EPA staff and also discussed certain aspects of the case with U.S. EPA staff. I have also conducted independent research for various economic inputs. Attached to the main body of this report is my resume, which includes a list of my publications and a list of the cases in which I have testified going back at least four years.

3. Economic Benefit: Context, Theory, and Methodology

In this section, I explain economic benefit's context, theory, and methodology. In the section after this one, I summarize and then provide my economic benefit analysis.

a. Context

Moran Beef is a open cattle feedlot located in Iowa's Pottawattamie County. U.S. EPA alleges that this facility has been illegally discharging livestock waste, without an NPDES permit.

Compliance would have entailed implementing the proper controls or lowering production levels. Instead, Respondent never undertook sufficient or adequate compliance measures during the noncompliance period. With the funds that should have been expended for compliance, Respondent could have instead, for instance, increased investment in other financially productive ventures or provided greater returns to its ownership for personal consumption. Alternatively, had Respondent come into compliance in a timely manner by lowering production levels, then it would have lost the incremental profits associated with that additional production.

b. Theory

When companies (such as Respondent in this case) delay or avoid compliance with environmental requirements, an economic benefit can occur from such delay or avoidance. By postponing compliance, a company can realize a benefit from delaying investing in capital equipment and/or incurring other costs, from delaying or avoiding business interruption losses necessitated by upgrades for compliance, and/or from avoiding the payment of certain necessary ongoing operating and maintenance costs. Economic benefit represents the financial gains that accrue through such delayed and/or avoided expenditures. Funds not spent on environmental compliance are available for financially productive economic activities or, alternatively, the costs associated with obtaining additional funds for environmental compliance are avoided.[1]

By contrast, if compliance were to be achieved via shutting down operations or lowering production levels, then a company can realize a benefit from the profits it would not otherwise have been able to earn were it not operating at that production level. (Economic benefit based on delayed and/or avoided expenditures also represents profits that would not have been available to a compliant company, but the incremental profits in those instances are measured indirectly by examining only the cost differentials, and assuming that all other aspects of the company's operations such as output, pricing, and sales are essentially unaffected.)

Either way, economic benefit is the amount by which a company is financially better off as a result of not having complied with environmental requirements in a timely manner. Economic benefit is "no fault" in nature: a company need not have deliberately chosen to delay compliance (for financial or any other reasons) – or in fact even have been aware of its noncompliance – for it to have accrued the economic benefit of noncompliance.

The appropriate economic benefit estimate should represent the amount of money that would make the company indifferent between compliance and noncompliance. Ideally, for penalty-setting purposes the economic benefit result should be adjusted for the probability of detection, prosecution, and ultimate payment.[2] That is, if Respondent in this case knew that for every noncompliant company in the industry, the probability of ultimately paying a penalty that recaptured economic benefit was only 25 percent (i.e., one-fourth), then the economic benefit result would have to be multiplied by a factor of four for penalty-setting purposes. As the probability of detection-prosecution-payment declines, then the amount of money proportionately increases that would make the company indifferent between compliance and noncompliance. Unfortunately, even rough estimates of these probabilities (whether industry- or medium-specific) are unavailable.[3] Therefore, for purposes of this report, I am unable to assess any probability-adjusted economic benefit component for a civil penalty, and do not apply any such probability-based multiplier factor to my economic benefit results. Hence, were my economic benefit results to be used as the basis for a civil penalty without any further adjustments, this would implicitly assume a 100-percent probability of detection-prosecution-payment for these types of violations.

---

[1] The concept that the true cost of any action can be measured by the value of the alternative that must be foregone is known in economics as the concept of "opportunity cost."

[2] This issue was raised by a peer review panel of academic experts in *An Advisory of the Illegal Competitive Advantage (ICA) Economic Benefit (EB) Advisory Panel of the EPA Science Advisory Board* (September 7, 2005). The advisory report is available for downloading at:
http://www.epa.gov/sab/pdf/ica_eb_sab-adv-05-003.pdf

[3] See U.S. EPA Office of Inspector General, *EPA Performance Measures Do Not Effectively Track Compliance Outcomes* (December 15, 2005), available at:
http://www.epa.gov/oig/reports/2006/20051215-2006-P-00006.pdf

If a civil penalty fails to recover at least this economic benefit, then Respondent will retain a gain from their noncompliance. Because of the precedent of this retained gain, Respondent and even other entities may see an economic advantage in similar noncompliance, and the penalty will fail to deter potential violators. Economic benefit does not represent compensation to Plaintiffs as in a typical "damages" calculation for a tort case, but instead is the minimum amount that Respondent must pay as a civil penalty to the government so as to return Respondent to the position it would have been in had it complied in a timely manner. Therefore, were the economic benefit not to be fully disgorged in the form of a civil penalty payment, the residual financial gain could be construed as representing an unfair competitive advantage to Respondent over other companies in its industry.

c. Methodology

The economic benefit calculation incorporates the concept of the "time value of money." For example, in simple terms, a dollar yesterday is worth more than a dollar today, because one had investment opportunities for yesterday's dollar. Thus, the further in the past that the dollar was obtained, the more it is worth in "present-value" terms. The greater the time value of money (i.e., the greater the "discount" or "compounding" rate), the more value past costs have in present-value terms.

To calculate economic benefit, I use standard financial cash flow and net present value analysis techniques, based on modern and generally accepted financial principles. Such an approach is the underpinning of any capital budgeting exercise, and is the standard approach by which alternative investments should be judged according to any financial economics or corporate finance text. This is the same approach that the U.S. EPA's "BEN" economic benefit computer model employs, and is also the same approach that I employ when testifying, whether on behalf of U.S. EPA, U.S. DOJ, state environmental enforcement agencies, or citizen litigators.

First, I calculate: (a) the costs that Respondent should have incurred in order to attain full on-time compliance; and, (b) the costs of delayed compliance that Respondent might be expected to eventually incur. I then adjust for the tax deductions available for these costs. Next, I calculate the present value of the costs, or "cash flows." This adjustment is performed with a rate that reflects the cost of capital over the period of noncompliance. Finally, I subtract the present value of the delayed compliance from the present value of the on-time compliance to determine the economic benefit for Respondent.

A civil penalty insufficient to disgorge the entire amount of the economic benefit figure would fail to make a company financially indifferent between compliance and noncompliance. Such indifference is the first step in achieving financial deterrence, which would additionally require an even higher penalty over and above the disgorgement of the economic benefit. For example, if the economic benefit were $1,000 and the civil penalty only $700, the company would have a $300 incentive to violate the law. By contrast, if the civil penalty were exactly $1,000, the company would come out even, and have no incentive either to comply or not comply. Alternatively, if the penalty were $1,500, the company would have a $500 incentive to comply. Note that all of these examples implicitly assume a 100-percent probability of detection, prosecution, and payment. As previously explained in section 3.b. above, as the probability of detection-prosecution-payment declines, then the amount of money proportionately increases that would make the company indifferent between compliance and noncompliance.

4. Economic Benefit Analysis

Below I explain how I calculate Respondent's economic benefit of noncompliance from avoiding and/or delaying the necessary compliance costs. First I describe the inputs and calculations that apply to all the different compliance scenarios, then I describe the scenarios and their respective economic benefit results.

Note that I do not analyze the economic benefit based upon an alternative scenario that entails achieving compliance by lowering production levels at an earlier date. This omission is because:

- I do not know whether Respondent would have chosen such a compliance option had it complied on time; and,
- I lack any information on the incremental profit associated with the additional production that would have been foregone had Respondent complied by operating at a lower level.

Also note that all of the calculations and results in the spreadsheet printout should be fully replicable for any analyst. These results are almost identical to those that would be obtained by running the U.S. EPA BEN model.[4]

a. Inputs and Calculations Applied to All Compliance Scenarios

The following numbered paragraphs correspond to the numbered rows in the first section of the spreadsheet printout that follows at the end of my report.

(1) I use the year-specific U.S. federal and Iowa state combined marginal corporate tax rates. I use the highest marginal rates, even though if anything the actual tax rates for Respondent might be lower. The highest marginal rates produce the lowest after-tax value of compliance costs, and therefore the most conservative, downwardly biased economic benefit results.

[4] The most significant difference in my calculations compared to the BEN model is in the treatment of the depreciation tax shields. BEN calculates the cash flows in each year, whereas for presentation purposes I apply a depreciation tax shield present value to a single year.

(2) I use an estimate of Respondent's weighted average cost of capital ("WACC") to compound and discount the company's cash flows. The WACC represents the cost of a company's debt and equity weighted by the value of each source of financing. On average, a company must earn a rate of return that enables it to repay its debt holders (e.g. banks, bondholders) and satisfy its equity owners (e.g., partners, stockholders). Although companies can earn rates in excess of their WACC, companies that do not on average earn returns equivalent to their WACC will not survive (i.e., their lenders will not receive their principal and/or interest payments, and their owners will be dissatisfied with their returns). As a result, standard business practices dictate that a company should make its business decisions by discounting cash flows at its WACC. Therefore, the WACC represents the return Respondent would have expected to earn on monies not invested in pollution control, or, viewed alternatively, represents the avoided costs of financing pollution control investments. For specific values, I use an average of Respondent's cost of capital for 2009 and 2010, and then use an average of these years' figures as the rate to discount and compound all cash flows throughout my economic calculations. Since I lack detailed information on Respondent's finances, I use the figures for "Meat Products" (SIC code 201) as provided by Morningstar's Ibbotson Associates *Cost of Capital Yearbook.*[5]

(3,4) I use the modified Accelerated Cost Recovery System ("MACRS") for initial capital investments as specified by the U.S. Internal Revenue Service, which entails a seven-year double declining balance schedule with conversion to straight line. This is the most rapid depreciation schedule that Respondent would likely use (and be legally allowed to use) for tax purposes, and thus produces the most conservative economic benefit calculation.[6] The tax rate is then applied to the present value of these tax shields.

(5) I use January 1, 2009 as the date by when Respondent should have achieved compliance. Therefore, on this date I model the compliance costs as having been incurred for on-time compliance. I use October 4, 2010 as the date for when Respondent actually did incur the compliance costs, since this date represents the weighted average (by dollar amount) of the submitted invoices. I calculate all my present values as of April 5, 2011, the date of the scheduled hearing. (Since any settlement or hearing judgment would occur after this date, I also provide calculations on the monthly increase for my economic benefit figures.)

---

[5] Although Ibbotson advocates an additional size premium for small companies like Respondent, I omit this to formulate a more conservative cost of capital, and hence more conservative, downwardly biased economic benefit result. The median industry values as reported by Ibbotson are 10.22 percent in 2009 and 9.84 percent in 2010, for an average across those years of 10.03 percent.

[6] Depreciation generates positive after-tax cash flows; the nearer these are to the current date, the lower the net present value of the pollution control expenditures.

(6) Based on all of the preceding data and calculations, I calculate the present value (as of April 5, 2011) of a dollar incurred at the dates for both on-time compliance and delayed compliance, and also the after-tax present value of a dollar at both dates.

(7-11) I also account for replacement of the environmental structures at the end of their 25-year life (as specified in Table 15 of the *Beef Feedlot Systems Manual* published by the Iowa Beef Center at Iowa State University). This additional calculation is necessary because even though the environmental structures have finally been put in place, they are newer than if they had been put in place in a timely manner. Hence, in the future, their actual replacement will be delayed. I use an imputed lease cost calculation to reflect the value of having newer structures.

b. Compliance Scenarios

The second section of the spreadsheet printout includes four lettered rows, A through D, that correspond to four different compliance scenarios.

(A) ***"Beef Manual":*** Moran Beef had indicated the intention to comply by constructing runoff controls at the facility and had submitted engineering plans for a control system for a 1,400-head open feedlot system along with a 990-head confinement barn. U.S. EPA Region 7 staff had developed construction cost estimates based on the 2006 document the *Beef Feedlot Systems Manual* published by the Iowa Beef Center at Iowa State University. Specifically, Region 7 examined only the open feedlot portion of the facility (and omitted any costs associated with the confinement building), as provided in the appendix's Table 10 ("Initial Investment for System 1, Earthen Lot with Windbreak") and Table 15 ("Depreciation Life and Repairs Rate"). Region 7 included only the cost estimates for engineering ($50,000 capital) and construction ($90,000 capital) associated with the environmental structures. Since Respondent's submitted plans did not indicate reliance on a center pivot irrigation system, no such cost estimates were included in the economic benefit calculation.

(B) ***"Invoices":*** Moran Beef recently submitted invoices documenting $86,312 of actually incurred costs, as summarized at the bottom of the spreadsheet printout. Whether additional in-house costs were unnecessary had not been specified.

(C) ***"Net of EQIP":*** Moran Beef recently claimed that it anticipates receiving Environmental Quality Incentives Program ("EQIP") funds from the U.S. Department of Agriculture ("USDA") to essentially subsidize construction of the wastewater controls. No documentation of any sort has been submitted to EPA substantiate this claim, but Moran Beef claims that USDA has provided assurances that $40,169 is forthcoming. Therefore, here I analyze the $86,312 net of $40,169 for both on-time and delayed compliance.

(D) ***"EQIP Delay":*** Here I analyze a scenario under which EQIP funds will indeed be received for delayed compliance yet would not have been available for on-time compliance. Since this analysis is provided mainly simply to illustrate how third-party funding can increase the economic benefit, I place all of these calculations in italics.

c. Economic Benefit Results

All four of the lettered compliance scenarios described above are run through the following calculations, with the number paragraphs below corresponding to the number columns.

(1,2,3) For each scenario, I provide the initial cost estimate and the cost date. For the *Beef Feedlot Systems Manual*, the date is the publication date. For the invoices, the date is the average across all invoices, weighted by the dollar amount of each invoice.

(4,5,6) To adjust cost estimates from their initial dates to the dates of on-time compliance and delayed compliance, I use the Construction Cost Index ("CCI") from *Engineering News Record.*

(7,8,9) The inflation-adjusted compliance costs for on-time compliance and delayed compliance are adjusted to after-tax present values as of the scheduled hearing date. I also calculated the avoided imputed lease cost (for the interim period when the on-time structures would need to be replaced but the delayed structures would still be within their useful life). Note that the lease cost for scenarios C and D does not consider EQIP reimbursement, given its uncertain existence 25 years in the future.

(10) The economic benefit is equal to the on-time after-tax present value, minus the delayed value, plus the lease value. My results show an economic benefit of approximately \$5,200 to \$18,400, with the range dependent on the applicable compliance scenario. The upper-end of the range, \$18,400, corresponds to standardized cost estimates for the compliance measures from the *Feedlot Systems Manual*. The lower-end of the range, \$5,200, corresponds to submitted invoices net of anticipated EQIP funding. A middle figure, \$9,800, corresponds to submitted invoices but without any EQIP funding. (And were the EQIP funding available only now for delayed compliance but not for on-time compliance, then the economic benefit is considerably higher.)

(11) This economic benefit is calculated as of the scheduled hearing date, i.e., April 5, 2011. If the penalty payment is further delayed, the economic benefit would continue to be compounded at the rate of 10.03 percent (i.e., my figure of Respondent's cost of capital). This translates into increases for each month of delay past October 5, 2011 as noted in the final column.

Economic Benefit Inputs, Calculations, and Results

(1)	Marginal corporate tax rates:	U.S.	Iowa	Combined		
		35%	12%	42.8%		
(2)	WACC for SIC Code 201 (Meat Products):	2009	2010	Average		
		10.22%	9.84%	10.03%		
(3)	0.7561	Present value of depreciation tax shields (MACRS) - see separate table below				
(4)	67.64%	After-tax (A-T) adjustment value (applies tax rate to tax shields)				
(5)	Dates (noncompliance, compliance, penalty):	On-Time	Delayed	Hearing		
		1-Jan-09	4-Oct-10	5-Apr-11		
(6)	Factors:	Present Value		A-T Present Value		
		On-Time	Delayed	On-Time	Delayed	
		1.2408	1.0489	0.8393	0.7095	
(7)	Interim period when On-Time (but not Delay) would need replacement:	Start	End	Years	Life (yrs)	
		1-Jan-34	4-Oct-35	1.7589	25	
(8)	14012.07	Construction Cost Index (CCI) value at start				
(9)	1.5707	Cost ratio for lease start : Delayed date (see table below for Delayed CCI)				
(10)	0.3051	Lease cost (ratio to delay cost)				
(11)	0.0597	After-tax present value factor				

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
				Monthly	Adjusted to (date/CCI):		After-Tax				
	Scenario	Initial	Cost	Value	1-Jan-09	4-Oct-10	Present Value:			Economic	Monthly
	Description	Cost	Date	for CCI	8549.00	8921.00	On-Time	Delayed	Lease	Benefit	Increase
(A)	Beef Manual	$140,000	Jan-06	7660.29	$156,242	$163,041	$131,134	$115,678	$2,969	$18,425	$148
(B)	Invoices	$86,312	Oct-10	8921.00	$82,713	$86,312	$69,421	$61,238	$1,572	$9,755	$78
(C)	Net of EQIP	$46,143	Oct-10	8921.00	$44,219	$46,143	$37,113	$32,738	$1,572	$5,947	$48
(D)	*EQIP Delay*				*$82,713*	*$46,143*	*$69,421*	*$32,738*	*$1,572*	*$38,255*	*$307*

Depreciation Schedule Tax Shield PV Factors (MACRS):

Year	0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5
PV Factor	0.9533	0.8664	0.7874	0.7157	0.6504	0.5911	0.5373	0.4883
MACRS %	0.1429	0.2449	0.1749	0.1249	0.0893	0.0892	0.0893	0.0446
PV	0.1362	0.2122	0.1377	0.0894	0.0581	0.0527	0.0480	0.0218

Submitted Invoices

Date	Amount	Vendor
4-Apr-10	$3,051	Neola IA
23-Jun-10	$9,295	Curry-Wille & Associates
1-Aug-10	$2,548	Wellman Construction
6-Aug-10	$12,895	Curry-Wille & Associates
1-Sep-10	$2,765	Wellman Construction
19-Oct-10	$2,382	HGM Associates
26-Oct-10	$2,454	Certified Testing Services
2-Nov-10	$5,289	Curry-Wille & Associates
22-Nov-10	$40,583	Wellman Construction
30-Nov-10	$600	Road Builders
30-Nov-10	$1,570	Certified Testing Services
23-Dec-10	$1,906	Curry-Wille & Associates
30-Dec-10	$974	Neola IA

5. Qualifications and Compensation

As previously noted under the section entitled Basis for Opinion, following the main body of this report is my resume, which also provides a list of publications and testimony experience. Via a subcontract with Industrial Economics, Incorporated, which in turn is contracting with the U.S. Environmental Protection Agency, my compensation for the time that I have spent preparing this report is $107.63 per hour.

I declare under the penalty of perjury that the statements in this report are true and accurate to the best of my knowledge.

5-18-2011
Dated

Jonathan S. Shefftz

JONATHAN S. SHEFFTZ

d/b/a JShefftz Consulting
14 Moody Field Road
Amherst MA 01002
www.JShefftzConsulting.com
413-256-1101 phone
866-252-7130 fax

Mr. Shefftz is an independent consultant who specializes in the application of financial economics to litigation disputes, regulatory enforcement, and public policy decisions. Previously he was a consultant with Industrial Economics, Incorporated ("IEc") from 1992 until 2006 when he moved to western Massachusetts. Mr. Shefftz has extensive experience in settlement and litigation support, and has been qualified as an expert witness in U.S. District Court, a federal agency's Administrative Court, and a state court.

Mr. Shefftz's recent experience includes work in the following areas.

- Calculating the economic damages suffered by companies and individuals from alleged wrongful actions.
- Applying financial economics to civil penalty factors in regulatory enforcement actions.
- Analyzing financial economic issues related to public policy decisions.

Mr. Shefftz has performed this work in a variety of contexts, including expert witness testimony, computer model development, training course delivery, and regulatory review. He has supervised project teams comprising economists, accountants, paralegals, and software developers, as well as worked in parallel with engineers, scientists, lawyers, and lobbyists. His clients have included federal and state governmental agencies, private litigators, and other private-sector entities.

Mr. Shefftz holds a B.A. *magna cum laude* and *Phi Beta Kappa* in Economics and Political Economy from Amherst College, and an M.P.P. degree, with concentrations in Government & Business and Energy & Environmental Policy, from the John F. Kennedy School of Government at Harvard University.

Mr. Shefftz's positions have included Eastern Vice President for the National Association of Forensic Economics, Chair for the Town of Amherst Planning Board, referee for the *Journal of Forensic Economics*, Course Liaison for the "Engineering Economic Decision Making" course at the University of Massachusetts Amherst, and member of the Finance Committee for the Jewish Community of Amherst. He is also a member of the Government Finance Officers Association, Eastern Economics Association, Western Economics Association International, and Amherst Area Chamber of Commerce.

Economic Damages

Mr. Shefftz has experience with the following work on economic damages and has provided expert witness deposition testimony in both U.S. District Court and a state court. He has also applied his expertise in unjust enrichment calculation, financial statement analysis, municipal financial assessment, and corporate control / ownership issues to private-party damages cases – this expertise is described in more detail in the "Financial Factors in Regulatory Enforcement" section.

Business Damages
Mr. Shefftz has modeled companies' cash flows under hypothetical "but-for" states of the world versus actual states of the world to calculate business damages in numerous cases. Sample contexts include an engineering firm that lost business to a spin-off competitor, timber companies that alleged a contract breach from U.S. Forest Service implementation of Congressional legislation, a furniture company whose relationship with a joint venture partner was interfered with by a key customer, a fixed base operator prohibited from selling jet fuel by a municipal airport commission, a brownfields remediation firm with an incapacitated key principal, a state-chartered joint underwriting association whose prior servicing carrier incorrectly determined premiums, a dealer who delivered contaminated diesel fuel, and a sports organization whose apparel licensee breached a contract.

Personal Damages
Mr. Shefftz has assessed lost earnings and household services along with incurred and anticipated medical costs in numerous cases involving wrongful death, personal injury, wrongful termination, estate disputes, and divorce proceedings. Sample contexts for this work include alleged employment discrimination, medical malpractice, workplace injuries, vehicular accidents, retail store accidents, below-market earnings, and an arrest instigated by a former spouse.

Groundwater Contamination
For a private landowner, Mr. Shefftz analyzed the diminution in real estate development value from groundwater contamination, projecting the development schedule with the contamination-induced delay vs. the original schedule. For a U.S. territory, Mr. Shefftz estimated the present value of future expenses for a proposed desalination plant to replace contaminated groundwater sources. On a class action lawsuit by property owners, he evaluated the defense economist's statistical analysis of property values; on another class action lawsuit, he assisted with present value calculations for whole-house drinking water treatment systems to replace contaminated well water.

Intellectual Property
For defense counsel in a copyright infringement lawsuit, Mr. Shefftz assessed declarations from the plaintiff's expert economist who asserted that a "companion" book would damage the author of the original series of novels. He also assisted counsel with preparation for trial cross examination.

Computer Model Development
For the U.S. Department of Justice Commercial Litigation Branch, Mr. Shefftz developed a standalone computer application to calculate statutorily determined interest accruing on damages claims under the Contract Disputes Act.

Financial Factors in Regulatory Enforcement

Mr. Shefftz has experience with the following work on enforcement actions brought under the Asbestos Hazard Emergency Response Act (AHERA), Clean Air Act (CAA), Clean Water Act (CWA), Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Emergency Planning and Community Right-to-Know Act (EPCRA), Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), Oil Pollution Act (OPA), Resource Conservation and Recovery Act (RCRA), Spill Prevention, Control and Countermeasure (SPCC) rule, Toxic Substances Control Act (TSCA), and others. Mr. Shefftz has been qualified as an expert witness on numerous occasions in Administrative Court, U.S. District Court, and a state court. His clients have included the U.S. Environmental Protection Agency (EPA), U.S. Department of Justice (DOJ), private litigators, state Attorneys General, and a corporate defendant.

Financial Statement Analysis / Ability-to-Pay / Economic Impact / Corporate Control & Ownership
Mr. Shefftz has examined the tax returns, financial statements, and other financial documentation for individuals, businesses, municipalities, territorial governments, and not-for-profits to assess the ability to pay for – and/or economic impact of – sought environmental expenditures, e.g., compliance costs, penalty demands, and cleanup/remediation costs. He has reviewed discovery documents and conducted research in many cases to assess the extent to which subsidiaries can rely on their corporate parents for financial support and the extent to which corporate control of their subsidiaries goes beyond that exercised by mere ownership.

Financial Gain / Economic Benefit / Unjust Enrichment
Mr. Shefftz has modeled companies' and municipalities' cash flows under hypothetical full and timely compliance states of the world versus actual delayed compliance states of the world to calculate the economic benefit (i.e., financial gain or unjust enrichment) on numerous enforcement actions. As part of this work, he has estimated the weighted-average cost of capital for a wide variety of companies and industries.

Other Financial Factors in Regulatory Enforcement Actions
Mr. Shefftz has performed work on other financial factors in regulatory enforcement actions: the "size of violator" penalty element; the relative weight of different financial indicators for establishing deterrence; and, the adequacy of financing plans to ensure environmental compliance.

Computer Model Development, Training, and Support
Mr. Shefftz has managed the development of the current versions of the BEN, PROJECT, ABEL, INDIPAY, and MUNIPAY computer models that U.S. EPA's Office of Enforcement and Compliance Assurance applies to financial economics issues in enforcement actions. He has prepared the models' help systems and training materials, as well as presented training courses and provided related support for federal and state enforcement staff. Mr. Shefftz has also assisted in several U.S. EPA academic peer reviews and public comment processes for the BEN computer model and related economic benefit recapture issues.

Public Policy

Cost of Capital Estimation
Mr. Shefftz assessed peer reviewer comments and then revised a draft report on cost of capital estimation for water systems. His work included applying the capital asset pricing model to the commercial drinking water industry and correcting for the earlier draft's assumptions regarding capital structure and industry-level business risk.

Financial Assurance
For a state agency, Mr. Shefftz proposed appropriate inflation forecasts and discount rates, drafted a guidance document, and then developed a stand-alone computer model to calculate the net present value of future remediation costs. For EPA's Office of Solid Waste, he provided recommendations on discounting future cleanup costs; for the Office of Site Remediation and Enforcement, he created a computer model to assess the combined affordability of financial assurance and cleanup costs; for another EPA office, he created a spreadsheet model to calculate the insurance and/or trust fund amounts necessary to provide for post-closure care. For the U.S. Department of the Interior's Office of Surface Mining Reclamation and Enforcement, he reviewed other agencies' approaches and developed a spreadsheet model to calculate initial trust fund amounts and then recalculate subsequent years' annual rebalancings to reflect actual returns and additional future costs.

Joint Cost Allocation
For a study of Bureau of Reclamation rate setting for California's Central Valley Project, Mr. Shefftz researched economically efficient methods for allocating water project costs to user classes.

Proposed Legislation
For an industry association, Mr. Shefftz designed and implemented a survey and analyzed its results to predict the impacts of a proposed national lead tax upon lead consumption and dependent industrial sectors. For a national waste management firm, he analyzed the financial impacts of a proposed state tax on hazardous waste land disposal.

Superfund Impacts
Mr. Shefftz examined the Department of Energy SURE model's predictions of economic impacts from Superfund liability and cost allocation reform. At a Superfund site, he critiqued a small city's claims that a proposed contaminated soil cleanup would lead to widespread economic disruptions.

Legislative Review
For the 1990 Clean Air Act amendments, Mr. Shefftz investigated the potential of fuel oxygenation requirements to cause petroleum refinery closures. For the Safe Drinking Water Act, he reviewed EPA's national-level drinking water affordability criteria, assessed their implications for small water systems' finances, proposed alternative criteria, created databases to predict how many systems would be judged unable to afford drinking water rules, and evaluated public comments.

JONATHAN S. SHEFFTZ

Representative Clients

Mr. Shefftz has been retained by the following clients, whether directly as an independent consultant, during his prior employment at Industrial Economics, Incorporated ("IEc"), and/or as an independent consultant via subcontract with IEc.

Private Law Firms
Adler, Cohen, Harvey, Wakeman & Guekguezian LLP
Law Office of Jacqueline L. Allen
Arnold & Porter LLP
Bayh, Connaughton and Malone
The Collins Law Firm, P.C.
D'Ambrosio Law Offices
Law Offices of John K. Dema, P.C.
Doherty, Wallace, Pillsbury & Murphy
The Garcia Law Firm
David S. Hammer, Esq.
Hanson Curran LLP
George E. Hays, Esq.
Henrichsen Siegel Moore, PLLC
Kasowitz, Benson, Torres & Friedman LLP
James E. Kolenich
Lucentini & Lucentini LLP
Meyers Nave
Motley Rice LLC
Patton Boggs LLC
Ryan, Ryan, Johnson & Deluca, LLP
Simonds, Winslow, Willis & Abbott
Stoel Rives LLP
Joseph J. Zajac III (pro se)
Meryl A. Kukura, Esq.
Marr Law Offices
Morrison Mahoney LLP
Law Office of Michael D. Parker
Edward M. Pikula, Esq.
Silverstein, Silverstein & Silverstein P.A.
Smith & Lowney, PLLC
Wilson Elser Moskowitz Edelman & Dicker LLP
Reed Zars, Esq.

State Agencies
California
Connecticut
Illinois
Indiana
Massachusetts
Michigan
New Hampshire
New Mexico
Ohio
Pennsylvania
Texas
Virginia
Wisconsin

Federal Agencies
U.S. Department of Justice (Civil Division – Commercial Litigation Branch; Environment and Natural Resources Division – Environmental Enforcement Section, Environmental Defense Section)
U.S. Environmental Protection Agency (various Headquarters Offices and Regional Counsels)
U.S. Fish and Wildlife Service (within U.S. Department of Interior)
National Oceanic and Atmospheric Administration (within U.S. Department of Commerce)
Office of Surface Mining Reclamation and Enforcement (within U.S. Department of Interior)

Citizen Groups and Industry
Alabama Environmental Council
Biodiversity Conservation Alliance
CWM Chemical Services, Incorporated
Grand Canyon Trust
Lead Industries Association
National Environmental Law Center
National Parks Conservation Association
Natural Resources Defense Council
Our Children's Earth Foundation
Pacific Environmental Advocacy Center
Puget Soundkeeper Alliance
Sierra Club
Tulane Environmental Law Clinic

Publications and Presentations

Corporate Control Issues in Insurance Indemnification Litigation, presentation at Fall Forensic Economics Workshop (Santa Fe NM), 10/7/11 (anticipated).

The Value of Future Earnings in Perfect Foresight Equilibrium, paper discussant at Allied Social Sciences Associations Conference (Denver CO), 1/8/11.

The Role of the Economic Expert in Litigation Directed at Piercing the Corporate Veil, presentation at Fall Forensic Economics Workshop (Durango CO), 10/8/10.

Alternative Perspectives for Breach-Nonbreach Scenario Specifications in Commercial Litigation, paper presentation at Western Economics Association International Annual Conference (Portland OR), 7/1/10.

Sampling Issues in Commercial Damages Cases, paper discussant at Western Economics Association International Annual Conference (Vancouver BC), 7/1/09.

Net Discount Rates: Does Duration Matter?, paper discussant at Eastern Economics Association Annual Conference (Boston MA), 3/7/08

Enforcement Economics: Deterrence, Economic Benefit, & Ability to Pay, presentation at California Environmental Protection Agency State Water Resources Control Board "Enforcenomics" Workshop (Berkeley CA), 1/11/08.

Alternative Focuses for "But-For" Scenario Specification in Commercial Litigation, paper presentation at Western Economics Association International Annual Conference (Seattle WA), 6/30/07

Expert Witness Role Play, presentation at U.S. EPA 9th Financial Analyst Workshop (Atlanta GA), 5/3/07.

Working with Experts in Environmental Cases: An Expert Economist's Perspective on Expert Testimony, presentation at Public Interest Environmental Law Conference (Eugene OR), 3/2/07.

Alternative Measures and Focuses for Economic Damages Calculations, paper presentation at Eastern Economics Association Annual Conference (New York NY), 2/23/07.

Lost Profit as a Measure of Lost Earning Capacity, panelist at Western Economics Association International Annual Conference (San Francisco CA), 7/7/05

"EPA's Economic Benefit Analysis Policy and Practice," *Natural Resources and Environment*, Fall 2004.

"Taxation Considerations in Economic Damages Calculations," *Litigation Economics Review*, Summer 2004.

Economic Benefit and Wrongful Profits in the Calculation of Penalties for Environmental Violations, presentation to Boston Bar Association Environmental Litigation Committee, 9/23/04.

Business Valuation / Commercial Damages, panelist at Western Economics Association International Annual Conference (Vancouver BC), 7/1/04.

"Wrongful Profits: Setting the Record, and the Concept, Straight," *Environment Reporter*, 1/2/04.

Present Value Sensitivity to Ex Ante vs. Ex Post Perspective, paper presentation at Western Economics Association International Annual Conference (Denver CO), 7/12/03.

Taxation Considerations in Economic Damages Calculations, paper presentation at Eastern Economics Association Annual Conference (New York NY), 2/22/03.

<u>Publications and Presentations</u> (continued)

Economic Benefit from Illegal Competitive Advantage and *Complex Economic Benefit Scenarios*, presentation at U.S. EPA 5th Financial Analyst Workshop (Boston MA), 7/26/00.

Economic Benefit in Wetlands Cases: Financial Analysis Issues, presentation at U.S. EPA Wetlands Enforcement Conference (Alexandria VA), 3/22/00.

Economic Benefit, presentation at U.S. EPA 4th Analyst Workshop (Denver CO), 3/10/99.

<u>Testimony History</u>

Chevron Corporation v. Jonathan S. Shefftz (USDC, Mass.) and *Maria Aguinda et al. v. Chevron Corporation* (Court of Justice of Nueva Loja, Ecuador), deposition 12/16/10.

Marvin Evans v. Certain Underwriters at Lloyd's London, KMS Associates, Inc., Greenwich Insurance Company, W. Brown & Associates, Inc. and Hub International Gulf South Limited f/k/a/ Hibernia Rosenthal Insurance Agency, LLC d/b/a Hibernia Rosenthal (Florida Circuit Court), deposition 11/15/10.

Elizabeth Russell and Katherine Gates v. Joseph Reilly and James Georges, Executors of the Estate of K. Mildred Dooling, a/k/a Mildred K. Dooling, and Patrick Curtin, Individually and as Trustee of the M.D. Realty Trust (Massachusetts Superior Court), courtroom testimony 7/21/10.

Hildagarde Bartling, et al. v. Country Villa Bay Vista Healthcare Center, et al. (California State Court), deposition 1/29/10.

Joseph J. Zajac III v. Pamela J. Trueblood, et al. (USDC, MD Fla.), affidavit 9/16/09.

In the matter of 99 Cents Only Stores (U.S. EPA Administrative Court), courtroom testimony 6/24/09.

U.S. v. Government of Guam (USDC, Guam), courtroom testimony 12/9/08 and 4/13/09.

U.S. v. James and Nancy Oliver d/b/a Safety Waste Incineration (USDC, Alaska), courtroom testimony 3/25/09 and 3/27/09.

In the matter of Valimet, Inc. (U.S. EPA Administrative Court), courtroom testimony 12/10/08.

Rectrix Aerodome Centers, Inc. v. Barnstable Municipal Airport Commission, et al. (USDC, Mass.), deposition 12/2/08.

State of Ohio v. The Shelly Holding Company et al. (Franklin County Municipal Court), depositions 7/30/08 and 9/19/08, courtroom testimony 10/16/08 and 10/17/08.

In the matter of Lowell Vos Feedlot (U.S. EPA Administrative Court), courtroom testimony 9/17/08.

French Heritage, Inc. v. Ethan Allen, Inc. (Connecticut State Court), deposition 6/28/06 and 6/29/06.

Oregon Public Interest Research Group, Diane Heintz, and Rena Taylor v. Pacific Coast Seafoods Company, Pacific Surimi Joint Venture, LLC, Pacific Surimi Co., Inc., and Dulcich Inc. d/b/a Pacific Seafood Group (USDC, Oregon), deposition 4/18/06.

In the matter of Rizing Sun LLC (U.S. EPA Administrative Court), courtroom testimony 2/7/06.

State of Ohio v. Container Recyclers, Inc. (Franklin County Municipal Court), deposition 4/1/05.

In the matter of Vico Construction Corporation and Smith Farm Enterprises (U.S. EPA Administrative Court), courtroom testimony 6/20/02 and 10/8/03.

U.S. v. The New Portland Meadows, Inc. (USDC, Oregon), courtroom testimony 5/20/03.

Testimony History (continued)

In the matter of Vico Construction Corporation and Amelia Venture Properties (U.S. EPA Administrative Court), courtroom testimony 1/14/03.

United States Public Interest Research Group, Stephen E. Crawford, and Charles Fitzgerald v. Heritage Salmon, Inc.; U.S. PIRG et al. v. Stolt Sea Farm, Inc.; U.S. PIRG et al. v. Atlantic Salmon of Maine LLC (USDC, Maine), deposition 6/5/01, courtroom testimony 10/15/02.

U.S. v. Murphy Oil USA, Inc. (USDC, WD Wis.), deposition 4/24/01.

U.S. v. Royal Oak Enterprises, Inc. (USDC, ED Va.), depositions 3/22/00 and 5/19/00.

In the matter of Titan Wheel Corporation of Iowa (U.S. EPA Administrative Court), affidavit 11/24/99.

U.S. v. Gulf States Steel, Inc. (USDC, ND Ala.), affidavit 12/30/98, deposition 10/22/99.

U.S. v. Koch Industries, Inc. (USDC, ND Okla. and SD Tex.), depositions 5/24/99 and 6/1/99.

State of Wisconsin v. I-K-I Manufacturing Company, Inc., deposition 4/13/99.

U.S. v. Borden Chemicals & Plastics (USDC, MD La.), deposition 2/5/98.

State of New Hampshire v. Johnson Products, Incorporated, deposition 2/3/98.

In the matter of EK Associates, L.P., d/b/a EKCO/GLACO, and EK Management Corporation (U.S. EPA Administrative Court), courtroom testimony 8/14/97.

U.S. v. Smithfield Foods, Inc., et al. (USDC, ED Va.), deposition 7/9/97.

U.S. v. Nucor Corporation (USDC, ND Ala.), deposition 6/12/97.

U.S. v. U.S. Metallics, Inc., and Town of Onalaska, Wis. (USDC, WD Wis.), affidavit 10/21/96.

COMPLAINANT'S
EX. NO. 31

P.O. Box 310
201 Front St.
Neola, IA 51559
712-310-0533
jturnersag@msn.com

Invoice No. 0010047

Invoice

Bill To
Moran Beef

Ship To

Date: 12/30/2010	Order #:	Sales Person:	Terms: Net 30 days
Shipped By:		Ship Date:	Tracking #:

Qty	Item ID	Description	Unit Price	TOTAL
2.00		Water Samples	$27.50	$55.00
2.00		Manure Samples	$42.50	$85.00
2.00		Nonpariel Public Notice 1 each Feedlot	$18.47	$36.94
1.00		World Herald Public notice Underwood Feedlot	$237.40	$237.40
1.00		Manure Filing fee	$85.00	$85.00
9.50		CNMP/MMP for NRCS and DNR for Underwood	$50.00	$475.00

SubTotal	$974.34
Shipping	$0.00
TOTAL	$974.34

Paid

Warranty Policy

Returns Policy

Your payment is overdue!

Complainant's Ex. No. 31

P.O. Box 310
201 Front St.
Neola, IA 51559
712-310-0533
jturnersag@msn.com

Invoice No. 0010059

Invoice

Bill To
Moran Beef

Ship To

Date: 4/4/2010	*Order #:*	*Sales Person:*	*Terms:* Net 30 days
Shipped By:		*Ship Date:*	*Tracking #:*

Qty	Item ID	Description	Unit Price	TOTAL
206.69		GPS Soil sampling underwood west	$6.50	$1,343.48
73.08		Gps Soil sampling underwood feedlot west	$6.50	$475.02
189.63		Gps Soil sampling underwood feedlot east	$6.50	$1,232.60
			SubTotal	$3,051.10
			Shipping	$0.00
			TOTAL	$3,051.10

Warranty Policy

Returns Policy

Your payment is overdue!

Wellman Construction Inc.

401 South 2nd Street
Box 39
Neola, IA 51559

Invoice

Date	Invoice #
8/1/2010	2011

PAID

Bill To

Moran Beef
C/O Joe Moran
25843 Old Lincoln Hwy.
Honey Creek, IA 51542

P.O. No.	Terms	Project
	Net 30	

Quantity	Description	Rate	Amount
	Tile for Lagoon at Underwood feedlot on 7-28-2010		
4	Hand labor charged by the hour	40.00	160.00T
3	D6 T Bulldozer charged by the hour	120.00	360.00T
2	420 Cat Backhoe charged by the Hour	80.00	160.00T
16	6" metal outlet pipe charged by the foot	7.65	122.40T
1	6" animal guard charged by the unit	11.50	11.50T
860	6" tile line placed and covered charged by the foot	1.95	1,677.00
	Iowa Sales Tax	7.00%	56.97

Thank you for your business!

Total $2,547.87

Invoice

Wellman Construction Inc.
401 South 2nd Street
Box 39
Neola, IA 51559

Date	Invoice #
11/22/2010	2139

Bill To
Moran Beef C/O Joe Moran 25843 Old Lincoln Hwy. Honey Creek, IA 51542

P.O. No.	Terms	Project
	Net 30	

Quantity	Description	Rate	Amount
	Oct. - November 2010		
	Build Runoff Control System For Moran Feedlot #2		
	25794 Magnolia Road		
140	D6 T Buildozer charged by the hour	120.00	16,800.00
40	Roller - 325 Cat charged by the hour	90.00	3,600.00
35	Cat 75E tractor and scraper charged by the hour	137.00	4,795.00
10	Cat. Backhoe Loader charged by the hour	80.00	800.00
40	320 Cat Excavator charged by the hour	106.00	4,240.00
80	Hand labor charged by the hour [Includes running rented roller]	40.00	3,200.00
	Materials used		
1,260	6" dual wall plastic tile sold by the foot	2.05	2,583.00T
3	6" Hickenbottom Intake	105.00	315.00T
20	6" metal outlet pipe charged by the foot	7.65	153.00T
2	6" animal guard charged by the unit	11.50	23.00T
11	48" Dual Wall Plastic Pipe sold by the foot	59.90	658.90T
240	5" tile charged by the foot	1.03	247.20T
1	5" tees & wyes charged by the unit	9.30	9.30T
200	6" tile line placed and covered charged by the foot	2.10	420.00
185	5" tile placed and covered charged by the foot	1.85	342.25
900	2025 Interdrain Trencher per foot	1.50	1,350.00
1.5	420 Cat Backhoe charged by the Hour	80.00	120.00T
6	Hand labor charged by the hour	40.00	240.00T
3.5	7 bag mix charged by the yard [Inv. No. 10849]	102.00	357.00T
	Iowa Sales Tax	7.00%	329.45

Thank you for your business!

Total $40,583.10

Pd 12-2-10

Weliman Construction Inc.

401 South 2nd Street
Box 39
Neola, IA 51559

Invoice

Date	Invoice #
9/1/2010	2039

Bill To
Moran Beef C/O Joe Moran 25843 Old Lincoln Hwy. Honey Creek, IA 51542

P.O. No.	Terms	Project
	Net 30	

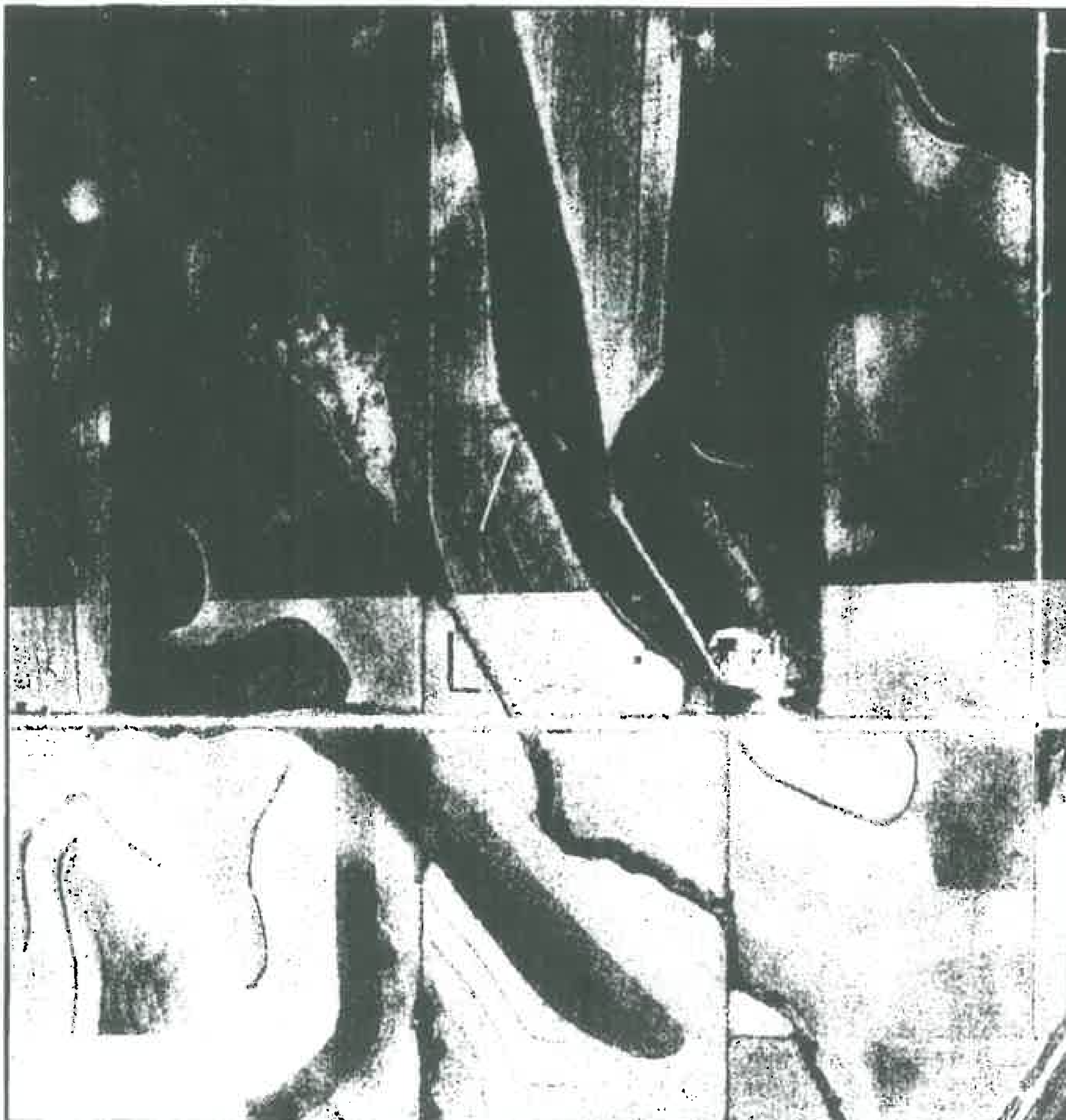
Quantity	Description	Rate	Amount
	8/23 thru 8/26/2010 - Work at Underwood Feedlot		
10.45	D6 T Bulldozer charged by the hour	120.00	1,254.00T
2	Cat. Backhoe Loader charged by the hour	80.00	160.00T
60	18" culvert sold by the foot [Used]	7.50	450.00T
3	24"x24" seep collar [Metal - welded on pipe]	100.00	300.00T
4	Wedgefoot Roller Charged by the Hour	65.00	260.00T
4	Hand labor charged by the hour [laying & tamping tubes]	40.00	160.00T
	Iowa Sales Tax	7.00%	180.88

Thank you for your business!

Total $2,764.88

Pd 9-9-10

2010 Tiling for Moran Beef



- 6" dual wall pipe
- 6" dual wall pipe
- 6" non perf. tile
- 5" non perf tile
- Existing tile

Underwood Feedlot Lagoon Project
Installed 11-6-10

N

0 500 1000
feet

WELLMAN
CONSTRUCTION INC.

712-485-2416

FARM WORKS

Road Builders Machinery and Supply Co. Inc.
Corporate Office:
1001 S. 7th Street Trafficway, Kansas City, KS 66105

Remit payment to:
P.O. BOX 5125
Kansas City, KS 66119

Kansas City 913-371-3822
Omaha 402-331-9200
Lincoln 402-325-0447
Grand Island 308-384-2620
www.roadbuildersmachinery.com

Ship to: MORAN BEEF INC
25843 OLD LINCOLN HWY
HONEY CREEK IA
51542
~~JOB SITE: OMAHA~~

Invoice to: MORAN BEEF INC
25843 OLD LINCOLN HWY
HONEY CREEK IA
51542

Branch		
02 - Omaha, NE		
Date	Time	Page
11/30/2010	8:13:00 (O)	1
Account No.	Phone No	Invoice No
MORAN001	7125452512	R06719
Ship Via	Purchase Order	
CPU	MORAN	
Sales Tax No.		
	Salesperson	
	DJM / GMW	

RENTAL INVOICE

DESCRIPTION INVOICE #: R06719 FOR CONTRACT #: 003273 AMOUNT

Covering from 10/31/2010 to 11/02/2010

ROLLER BW142PDB-2 56
BW145PDB-3 Charge for usage of 2 DAYS 600.00
Stock #: 3483 Serial #: 901581491193
Date out: 10/31/2010 11:30 Date returned: 11/02/2010 08:12
Rates: 300.00/DAY 900.00/WEEK 2700.00/MONTH
O/T Rates Per HR: 37.50/DAY 37.50/WEEK 22.50/MONTH

Subtotal: 600.00
Total Charge: 600.00

Pd. 12-8-10

Date ______________ Customer Name (Print) ______________________________ Signature ______________________________

Certified Testing Services, Inc.
419 W 6th Street
P.O. Box 1193
Sioux City, IA 51102
(712) 252-5132

Invoice

Invoice Date:	Invoice #.
10/26/2010	SC25036

PAST DUE

PLEASE REMIT

Bill To:

Attn: Mr. Frank Moran
Moran Beef, Inc.
25843 Old Lincoln Highway
Honey Creek, Iowa 51542

Project:	Location:
G2987 - Permeability Tests-Moran # 2	Near Underwood, IA

Date	Item	Quantity	Unit Rate	Amount
10/26/10	Mobilization-Per Mile	210	0.65	136.50
10/26/10	Senior Engineering Tech-Per Hr	6.5	58.00	377.00
10/26/10	Permeability Tests, Each	6	300.00	1,800.00
10/26/10	Senior Engineer-Per Hour	1	140.00	140.00

Payment terms net 30 days. A service charge of 1.5% per month which is an annual percentage rate of 18% will be added to all past due accounts.

Subtotal	$2,453.50
Sales Tax (0.0%)	$0.00
Balance Due	$2,453.50

Pd 12-9-10

hgm
ASSOCIATES INC.

****INVOICE****

Mr. Frank Moran
28460 Coldwater Ave.
Honey Creek, Iowa 51142

DATE	:	10/19/2010
CLIENT NO.	:	2048
INVOICE NO.	:	113210-1

Progress billing for professional engineering services for the Moran Feed Lot #2, 25794 Magnolia Ave., Underwood, Iowa as per agreement; through 10/15/10.

	HOURS	RATE		EXTENSION
Land Surveyor	2.00	141.00	$	282.00
Land Surveyor	14.50	76.50		1,109.25
Engineering Technician I	2.50	86.55		216.38
Engineering Technician II	7.00	58.50		409.50
Engineering Technician III	7.50	48.60		364.50
	Current Amount Due		$	2,381.63

TERMS: PAYMENTS ARE DUE AND PAYABLE UPON RECEIPT. A SERVICE CHARGE OF 1-1/2% PER MONTH WILL BE ADDED TO ACCOUNTS OVER 30 DAYS PAST DUE.

Paid 12-14-10

Certified Testing Services, Inc.
1330 Michigan Avenue
P.O. Box 740
Storm Lake, IA 50588

Invoice

Invoice Date	Invoice #
11/30/2010	SL11768

Bill To
Moran Beef, Inc
25843 Old Lincoln Highway
Honey Creek, Iowa 51542
Attn: Mr. Frank Moran

Project	Location
SL1527 - Lagoon Permiability	Underwood, Iowa

Date	Item	Quantity	Unit Rate	Amount
11/01/10	Vehicle Fee-Per Mile	225	0.65	146.25
11/01/10	Soils Tech Per Hour	9	56.00	504.00
11/01/10	Permeability Test	3	300.00	900.00
11/02/10	Report Preparation-Per Hour	1	20.00	20.00

Payment terms are net 30 days. A service charge of 1.5% per month which is an annual percentage of 18% will be added to all past due accounts.

Subtotal	$1,570.25
Sales Tax (0.0%)	$0.00
Total	$1,570.25

Please remit all payments to:
Certified Testing Services, Inc.
P.O. Box 1193
Sioux City, IA 51102

Pd 12-4-10

Curry-Wille & Associates

Consulting Engineers, P.C.
425 So. 2nd Street - P.O. Box 1732
Ames, IA 50010-1732
515-232-9078

PAID

INVOICE

DATE	INVOICE NO.
6/23/2010	4163
TERMS	

Moran Beef, Inc.
Frank Moran
25843 Old Lincoln Highway
Honey Creek, IA 51542

CWA #	10-1754

PROJECT LOCATION:

ITEM	DESCRIPTION	Q...	RATE	AMOUNT
10SM	Fieldwork and preparation of Plat of Topography / Surveying done by Stumbo & Associates, Ames, Iowa		3,575.00	3,575.00
10SM	Geotechnical Report by Certified Testing Services, Inc., Sioux City, Iowa		5,720.00	5,720.00
				0.00

Total	$9,295.00

Curry-Wille & Associates

Consulting Engineers, P.C.
425 So. 2nd Street - P.O. Box 1732
Ames, IA 50010-1732
515-232-9078

PAID

INVOICE

DATE	INVOICE NO.
3/6/2010	4212
TERMS	

Moran Beef, Inc.
Frank Moran
25843 Old Lincoln Highway
Honey Creek, IA 51542

CWA #	10-1754

PROJECT LOCATION:

ITEM	DESCRIPTION	Q...	RATE	AMOUNT
	Site visit to feedlot on 03/23/10			
	Coordination of survey and geotech information			
	Design of system to meet IDNR requirements			
	Preparation of plans, specification and Engineering Report			
	Permit application and delivery to IDNR for review			
10SM	Stewart W. Melvin, P.E., Project Manager	65	145.00	9,425.00
10DH	CAD Operator	29	80.00	2,320.00
10BB	Bradley Bond, Project Engineer	9	106.00	954.00
	Rental car for 03/23/10 site visit - S. Melvin		63.79	63.79
	Gasoline for rental car/site visit 03/23/10		26.80	26.80
	Printing of Moran Beef Engineering Report and Drawings 07/21/101		98.39	98.39
	07/21/10 UPS shipping to Paul Petitti, IDNR		7.49	7.49
Reim...	Total Reimbursable Expenses			196.47

Total $12,895.47

Curry-Wille & Associates

Consulting Engineers, P.C.
425 So. 2nd Street - P.O. Box 1732
Ames, IA 50010-1732
515-232-9078

PAID

INVOICE

DATE	INVOICE NO.
11/2/2010	4257
TERMS	

Moran Beef, Inc.
Frank Moran
25843 Old Lincoln Highway
Honey Creek, IA 51542

CWA #	10-1754

PROJECT LOCATION:

ITEM	DESCRIPTION	Q...	RATE	AMOUNT
	Plan revisions per 08/16, 09/02 and 09/07 IDNR requests. Well variance requests, communication with client, legal council and IDNR prior to construction. Permit issues.			
	Billing through September 30, 2010			
10SM	Stewart W. Melvin, P.E., Project Manager	21	145.00	3,045.00
10RS	Renee Stephens, CAD Operator	9	80.00	720.00
10BB	Bradley Bond, Project Engineer	7	106.00	742.00
10DH	Dan Hobbs, CAD Operator	7	80.00	560.00
	UPS shipping 09/02/10 - to Moran Beef		6.90	6.90
	UPS shipping 09/02/10 - to P. Pettiti, IDNR		7.08	7.08
	Printing - Invoice No. 37492, 09/09/10 - copies of drawings/Moran		56.50	56.50
	Printing - Invoice No. 37473, 08/31/10 - copies of drawings/Moran		56.50	56.50
	UPS Invoice No. 0000F4051W380, dated 09/18/10		7.04	7.04
	Printing, dated 09/29/10		74.15	74.15
	UPS Invoice No. 0000F4051W400, to IDNR, Spencer, IA 09/29/10		13.40	13.40
Reim...	Total Reimbursable Expenses			221.57

Total	$5,288.57

Curry-Wille & Associates

Consulting Engineers, P.C.
425 So. 2nd Street - P.O. Box 1732
Ames, IA 50010-1732
515-232-9078

INVOICE

DATE	INVOICE NO.
12/23/2010	4272
TERMS	

Moran Beef, Inc.
Frank Moran
25843 Old Lincoln Highway
Honey Creek, IA 51542

CWA #	10-1754

PROJECT LOCATION:

ITEM	DESCRIPTION	Q...	RATE	AMOUNT
	Construction standards communication. Site visit and Certification of Completion to IDNR.			
10SM	Stewart W. Melvin, P.E., Project Manager	13	145.00	1,885.00
	1/3 of car rental 11/02/10 - S. Melvin site visit		21.26	21.26
	Billing through 12/17/10			

Total	$1,906.26

COMPLAINANT'S
EX. NO. 32

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION 7
901 NORTH 5TH STREET
KANSAS CITY, KANSAS 66101

3/8/2011

MEMORANDUM

Subject: Modified Data Transmittal for ASR #4705
Project ID: TUMBINCAFO
Project Description: Moran Beef, Inc. – CAFO sampling

From: Michael F. Davis, Chief
Chemical Analysis and Response Branch,
Environmental Services Division

To: Trevor Urban
ENSV/EFCB

Attached is the modified data transmittal for ASR #4705.

After review, verification and transmittal of the subject data, and during an independent review of the Total Kjeldahl Nitrogen in Water Colorimetric (TKN)/Total Phosphorus in Water, Colorimetric (TP) data, the reviewer identified an error with the dilution factor used to calculate the final concentration. The data was corrected by the chemist and a modified report sent to the project manager.

Please contact Margie St. Germain (x5154), if have any questions or concerns.

Attachment

United States Environmental Protection Agency
Region 7
901 N. 5th Street
Kansas City, KS 66101

Date: 03/08/2011

Subject: Transmittal of Sample Analysis Results for ASR #: 4705

Project ID: TUMBINCAFO

Project Description: Moran Beef, Inc. - CAFO sampling

From: Michael F. Davis, Chief
Chemical Analysis and Response Branch, Environmental Services Division

To: Trevor Urban
ENSV/EFCB

Enclosed are the analytical data for the above-referenced Analytical Services Request (ASR) and Project. The Regional Laboratory has reviewed and verified the results in accordance with procedures described in our Quality Manual (QM). In addition to all of the analytical results, this transmittal contains pertinent information that may have influenced the reported results and documents any deviations from the established requirements of the QM.

Please contact us within 14 days of receipt of this package if you determine there is a need for any changes. Please complete the enclosed Customer Satisfaction Survey and Data Disposition/Sample Release memo for this ASR as soon as possible. The process of disposing of the samples for this ASR will be initiated 30 days from the date of this transmittal unless an alternate release date is specified on the Data Disposition/Sample Release memo.

If you have any questions or concerns relating to this data package, contact our customer service line at 913-551-5295.

Enclosures

cc: Analytical Data File.

Project Manager: Trevor Urban **Org:** ENSV/EFCB **Phone:** 913-551-7133

Project ID: TUMBINCAFO

Project Desc: Moran Beef, Inc. - CAFO sampling

Location: Underwood **State:** Iowa **Program:** Water Enforcement

Purpose: Enforcement **GPRA PRC:** 501E50C

Explanation of Codes, Units and Qualifiers used on this report

Sample QC Codes: QC Codes identify the type of sample for quality control purpose.

__ = Field Sample

Units: Specific units in which results are reported.

Deg C = Degrees Celsius
SU = Standard Units (pH)
mg/L = Milligrams per Liter

Data Qualifiers: Specific codes used in conjunction with data values to provide additional information on the quality of reported results, or used to explain the absence of a specific value.

(Blank)= Values have been reviewed and found acceptable for use.
U = The analyte was not detected at or above the reporting limit.

ASR Number: 4705 **Sample Information Summary** **03/08/2011**

Project ID: TUMBINCAFO **Project Desc:** Moran Beef, Inc. - CAFO sampling

Sample No	QC Code	Matrix	Location Description	External Sample No	Start Date	Start Time	End Date	End Time	Receipt Date
101 - __		Water	Steam sample = 10' upstream/North of discharge outfall directly NW of confinement bldg.		10/30/2009	12:15	10/30/2009	12:18	10/30/2009
102 - __		Water	Discharge from Outfall pipe on West side of facility NW of confinement bldg.		10/30/2009	12:20	10/30/2009	12:24	10/30/2009
103 - __		Water	Stream sample = 10' downstream/South of discharge directly NW of confinement bldg.		10/30/2009	12:18	10/30/2009	12:20	10/30/2009
104 - __		Water	Stream sample directly below discharge pipe NW of confinement bldg.		10/30/2009	12:26	10/30/2009	12:30	10/30/2009

Analysis **Comments About Results For This Analysis**

1 Ammonia in Water by Automated Distillation

Lab: Region 7 EPA Laboratory - Kansas City, Ks.

Method: EPA Region 7 RLAB Method 3133.1G

Samples: 101-__ 102-__ 103-__ 104-__

Comments:

1 NFS or Nonfilterable Solids

Lab: Region 7 EPA Laboratory - Kansas City, Ks.

Method: EPA Region 7 RLAB Method 3142.3E

Samples: 101-__ 102-__ 103-__ 104-__

Comments:

1 Nitrogen, Nitrate+Nitrite in Water

Lab: Region 7 EPA Laboratory - Kansas City, Ks.

Method: EPA Region 7 RLAB Method 3133.2H for acidified samples (for total NO3+NO2 analysis).

Samples: 101-__ 102-__ 103-__ 104-__

Comments:

1 pH of Water by Field Measurement

Lab: (Field Measurement)

Method: Measurement of field parameter

Samples: 101-__ 102-__ 103-__ 104-__

Comments:
(N/A)

1 Temperature of Water by Field Measurement

Lab: (Field Measurement)

Method: Measurement of field parameter

Samples: 101-__ 102-__ 103-__ 104-__

Comments:
(N/A)

1 Total Kjeldahl Nitrogen in Water Colorimetric

Lab: Region 7 EPA Laboratory - Kansas City, Ks.

Analysis **Comments About Results For This Analysis**

Method: EPA Region 7 RLAB Method 3133.3F

Samples: 101-__ 102-__ 103-__ 104-__

Comments:
During an independent review of the TKN/TP data, the reviewer identified an error with the dilution factor used to calculate the final concentration. The data was corrected by the chemist and a modified report sent to the project managers. Data was edited on 3/7/11. The only sample affected was sample 104. All other samples, including QC, were not edited.

1 Total Phosphorus in Water, Colorimetric

Lab: Region 7 EPA Laboratory - Kansas City, Ks.

Method: EPA Region 7 RLAB Method 3133.4E

Samples: 101-__ 102-__ 103-__ 104-__

Comments:
During an independent review of the TKN/TP data, the reviewer identified an error with the dilution factor used to calculate the final concentration. The data was corrected by the chemist and a modified report sent to the project managers. Data was edited on 3/7/11. The only sample affected was sample 104. All other samples, including QC, were not edited.

Analysis/ Analyte	Units	101-__	102-__	103-__	104-__
1 Ammonia in Water by Automated Distillation					
Ammonia as Nitrogen	mg/L	0.23	59.4	0.15	2.34
1 NFS or Nonfilterable Solids					
Solids, nonfilterable	mg/L	5.25	510	105	69.6
1 Nitrogen, Nitrate+Nitrite in Water					
Nitrate + Nitrite as Nitrogen	mg/L	9.40	0.549	8.71	8.80
1 pH of Water by Field Measurement					
pH	SU	7.36	7.62	7.61	7.59
1 Temperature of Water by Field Measurement					
Temperature	Deg C	11.1	9.9	11.4	11.4
1 Total Kjeldahl Nitrogen in Water Colorimetric					
Total Kjeldahl Nitrogen	mg/L	0.487	171	2.06	7.78
1 Total Phosphorus in Water, Colorimetric					
Phosphorus	mg/L	0.100 U	52.7	0.609	2.19

COMPLAINANT'S
EX. NO. 33

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 7
901 NORTH 5TH STREET
KANSAS CITY, KANSAS 66101

JAN 21 2011

CERTIFIED MAIL
RETURN RECEIPT REQUESTED
Article No.: 7006 2760 0000 8646 1674

Frank Moran, Assistant Vice President
Moran Beef, Incorporated
25794 Magnolia Road
Underwood, Iowa 51576

Re: Clean Water Act Section 308 Information Request

Dear Mr. Moran:

The Environmental Protection Agency (EPA) seeks your assistance in providing information regarding your compliance with the federal Clean Water Act (CWA).

On October 6, 2010, EPA issued a Notice of Violation (NOV) to you for violations of both the CWA and EPA's Administrative Compliance Order (Docket No. CWA-7-2010-0046) that were discovered during EPA's September 23, 2010 inspection. During this inspection, EPA observed and sampled a discharge from the Facility to a tributary of Mosquito Creek. Specifically, EPA observed and documented a drainage pipe associated with your confinement barn that was discharging manure litter and process wastewater that originated from both inside and outside of the confinement barn. The NOV noted that the discharge was a violation of the ACO and the CWA. It also required you to immediately cease the discharges from the drainage pipe or reduce the number of cattle confined at your operation below regulatory thresholds.

In order to document that this violation has been corrected, EPA requests that you answer the questions and provide the information and/or documents requested in the attached enclosures. Section 308 of the CWA, 33 U.S.C.§ 1318, authorizes EPA to request information from any person to determine compliance with the CWA. Please respond to this Information Request within 7 days of the receipt of this Request. Also, your response to this request must be accompanied by the attached certificate. The certificate must be signed and dated by you and notarized by a certified notary public.

Please send your response and signed certificate to:

Stephen Pollard
U.S. Environmental Protection Agency
Water, Wetlands and Pesticides Division
Water Enforcement Branch
901 N. 5th Street
Kansas City, Kansas 66101

The information requested herein must be provided even though you may contend that it includes confidential business information or trade secrets. You may assert a confidentiality claim covering part or all of the information requested, pursuant to Section 308 of CWA and 40 C.F.R. § 2.203(b). A confidentiality claim requires certain steps on your part to justify such a claim. If EPA determines that submitted information is confidential business information, EPA will take steps to protect the confidential portions of the submitted information. Information covered by such claim will be disclosed by EPA only to the extent permitted by CWA Section 308. If no such claim accompanies the information when it is received by EPA, then it may be made available to the public by EPA without further notice to you.

Although EPA seeks your cooperation, compliance with this Information Request is required by law. Failure to provide all the information required or the making of any false material statements or representation in response to this letter, constitute violations of Section 308 of the CWA, and may result in an enforcement action and the imposition of civil and/or criminal penalties pursuant to Section 309 of the CWA, 33 U.S.C.§ 1319.

If you have any questions or need additional information, please contact Stephen Pollard at (913) 551-7582.

Sincerely,

Karen A. Flournoy
Acting Director
Water, Wetlands, and Pesticides Division

Enclosures

cc: Dan Stipe – Iowa Department of Natural Resources, Field Office #4
Eldon McAfee – Beving, Swanson & Forest, P.C.

Enclosure 1
Information Request

1. Please provide a detailed description of the confinement building drainage system that, at the time of the September 23, 2010 EPA inspection, was discharging into the tributary of Mosquito Creek. This description shall include but is not limited to the following:

a. a description of all sources of process wastewater that discharged to the confinement building drainage system;
b. a diagram identifying the locations of all surface inlets/drains from both inside and outside of the confinement building; and
c. a diagram identifying the location of all drainage outlets including the outlet sampled by EPA.

2. Please provide copies of all analytical results obtained in the last five years that are associated with effluent discharged from the confinement barn drainage system.

3. Please provide a detailed description of all actions and/or modifications taken to eliminate the discharge from the confinement barn and surrounding area since the NOV issued on October 6, 2010.

Enclosure 2

STATEMENT OF CERTIFICATION

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine or imprisonment.

____
Signature

____
Date

____
Printed Name

____
Official Title

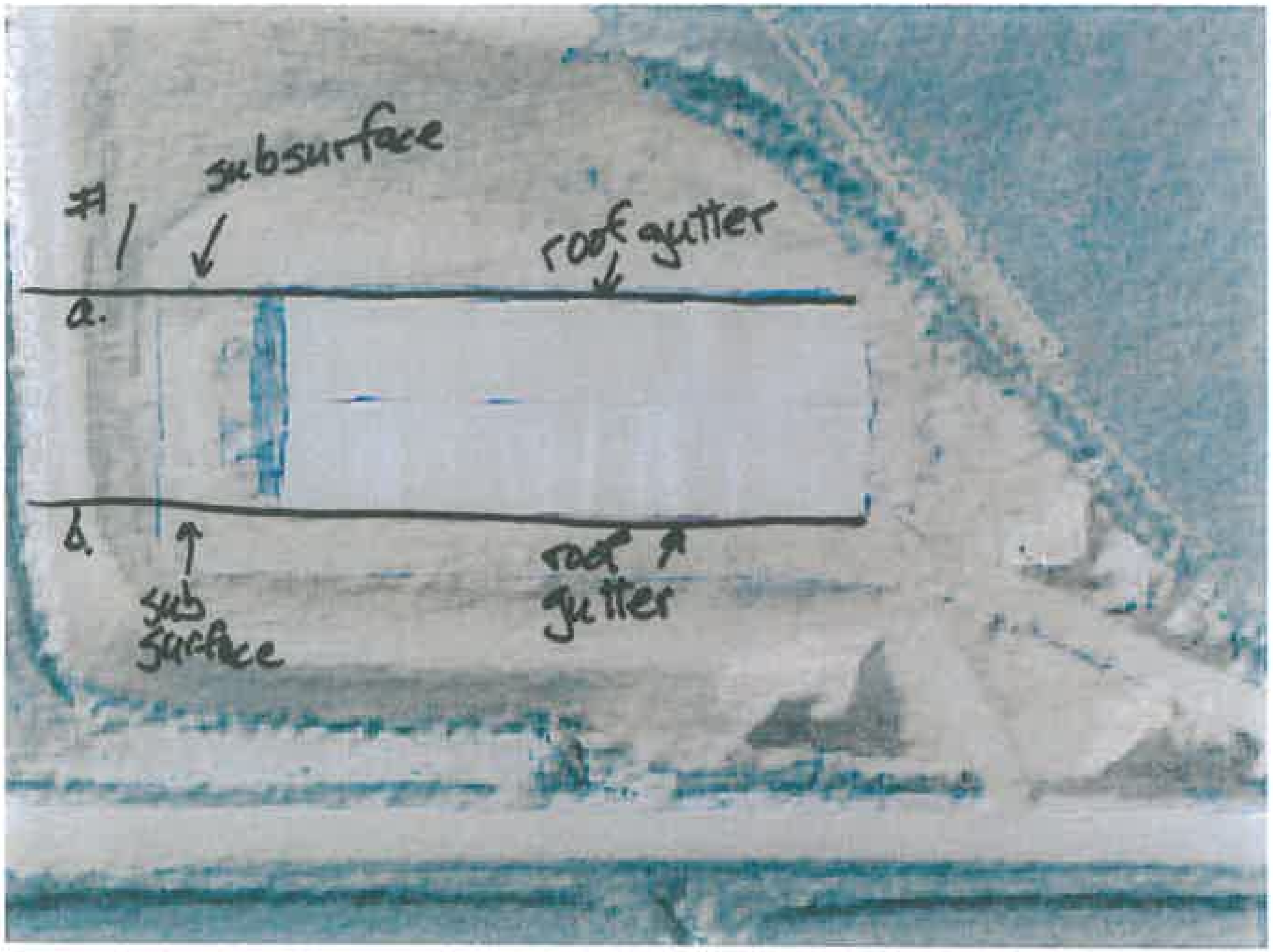
COMPLAINANT'S
EX. NO. 34

INFORMATION REQUEST RESPONSES
MORAN BEEF, INC.

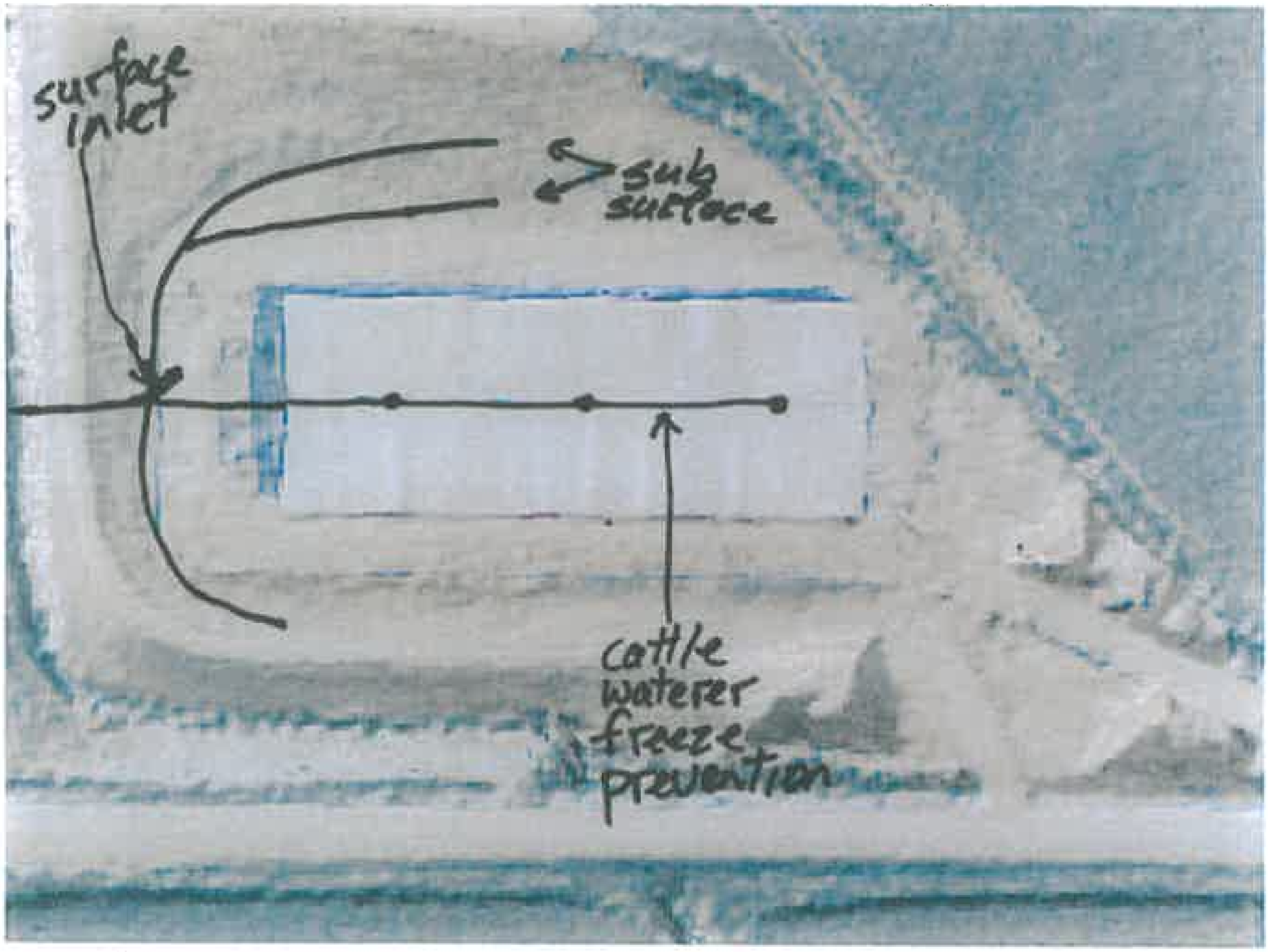
Request No. 1
The attached diagrams show three of the four the drainage outlets on the Moran property that drain into the tributary of Mosquito Creek (the fourth is a field outlet that does not drain any of the area associated with the confinement barn). Please note that other than the roof gutters (#1a and #1b) and the cattle waterer freeze prevention system (#2), the confinement barn has not drained into the tributary, including but not limited on September 23, 2010.

Request No. 2
All analytical results associated with alleged effluent discharges from the Moran Beef operation obtained in the last five years have been provided to EPA in Respondent's Initial Prehearing Exchanges. There are no analytical results associated with alleged effluent discharges from the confinement barn.

Request No. 3
To obtain a construction permit from the Iowa DNR, the Iowa DNR required that tile #2 on the attached diagram be rerouted (except for the subsurface drainage tile line) to the settled open feedlot runoff control basin. This tile was rerouted as required by Iowa DNR and a construction permit was issued.


#1
subsurface
roof gutter
a.
b.
sub surface
roof gutter

#2



surface
inlet
sub
surface
cattle
waterer
freeze
prevention

Enclosure 2

STATEMENT OF CERTIFICATION

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine or imprisonment.

Frank Moran
Signature

2-4-11
Date

Frank Moran
Printed Name

V.P.
Official Title

COMPLAINANT'S
EX. NO. 35

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION 7
901 NORTH 5TH STREET
KANSAS CITY, KANSAS 66101

MAR 1 6 2011

MEMORANDUM

SUBJECT: Addendum to Inspection Report dated September 23, 2010

FROM: Joe Heafner
EFCB/ENSV

TO: Facility File

This is an addendum to the report of inspection for Moran Beef Feedlot that EPA conducted on September 23, 2010. The addendum presents all sample results including those that were not available at the time that the September 23, 2010 report was completed.

Table 1 represents the analytical data from the samples collected on September 23, 2010 (**see attachments 1 and 2 for complete data transmittal packets**).

Table 1: Analytical Results for Samples Collected During Inspection.

Parameter[1]	Site #1 5120-1	Site #2 5120-2	Site #3 5120-6	Site #4 5120-5
NH_3-N	0.570	3.88	0.394	0.1U
TKN	10.5	17.9	1.24	0.841
Total P	2.54	7.26	0.327	0.189
NFS	87.2	2740	67.8	4.00U
NO_2+NO_3-N	0.251	25.5	13.8	13.0
BOD	18	68	5	2
E. coli	>2500	>2500	>2500	1200
pH	8.43	7.02	7.4	7.52
Temperature	23.0	18.6	19.5	19.3

[1]Parameters are reported in milligrams per liter (mg/L)
[2]The analyte was not detected at or above the reporting limit.

Attachments
1. Data Transmittal Packet for Activity JAH1012 (11 pages)
2. Transmittal from Midwest Laboratories (3 pages)

Complainant's Ex. No. 35

United States Environmental Protection Agency
Region 7
901 N. 5th Street
Kansas City, KS 66101

Date: OCT 26 2010

Subject: Transmittal of Sample Analysis Results for ASR #: 5120

Project ID: JHMBFLCAFO

Project Description: Moran Beff - CAFO sampling

From: Michael F. Davis, Chief [signature] 10/27/10
Chemical Analysis and Response Branch, Environmental Services Division

To: Joe Heafner
ENSV/EFCB

Enclosed are the analytical data for the above-referenced Analytical Services Request (ASR) and Project. The Regional Laboratory has reviewed and verified the results in accordance with procedures described in our Quality Manual (QM). In addition to all of the analytical results, this transmittal contains pertinent information that may have influenced the reported results and documents any deviations from the established requirements of the QM.

Please contact us within 14 days of receipt of this package if you determine there is a need for any changes. Please complete the enclosed Customer Satisfaction Survey and Data Disposition/Sample Release memo for this ASR as soon as possible. The process of disposing of the samples for this ASR will be initiated 30 days from the date of this transmittal unless an alternate release date is specified on the Data Disposition/Sample Release memo.

If you have any questions or concerns relating to this data package, contact our customer service line at 913-551-5295.

Enclosures

cc: Analytical Data File.

ATTACHMENT 1 Page 1 of 11

Project Manager: Joe Heafner **Org:** ENSV/EFCB **Phone:** 913-551-7091

Project ID: JHMBFLCAFO

Project Desc: Moran Beff - CAFO sampling

Location: Underwood **State:** Iowa **Program:** Water Enforcement

Purpose: Enforcement **GPRA PRC:** 501E49C

Moran Beef Feedlot CAFO sampling in Ireton, Iowa.

Explanation of Codes, Units and Qualifiers used on this report

Sample QC Codes: QC Codes identify the type of sample for quality control purpose.

__ = Field Sample

Units: Specific units in which results are reported.

Deg C = Degrees Celsius
SU = Standard Units (pH)
mg/L = Milligrams per Liter

Data Qualifiers: Specific codes used in conjunction with data values to provide additional information on the quality of reported results, or used to explain the absence of a specific value.

(Blank)= Values have been reviewed and found acceptable for use.
U = The analyte was not detected at or above the reporting limit.

ATTACHMENT 1 Page 2 of 11

ASR Number: 5120 **Sample Information Summary** **10/26/2010**

Project ID: JHMBFLCAFO **Project Desc:** Moran Beff - CAFO sampling

Sample No	QC Code	Matrix	Location Description	External Sample No	Start Date	Start Time	End Date	End Time	Receipt Date
1 -	__	Water	Effluent near NE corner of confinement barn		09/23/2010	13:45	09/23/2010	13:45	09/24/2010
2 -	__	Water	Outfall from confinement barn, collection basin		09/23/2010	14:05	09/23/2010	14:05	09/24/2010
5 -	__	Water	Upstream sample of unnamed Trib. to Mosquitto Creek		09/23/2010	14:15	09/23/2010	14:15	09/24/2010
6 -	__	Water	Downstream sample of unnamed Trib. to Mosquitto Creek		09/23/2010	14:10	09/23/2010	14:10	09/24/2010

ATTACHMENT 1 Page 3 of 11

Analysis **Comments About Results For This Analysis**

1 Ammonia in Water by Automated Distillation

Lab: Region 7 EPA Laboratory - Kansas City, Ks.

Method: EPA Region 7 RLAB Method 3133.1G

Samples: 1-__ 2-__ 5-__ 6-__

Comments:

1 NFS or Nonfilterable Solids

Lab: Region 7 EPA Laboratory - Kansas City, Ks.

Method: EPA Region 7 RLAB Method 3142.3E

Samples: 1-__ 2-__ 5-__ 6-__

Comments:

1 Nitrogen, Nitrate+Nitrite in Water

Lab: Region 7 EPA Laboratory - Kansas City, Ks.

Method: EPA Region 7 RLAB Method 3133.2H for acidified samples (for total NO3+NO2 analysis).

Samples: 1-__ 2-__ 5-__ 6-__

Comments:

1 pH of Water by Field Measurement

Lab: (Field Measurement)

Method: Measurement of field parameter

Samples: 1-__ 2-__ 5-__ 6-__

Comments:
(N/A)

1 Temperature of Water by Field Measurement

Lab: (Field Measurement)

Method: Measurement of field parameter

Samples: 1-__ 2-__ 5-__ 6-__

Comments:
(N/A)

ATTACHMENT 1 Page 4 of 11

1 Total Kjeldahl Nitrogen in Water Colorimetric

Lab: Region 7 EPA Laboratory - Kansas City, Ks.

ASR Number: 5120 **RLAB Approved Sample Analysis Results** **10/26/2010**

Project ID: JHMBFLCAFO **Project Desc:** Moran Beff - CAFO sampling

Analysis/ Analyte	Units	1-__	2-__	5-__	6-__
1 Ammonia in Water by Automated Distillation					
Ammonia as Nitrogen	mg/L	0.570	3.88	0.1 U	0.394
1 NFS or Nonfilterable Solids					
Solids, nonfilterable	mg/L	87.2	2740	4.00 U	67.8
1 Nitrogen, Nitrate+Nitrite in Water					
Nitrate + Nitrite as Nitrogen	mg/L	0.251	25.5	13.0	13.8
1 pH of Water by Field Measurement					
pH	SU	8.43	7.02	7.52	7.4
1 Temperature of Water by Field Measurement					
Temperature	Deg C	23.0	18.6	19.3	19.5
1 Total Kjeldahl Nitrogen in Water Colorimetric					
Total Kjeldahl Nitrogen	mg/L	10.5	17.9	0.841	1.24
1 Total Phosphorus in Water, Colorimetric					
Phosphorus	mg/L	2.54	7.26	0.189	0.327

ATTACHMENT 1 Page 5 of 11

Analysis	**Comments About Results For This Analysis**

Method: EPA Region 7 RLAB Method 3133.3F

Samples: 1-__ 2-__ 5-__ 6-__

Comments:
(N/A)

1 Total Phosphorus in Water, Colorimetric

Lab: Region 7 EPA Laboratory - Kansas City, Ks.

Method: EPA Region 7 RLAB Method 3133.4E

Samples: 1-__ 2-__ 5-__ 6-__

Comments:
(N/A)

ATTACHMENT 1 Page 6 of 11

CHAIN OF CUSTODY RECORD
ENVIRONMENTAL PROTECTION AGENCY REGION VII

ACTIVITY LEADER(Print)	NAME OF SURVEY OR ACTIVITY	DATE OF COLLECTION (DAY / MONTH / YEAR)	SHEET
Joe Heafner	ASR 5120	23 / 7 / 10	1 of 1

CONTENTS OF SHIPMENT

SAMPLE NUMBER	1L CUBITAINER	BOTTLE	BOTTLE	BOTTLE	VOA SET (2 VIALS EA)	water	soil	sediment	dust	other	RECEIVING LABORATORY REMARKS/OTHER INFORMATION (condition of samples upon receipt, other sample numbers, etc.)
	NUMBERS OF CONTAINERS PER SAMPLE NUMBER										
5120-1	2					X					
5120-2	2					X					
5120-5	2					X					
5120-6	2					X					
											ATTACHMENT 1 Page 7 of 11
Total	8										
											Ctr. Temp. Rec'd. 6.8, 3.3 – 4.7°C ~9/24/10

Activity Complete

ATTACHMENT Page of

DESCRIPTION OF SHIPMENT

8 PIECE(S) CONSISTING OF NA BOX(ES)

1 ICE CHEST(S); OTHER

MODE OF SHIPMENT

COMMERCIAL CARRIER:

COURIER

X SAMPLER CONVEYED

(SHIPPING DOCUMENT NUMBER)

PERSONNEL CUSTODY RECORD

RELINQUISHED BY (SAMPLER)	DATE	TIME	RECEIVED BY	REASON FOR CHANGE OF CUSTODY
Joe Heafner — SEALED [X] UNSEALED [ ]	7/23/10	1930	Nicole Roblee (9/24/10) — SEALED [X] UNSEALED [ ]	Analysis
RELINQUISHED BY — SEALED [ ] UNSEALED [ ]	DATE	TIME	RECEIVED BY [illegible] — SEALED [ ] UNSEALED [ ]	REASON FOR CHANGE OF CUSTODY
RELINQUISHED BY — SEALED [ ] UNSEALED [ ]	DATE	TIME	RECEIVED BY — SEALED [ ] UNSEALED [ ]	REASON FOR CHANGE OF CUSTODY

Sample Collection Field Sheet

US EPA Region 7
Kansas City, KS

ASR Number: 5120 **Sample Number:** 1 **QC Code:** __ **Matrix:** Water **Tag ID:** 5120-1-__

Project ID: ~~JHNWIACAFO~~ SHMBFLCAFO **Project Manager:** Joe Heafner
Project Desc: ~~CAFO sampling in Northwest Iowa~~ Moran Beff
City: ~~Various~~ Underwood **State:** Iowa
Program: Water Enforcement

Location Desc: ~~Discharge of Effluent nea~~ Effluent near NE corner of Confinement Barn

Storet ID: ________ **External Sample Number:** ________

Expected Conc (or Circle One: Low Medium High) **Date** **Time(24 hr)**

Latitude: ___ ___ ___ **Sample Collection: Start:** 09/23/2010 13:45

Longitude: ___ ___ ___ **End:** 09/23/2010 13:45

Field Measurement

Parameter	Value	Units
Temperature :	23.0	Deg C
pH :	8.43	SU

Laboratory Analyses:

Container	Preservative	Holding Time		Analysis
1 - 1 Liter Cubitainer	2 mL H2SO4/L	28	Days	1 Nitrogen, Nitrate+Nitrite in Water
1 - 1 Liter Cubitainer	4 Deg C	7	Days	1 NFS or Nonfilterable Solids
1 - 1 Liter Cubitainer	5 mL H2SO4/L	28	Days	1 Ammonia in Water by Automated Distillation
1 - 1 Liter Cubitainer	5mL H2SO4 to pH<2.5, 4 Deg C	28	Days	1 Total Kjeldahl Nitrogen in Water Colorimetric
1 - 1 Liter Cubitainer	5mL H2SO4 to pH<2.5, 4 Deg C	28	Days	1 Total Phosphorus in Water, Colorimetric

(2) (2)

Sample Comments

(N/A)

BOD and E. coli samples conveyed to MidWest Labs in Omaha NE

ATTACHMENT 1 Page 8 of 11

Sample Collected By: Joe Heafner Joe Heafner

Sample Collection Field Sheet

US EPA Region 7
Kansas City, KS

ASR Number: 5120 **Sample Number:** 2 **QC Code:** __ **Matrix:** Water **Tag ID:** 5120-2-__

Project ID: ~~JHNWIACAFO~~ SHMBFLCAFO **Project Manager:** Joe Heafner
Project Desc: ~~CAFO sampling in Northwest Iowa~~ Moran Beff
City: ~~Various~~ Underwood **State:** Iowa
Program: Water Enforcement

Location Desc: Outfall from Confinement Barn Collection Basin

Storet ID: ____________ **External Sample Number:** ____________

Expected Conc (or Circle One: Low Medium High) **Date** **Time(24 hr)**

Latitude: __ __ __ **Sample Collection: Start:** 09/23/2010 14:05
Longitude: __ __ __ **End:** 09/23/2010 14:05

Field Measurement

Parameter	**Value**	**Units**
Temperature :	19.6	Deg C
pH :	7.02	SU

Laboratory Analyses:

Container	**Preservative**	**Holding Time**		**Analysis**
1 - 1 Liter Cubitainer	2 mL H2SO4/L	28	Days	1 Nitrogen, Nitrate+Nitrite in Water
1 - 1 Liter Cubitainer	4 Deg C	7	Days	1 NFS or Nonfilterable Solids
1 - 1 Liter Cubitainer	5 mL H2SO4/L	28	Days	1 Ammonia in Water by Automated Distillation
1 - 1 Liter Cubitainer	5mL H2SO4 to pH<2.5, 4 Deg C	28	Days	1 Total Kjeldahl Nitrogen in Water Colorimetric
1 - 1 Liter Cubitainer	5mL H2SO4 to pH<2.5, 4 Deg C	28	Days	1 Total Phosphorus in Water, Colorimetric

D (2)

Sample Comments

(N/A)

BOD and E. coli samples conveyed to Midwest Labs in Omaha NE

ATTACHMENT 1 Page 9 of 11

Sample Collected By: Joe Heafner

Sample Collection Field Sheet
US EPA Region 7
Kansas City, KS

ASR Number: 5120 **Sample Number:** 5 **QC Code:** __ **Matrix:** Water **Tag ID:** 5120-5-__

Project ID: ~~JHNWIACAFO~~ JHMBFLCAFO **Project Manager:** Joe Heafner
Project Desc: ~~CAFO sampling in Northwest Iowa~~ Moran Beff
City: ~~Various~~ Underwood **State:** Iowa
Program: Water Enforcement

Location Desc: Upstream sample of Unnamed Trib. to Mosquitto Creek

Storet ID: ________ **External Sample Number:** ________

Expected Conc (or Circle One: Low Medium High) **Date** **Time(24 hr)**

Latitude: __ __ __ **Sample Collection: Start:** 09/23/2010 14:15
Longitude: __ __ __ **End:** 09/23/2010 14:15

Field Measurement

Parameter	Value	Units
Temperature :	17.3	Deg C
pH :	7.52	SU

Laboratory Analyses:

2

Container	Preservative	Holding Time		Analysis
1 - 1 Liter Cubitainer	2 mL H2SO4/L	28	Days	1 Nitrogen, Nitrate+Nitrite in Water
1 - 1 Liter Cubitainer	4 Deg C (2)	7	Days	1 NFS or Nonfilterable Solids
1 - 1 Liter Cubitainer	5 mL H2SO4/L	28	Days	1 Ammonia in Water by Automated Distillation
1 - 1 Liter Cubitainer	5mL H2SO4 to pH<2.5, 4 Deg C	28	Days	1 Total Kjeldahl Nitrogen in Water Colorimetric
1 - 1 Liter Cubitainer	5mL H2SO4 to pH<2.5, 4 Deg C	28	Days	1 Total Phosphorus in Water, Colorimetric

Sample Comments

(N/A)

BOD and E. coli samples conveyed to Midwest Labs in Omaha NE

ATTACHMENT 1 Page 10 of 11

Sample Collected By: [signature]

Sample Collection Field Sheet

US EPA Region 7
Kansas City, KS

ASR Number: 5120 **Sample Number:** 6 **QC Code:** __ **Matrix:** Water **Tag ID:** 5120-6-__

Project ID: ~~JHNWIACAFO~~ JHMBFLCAFO **Project Manager:** Joe Heafner
Project Desc: ~~CAFO sampling in Northwest Iowa~~ Moran Beff
City: ~~Various~~ Underwood **State:** Iowa
Program: Water Enforcement

Location Desc: Downstream Sample of Unnamed Trib to Mosquitto Creek

Storet ID: ________ **External Sample Number:** ________

Expected Conc (or Circle One: Low Medium High)

		Date	Time(24 hr)
Latitude: ___ ___ ___	**Sample Collection: Start:**	09/23/2010	14:10
Longitude: ___ ___ ___	**End:**	09/23/2010	14:10

Field Measurement

Parameter	Value	Units
Temperature :	19.5	Deg C
pH :	7.4	SU

Laboratory Analyses:

Container	Preservative	Holding Time		Analysis
1 - 1 Liter Cubitainer	2 mL H2SO4/L	28	Days	1 Nitrogen, Nitrate+Nitrite in Water
1 - 1 Liter Cubitainer	4 Deg C (2)	7	Days	1 NFS or Nonfilterable Solids
1 - 1 Liter Cubitainer	5 mL H2SO4/L	28	Days	1 Ammonia in Water by Automated Distillation
1 - 1 Liter Cubitainer	5mL H2SO4 to pH<2.5, 4 Deg C	28	Days	1 Total Kjeldahl Nitrogen in Water Colorimetric
1 - 1 Liter Cubitainer	5mL H2SO4 to pH<2.5, 4 Deg C	28	Days	1 Total Phosphorus in Water, Colorimetric

(1) (bracket joining rows)

Sample Comments

(N/A) BOD and E. coli samples conveyed to Midwest Labs in Omaha NE

ATTACHMENT 1 Page 11 of 11

Sample Collected By: [signature]

Report Number
10-272-2125

Midwest Laboratories Inc.®

13611 "B" Street • Omaha, Nebraska 68144-3693 • (402) 334-7770 • FAX (402 334-9121
www.midwestlabs.com

REPORT OF ANALYSIS

For: (25910) SAIC
(703)375-2287

Mail to: SAIC
KATIE MERRIMAN/DAVID LARIT
12100 SUNSET HILLS ROAD MS 4-3
RESTON VA 20190

Date Reported: 09/29/10
Date Received: 09/23/10

ASR 5021

ATTACHMENT 2 Page 1 of 3

Lab number: 1762148

Analysis	Level Found	Units	Detection Limit	Method	Analyst-Date	Verified-Date
Sample ID: 5021-1						
E coli	> 2500	MPN/100 mL	1	IDEXX SM 9223B	clh-09/24	kej-09/28
Biochemical oxygen demand	18	mg/L	2	SM 5210B	kkr-09/24	cmw-09/29
Sample ID: 5021-2						
E coli	> 2500	MPN/100 mL	1	IDEXX SM 9223B	clh-09/24	kej-09/28
Biochemical oxygen demand	68	mg/L	2	SM 5210B	kkr-09/24	cmw-09/29
Sample ID: 5021-5						
E coli	1,200	MPN/100 mL	1	IDEXX SM 9223B	clh-09/24	kej-09/28
Biochemical oxygen demand	2	mg/L	2	SM 5210B	kkr-09/24	cmw-09/29
Sample ID: 5021-6						
E coli	> 2500	MPN/100 mL	1	IDEXX SM 9223B	clh-09/24	kej-09/28
Biochemical oxygen demand	5	mg/L	2	SM 5210B	kkr-09/24	cmw-09/29

Notes:
*Sample was setup with 100 mL used in E coli determination. All the
*wells were positive for 3 of 4 samples. If high amounts were
*expected, we could have done dilutions to determine the exact #

For questions contact

Prem W. Arora

Prem Arora
Environmental Project Manager
prem@midwestlabs.com (402)829-9878

25910

09-23-10P04:02 RCVD

CHAIN OF CUSTODY RECORD
ENVIRONMENTAL PROTECTION AGENCY REGION VII

ACTIVITY LEADER(Print)	NAME OF SURVEY OR ACTIVITY	DATE OF COLLECTION (DAY / MONTH / YEAR)	SHEET
Joe Heafner	ASR 5021	23 / 9 / 10	1 of 1

CONTENTS OF SHIPMENT

SAMPLE NUMBER	1L CONTAINER	Bact BOTTLE	BOTTLE	BOTTLE	VOA SET (2 VIALS EA)	water	soil	sediment	dust	other	RECEIVING LABORATORY REMARKS/OTHER INFORMATION (condition of samples upon receipt, other sample numbers, etc.)
5021-1	1	1	1762148 2			X					BOD E.Coli
5021-2	1	1	1762149 2			X					↓
5021-5	1	1	1762150 2			X					↓
5021-6	1	1	1762151 2			X					↓
Total	4	4									
	(8)										

NUMBERS OF CONTAINERS PER SAMPLE NUMBER

U.S. Environmental Protection Agency
Region 7 Kansas, Missouri, Iowa, Nebraska

Joe Heafner
Life Scientist
Environmental Services Division

ENSV/EFCB
901 North 5th Street
Kansas City, Kansas 66101

Phone: 913-551-7091
Fax: 913-551-8699
E-mail: heafner.joseph@epa.gov

HAND DELIVERED ON ICE

4

1762148 - 1762151

DESCRIPTION OF SHIPMENT	MODE OF SHIPMENT
1 PIECE(S) CONSISTING OF 1 BOX(ES)	___ COMMERCIAL CARRIER:
X ICE CHEST(S); OTHER	___ COURIER
	X SAMPLER CONVEYED — Conveyed to Midwest Labs Omaha NE (SHIPPING DOCUMENT NUMBER)

PERSONNEL CUSTODY RECORD

RELINQUISHED BY (SAMPLER)	DATE	TIME	RECEIVED BY	REASON FOR CHANGE OF CUSTODY
[signature] SEALED ☐ UNSEALED ☐	9/23/10	1527	Heather Ramig SEALED ☐ UNSEALED ☐	
RELINQUISHED BY SEALED ☐ UNSEALED ☐	DATE	TIME	RECEIVED BY SEALED ☐ UNSEALED ☐	REASON FOR CHANGE OF CUSTODY
RELINQUISHED BY SEALED ☐ UNSEALED ☐	DATE	TIME	RECEIVED BY SEALED ☐ UNSEALED ☐	REASON FOR CHANGE OF CUSTODY

7-EPA-9262(Revised 5/85)

CHAIN OF CUSTODY RECORD
ENVIRONMENTAL PROTECTION AGENCY REGION VII

ACTIVITY LEADER (Print)	NAME OF SURVEY OR ACTIVITY	DATE OF COLLECTION (DAY / MONTH / YEAR)	SHEET
Joe Heafner	ASR ~~5521~~ 5120 (JAH 7-23/10)	23 / 7 / 10	1 of 1

CONTENTS OF SHIPMENT

SAMPLE NUMBER	CUBITAINER	BOTTLE	BOTTLE	BOTTLE	VOA SET (2 VIALS EA)	water	soil	sediment	dust	other	RECEIVING LABORATORY REMARKS/OTHER INFORMATION (condition of samples upon receipt, other sample numbers etc.)
	1L	Bact									
5120 JAH ~~5521~~-1	1	1				X					BOD & Col.
5120 JAH ~~5521~~-2	1	1				X					↓
5120 JAH ~~5521~~-5	1L	1				X					↓
5120 JAH ~~5521~~-11	1L	1				X					↓
Total	4	4									

Project Manager Transposed #s on samples JAH 7/23/10

ATTACHMENT 2 Page 3 of 3

DESCRIPTION OF SHIPMENT

1 PIECE(S) CONSISTING OF 1 BOX(ES)

X ICE CHEST(S): OTHER

MODE OF SHIPMENT

COMMERCIAL CARRIER:

COURIER

X SAMPLER CONVEYED

Conveyed to Midwest Labs (Mike) (SHIPPING DOCUMENT NUMBER)

PERSONNEL CUSTODY RECORD

RELINQUISHED BY (SAMPLER)	DATE	TIME	RECEIVED BY	REASON FOR CHANGE OF CUSTODY
[signature] SEALED / UNSEALED	7/23/10	1527	Matthew Konig SEALED / UNSEALED	
RELINQUISHED BY: SEALED / UNSEALED	DATE	TIME	RECEIVED BY: SEALED / UNSEALED	REASON FOR CHANGE OF CUSTODY
RELINQUISHED BY: SEALED / UNSEALED	DATE	TIME	RECEIVED BY: SEALED / UNSEALED	REASON FOR CHANGE OF CUSTODY

7-EPA-9262 (Revised 5/85)

COMPLAINANT'S
EX. NO. 36

Complainant's Ex. No. 36

COMPLAINANT'S
EX. NO. 37

Complainant's Ex. No. 37

COMPLAINANT'S
EX. NO. 38

Missouri Department of Natural Resources
Water Pollution Control Program

Total Maximum Daily Loads (TMDLs)

for

Muddy Creek and Brushy Creek
Pettis County, Missouri

Completed: December 27, 2001
Approved: February 11, 2002

Table of Contents

Total Maximum Daily Loads (TMDLs)
For Muddy Creek
Pollutant: Biochemical Oxygen Demand (BOD)
and
Brushy Creek (Fork)
Pollutants: Biochemical Oxygen Demand (BOD), Ammonia (NH_3-N) and Non-Filterable Residue (NFR)

Name: Muddy Creek

Location: Near Sedalia in Pettis County, Missouri

Hydrologic Unit Code (HUC): 10300103-040003

Water Body Identification (WBID): 0855

Missouri Stream Class: P[1]

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

Size of Impaired Segment: 1 mile

Location of Impaired Segment: From NW ¼ Section 19, T46N, R21W (downstream) to SE ¼ Section 18, T46N, R21W (upstream)

Pollutant: Biochemical Oxygen Demand (BOD)

Pollutant Source: Sedalia Central Wastewater Treatment Plant

Permit Number: Missouri State Operating Permit No. MO-0023019 [2]

TMDL Priority Ranking: Low

Name: Brushy Creek (Fork)

Location: Near Sedalia in Pettis County, Missouri

Hydrologic Unit Code (HUC): 10300103-040003

[1] Class P streams maintain flow even during drought conditions. See the Missouri Water Quality Standards (WQS) at 10 CSR 20-7.031(1)(F)
[2] State Operating Permits are Missouri's substitute for the federal National Pollution Discharge Elimination System (NPDES) permits.

Water Body Identification (WBID): 0859

Missouri Stream Class: 3.0 miles from the mouth is Class P. The next 0.5 mile is C (Class C streams may cease to flow in dry periods but maintain permanent pools which support aquatic life.) [3]

Beneficial Uses:

- Livestock and Wildlife Watering
- Protection of Aquatic Life and Human Health associated with Fish Consumption
- Limited Warm Water Fishery[4]

Size of Impaired Segment: 1 mile[5]

Location of Impaired Segment: NW ¼ Section 19, T46N, R21W (mouth) to NW ¼ Section 30, T46N, R21W (upstream) Refer to footnote 4 and 5.

Pollutants:

- Biochemical Oxygen Demand (BOD)
- Ammonia (NH_3-N)
- Non-Filterable Residue (NFR)

Pollutant Source: Sedalia Central Wastewater Treatment Plant

Permit Number: Missouri State Operating Permit No. MO-0023019

TMDL Priority Ranking: Low

1.0 BACKGROUND AND WATER QUALITY PROBLEMS

1.1 History of the Area:

Muddy Creek is a fifth order, transitional prairie stream[6] with its headwaters in Johnson County. It flows northeasterly across north central Pettis County and empties into the Lamine River near the Cooper County boundary. It is a Class P stream, which means it maintains flow even during drought conditions. The watershed drains an area of nearly 300 square miles.

When the Osage Tribe lived in present day Pettis County, it was mostly open prairie. According to one history of Sedalia[7], there was waist high grass, Carolina parrots, passenger pigeons and plenty of bass in Pearl River, now called Sewer Branch, which runs through Sedalia. About 700 people lived in Pettis County when it was formed from west Cooper County and the southern two-thirds of Saline

[3] See 10 CSR 20-7.031(1)(F)

[4] Brushy Creek is classified as a Limited Warm Water Fishery because it is a non-Ozark Class C stream with a low flow of less that 0.1 cubic feet per second. See WQS 10 CSR 20-7.031(1)(C)6.

[5] The impaired section was erroneously listed as one mile on the 1998 303(d) list. This will be corrected to 3.4 miles in the next listing with the upstream legal of SE ¼ Sec. 31, T46N, R21W.

[6] Muddy Creek is considered transitional because it crosses from the Osage Plains ecoregion (prairie) to the Ozark Highlands ecoregion.

[7] The First One Hundred Years, Hurlbut Printing Co. Inc., Sedalia, Mo., just prior to the 1960 census.

County on Jan. 28, 1933. The county was named for Spencer Pettis, who was the third representative to congress from Missouri and served from 1828 to 1831. Pettis was a protégé of Senator Thomas Hart Benton.

A settler named Thomas Wasson established a gristmill on Muddy Creek at Pin Hook. The settlement that grew there became the first county seat in 1833 and was called St. Helena. The county seat was moved to Georgetown (three miles north of present-day Sedalia) in 1837, and it was there that George R. Smith settled his large family when they moved to Missouri from Kentucky. Smith camped on Muddy Creek when he first arrived in November 1833. In 1857 he bought acreage, laid out the city of Sedalia and raised money to attract the Missouri Pacific Railroad to build across the high plain past Sedalia instead of along the Missouri River. He named the town Sedville for his youngest daughter, Sarah E. Smith, whose pet name was "Sed". At the suggestion of a friend, he later changed the name to Sedalia.

During the Civil War, both the Union and the Confederacy actively recruited in Sedalia. Even though no major battles were waged in Pettis County, civilians there suffered at the hands of both armies.

The well-known benefactor of Sedalia, John H. Bothwell, arrived in 1871 at the age of 22. Sedalia's hospital, a hotel, a lodge and a rural school were all named after him. Of Muddy Creek, he commented that it was unfortunate a creek so important to the county had such a commonplace name. A picture of his niece, Ada Bothwell, appears on the cover of the book Pettis County, Missouri, A Pictorial History[8]. She is shown canoeing a section of Muddy Creek below Bothwell Lodge around 1910. The caption reads, "When highway 65 was relocated in the early 1960s, the state dug a new creek channel which effectively drained and destroyed this idyllic spot." On another note, untreated sewage was allowed to run into Flat and Muddy creeks until 1916.

Brushy Creek is a tributary to Muddy Creek. It is also referred to as Brushy Fork and was listed as such on the 1998 303(d) list. On topographic maps and in Missouri's Water Quality Standards, however, it is called Brushy Creek. The name will be corrected in the 2002 303(d) list. This third order stream runs along the border of the prairie and the Ozark ecoregions. Its headwaters drain the west side of Sedalia and it flows northerly nearly four miles to Muddy Creek. This stream is Class P from its mouth upstream for 3.0 miles. The next one-half mile of the creek is Class C and above that it is unclassified.

1.2 Soil Types and Land Use:

The soils in the Brushy-Muddy Creek watershed are in the Bluelick-Goss-Pembroke association. These soils all exhibit moderate permeability and moderate to fast runoff, depending on slope. Bluelick and Pembroke are gently to strongly sloping and Goss is a very cobbly silt loam with a 14-35 percent slope. The bottomland soils along the streams are the nearly level Dockery silt loam with moderate permeability and slow runoff. The rock that underlies these soils is shale and limestone.

Land use within the upper portion of the Brushy Creek watershed is mostly urban and industrial. Land use in the lower reaches of Brushy Creek and the portion of Muddy Creek watershed within the study area is a mixture of row crop, pasture and timber. 1993 data (30 meter resolution) obtained from Thematic Mapper imagery was used to calculate landuse statistics (Table 1) for both watersheds (Also see maps in Appendix A).

[8] Claycomb, Wm. B, and Ed Brummet, photo ed., 1998,The Donning Company Publishers, Virginia Beach, VA

Table 1. Thematic Mapper Land Use (1993) for Brushy Creek and Muddy Creek Watersheds

Land Use Class	Brushy Creek (%)	Muddy Creek (%)
Cool-Season Grassland	39.6	47
Row and Close Grown Crops	19	39
Urban Impervious	16	1.4
Urban Vegetated	11	0.6
Deciduous Woodland	8	3
Upland Deciduous Forest	4	5
Bottomland Deciduous Forest & Woodland	2	2
Barren or Sparsely Vegetated	0.4	1
Warm Season Grassland	<0.1	0.4
Open Water		0.4
Eastern Redcedar Woodland		0.2

1.3 The Impairments:

A map showing the impaired segments of both streams may be found in Appendix C.1. **Muddy Creek** is on the 1998 303(d) list due to high Biochemical Oxygen Demand (BOD). This was a result of several low flow stream surveys[9] conducted by department personnel and the Missouri Department of Conservation. Wastewater from sewage treatment plants or runoff containing fertilizer or manure (farm or urban) can be high in BOD. High BOD causes low dissolved oxygen in the receiving stream, and many aquatic organisms require high levels of oxygen to survive. The TMDL priority ranking for Muddy Creek is low.

Brushy Creek is on the 303(d) list for BOD (footnote 8), ammonia (NH_3-N)[10] and Non-Filterable Residue (NFR)[11]. Ammonia is a common by-product of wastewater treatment and under certain conditions can be toxic to aquatic life. NFR is the same thing as Total Suspended Solids (TSS) and is measured (analyzed) in the same way. It includes organic and mineral solids. The NFR in this case is sewage sludge. This sludge settles onto the bottom of the stream and smothers habitat, aquatic invertebrates and fish eggs. It is aesthetically displeasing and contributes to a sediment oxygen demand. This demand consumes oxygen from the water during the decomposition of the sludge. The TMDL priority ranking for Brushy Creek is low.

1.4 Source Assessment:

The largest permitted facility close to the impaired section of **Muddy Creek** is the Sedalia Central Wastewater Treatment Plant (WWTP)[12]. See Appendix B.1 for a list of all the permitted facilities in the watershed (above the confluence with Brushy Creek) and B.2 and B.3 for the accompanying maps. Based on design conditions, Sedalia Central contributed 77 percent of the baseflow BOD load to Muddy Creek in 1998. Other relatively larger sources of BOD, such as Whiteman Air Force Base (AFB) and the La Monte SE Lagoons, are not believed to significantly contribute to the impairment because of the distance between the facilities and the impaired reach of Muddy Creek. Whiteman AFB is approximately 23 miles from the impaired segment and La Monte Lagoons are 16 miles away. This

[9] These surveys were conducted in 1993, 1995 (the department) and 1997-8 (MDC).
[10] Listed due to 1993 and 1995 waste load allocation studies by the department, and the occurrence of fishkills recorded by Missouri Department of Conservation in 1992 and 1994.
[11] Listed due to low flow and waste load allocation studies conducted by the department from 1983-1995.
[12] State Operating Permit number MO-0023019

is significant because, even by conservative estimates that consider design flow and low-flow scenarios, the BOD would decay over that distance. These two facilities have relatively small discharges and other facilities in the watershed discharge even less.

Animal feeding operations can be sources of ammonia, non-filterable residue or low dissolved oxygen (DO); however, there are no permitted operations in the **Brushy Creek** watershed. It is also noted that while Brushy Creek drains the west side of Sedalia, storm water runoff from the city does not contribute to the impairments. This is because low flow conditions (when ammonia toxicity and low DO can be problems) are the critical period, not high flow, runoff events. Additionally, due to the small size of the watershed (7.1 mi^2) and the fact that Brushy Creek (upstream of the WWTP) does not have flow year around, any persistent suspended solids (NFR/sludge) problems during low flow periods are likely point source issues. Other than wastewater treatment facilities in Sedalia, sources of ammonia nitrogen and quantifiable sources of BOD and sewage sludge were not identified.

The largest permitted facility in the Brushy Creek watershed is the Sedalia Central WWTP, which contributes 98 percent of the flow. Other small point source discharges in this watershed (Appendix B.4) were not considered in this TMDL for the following reasons:

- Because Sedalia Central WWTP contributes the largest load of BOD to the watershed, it is believed to represent the primary cause of depleted or reduced dissolved oxygen in Brushy Creek.
- Data collection indicates dissolved oxygen averages *up*stream of the WWTP were greater than 5.0 mg/L, which is the state standard for DO. This indicates the water holds adequate oxygen before it gets to the WWTP.
- Ammonia limits and monitoring have only recently been required in the Sedalia Central WWTP operating permit and have not been included in other permits within the watershed. According to Missouri permitting protocols, ammonia monitoring is required if significant loading would occur as a result of discharge. Due to the relative difference in design flows, it is believed that the primary source of ammonia loading to Brushy Creek during low flow conditions is the Sedalia Central WWTP.

The Sedalia Central WWTP was recently upgraded from a trickling filter to an activated sludge facility with two final clarifiers. The design flow is 2.5 MGD (million gallons per day), which translates to 3.88 cubic feet per second (cfs). The facility discharges wastewater to Brushy Creek, and the outfall is located approximately 3.4 miles up from Brushy Creek's confluence with Muddy Creek. Brushy Creek is Class C at the point of discharge. The recent improvements to the facility were completed in May 2000 (See Appendix B.5).

On Sept. 3, 1992, there was a complete fish kill in 2.5 miles of Brushy Creek and one mile of Muddy Creek due to high levels of ammonia in the discharge from Sedalia Central. Another fish kill occurred on July 14, 1994 due to toxic concentrations of ammonia. The Missouri Department of Conservation (MDC) documented these fish kills and their causes. Low flow studies and waste load allocation surveys conducted by the Department of Natural Resources from 1983 to 1996 indicated that conditions were not protective of aquatic life in Brushy Creek and part of Muddy Creek. The ammonia was too high, the dissolved oxygen was too low and excessive deposits of sewage sludge were observed. The department conducted two stream surveys of Muddy and Brushy Creeks Aug. 24-26, 1993, and Aug. 29-31, 1995, as part of a waste load allocation study. Sedalia Central WWTP was planning to upgrade and improve its facility and wanted to know their permit limits. The surveys resulted in confirmation of the problems and determination of limits for Sedalia's new permit that would be protective of water quality.

2.0 DESCRIPTION OF THE APPLICABLE WATER QUALITY STANDARDS AND NUMERIC WATER QUALITY

2.1 Beneficial Uses:

The beneficial uses of Muddy and Brushy Creeks, WBID 0855 and 0859 respectively, are:

- Livestock and Wildlife Watering
- Protection of Aquatic Life and Human Health associated with Fish Consumption
- Muddy Creek is a General Warm Water Fishery
- Brushy Creek is a Limited Warm Water Fishery[13]

The use that is impaired is Protection of Aquatic Life. The designated uses and stream classifications may be found in the Water Quality Standards at 10 CSR 20-7.031(1)(C), (1)(F) and table H.

2.2 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.

2.3 The Standards (Criteria) That Apply:

2.3.1 Biochemical Oxygen Demand (BOD)

Dissolved oxygen (DO) is the water quality standard that is exceeded in Brushy and Muddy creeks. 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

[13] Brushy Creek is classified as a Limited Warm Water Fishery because it is a non-Ozark Class C stream with a low flow of less that 0.1 cubic feet per second. See WQS 10 CSR 20-7.031(1)(C)6.

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 oxygen demand (CBOD) and nitrogenous 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 U. S. Environmental Protection Agency (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 call for daily minimum of **5 milligrams per liter (mg/L or parts per million) dissolved oxygen**[14] or the normal background level of dissolved oxygen, whichever is lower.[15]

2.3.2 Ammonia

Chronic criteria apply only to classified waters, according to Missouri's WQS 10 CSR 20-7.015(1)(F), while unclassified waters and mixing zones are subject to acute criteria. In Brushy Creek, the lower three and one-half miles are subject to chronic criteria while the mixing zone below the WWTP is protected with acute limits. The specific criteria for ammonia are found in 10 CSR 20-7.031 Table B. Ammonia limits are pH and water temperature dependent. To determine the ammonia criteria that apply to this TMDL, data was used from a draft 1997-1998 water quality study of Brushy Creek conducted by the Missouri Department of Conservation (Appendix D). Medians of temperature and pH (Table 2) were derived from this data and the 95th percentile was selected to provide the highest level of protection for the stream.

Table 2. Median temperature and pH values for Brushy Creek at Cloney Rd., MDC 1997-1998

Season	Parameter	Median	95th Percentile
Summer	Temperature (°C)	20.5	**25**
	pH (SU)	7.6	**7.9**
Winter	Temperature (°C)	6.2	**14**
	pH (SU)	7.4	**8.1**

The criteria for ammonia that apply to this TMDL were selected from Table B in 10 CSR 20-7.031 using the temperature and pH values from Table 2 (above). Where a value fell between two figures in Table B, the midway value was calculated. These are presented in Table 3. Note that all values in 10 CSR 20-7.031 Table B are given as total ammonia.

Table 3. Instream Criteria (Standards) for Brushy Creek as Total Ammonia
Criteria for a Limited Warm Water Fishery

Season	*Acute Limits*	*Chronic Limits*
Summer (April-September)	19.8	1.8
Winter (October-March)	14.3	1.8

[14] 10 CSR 20-7.031(4)(J)
[15] 10 CSR 20-7.031(4)(A)(3)

2.3.3 Non-Filterable Residue (NFR)

Several stream surveys 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. Deposits of sewage sludge (represented as NFR) in waters of the state are interpreted as violations of the general (narrative) criteria of the Water Quality Standards. 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."

2.4 Numeric Water Quality Targets for These TMDLs:

2.4.1 Biochemical Oxygen Demand

As stated in Section 2.3.2, chronic criteria apply to classified waterbodies, while unclassified waters and mixing zones are subject to acute criteria. Again, the lower 3.5 miles of Brushy Creek are subject to chronic criteria while the mixing zone is protected with acute limits. Muddy Creek is a classified permanent-flowing stream and is therefore subject to chronic criteria. The dissolved oxygen standard of 5.0 mg/l in the state of Missouri is interpreted as chronic criteria. Diurnal effects are taken into account by using a daily mean (average). Thus the goal of this TMDL is to maintain **5.0 mg/l dissolved oxygen** (as a daily average) in Muddy Creek and lower section of Brushy Creek.

Dissolved oxygen in water is depleted and renewed through several processes. These processes are presented in Figure 1. Biochemical oxygen demand (BOD) reflects the amount of oxygen consumed through two processes: carbonaceous biochemical oxygen demand (CBOD) and nitrogenous biochemical oxygen demand (NBOD). CBOD is the reduction of organic carbon material to its lowest energy state, CO_2, through the metabolic action of microorganisms. NBOD is the term for the oxygen required for the biological oxidation of ammonia to nitrate, called nitrification (Figure 2).

Sediment oxygen demand (SOD) is a combination of several processes. Primarily it is the decay of organic materials that settle to the bottom of the stream. SOD is usually considered negligible in free flowing streams like Brushy and Muddy creeks due to the frequency of scouring events (floods) that prevent long-term accumulation of organic materials.

Figure 1. Major Dissolved Oxygen Kinetic Processes

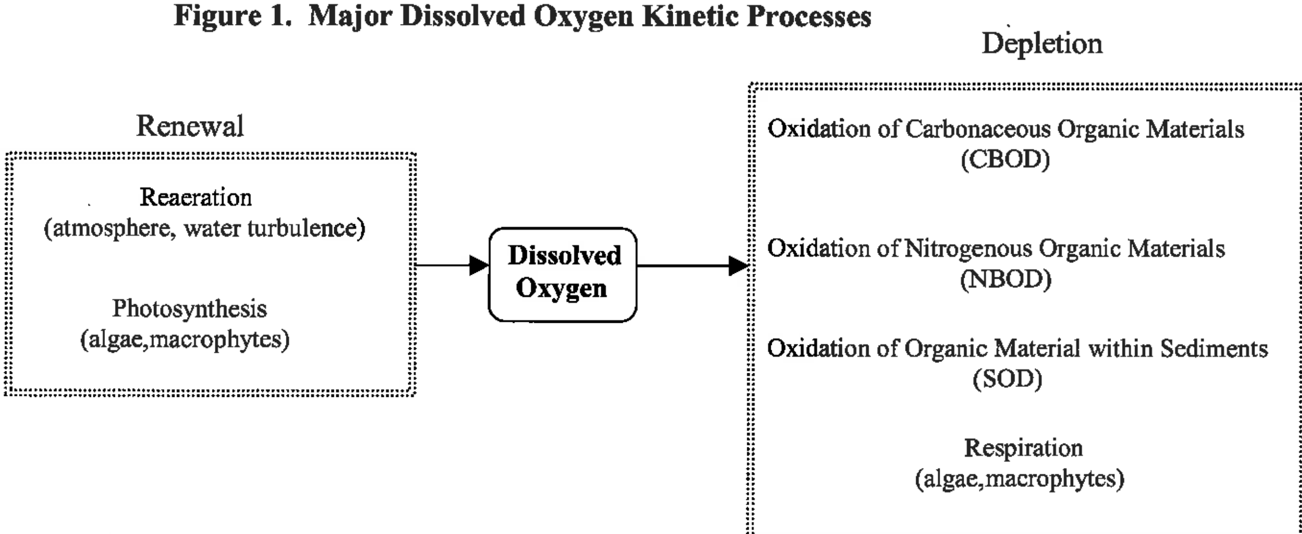
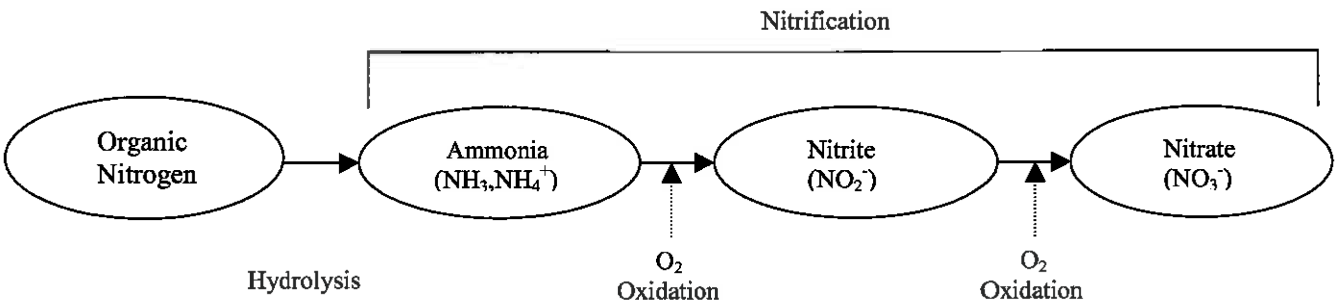


Figure 2. Nitrogen Decomposition Cycle



Appropriate levels of BOD (CBOD and NBOD) will be allocated such that dissolved oxygen of 5.0 mg/L (daily average) is maintained in Muddy Creek and the classified section of Brushy Creek.

2.4.2 Ammonia (NH_3-N)

The targets for this TMDL are listed in Table 4 as ammonia nitrogen (NH_3-N). As was mentioned in section 2.3.2, all values in 10 CSR 20-7.031 Table B are given as total ammonia. These values are converted to NH_3-N by **dividing** by 1.2.

Table 4. Ammonia Nitrogen (NH_3-N) Target Concentrations (Instream) for the Brushy Creek TMDL

Season	Acute Criterion (mg/L)	Chronic Criterion (mg/L)
Summer	16.5	1.5
Winter	11.9	1.5

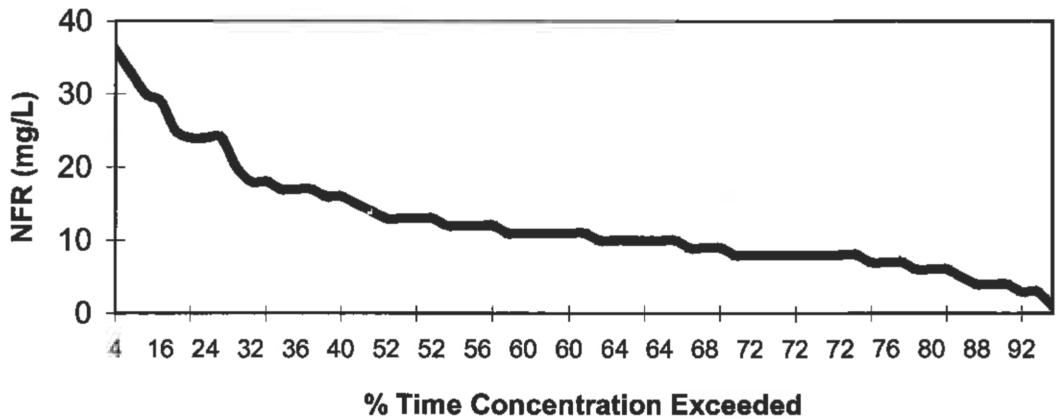
The TMDL will allocate loads such that ambient concentrations of NH_3-N do not exceed chronic criteria in classified segments while not exceeding acute criteria in the mixing zone below the primary outfall. The mixing zone is defined by WQS, 10 CSR 20-7.031(4)(A)5.B.(I)(a), as the full width of the stream for one-quarter mile below the outfall. The NH_3-N target will be applied at the downstream end of the mixing zone.

2.4.3 Non-Filterable Residue (NFR)

The Sedalia Central WWTP began plant facility upgrades in November 1998. These upgrades have improved effluent quality. The facility went from a trickling filter/anaerobic sludge digester to an activated sludge system with two final clarifiers, which lowers the NFR output. Upgrades were completed and operational by May 17, 2000. Prior to construction, permit limits for NFR were 60 mg/L as a weekly average and 40 mg/L as a monthly average. Following the upgrades, NFR limits were reduced to a 45 mg/L weekly average and 30 mg/L monthly average. The department conducted two low flow waste load allocation surveys in July 2001. During these surveys, no objectionable bottom deposits were observed. This may be an indication that the problem of excessive sewage deposition has been resolved through improved treatment technology at the WWTP.

TMDL (Total Maximum **Daily** Load) guidelines require that a maximum daily pollutant load be calculated which, if achieved, will fully maintain the designated use(s) of impaired waters. As has been noted, Missouri does not have numeric standards for NFR. Since the stream is improving with the new permit limits, showing a 65 percent reduction in NFR since the facility upgrades, the target will be based on the **post**-upgrade Discharge Monitoring Report (DMR) from Sedalia Central. The DMR covering the years 1997-2001 may be found in Appendix G. Figure 3 is based on the post-upgrade DMR data. It shows that an acute maximum daily concentration of 35 mg/L was exceeded only 5 percent of the time. As compliance with daily maximum limits is measured by a 5 percent or less exceedence rate, a maximum daily permit limit of 35 mg/L should comply with permitting requirements. This is noteworthy because the facility just underwent the major upgrades already mentioned. By not requiring further upgrades to the facility at this time, it allows for assessment of the effect of the new upgrades. As this is a phased TMDL, the appropriateness of the established target will be re-evaluated based on future monitoring data.

Figure 3. Post-Upgrade Concentration Frequency Curve for Sedalia Central WWTP



3.0 CALCULATION AND ALLOCATION OF LOADS

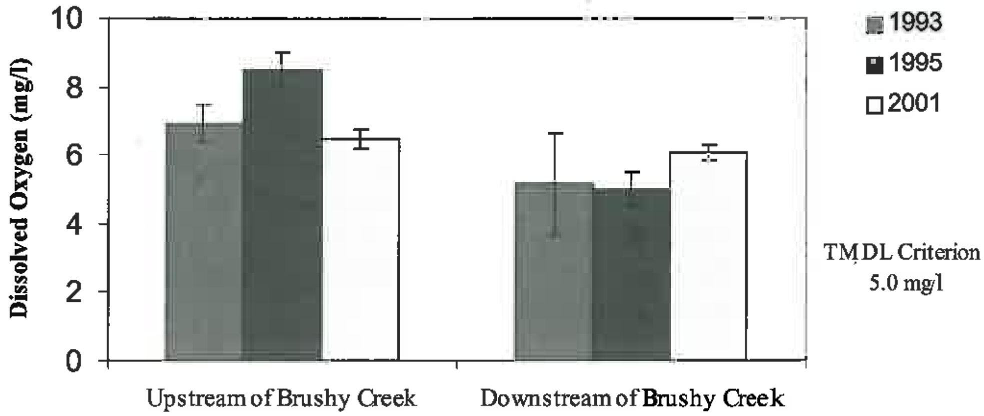
3.1 Biochemical Oxygen Demand (BOD):

3.1.1 Existing Data

Muddy Creek: Data from summer waste load allocation studies indicate (Z_{rs} = -2.7, p = 0.007) reduced dissolved oxygen in Muddy Creek below the confluence of Brushy Creek (Figure 4 and Appendix C.2). Improvements to the Sedalia Central WWTP from 1998 to 2000 are observed in the increase in average dissolved oxygen below the Brushy Creek confluence. Due to laboratory quantification levels (less than 4 mg/L), $CBOD_5$ comparisons on Muddy Creek upstream versus downstream of the Brushy Creek confluence were not possible.

Complainant's Ex. No. 38 Page 13

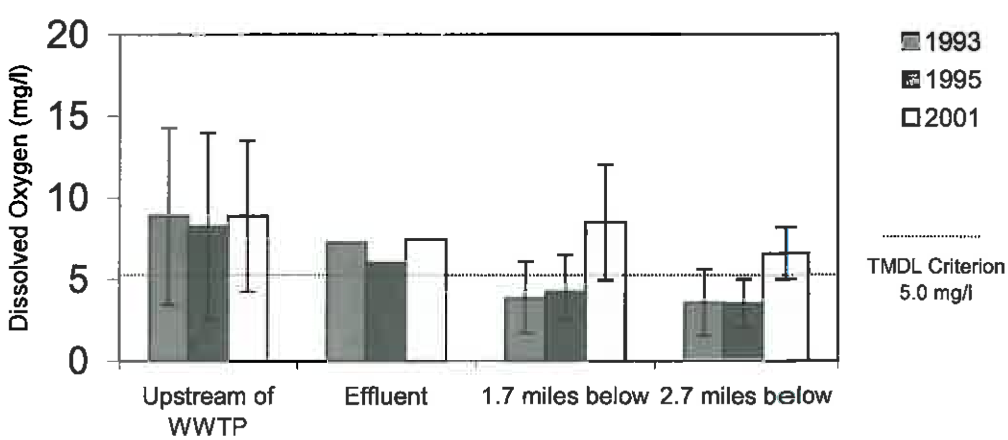
Figure 4. Summer Daily Mean Dissolved Oxygen in Muddy Creek



As previously stated, the largest permitted facility in the Muddy Creek watershed is the Sedalia Central WWTP, which contributed 77 percent to the baseflow BOD load to Muddy Creek in 1998. Of $CBOD_5$ samples taken upstream of the confluence with Brushy Creek from 1993 to 2001, 14 of the 16 were non-detects (less than 4 mg/L and less than 2 mg/L) while the remaining two were 2.00 mg/L (Appendix C.2). For these reasons, it is believed that reductions in BOD (CBOD + NBOD) limits in the Sedalia Central operating permit to levels that allow maintenance of at least 5.0 mg/L dissolved oxygen are removing the impairment in Muddy Creek.

Brushy Creek: The Sedalia plant upgrades may also explain increases in daily average dissolved oxygen below the treatment plant (Figure 5 and Appendix C.2). Also, in 1998 BOD_5 limits[16] of 10 mg/L in the summer and 20 mg/L in the winter were incorporated into the Sedalia permit. These limits are stated as monthly and weekly averages. In all years, *up*stream dissolved oxygen averages were greater than 5.0 mg/L. Only in 2001, after upgrades to the treatment plant and changes to the permit, did dissolved oxygen levels rise above 5.0 mg/L *down*stream.

Figure 5. Summer Daily Mean Dissolved Oxygen in Brushy Creek



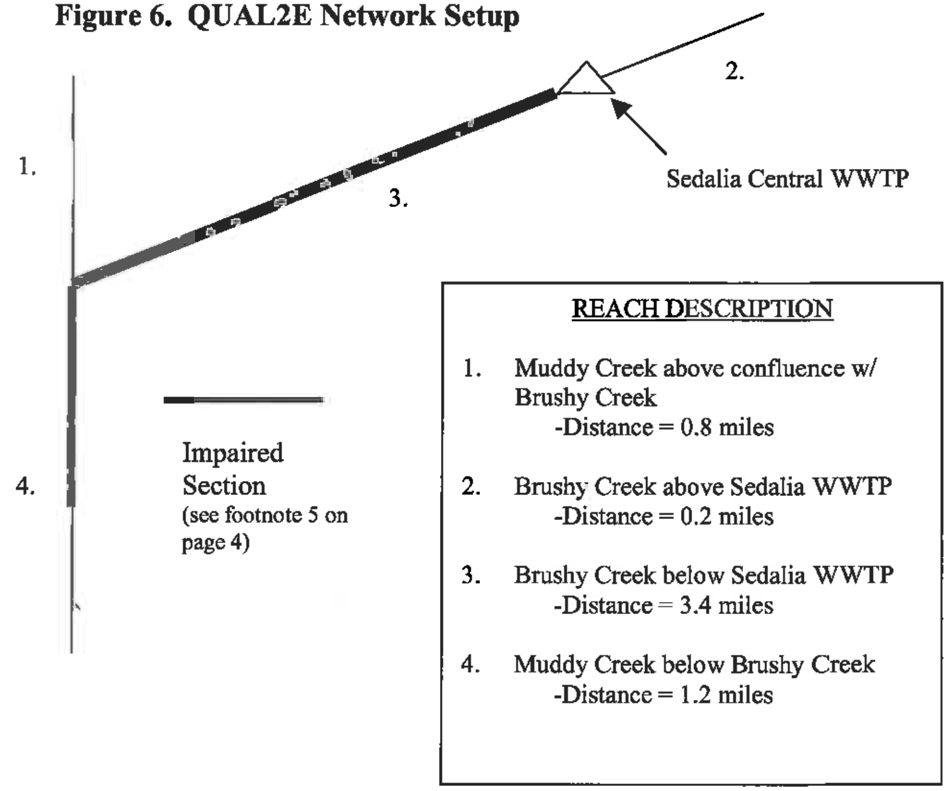
[16] BOD_5 is the amount of oxygen used to decompose the organic matter present in a water sample in a five-day period. BOD (total or ultimate BOD) is the amount of oxygen needed for complete oxidation, which can take up to 100 days.

Sedalia Central contributes 98 percent of the baseflow BOD loading to Brushy Creek. Also, Sedalia Central effluent discharge **is** the flow in Brushy Creek during 7Q10 conditions. No significant quantifiable nonpoint sources of BOD were identified. As with Muddy Creek, it is believed that the reductions in BOD (NBOD, CBOD) limits in the Sedalia Central operating permit are allowing maintenance of at least 5.0 mg/L dissolved oxygen. This eliminates the impairment.

3.1.2 The Model

A QUAL2E water quality model was calibrated and validated at steady state for use on Brushy and Muddy creeks using data obtained in July and August of 2001. QUAL2E simulates processes responsible for the breakdown of sewage-derived carbon and nitrogen by a series of first order decay reactions. Organic nitrogen levels in the effluent are assumed to be 1.15 mg/L year around (see Section 3.2.3). Ammonia nitrogen in the effluent is assumed to be 1.13 mg/L in the summer (from the waste load allocation of 23.6 lbs/day at design flow; refer to section 3.2.6) and 1.8 mg/L in the winter (37.7 lbs/day at design flow). Brushy and Muddy creeks as seen by the QUAL2E model are presented in Figure 6.

Figure 6. QUAL2E Network Setup



Model hydrology (Appendix F.1) and water quality coefficients (Appendix F.2) were adjusted to fit July 2001 data (calibration) and then compared to observations from August 2001 (verification).

3.1.3 Load Capacity

Load capacity (LC) is defined as the greatest amount of loading of a pollutant that a waterbody can receive without violating water quality standards. This load is then divided among the point source (waste load allocation) and nonpoint source (load allocation) contributions to the stream, with an allowance for an explicit margin of safety. If the margin of safety is implicit, no numeric allowance is necessary. Critical conditions are considered when the LC is calculated.

Dissolved oxygen levels that threaten the integrity of aquatic communities generally occur during low flow periods, therefore this time is considered the critical condition. The 7Q10 flow is the lowest average flow for seven consecutive days that have a recurrence interval of once in 10 years. This represents the worse case flow scenario reasonably expected to occur. Allocations developed under 7Q10 conditions are believed to be protective during other seasons and expected flow scenarios, so they were chosen as the critical conditions.

Flat Creek in Pettis County (Appendix E.2) was used as a surrogate watershed (148 $mi.^2$) for the purpose of estimating 7Q10 conditions for the Muddy Creek watershed upstream of Brushy Creek (146 $mi.^2$) on the basis of watershed area and ecoregion. Using daily mean streamflow data from United States Geological Survey (USGS) gage 06906700, 7Q10 conditions were determined with the SWSTAT 4.0 USGS program. Both winter (Oct. 1– March 31) and summer (April 1– Sept. 30) 7Q10 flows were near 0.0 cubic feet per second (cfs) based on data from 1961–1966 (Appendix E.1). Though a few years record flow of greater than zero, the relatively few years of data at the Flat Creek gage station make the 0.0 cfs 7Q10 estimate the only defensible conclusion.

Starks Creek near Preston in Hickory County (Appendix E.4) was used as a surrogate watershed for the purpose of estimating 7Q10 conditions in Brushy Creek. Using daily mean streamflow data for USGS gage 06925200, 7Q10 conditions were determined with the SWSTAT 4.0 USGS program. Both winter (Oct. 1– March 31) and summer (April 1– Sept. 30) 7Q10 flows were 0.0 cfs based on data from 1957–1975 (Appendix E.3). Thus, under low flow 7Q10 conditions, Brushy Creek is dominated by discharge (effluent) from Sedalia Central WWTP.

Using the QUAL2E model, $CBOD_5$ allocations were developed for summer and winter periods. Model inputs that vary by season (climatology, headwater characteristics) were adjusted accordingly to calculate the load capacity (LC). Load Capacities were developed for both Muddy and Brushy creeks; however, since limits that will protect Brushy Creek will also protect Muddy, the Brushy Creek figures will be used. Based on the model results, the loading expressed as $CBOD_5$ is 7.1 mg/l in the summer and 65 mg/l in the winter.

The summer and winter LC for both creeks are dependent on WWTP discharge because nonpoint source contributions are zero and the stream is therefore the plant discharge. The LC is translated to pounds per day using the following formula (5.395 is the constant used to convert cubic feet per second (cfs) times milligrams per liter (mg/L) to lbs/day):

Load Capacity = (Design flow in cfs)(Limit in mg/L)(5.395)

Summer: LC_{CBOD5} = (3.88)(**7.1 mg/L**)(5.395) = **148.6 lbs/day**

Winter: LC_{CBOD5} = (3.88)(**65 mg/L**)(5.395) = **1360 lbs/day**

3.1.4 Load Allocation (Nonpoint Source)

Muddy Creek: The Load Allocation (LA) includes all existing and future nonpoint sources and natural background contributions (40 CFR § 130.2(g)). The six permitted animal feeding operations in Muddy Creek watershed are either no-discharge permits or are too small and too far away to impact the impaired section of the creek. Upstream estimates of $CBOD_5$ and ammonia nitrogen in Muddy Creek have been undetectable in past sampling efforts and organic nitrogen values averaged 0.8 mg/L in the summer 2001 surveys. The 7Q10 condition is 0.0 cfs, however, so nonpoint source contributions (the LA) are calculated at 0.0 lbs/day for this TMDL.

Brushy Creek: No significant nonpoint sources of BOD have been identified in the Brushy Creek watershed. Upstream flow is considered 0.0 cfs during summer and winter in regard to 7Q10 conditions, so the LA for Brushy Creek is also 0.0 lbs/day.

3.1.5 Waste Load Allocation (Point Source)

The Waste Load Allocation (WLA) is the proportion of a receiving water's load capacity that is allocated to its existing or future point sources of pollution. Due to the reasons listed in Source Assessment (Section 1.4), it is believed that the Sedalia Central WWTP is the primary cause for the low dissolved oxygen impairment. The current BOD_5 limits for the Sedalia Central WWTP are 10 mg/L (as a weekly and a monthly average) in summer and 20 mg/L in winter. Output from the QUAL2E model indicates that a daily average of 5.0 mg/L dissolved oxygen will be achieved in the impaired sections of both creeks through current permit limits. The LC must be allocated to point and nonpoint sources and a margin of safety (MOS) and can be written as:

$$LC = LA + WLA + MOS$$

Summer: 148.6 lbs/day = 0.0 lbs/day +133.7 lbs/day +14.9 lbs/day

LC = (3.88)(7.1 mg/L)(5.395) = 148.6 lbs/day
LA = 0.0 lbs/day
WLA = (3.88 cfs)(6.39 mg/L)(5.395) = **133.7 lbs/day**
MOS = (3.88 cfs)(0.71 mg/L)(5.395) = 14.9 lbs/day

Winter: 1360 lbs/day = 0.0 lbs/day + 1224 lbs/day + 136 lbs/day

LC = (3.88)(**65 mg/L**)(5.395) = 1360 lbs/day
LA = 0.0 lbs/day
WLA = (3.88 cfs)(58.5 mg/L)(5.395) = **1224 lbs/day**
MOS = (3.88 cfs)(6.5 mg/L)(5.395) = 136 lbs/day

Where an allocation in lbs/day = (flow in cfs)(concentration in mg/L)(5.395 conversion factor)

Calculated as concentrations, the WLAs are 6.39 mg/L for summer and 58.5 mg/L for winter. Using these WLAs, the maximum daily limits (MDLs) are derived following EPA protocol[17] for developing permit limits. (Refer to Section 3.3.4 for a detailed example. The Coefficient of Variation for $CBOD_5$ is 0.7.) The MDLs calculated this way are 6.39 mg/L for summer and 58.5 mg/L for winter. The Average Monthly Limits (AMLs) are 3.7 (LTA = 6.39*0.281=1.79, @ the 99th percentile, n=4, CV =0.7) mg/L (summer) and 32 mg/L (winter) {LTA = 58.5*0.281=16.43, @ the 99th percentile, n=4, CV =0.7}. Again, refer to Section 3.3.4 for the method. Of note, Effluent Regulation 10 CSR 20 7.015(8)(B)6 allows 5 mg/L to be added to $CBOD_5$ for the BOD_5 limit. Adding this, the calculated

[17] *Technical Support Document (TSD) for Water Quality-based Toxics Control*, EPA/505/2-90-001

permit limits for MDL would be 11.4 mg/L (summer) and 63.5 mg/L (winter). AMLs would be 8.7 mg/L (summer) and 38 mg/L (winter).

3.1.6 Margin of Safety

For an overview of the Margin of Safety (MOS), see Section 4.0. Due to inherent inaccuracies in the QUAL2E model, and based on experience with similar streams in the region, 10 percent of the load capacities presented in Section 3.1.3 for both Muddy and Brushy creeks is an appropriate MOS for the purposes of this TMDL. The MOS is 14.9 lbs/day in summer and 136 lbs/day for winter.

3.1.7 Seasonal Variation

Dissolved oxygen, like other gases, is less soluble at higher temperatures and altitudes. Due to temperature considerations, both summer and winter TMDL allocations have been developed.

3.1.8 Total Maximum Daily Load (TMDL) Calculation

The TMDLs for both creeks may be found in Table 5 below. The TMDL is equal to the LC and is the sum of the WLA, LA and MOS. The generalized TMDL calculation is as follows:

TMDL = Load Capacity = Waste Load Allocation + Load Allocation + Margin of Safety

Table 5. Muddy Creek and Brushy Creek $CBOD_5$ Loads (lbs/day)

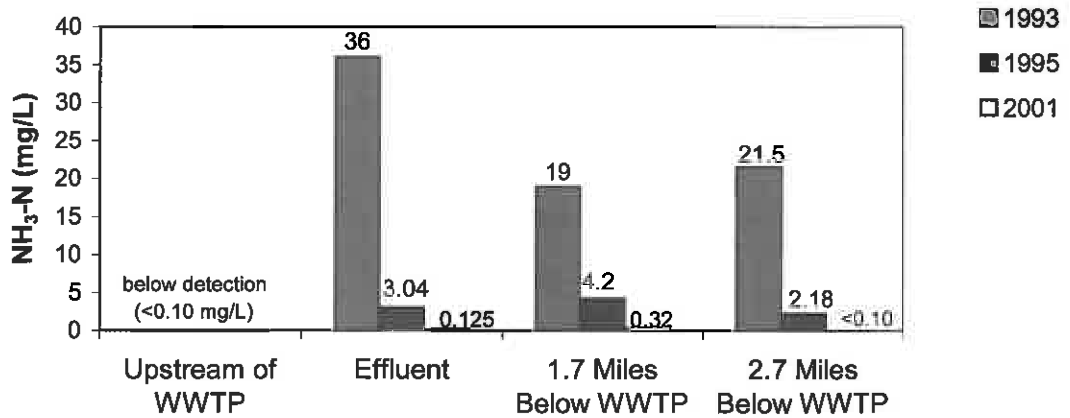
		Point Load (WLA)	Non-Point Load (LA)	Margin of Safety (MOS)	**TMDL**
Summer	$CBOD_5$	133.7	0.0	14.9	**148.6**
Winter	$CBOD_5$	1224.0	0.0	136	**1360**

3.2 Ammonia (NH_3-N):

3.2.1 Existing Data for Ammonia

Summer ammonia data from 1993 and 1995 indicate higher concentrations below Sedalia Central WWTP compared to upstream sites (Figure 7). Studies conducted in July 2001 show reduced ammonia concentrations below the WWTP relative to 1993-1995 that may be a result from improvements made to the plant from 1998 through 2000. Existing department data on Brushy Creek is listed in Appendix C.2.

Figure 7. Summer Daily Mean Ammonia Nitrogen in Brushy Creek



Ammonia monitoring of effluent from Sedalia Central WWTP was optional until 1998 when the revised State Operating Permit instituted a summer ammonia nitrogen limit of 2.5 mg/L and a winter limit of 3.5 mg/L. There have been no violations of these limits as of August 2001.

3.2.2 The Nitrogen Cycle

The nitrogen in raw sewage is generally composed of organic nitrogenous compounds (amino acids, urea, protein) and ammonia. As part of the nitrogen cycle (Figure 8), organic nitrogen is eventually hydrolyzed into ammonia in a process called ammonification (Figure 9). Following ammonification, ammonia is oxidized to nitrite and then nitrate. Due to the ammonification processes, allocation of ammonia loads depends on levels of organic nitrogen as well as ammonia nitrogen.

Figure 8. Nitrogen Decomposition Cycle below Sedalia Central WWTP

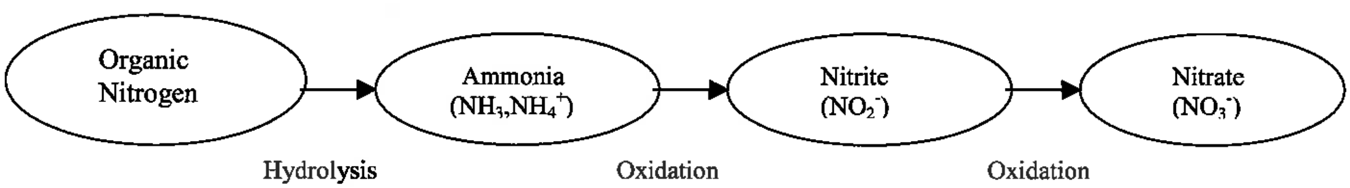


Figure 9. Decomposition of Urea in Natural Waters (Ammonification)

$$NH_2-\overset{\overset{\displaystyle O}{||}}{C}-NH_2 + H_2O \xrightarrow[\text{Urease}]{} 2NH_3 + CO_2$$

3.2.3 The Model for Ammonia

A QUAL2E water quality model was calibrated and validated at steady state for use on Brushy Creek using data obtained in July and August 2001. Earlier data sets were not used because some lacked organic nitrogen data and others lacked flow data. QUAL2E simulates the nitrogen cycle depicted in Figure 8 by a series of first order decay reactions. The small number of samples (n=2) of organic nitrogen limits the reliability of the coefficient of variation estimates needed for projecting maximum organic nitrogen concentration. For model input purposes, the maximum observed value (7/17/01) of 1.15 mg/L organic nitrogen will be assumed constant in the effluent. Although reasonable potential may exist for the effluent to contain more than 1.15 mg/L, conservative assumptions were built into the model and the TMDL to provide adequate protection to aquatic life. Brushy Creek as seen by the QUAL2E model is presented in Figure 6 (page 14).

Model hydrology (Appendix F.1) and water quality (Appendix F.3) coefficients were adjusted to fit July 2001 data (calibration) and then compared to observations from August 2001 (verification).

3.2.4 Load Capacity for Ammonia

Load capacity (LC) is defined as the greatest amount of loading of a pollutant that a waterbody can receive without violating water quality standards. This load is then divided among the point source (waste load allocation) and nonpoint source (load allocation) contributions to the stream, with an allowance for an explicit margin of safety. If the margin of safety is implicit, no numeric allowance is necessary. Critical conditions are considered when the LC is calculated.

The critical conditions for ammonia are low flow conditions, which are most likely to accompany exceedences of ammonia standards. Under low flow conditions there is less water available to dilute pollutant loads. The 7Q10 flow is the lowest average flow for seven consecutive days that have a recurrence interval of once in ten years. This represents the worse case scenario reasonably expected to occur and is therefore considered the critical condition. Allocations developed under low flow 7Q10 conditions are believed to be protective during other seasons and expected flow scenarios.

As noted in Section 3.1.4, Starks Creek near Preston in Hickory County (Appendices E.3 and 4) was used as a surrogate watershed for the purpose of estimating 7Q10 conditions in Brushy Creek.

Using the QUAL2E model, ammonia nitrogen criteria and loads were developed for summer and winter periods. Model inputs that vary by season (climatology, headwater characteristics) were adjusted accordingly. Thus computed, the summer and winter load capacities for Brushy Creek are 1.25 mg/L and 2.0 mg/L respectively. Expressed as pounds per day, these loads are dependent on the WWTP discharge because nonpoint source contributions are considered zero. Because this is concentration based, the load will vary with the volume of discharge.

Load Capacity = (Design flow in cfs)(Limit in mg/L)(5.395 conversion factor)

Summer: LC = (3.88)(**1.25 mg/L**)(5.395) = **26.2 lbs/day**

Winter: LC = (3.88)(**2.0 mg/L**)(5.395) = **41.9 lbs/day**

3.2.5 Load Allocation (Nonpoint Source) for Ammonia

The Load Allocation includes all existing and future nonpoint sources along with the natural background contribution. As was discussed in Section 1.4 Source Assessment, no significant quantifiable nonpoint sources of ammonia nitrogen have been identified in the Brushy Creek watershed. Due to the small watershed size (7.1 mi^2) and non-permanent nature of the stream, any persistent ammonia nitrogen problems observed during low flow periods are likely point source problems. Thus the load allocation is equal to 0.0 lbs/day in summer and winter with respect to 7Q10 conditions.

3.2.6 Waste Load Allocation (Point Source) for Ammonia

Waste Load Allocations are the proportion of receiving water's load capacity that is allocated to existing or future point sources of pollution. Sedalia Central WWTP (MO-0023019) is the only significant quantifiable point source of ammonia nitrogen. The current NH_3-N (ammonia nitrogen) limits for the Sedalia Central WWTP permit are 2.5 mg/L in summer and 3.5 mg/L in winter, as daily maximums. Output from QUAL2E indicates that these limits may not be protective of chronic ammonia criteria. Since this is a phased TMDL, further in-stream monitoring is required to determine whether this is the case.

Since the LC must be allotted to point and nonpoint sources and the margin of safety (MOS), LC can be written as:

$$LC = LA + WLA + MOS$$

Summer: 26.2 lbs/day = 0.0 lbs/day + 23.6 lbs/day + 2.6 lbs/day

LC = (3.88)(1.25 mg/L)(5.395) = 26.2 lbs/day
LA = 0.0 lbs/day
WLA = (3.88 cfs)(1.125 mg/L)(5.395) = **23.6 lbs/day**
MOS = (3.88 cfs)(0.125 mg/L)(5.395) = 2.6 lbs/day

Winter: 41.9 lbs/day = 0.0 lbs/day + 37.7 lbs/day + 4.2 lbs/day

LC = (3.88)(2.0 mg/L)(5.395) = 41.9 lbs/day
LA = 0.0 lbs/day
WLA = (3.88 cfs)(1.8 mg/L)(5.395) = **37.7 lbs/day**
MOS = (3.88 cfs)(0.2 mg/L)(5.395) = 4.2 lbs/day

Where an allocation in lbs/day = (flow in cfs)(concentration in mg/L)(5.395 conversion factor)

Calculated as concentrations, the WLAs are 1.13 mg/L for summer and 1.8 mg/L for winter. Using these WLAs, the maximum daily limits (MDLs) are derived following EPA protocol (the TSD) for developing permit limits. (Refer to Section 3.3.4 for a detailed example. The Coefficient of Variation for ammonia is 1.103.) The MDLs calculated this way are 2.1 mg/L for summer and 3.3 mg/L for winter. Because a TMDL relates to maximum daily loads or limits, flexibility may exist to use only daily maximum limits in the permit. Given that degree of flexibility, existing permit limits (which will be retained) are less stringent than required according to model output. As has been noted, this is a phased TMDL. Extensive monitoring will be conducted before any permit limits are adjusted. Of note, the Average Monthly Limit calculated according to the TSD is 0.8 mg/L (summer) and 1.3 mg/L (winter). Again, refer to Section 3.3.4 for the method.

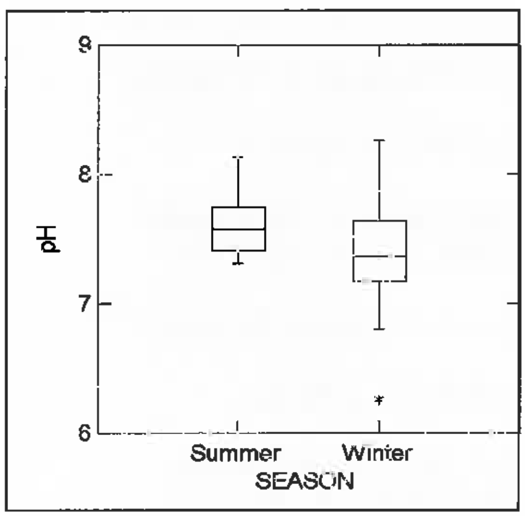
3.2.7 Margin of Safety for Ammonia

For an overview of the Margin of Safety (MOS), see Section 4.0. Due to inherent inaccuracies in the QUAL2E, and based on experience with similar streams in the region, 10 percent of the load capacities presented in Section 3.2.4 for Brushy Creek is an appropriate margin of safety for the purposes of this TMDL. The MOS is 2.6 lbs/day for summer and 4.2 lbs/day in winter.

3.2.8 Seasonal variation for Ammonia

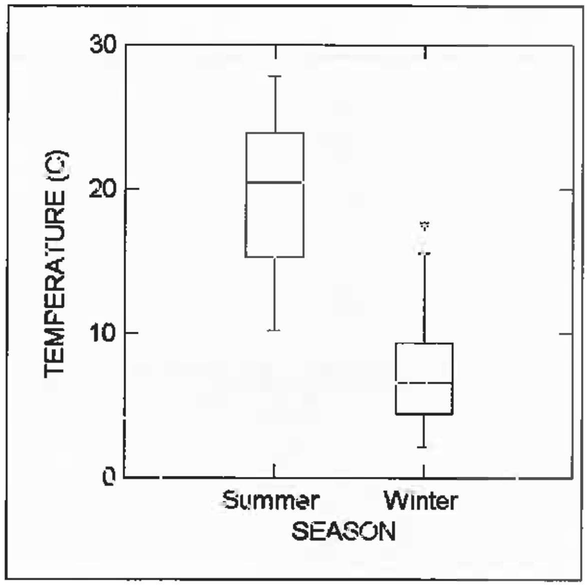
Toxicity of ammonia species (NH_3 & NH_4^+) to fishes and invertebrates is well documented[18]. High pH and temperature increase the proportion of the more toxic NH_3 form and thus ammonia toxicity limits are seasonal in nature. Listed below (Figure 10, Figure 11) are temperature and pH boxplots created from a draft 1997-1998 water quality study of Brushy Creek conducted by the Missouri Department of Conservation (Appendix D). The location for the study site is SE1/4, SE1/4, Section 24, T46N, R21W; Brushy Creek at Cloney Road.

Figure 10. Seasonal variation of pH within classified reaches of Brushy Creek, 1997-1998 Summer (April – September), Winter (October – March)



[18] *Ambient Water Quality Criteria for Ammonia-1984*, EPA 440/5-85-001, and *1999 Update of Ambient Water Quality Criteria for Ammonia*, EPA-822-R-99-014

Figure 11. Seasonal variation of temperature within classified reaches of Brushy Creek, 1997- 1998. Summer (April – September), Winter (October – March)



3.2.9 TMDL Calculation for Ammonia

As mentioned before, discharge from the Sedalia Central WWTP is the streamflow during 7Q10 conditions and thus no upstream considerations of flow or pollutant loading were given. TMDL results are summarized in Table 6. The TMDL is equal to the LC and is the sum of the WLA, LA and MOS. The generalized TMDL calculation is as follows:

TMDL = Load Capacity = Waste Load Allocation + Load Allocation + Margin of Safety

Table 6. Brushy Creek Ammonia Loads (lbs/day)

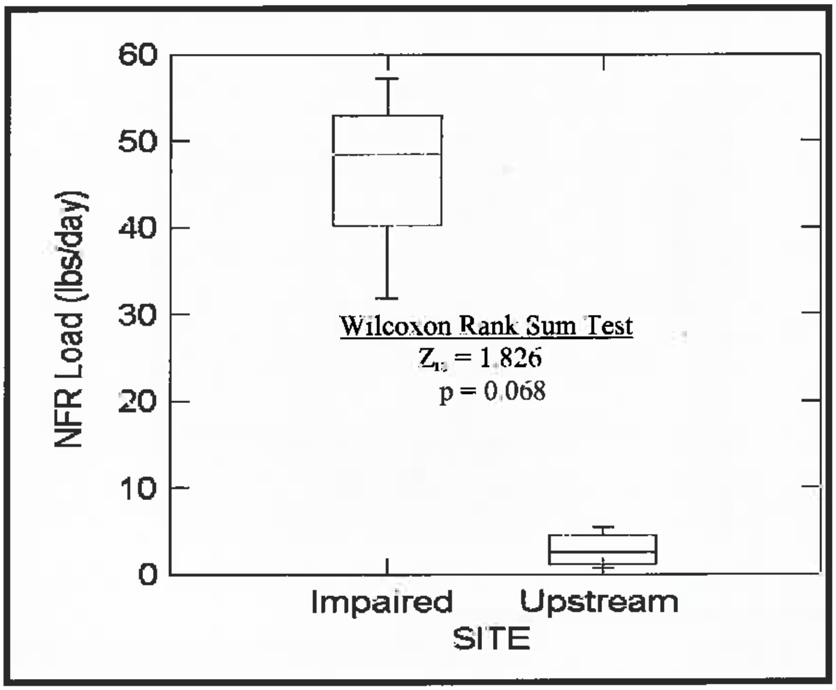
		Point Load (WLA)	Non-Point Load (LA)	Margin of Safety (MOS)	**TMDL**
Summer	Ammonia (NH_3-N)	23.6	0.0	2.6	**26.2**
Winter	Ammonia (NH_3-N)	37.7	0.0	4.2	**41.9**

3.3 Non-Filterable Residue (NFR):

3.3.1 Existing Data for NFR

Observations of excessive deposits of sewage sludge below the WWTP were made by the department personnel during low flow and waste load allocation surveys from 1983 to 1995 which resulted in listing on the 1998 303(d) list. However, in-stream NFR data were not collected until 2001. Waste load allocation studies conducted by the department in July 2001 (Appendix C.2) indicate ($p<0.069$) higher NFR loads downstream of Sedalia Central WWTP compared to upstream sites (Figure 12).

Figure 12. NFR Loading Upstream of Sedalia Central WWTP compared to downstream impaired segments.



The Discharge Monitoring Report (DMR) data from the treatment plant may be found in Appendix G. This appendix contains wastewater discharge (flow) and NFR data from 01/01/1997 – 9/28/2001.

3.3.2 Load Capacity for NFR

Load capacity (LC) is defined as the greatest amount of loading of a pollutant that a waterbody can receive without violating water quality standards. This load is then divided among the point source (waste load allocation) and nonpoint source (load allocation) contributions to the stream, with an allowance for an explicit margin of safety. Since the margin of safety for NFR is implicit in this case, no numeric allowance is necessary. Critical conditions are considered when the LC is calculated.

Excessive sewage sludge gets deposited during periods of receding and low stream velocities. Also, the relative impact of stress exerted by sediment oxygen demand is higher during warm weather, low-flow periods. For these reasons, and the fact that data from pre-1998 low flow surveys indicate an impairment, the critical period for this TMDL will be low flow, 7Q10 conditions. Allocations developed under these conditions are believed to be protective during other seasons and expected scenarios. Starks Creek near Preston in Hickory County was used as a surrogate watershed for the purpose of estimating 7Q10 conditions in Brushy Creek. See Section 3.2.4 and Appendices E.3-4.

The Load Capacity (LC) for NFR is 35 mg/L maximum daily limit, the target arrived at in Section 2.4.3. Expressed as pounds per day, the LC is dependent on the WWTP discharge because nonpoint source contributions are considered zero. It is calculated as follows (5.395 is the conversion factor):

LC in pounds/day = (design flow in cfs)(limit in mg/L)(5.395)

NFR: LC = (3.88 cfs)(35 mg/L)(5.395) = **732 lbs/day**

3.3.3 Load Allocation (Nonpoint Source Load) for NFR

Other than Sedalia Central WWTP (MO-0023019), no other significant quantifiable sources of sewage sludge have been identified. Thus the load allocation (LA) for NFR is equal to 0.0 lbs/day under 7Q10 conditions.

3.3.4 Waste Load Allocation (Point Source Loads) for NFR

The largest permitted facility (municipal, non-municipal, CAFO) in the Brushy Creek watershed is the Sedalia Central WWTP that contributes 96 percent of the potential baseflow loading of NFR. Appendix B.4 contains a map and a list of the facilities in this watershed. Due to the small watershed size (7.1 mi^2) and the fact that Brushy Creek does not have flow year around, any persistent suspended solids problems during low flow periods are likely point source problems.

Conversion of maximum daily permit limits to waste load allocations (WLA) is accomplished through back-calculation of long term averages according to EPA protocols[19] used for calculating permit limits.

Step 1. Convert Maximum Daily Limit (MDL) to a Long-Term Average (LTA) using a Percentile Occurrence Multiplier (POM), where POM equals 3.11 for a Coefficient of Variation (CV) of 0.6. This coefficient was calculated using the DMR data from Sedalia Central, and 3.11 was read from Table 5-2 in the EPA protocol for the 99th percentile corresponding to 0.6 CV. The length of time covered in the LTA is the extent of the available DMR data, in this case about 18 months. The LTA is calculated using the following equation:

LTA = MDL / POM
LTA = 35 / 3.11=11.254

Step 2. Convert the calculated LTA to a daily WLA concentration by dividing by a second POM, 0.321 taken from Table 5-1 in the EPA protocol for WLA multipliers corresponding to a CV of 0.6.

WLA = LTA / POM
WLA=11.254 / 0.321 = 35 mg/L

The fact that the WLA came out the same as the original concentration is a factor of the calculated CV and the chosen percentile (99th). The waste load allocation for the TMDL is then calculated as follows (5.395 is the conversion factor):

(design flow in cfs) (maximum daily limit in mg/L) (5.395) = WLA (lbs/day)

(3.88 cfs) (35 mg/L) (5.395) = 732 lbs/day

A weekly average was not calculated because the TSD recommends using monthly averages and daily maximums. Weekly averages were not suggested. Of note, the Average Monthly Limit that would be placed in Sedalia's operating permit is 17.4 mg/L. This is calculated using the LTA from above, and

[19] *Technical Support Document (TSD) for Water Quality-based Toxics Control*, EPA/505/2-90-001

drawing the POM from EPA Table 5-2 again, reading from the Average Monthly Limit (AML) section. Using the 95th percentile and reading from the "n=4" column (for weekly sampling at four times per month), the POM equals 1.55. Solving the following equation yields the AML:

$$AML = (LTA)(POM)$$

$$AML = (11.254)\ (1.55) = 17.4\ mg/L$$

Sedalia can technologically achieve NFR limits 5 mg/L above those of the BOD_5, or 15 mg/L for summer (low flow conditions). This is less than the 17.4 calculated above and monthly averages from the DMR data since the upgrades shows Sedalia has exceeded this only once, in July 2000. Thus, a 35 mg/L maximum daily NFR limit is achievable under the present permit limits.

3.3.5 Margin of Safety for NFR

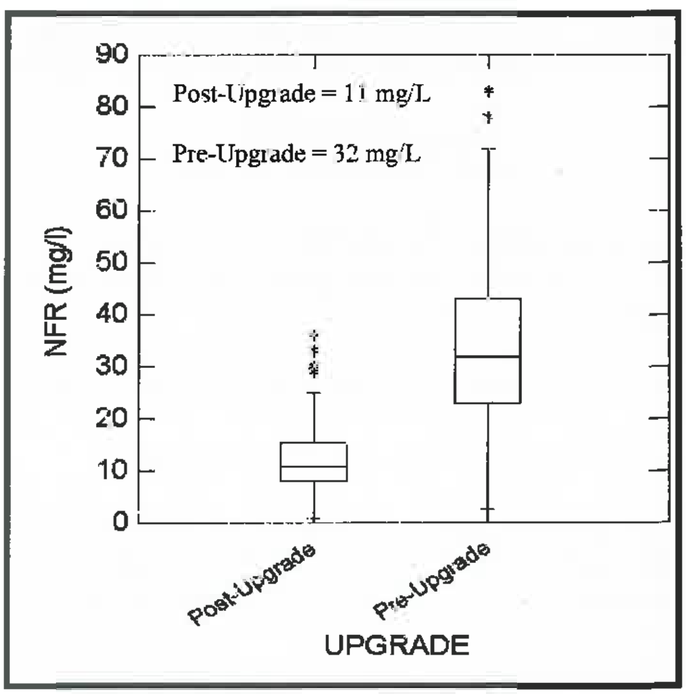
The margin of safety (MOS) is implicit for NFR in this TMDL and is recognized in two ways:

(1) Since Brushy Creek is effluent dominated, water quality is actually Sedalia Central's effluent quality. This means that there is little uncertainty between the effluent limits and resultant water quality during critical conditions.

(2) An implicit MOS is present due to the Sedalia Central WWTP making upgrades to their facility from 1998 – 2000. This has resulted in improved effluent that is more consistent in quality.

Using the Discharge Monitoring Report (DMR) data from Sedalia Central from 1997-2001, a median of NFR concentration was calculated for before and after upgrades to the treatment plant. Using the Mann-Whitney Test ($U=1146$, $p<0.001$), NFR concentrations present in the effluent before and after upgrades (May 17, 2000) were significantly different. See Figure 13. A decline from 32 mg/L to 11 mg/L as a median NFR concentration (before and after the upgrades) is equivalent to a 65 percent reduction.

Figure 13. Post-Upgrade NFR Effluent Concentrations compared to Pre-Upgrade Concentrations



This is a Phased TMDL and any further uncertainty will be addressed through the monitoring plan.

3.3.6 Seasonal Variation for NFR

Summer and winter standards have not been developed for NFR and the percent reduction of NFR arrived at for this TMDL does not consider seasonality. However, since 7Q10 conditions are the critical ones, any allocations developed under these conditions are believed to be protective during all seasons and expected scenarios.

3.3.7 TMDL Calculation for NFR

The TMDL is equal to the Load Capacity and is the sum of all the loads plus the Margin of Safety. The calculation is as follows:

*Waste Load Allocation + Load Allocation + Margin of Safety = Load Capacity = **TMDL***

732 lbs/day + 0.0 lbs/day + 0.0 lbs/day (implicit) = **732 lbs/day = TMDL**

4.0 MARGIN OF SAFETY

A margin of safety (MOS) is developed due to 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 design conditions for the waste load allocation and the load allocation calculations (or conservative assumptions in the analysis).

While some parameters entered into a model are known with a higher degree of confidence, some are not. Evaluating model sensitivity and uncertainty requires an understanding of the inconsistency of input variables and parameters. The large data sets of model mixing, decay and hydraulic coefficients required to estimate variation are generally unavailable, therefore an MOS is necessary. For the specifics on each pollutant, refer to the MOS section for the pollutant in question.

5.0 SEASONAL VARIATION

Seasonal variation is simulated in the QUAL2E model via the use of different water temperatures, different ammonia and $CBOD_5$ (which are used to calculate BOD) decay coefficients and adjustments to seasonal low flow values. Seasonal limits for BOD_5 and ammonia are necessary because decay of these substances depends on many variables, including water temperature, and because dissolved oxygen gas saturation varies with water temperature. For more details, refer to the seasonal variation section of the pollutant in question.

6.0 MONITORING PLANS FOR TMDLs DEVELOPED UNDER THE PHASED APPROACH

To better assess the impact to Muddy and Brushy creeks from effluent discharged by the Sedalia Central WWTP, the continuous monitoring plan incorporates upstream and downstream monitoring sites for the pollutants of concern (Tables 7-9). A map showing these sites is presented in Appendix H.

As noted before, the Sedalia Central WWTP began constructing improved treatment technology in November 1998. These improvements to plant operation have resulted in ammonia nitrogen levels less than 2.5 mg/L in the summer and less than 3.5 mg/L in the winter (the present permit limits). Higher (improved) dissolved oxygen levels have also been recorded and the NFR shows a 65 percent reduction. Unless discharge-monitoring reports warrant, further WLA studies will not be scheduled. The department does plan, however, to conduct low flow visual qualitative and benthic examinations of these streams for the next two years (2002 and 2003). If the observed water quality improvements are **not** substantiated with this monitoring, the TMDL will be reopened and re-evaluated.

Table 7. Additional Monitoring Requirements for All Outfalls for MO-0023019

Parameter	Sample Frequency	*Sample Type
$CBOD_5$ (mg/L)	Weekly	24 hour Composite
Dissolved Oxygen (mg/l)	Weekly	24 hour Composite
Ammonia Nitrogen (mg/L)	Weekly	24 hour Composite
Organic Nitrogen (mg/L)	Weekly	24 hour Composite
Non-Filterable Residue (mg/L)	Weekly	24-hour Composite
Volatile Suspended Solids (mg/L)	Weekly	24-hour Composite
Settleable Solids (mg/L)	Weekly	24-hour Composite
Flow (MGD)	Daily	24-hour Total

*Stormwater Outfalls are to be grab sampled when discharging.

Tables 8 and 9. Instream Sampling Requirements for MO-0023019

Sampling Site: On Brushy Creek, upstream of all outfalls and below tributary downstream of bridge

Parameter	Sample Frequency	Sample Type
$CBOD_5$ (mg/L)	Monthly	Grab
Dissolved Oxygen (mg/l)	Monthly	Grab
Ammonia Nitrogen (mg/L)	Monthly	Grab
Organic Nitrogen (mg/L)	Monthly	Grab
Temperature	Monthly	Grab
pH	Monthly	Grab
Non-Filterable Residue (mg/L)	Monthly	Grab
Volatile Suspended Solids (mg/L)	Monthly	Grab
Settleable Solids (mg/L)	Monthly	Grab
Flow (cfs)	Monthly	24-hour Total

Sampling site: On Brushy Creek, below all outfalls and upstream of Sunset Village Branch.

Parameter	Sample Frequency	Sample Type
$CBOD_5$ (mg/L)	Monthly	Grab
Dissolved Oxygen (mg/l)	Monthly	Grab
Ammonia Nitrogen (mg/L)	Monthly	Grab
Organic Nitrogen (mg/L)	Monthly	Grab
Temperature	Monthly	Grab
pH	Monthly	Grab

Non-Filterable Residue (mg/L)	Monthly	Grab
Volatile Suspended Solids (mg/L)	Monthly	Grab
Settleable Solids (mg/L)	Monthly	Grab

7.0 IMPLEMENTATION PLANS

Implementation will be accomplished through permit action. The Sedalia Central State Operating Permit MO-0023019 was revised July 18, 1997, and expires May 22, 2002. According to the QUAL2E model (TMDL allocations) and the most recent data, the present effluent limits for BOD_5 are protective of aquatic life in both streams. The QUAL2E model prescribes lower limits for NH_3-N, however the present permit limits appear to be protective of the water quality in Brushy Creek, according to 2001 data. Since this is a phased TMDL, new NH_3-N limits will not be added when the permit comes up for renewal to allow time for evaluation with the new monitoring requirements.

Present permit limits for NFR (often referred to as TSS or Total Suspended Solids) also appear to be protective of the water quality in Brushy Creek. The 2001 monitoring showed no bottom deposits of sludge and the DMR data indicate a 65 percent reduction in NFR since the upgrades. The DMR data is significant because the effluent dominates the flow in this stream and the effluent quality is essentially the stream quality. For these reasons the NFR limits will not be modified when the permit comes up for renewal.

The additional monitoring requirements for the WWTP outlined in this document, however, will be added during the permit renewal process in 2002. If future monitoring data substantiates the improvements in water quality that were observed in 2000-2001 sampling data, Muddy and Brushy creeks will be proposed for delisting for the impairments of BOD, NH_3-N and NFR. If, however, data indicates the problems are not resolved by the existing plant upgrades, that WQS are not being met, the TMDL will be reopened and re-evaluated.

These TMDLs will be incorporated into Missouri's Water Quality Management Plan.

8.0 REASONABLE ASSURANCES

The department has the authority to write and enforce Missouri State Operating Permits, which should provide reasonable assurance that instream water quality standards will be met. Inclusion of the monitoring plans outlined in this TMDL will evaluate whether the stream water quality is truly protective of aquatic life. If there is no improvement, as has been stated before, the TMDL will be reopened and revised.

9.0 PUBLIC PARTICIPATION

These water quality limited segments are included on the approved 1998 303(d) list for Missouri. Six public meetings to allow input from the public on the proposed 1998 303(d) list were held between August 18 and September 22, 1999. No comments pertaining to the listing of Brushy or Muddy creeks were received during those meetings.

The Missouri Department of Natural Resources developed these TMDLs. This TMDL document was sent to EPA for examination and then the edited draft was placed on public notice from Nov. 9, 2001 to Dec. 9, 2001. Groups that received the public notice announcement included the Missouri Clean Water Commission, Sedalia Central WWTP, the Water Quality Coordinating Committee, the TMDL Policy Advisory Committee, Stream Team volunteers in the watershed (40), the appropriate legislators (4) and others that routinely receive the public notice of Missouri State Operating Permits. Additionally, a news release of the public notice was distributed to Pettis County. Comments were received during the public notice period and adjustments were made to the TMDL; however, since the adjustments did not impact the basic sense and outcome, no further public notice was needed. A copy of the notice, the comments received and the department responses may be found in the Brushy/Muddy Creek file.

10.0 ADMINISTRATIVE RECORD AND SUPPORTING DOCUMENTATION

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

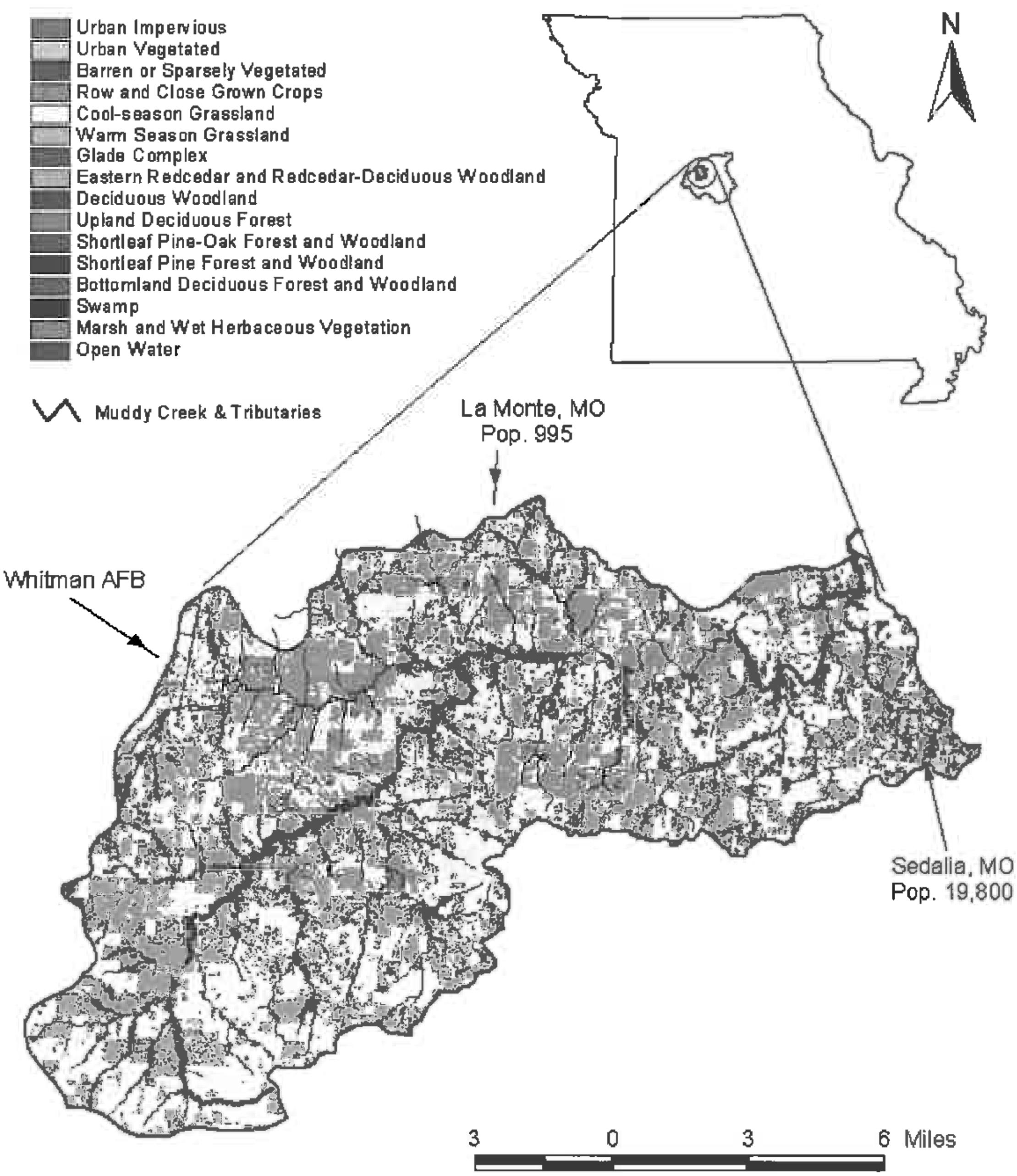
- Sedalia Central State Operating Permit MO-0023019
- Environmental Services Program stream surveys of August 24-26, 1993, and August 29-31, 1995
- Missouri Department of Conservation fish kill reports from 1992 and 1994
- Water Pollution Control Program 2001 data
- Department low flow surveys
- Input and output for QUAL2E
- Public Notice announcement
- Muddy Creek and Brushy Creek Information Sheet
- Public comments and the department's responses

11.0 APPENDICES

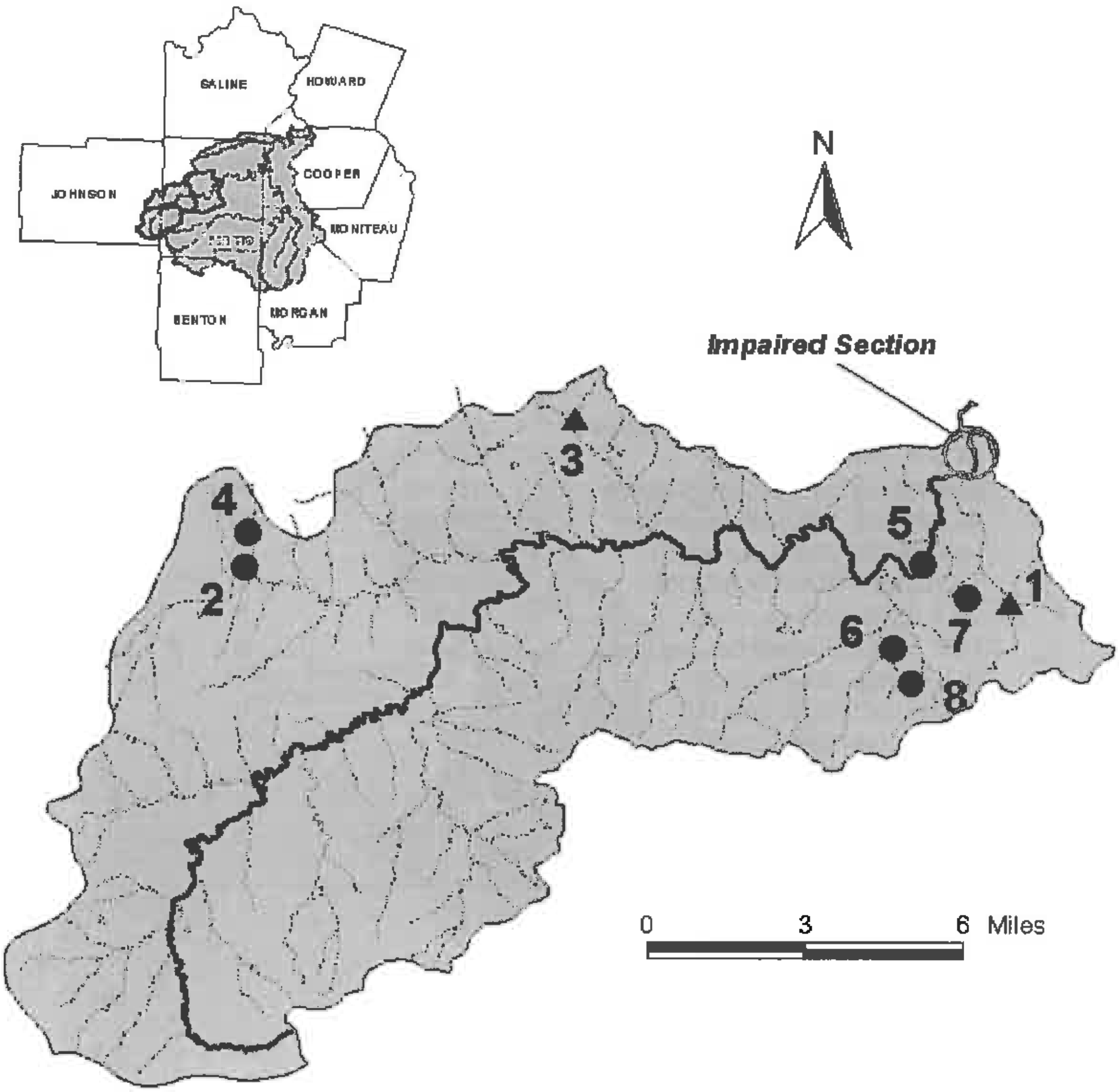
Appendix A – Land Use Maps for Muddy and Brushy Creek Watersheds
Appendix B – Permitted Facilities in Muddy and Brushy Creek Watersheds, including a list of the upgrades to the Sedalia Central WWTP
Appendix C – Map of Impaired Waterbody Segments with Sampling Sites and Corresponding Water Quality Data
Appendix D – Missouri Department of Conservation Temperature and pH data in Brushy Creek
Appendix E – 7Q10 Low Flow Data (Watershed Maps and USGS Stream Gage Data)
Appendix F – Hydrology and Water Quality Coefficients Used in QUAL2E
Appendix G – Sedalia Central WWTP Discharge Monitoring Report
Appendix H – Map of Instream Monitoring Sites

Appendix A
Land Use Maps for Muddy Creek and Brushy Creek Watersheds

Appendix A.1 Muddy Creek 1993 Land Use



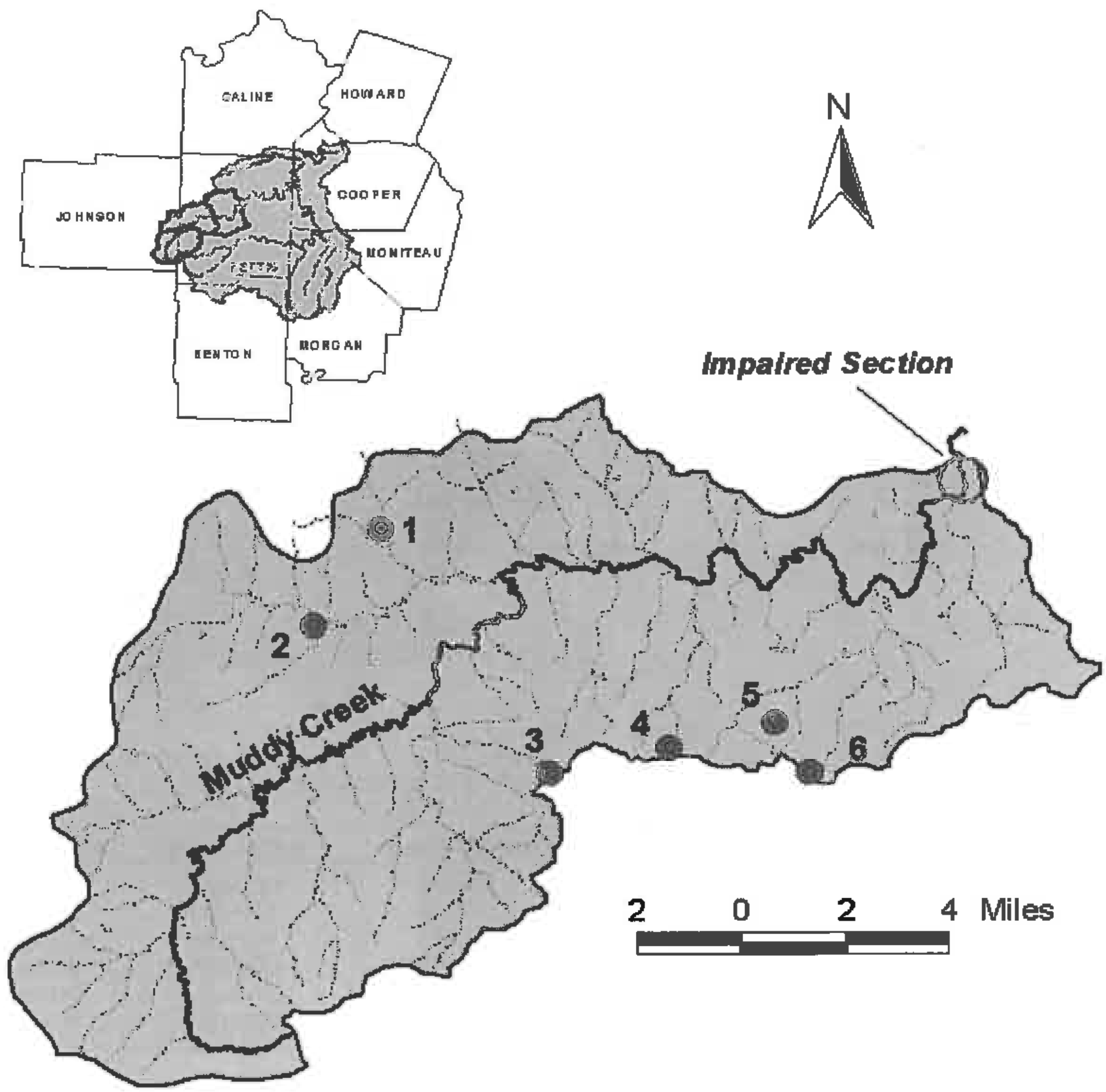
Appendix B.2 Permitted WWTPs in the Muddy Creek Watershed



Facilities Discharging >1% of total BOD Load

Map Number	NPDES#	Facility Name	Design Flow (cfs)	BOD Limit (mg/l)
1	MO-0023019	Sedalia Central WWTP	3.88	10 (summer), 20 (winter)
2	MO-0119644	Whiteman AFB	0.37	50
3	MO-0108081	La Monte SE Lagoons	0.17	45
4	MO-0109142	Whiteman AFB Villages	0.15	45
5	MO-0104540	Central MO Landfill	0.08	45
6	MO-0109592	Hunters Ridge Subdivision	0.08	30
7	MO-0091553	Sunset Village MHP	0.04	45
8	MO-0090263	Walnut Hills Subdivision	0.04	45

Appendix B.3 Permitted Animal Feeding Operations in the Muddy Creek Watershed



Map Number	NPDES Number	PE Design	Design Flow (MGD)
1	LA3103743	3088	0.0023
2	MO0118877	119700	0.062
3	MOG010042	16161	0.0
4	MOG010031	21539	0.0
5	LA3103770	756	0.0136
6	MOG010116	10770	0.0

Appendix B.4 Permitted Facilities in the Brushy Creek Watershed

Map Number	Facility Name	Design Flow	NFR Limit	BOD Limit
1	Sedalia Central WWTP	3.88 cfs	40 mg/l	40 mg/l
2	Sunset Village	0.04 cfs	70 mg/l	45 mg/l
3	Wire Rope Corp.	0.01 cfs	70 mg/l	30 mg/l
4	Pittsburg Corning	0.01 cfs	60 mg/l	0 mg/l
5	Western View Estates	0.02 cfs	30 mg/l	30 mg/l
6	LaFarge Construction	Stormwater	70 mg/l	0 mg/l

Note: NFR and BOD_5 permit limits are the monthly averages that were in effect when Brushy Creek was placed on the 1998 303(d) list.

Appendix B.5 Upgrades to Sedalia Central Wastewater Treatment Plant

Construction on improvements to the Sedalia Central WWTP began in 1998 and was completed May 2000. The following is quoted from Sedalia's Construction Permit and outlines the improvements that were planned.

Sedalia, Missouri Permit No. 2873

CONSTRUCTION PERMIT

Expand existing wastewater treatment facility. The expanded wastewater treatment facility will have a design flow of 2.5 MGD with a peak flow capacity of 7.0 MGD.

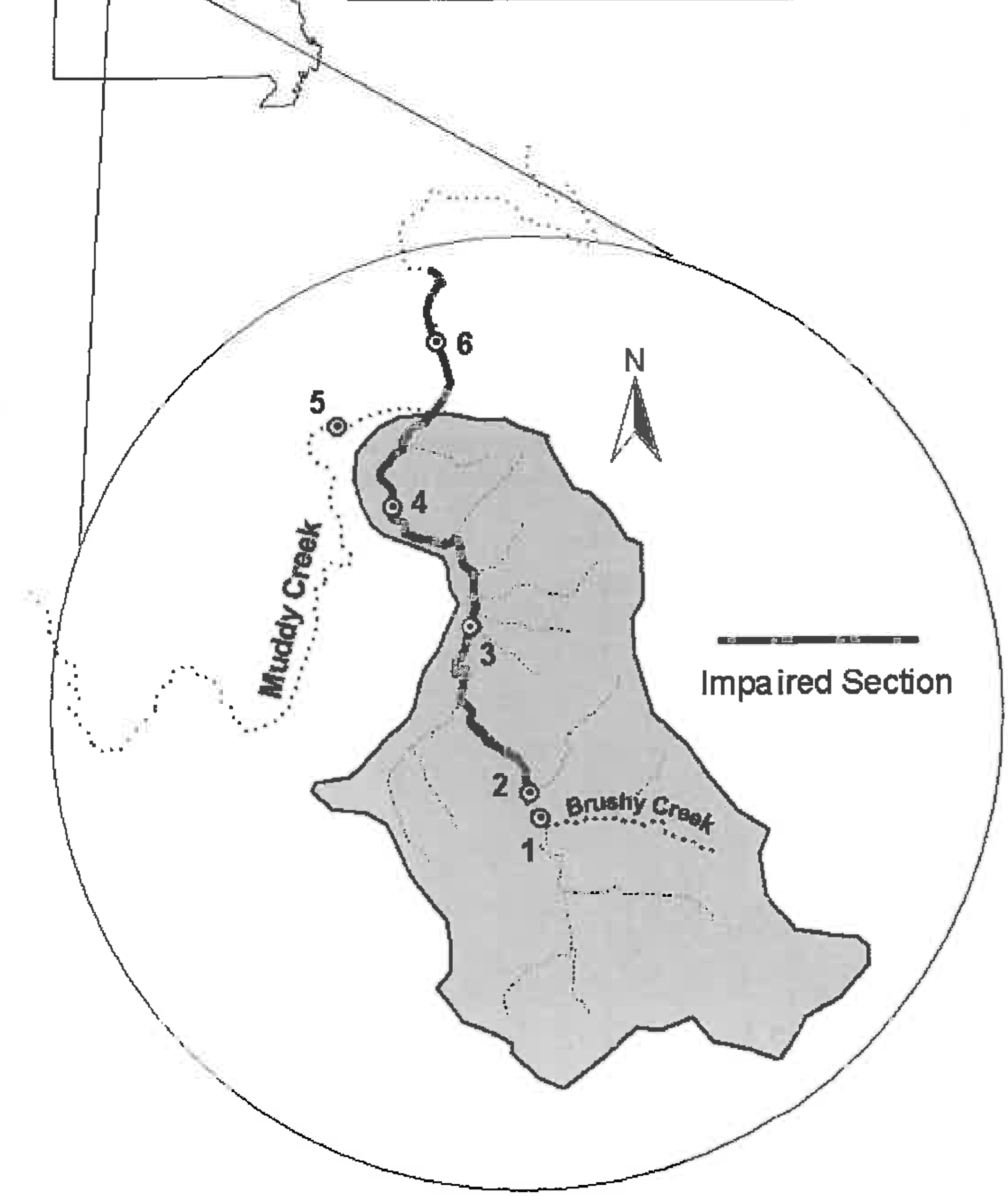
Work shall consist of constructing a peak flow sedimentation basin, influent pump station, aeration basin, two clarifiers, effluent flow measurement; installing a gravity belt thickener in the existing sludge handling facility; installing grease removal equipment; converting existing secondary clarifiers to sludge holding tanks; removing sludge from the existing peak flow lagoon; modifying outfall structure in existing peak flow lagoon; modifying existing bar screen; and modifying peak flow bypass structure.

Install, modify or replace miscellaneous piping, appurtenances and general site work appropriate to the scope and purpose of the project. All construction shall be in accordance with the approved plans and specifications.

Appendix C

Appendix C.1 Map of Impaired Sections of Muddy and Brushy Creeks with Sampling Sites

Site	Description	Latitude	Longitude
1.	Upstream of Sedalia Central WWTP	38.7133	-93.2628
2.	Sedalia Central WWTP Outfall	38.7165	-93.2648
3.	Brushy Creek, 1.7 miles below WWTP	38.7326	-93.2718
4.	Brushy Creek, 2.7 miles below WWTP	38.7437	-93.2806
5.	Muddy Creek, 0.6 miles above Brushy Creek	38.7507	-93.2887
6.	Muddy Creek, 0.5 miles above Brushy Creek	38.7593	-93.2756



Appendix C.2 Water quality data collected on Muddy and Brushy Creeks during waste load allocation surveys.

Site	Description	Date	Time	Temp. (°C)	D.O. (mg/L)	$CBOD_5$ (mg/L)	TKN (mg/L)	NH_3-N (mg/L)	NO_2+NO_3 (mg/L)	Flow (cfs)	NFR* (mg/L)
ESP #1	Upstream of WWTP, 0.1 mi.	08/25/93	8:20	25.5	4.1	<4	n/a	<.05	0.09	0.05	n/a
ESP #1	Upstream of WWTP, 0.1 mi.	08/25/93	12:45	34.0	13.8	<4	n/a	<.05	<.05	0.05	n/a
ESP #1	Upstream of WWTP, 0.1 mi.	08/26/93	7:30	26.0	2.8	<4	n/a	<.05	<.05	0.05	n/a
ESP #1	Upstream of WWTP, 0.1 mi.	08/26/93	12:50	35.0	14.8	<4	n/a	<.05	<.05	0.05	n/a
ESP #2	Sedalia Central WWTP Effluent	08/25/93	12:00	26.5	7.25	19	n/a	36	3.8	1.05	n/a
ESP # 3	Brushy Creek, 1.7 mi. below WWTP	08/25/93	13:10	29	6.1	<4	n/a	27	3.1	1.1	n/a
ESP # 3	Brushy Creek, 1.7 mi. below WWTP	08/26/93	6:50	25	1.6	<4	n/a	17	1.4	1.1	n/a
ESP # 3	Brushy Creek, 1.7 mi. below WWTP	08/26/93	13:20	30	5.9	<4	n/a	11	<0.25	1.1	n/a
ESP # 4	Brushy Creek, 2.7 mi. below WWTP	08/25/93	7:45	25	1.6	<4	n/a	28	1.7	1.1	n/a
ESP # 4	Brushy Creek, 2.7 mi. below WWTP	08/25/93	13:35	27	5.6	4	n/a	31	2.5	1.1	n/a
ESP # 4	Brushy Creek, 2.7 mi. below WWTP	08/26/93	7:15	26	1.5	5	n/a	12	1.7	1.1	n/a
ESP # 4	Brushy Creek, 2.7 mi. below WWTP	08/26/93	13:45	28	5.6	<4	n/a	12	2.7	1.1	n/a
ESP # 5	Muddy Creek, 0.6 mi. upstream of Brushy Creek	08/25/93	7:00	25	6	<4	n/a	<.05	0.21	1.4	n/a
ESP # 5	Muddy Creek, 0.6 mi. upstream of Brushy Creek	08/25/93	12:55	27	7.1	<4	n/a	<.05	0.15	1.4	n/a
ESP # 5	Muddy Creek, 0.6 mi. upstream of Brushy Creek	08/26/93	6:55	26.5	6.8	<4	n/a	<.05	0.11	1.4	n/a
ESP # 5	Muddy Creek, 0.6 mi. upstream of Brushy Creek	08/27/93	12:25	38.0	7.8	<4	n/a	<.05	0.09	1.4	n/a
ESP # 6	Muddy Creek, 0.5 mi. downstream of Brushy Creek	08/25/93	8:10	26.0	3.6	<4	n/a	22	2.5	2.5	n/a
ESP # 6	Muddy Creek, 0.5 mi. downstream of Brushy Creek	08/25/93	13:50	27.0	7.3	<4	n/a	19	2.8	2.5	n/a
ESP # 6	Muddy Creek, 0.5 mi. downstream of Brushy Creek	08/26/93	7:50	26.0	3.7	4.0	n/a	7	2.5	2.5	n/a
ESP # 6	Muddy Creek, 0.5 mi. downstream of Brushy Creek	08/26/93	13:05	28.0	6.0	<4	n/a	7	2.9	2.5	n/a
ESP #1	Upstream of WWTP, 0.1 mi.	08/30/95	6:50	23.0	2.0	2.0	n/a	<.05	<.05	0.7	n/a
ESP #1	Upstream of WWTP, 0.1 mi.	08/30/95	13:10	35.0	15.0	3.0	n/a	<.05	<.05	0.7	n/a
ESP #1	Upstream of WWTP, 0.1 mi.	08/31/95	6:45	25.0	3.0	<2	n/a	<.05	<.05	0.7	n/a
ESP #1	Upstream of WWTP, 0.1 mi.	08/31/95	12:15	30.0	13.0	<5	n/a	<.05	<.05	0.7	n/a
ESP #2	Sedalia Central WWTP Effluent	08/30/95	7:30	25.0	6.0	19.0	n/a	1.94	10.1	1.23	n/a
ESP #2	Sedalia Central WWTP Effluent	08/31/95	7:10	25.0	6.0	15.0	n/a	4.14	12.4	1.23	n/a
ESP #3	Brushy Creek, 1.7 mi. below WWTP	08/30/95	8:00	24.0	2.0	4.0	n/a	5.34	3.36	1.3	n/a
ESP #3	Brushy Creek, 1.7 mi. below WWTP	08/30/95	14:00	28.0	7.0	5.0	n/a	3.59	3.49	1.3	n/a
ESP #3	Brushy Creek, 1.7 mi. below WWTP	08/31/95	7:55	24.0	2.0	4.0	n/a	3.81	1.63	1.3	n/a
ESP #3	Brushy Creek, 1.7 mi. below WWTP	08/31/95	13:30	26.0	6.0	4.0	n/a	3.06	3.29	1.3	n/a
ESP #4	Brushy Creek, 2.7 mi. below WWTP	08/30/95	8:35	25.0	2.0	<2	n/a	3.95	2.84	1.3	n/a
ESP #4	Brushy Creek, 2.7 mi. below WWTP	08/30/95	14:20	27.0	6.0	<2	n/a	2.5	3.62	1.3	n/a
ESP #4	Brushy Creek, 2.7 mi. below WWTP	08/31/95	8:20	25.0	2.0	<2	n/a	1.02	2.73	1.3	n/a
ESP #4	Brushy Creek, 2.7 mi. below WWTP	08/31/95	03:00	26.0	4.0	<2	n/a	0.4	2.9	1.3	n/a
ESP #5	Muddy Creek, 0.6 mi. upstream of Brushy Creek	08/30/95	6:55	27.0	8.0	<2	n/a	<.05	0.14	1.9	n/a
ESP #5	Muddy Creek, 0.6 mi. upstream of Brushy Creek	08/30/95	13:10	28.0	10.0	2.0	n/a	<.05	0.29	1.9	n/a

Site	Description	Date	Time	Temp. (°C)	D.O. (mg/L)	$CBOD_5$ (mg/L)	TKN (mg/L)	NH_3-N (mg/L)	NO_2+NO_3 (mg/L)	Flow (cfs)	NFR* (mg/L)
ESP #5	Muddy Creek, 0.6 mi. upstream of Brushy Creek	08/31/95	6:25	26.0	8.0	2.0	n/a	0.1	<.05	1.9	n/a
ESP #5	Muddy Creek, 0.6 mi. upstream of Brushy Creek	08/31/95	12:15	27.0	8.0	<2	n/a	0.05	<.05	1.9	n/a
ESP #6	Muddy Creek, 0.5 mi. downstream of Brushy Creek	08/30/95	7:52	27.0	5.0	<2	n/a	0.14	3.18	3.2	n/a
ESP #6	Muddy Creek, 0.5 mi. downstream of Brushy Creek	08/30/95	14:00	30.0	6.0	2.0	n/a	0.25	3.27	3.2	n/a
ESP #6	Muddy Creek, 0.5 mi. downstream of Brushy Creek	08/31/95	7:30	26.0	4.0	<2	n/a	0.16	3.95	3.2	n/a
ESP #6	Muddy Creek, 0.5 mi. downstream of Brushy Creek	08/31/95	13:00	27.0	5.0	<2	n/a	0.21	3	3.2	n/a
ESP #1	Upstream of WWTP, 0.1 mi.	07/17/01	6:00	23.0	5.5	<2.00	0.32	<0.05	0.23	0.11	9
ESP #1	Upstream of WWTP, 0.1 mi.	07/17/01	13:40	30.0	15.8	<2.00	0.29	<0.05	0.15	0.11	6
ESP #2	Sedalia Central WWTP Effluent	07/17/01		26.0	7.4	2.0	1.35	0.2	7.54	3.49	6
ESP #3	Brushy Creek, 1.7 mi. below WWTP	07/17/01	13:10	26.0	11.8	<2.00	0.39	0.24	7.01	3.6	2.499
ESP #3	Brushy Creek, 1.7 mi. below WWTP	07/17/01	6:35	22.0	5.9	<2.00	<0.20	0.39	7.47	3.6	2.499
ESP #3	Brushy Creek, 1.7 mi. below WWTP	07/17/01	13:10	26.0	11.8	<2.00	0.55	0.24	6.95	3.6	n/a
ESP #4	Brushy Creek, 2.7 mi. below WWTP	07/17/01	13:15	25.0	8.1	<2.00	0.64	<0.05	6.49	3.6	2.499
ESP #4	Brushy Creek, 2.7 mi. below WWTP	07/17/01	6:05	22.0	6.0	<2.00	<0.20	<0.05	6.36	3.6	2.499
ESP #5	Muddy Creek, 0.6 mi. upstream of Brushy Creek	07/17/01	13:40	26.0	6.5	<2.00	0.97	<0.05	0.69	26.6	n/a
ESP #5	Muddy Creek, 0.6 mi. upstream of Brushy Creek	07/17/01	6:25	24.0	6.4	<2.00	0.93	<0.05	0.68	26.6	n/a
ESP #6	Muddy Creek, 0.5 mi. downstream of Brushy Creek	07/17/01	14:00	26.0	6.4	<2.00	1.03	<0.05	1.32	30.2	n/a
ESP #6	Muddy Creek, 0.5 mi. downstream of Brushy Creek	07/17/01	6:50	24.0	6.6	<2.00	0.88	<0.05	1.46	30.2	n/a
ESP #1	Upstream of WWTP, 0.1 mi.	07/24/01	13:35	38.0	11.3	<2.00	0.39	<0.10	<0.05	0.07	6
ESP #1	Upstream of WWTP, 0.1 mi.	07/24/01	6:20	28.0	2.9	<2.00	0.41	<0.10	<0.05	0.07	2.499
ESP #2	Sedalia Central WWTP Effluent	07/24/01	13:45	28.0	6.5	3.0	1.13	<0.10	18.6	1.11	14
ESP #3	Brushy Creek, 1.7 mi. below WWTP	07/24/01	13:10	30.0	12.3	<2.0	<0.20	0.28	14.5	1.18	2.499
ESP #3	Brushy Creek, 1.7 mi. below WWTP	07/24/01	5:55	26.0	4.0	<2.00	<0.20	0.4	14.5	1.18	2.499
ESP #4	Brushy Creek, 2.7 mi. below WWTP	07/24/01	13:15	29.0	8.3	<2.00	<0.20	<0.10	10.8	1.18	9
ESP #4	Brushy Creek, 2.7 mi. below WWTP	07/24/01	5:50	28.0	4.0	<2.00	<0.20	<0.10	10.4	1.18	5
ESP #5	Muddy Creek, 0.6 mi. upstream of Brushy Creek	07/24/01	13:45	31.0	7.0	<2.00	0.82	<0.10	0.29	6.63	n/a
ESP #5	Muddy Creek, 0.6 mi. upstream of Brushy Creek	07/24/01	6:05	30.0	6.0	<2.00	0.69	<0.10	0.35	6.63	n/a
ESP #6	Muddy Creek, 0.5 mi. downstream of Brushy Creek	07/24/01	14:00	31.0	6.0	<2.00	1.29	<0.10	2.42	7.81	n/a
ESP #6	Muddy Creek, 0.5 mi. downstream of Brushy Creek	07/24/01	6:30	29.0	5.3	<2.00	0.88	<0.10	2.36	7.81	n/a

D.O.=Dissolved Oxygen; $CBOD_5$=Chemical Biochemical Oxygen Demand; TKN=Total Kjeldahl Nitrogen; NH_3-N=Ammonia as Nitrogen; NO_2+NO_3= Nitrite plus Nitrate as Nitrogen; NFR=Non-Filterable Residue

* Values reported as <5.00 mg/L were used and considered equivalent to 2.499 mg/L

Appendix D

MDC Temperature and pH Data in Brushy Creek at Cloney Road, 2.7 miles below WWTP outfall.

Date	Temperature (°C)	pH	Date	Temperature (°C)	pH
1/8/98	3.9	6.25	5/15/97	14.8	7.45
1/9/98	4.6	6.8	5/20/97	16.1	7.32
1/20/98	4.3	7.36	5/25/97	24.9	7.41
1/22/98	3.6	7.97	5/28/97	15.3	7.39
1/26/98	7.3	8.16	5/31/97	17.5	7.57
1/30/98	4.3	7.62	5/6/97	18	8.13
2/18/98	5.1	7.19	6/11/97	20.2	7.52
2/20/98	6.9	7.15	6/16/97	21.7	7.73
2/25/98	10.7	7.78	6/21/97	24.2	7.4
2/26/98	11.3	7.66	6/26/97	25.6	7.5
2/2/98	5.9	7.22	6/5/97	21.1	7.62
2/3/98	5.4	7.52	6/8/97	19.1	7.55
2/9/98	6.2	7.99	7/17/97	25.1	7.59
12/11/97	3.9	7.1	7/1/97	24.8	7.52
12/12/97	4	7.05	7/27/97	27.8	7.75
12/15/97	5.4	7.36	7/31/97	20.7	7.74
12/22/97	5.2	7.25	7/9/97	23.7	7.57
12/2/97	8.9	7.25	8/15/97	24.5	7.45
3/12/98	2.1	7.2	8/24/97	21.6	7.31
3/20/98	4.3	7.58	8/5/97	23.8	7.59
3/24/98	9.7	8.05	9/17/97	23.9	7.41
3/26/98	15.5		9/21/97	20.1	7.39
3/2/98	5.1	8.26	9/3/97	23.3	7.41
3/30/98	17.5		10/14/97	13.6	7
4/10/98	10.2	7.8	10/21/97	12	7.59
4/15/98	15.5	7.77	10/30/97	12.9	7.35
4/17/98	11.1	7.69	11/10/97	7.6	7.33
4/21/97	14	7.76	11/19/97	6.1	6.84
4/28/97	14	7.75	11/20/97	6.6	7.52
4/3/98	10.8	7.65	11/24/97	8.5	7.44
4/8/98	11.1	7.97	11/3/97	7.1	7.1

Source: Missouri Department of Conservation (MDC)

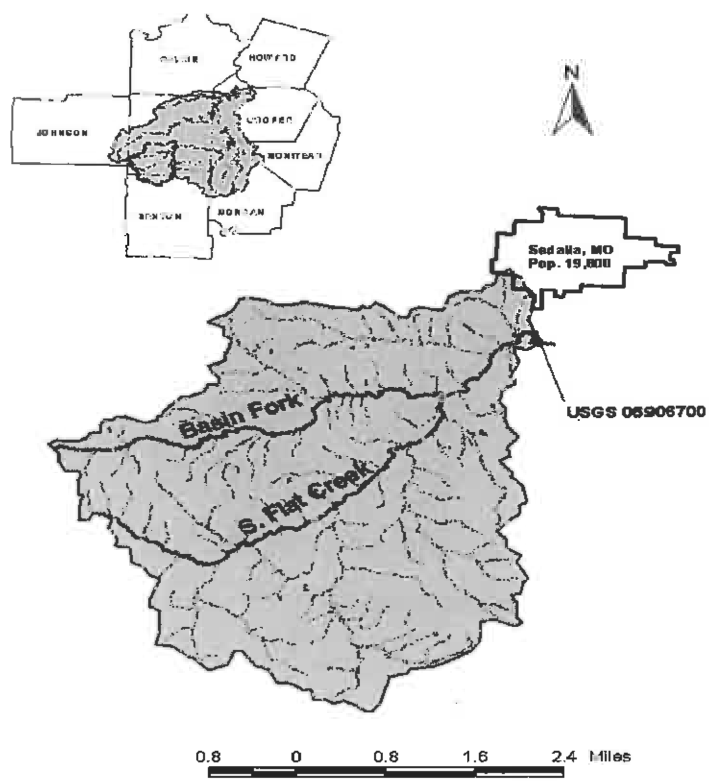
Appendix E

7Q10 Low Flow USGS Stream Gage Data and Watershed Maps

Appendix E.1 7-day Consecutive Low Flows for Flat Creek, USGS Gage 06906700

Year	April - September Low Flow (cfs)	October - March Low Flow (cfs)
1961	1.3	2.4
1962	0.0	0.3
1963	0.0	0.0
1964	0.0	0.0
1965	0.9	2.0
1966	0.1	

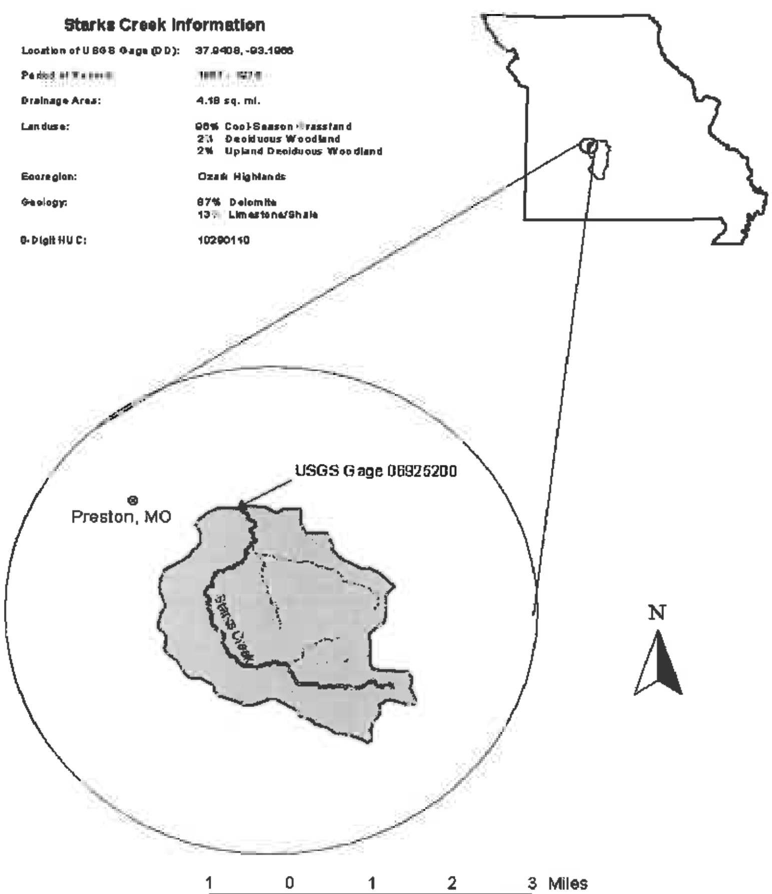
Appendix E.2 Flat Creek above USGS Gage 06906700



Appendix E.3 7-day Consecutive Low Flows for Starks Creek, USGS Gage 06925200

Year	April - September Low Flow (cfs)	October - March Low Flow (cfs)
1957	0.0	0.0
1958	0.0	0.0
1959	0.0	0.0
1960	0.0	0.49
1961	0.0	0.0
1962	0.0	0.0
1963	0.0	0.04
1964	0.0	0.0
1965	0.0	0.0
1966	0.0	0.24
1967	0.0	0.0
1968	0.0	0.37
1969	0.0	0.0
1970	0.0	0.0
1971	0.0	0.36
1972	0.0	0.0
1973	0.0	0.0
1974	0.0	0.24
1975	0.0	0.06

Appendix E.4 Upper Reaches of Starks Creek



Appendix F

Hydrology and Water Quality Coefficients Used in QUAL2E

Appendix F.1 Hydraulic Calibration and Coefficients

Point estimates of depth and water velocity were taken four sites listed below on 07-24-01 by the Environmental Services Program. Effluent discharge was obtained from Sedalia Central WWTP operators the day of the survey. Cross-sectional area and total flow were calculated by integration over a definite interval using Simpson's Rules. Channel slopes were calculated using topographic maps and Mannings N was adjusted to reach observed velocity measurements with the model.

Reach	Dispersion	Mannings N	Slope 1	Slope 2	Width (ft)	Bed Slope
1	350	0.054	12.1	18.2	37.3	0.00055
2	100	0.2	7	6.75	2.4	0.00408
3	200	0.119	4	12.5	0.8	0.00381
4	400	0.133	17.9	7.54	17.5	0.0005

Appendix F.2 Validated BOD/DO Coefficients used in the QUAL2E Model

Reach	BOD Decay	BOD Settling	SOD Rate	Reaeration Option
1	1.03	0	0.45	Owens and Gibbs
2	1.05	0	0.1	Owens and Gibbs
3	0.9	0.1	0.17	Owens and Gibbs
4	0.85	0	0.16	Owens and Gibbs

Appendix F.3 Validated Nitrogen Decay Coefficients used in the QUAL2E Model

Reach	Organic Nitrogen Hydrolysis	Organic Nitrogen Settling	NH_3 Oxidation	NH_3 Benthos Source	NO_2 Oxidation
1	0.1	0	1.2	0	2.5
2	0.1	0	7	0	2.5
3	5	0.1	4.8	0	2.5
4	0.05	0	1.2	0	2.5

Appendix G

Sedalia Central WWTP Discharge Monitoring Report (DMR) 1997 – 2001

Date	Flow (MGD)	NFR (mg/L)
9/28/01	1.394	13
9/21/01	1.437	4
9/12/01	1.251	4
9/5/01	1.505	7
8/30/01	2.073	17
8/22/01	1.42	8
8/15/01	1.25	16
8/8/01	1.424	11
8/1/01	1.405	13
5/30/01	1.575	11
5/23/01	2.837	3
5/16/01	1.48	6
5/9/01	1.377	10
5/2/01	1.486	6
4/25/01	1.576	1
4/19/01	2.243	12
4/11/01	3.412	12
4/3/01	1.194	10
3/27/01	0.756	8
3/20/01	1.305	7
3/9/01	1.092	10
3/1/01	1.834	30
2/23/01	0.823	12
2/15/01	1.523	14
2/6/01	0.79	16
1/30/01	3.819	8
1/25/01	0.535	25
1/17/01	1.378	13
1/12/01	1.439	10
1/3/01	1.423	24
12/28/00	1.123	29
12/19/00	1.124	8
12/13/00	0.851	17
12/6/00	0.389	13
11/28/00	0.491	11
11/22/00	0.506	8
11/15/00	0.684	7
11/8/00	1	8
11/1/00	0.955	11
10/24/00	1.633	9
10/17/00	2.153	11
10/9/00	0.643	9
10/3/00	1.05	9
9/26/00	1.743	3
9/19/00	0.974	18
9/13/00	1.229	6

Date	Flow (MGD)	NFR (mg/L)
3/2/99	1.129	28
2/23/99	1.48	31
2/16/99	0.5	43
2/16/99	1.692	27
2/10/99	2.24	21
2/8/99	1.6	41
2/2/99	3.058	35
2/1/99	0.54	2.6
1/26/99	1.622	8.5
1/21/99	1.364	60
1/13/99	3.09	29
1/5/99	0.861	59
12/8/98	1.854	56
12/1/98	1.759	16
11/24/98	0.968	22
11/17/98	1.157	35
11/11/98	2.183	40
11/3/98	2.712	32
10/27/98	1.062	14
10/22/98	2.614	32
10/14/98	1.311	14
10/6/98		20
10/6/98	0.75	64
9/29/98	1.557	17
9/22/98	2.302	32
9/15/98	3.804	23
9/8/98	0.996	16
9/2/98	2.104	13
8/25/98	1.485	26
8/18/98	1.733	21
8/11/98	2.551	29
8/4/98	2.663	20
7/28/98	2.622	19
7/27/98	1.1	63
7/21/98	0.897	21
7/14/98	0.855	25
7/7/98	1.543	12
6/30/98	n/a	47
6/23/98	n/a	48
6/22/98	7.14	40
6/16/98	n/a	46
6/9/98	n/a	59
6/3/98	n/a	15
5/26/98	n/a	64
5/21/98	n/a	32
5/12/98	n/a	21

Date	Flow (MGD)	NFR (mg/L)
9/6/00	0.96	24
8/31/00	1.25	5
8/23/00	1.235	15
8/16/00	1.44	36
8/9/00	1.573	8
8/1/00	1.118	11
7/26/00	1.278	17
7/19/00	2.474	18
7/12/00	1.894	33
7/1/00	2.469	24
6/28/00	2.027	8
6/21/00	3.327	10
6/14/00	1.248	20
6/7/00	0.956	4
5/31/00	1.176	10
5/25/00	1.02	8
5/17/00	0.929	12
5/10/00	1.717	25
5/3/00	0.679	53
4/26/00	0.346	18
4/19/00	0.38	31
4/12/00	0.58	41
4/5/00	0.422	50
3/29/00	1.002	26
3/22/00	1.066	40
3/15/00	1.499	40
3/8/00	0.846	53
3/1/00	0.897	22
2/23/00	1.021	40
2/17/00	0.665	20
2/9/00	0.66	71
2/3/00	0.786	70
1/26/00	0.696	57
1/19/00	0.61	71
1/13/00	0.78	78
1/4/00	1.006	28
12/29/99	0.62	40
12/22/99	0.769	48
12/17/99	0.965	27
12/8/99	0.929	33
12/1/99	0.66	61
11/23/99	1.074	48
11/16/99	0.667	72
11/9/99	0.682	36
11/1/99	0.465	40
10/26/99	0.681	69
10/18/99	0.813	31
10/12/99	0.775	33
10/5/99	0.959	24
9/28/99	1.664	23
9/21/99	0.915	28
9/14/99	0.856	25

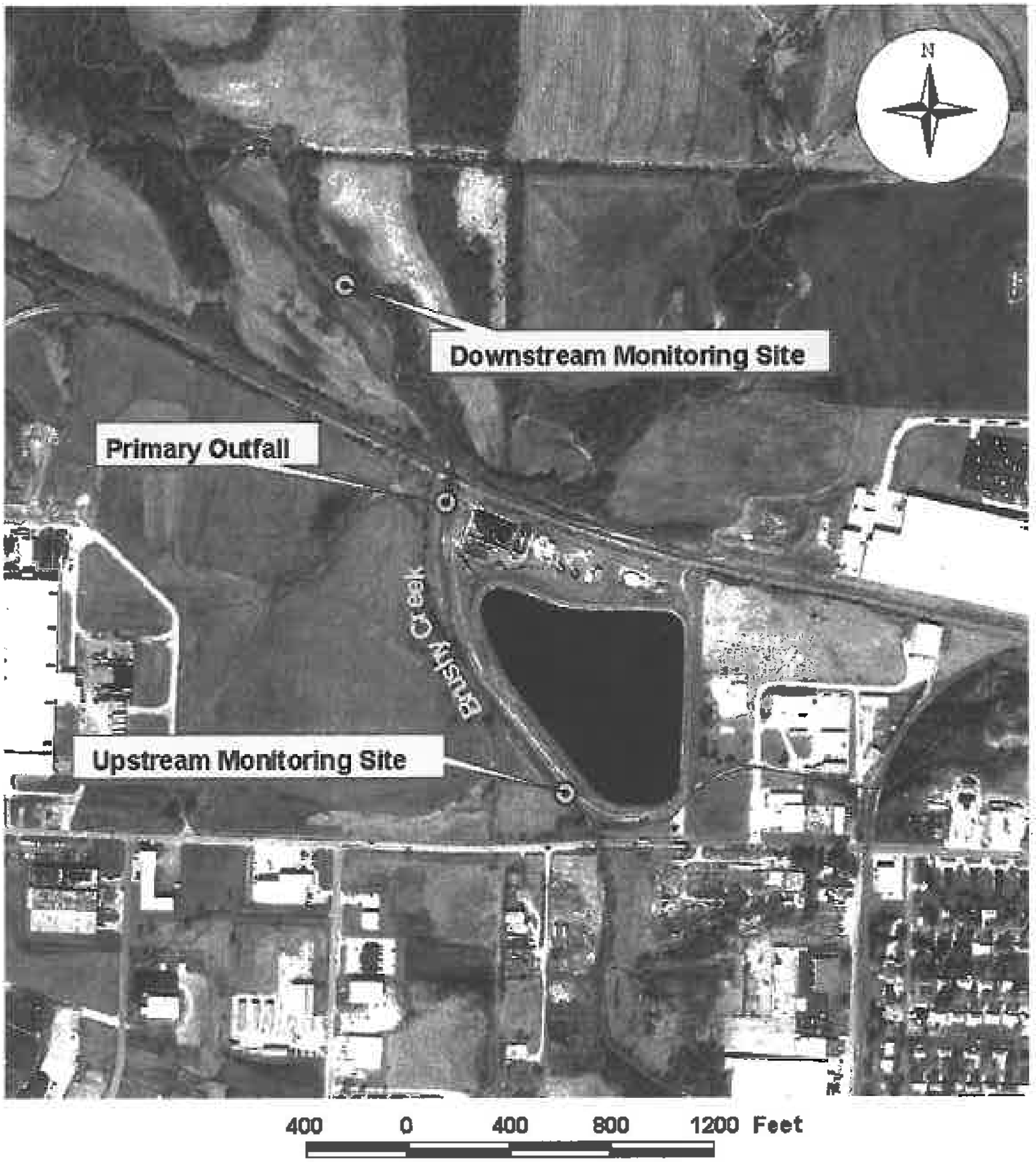
Date	Flow (MGD)	NFR (mg/L)
5/5/98	n/a	8
4/29/98	1.5	30
4/28/98	n/a	42
4/28/98	4.3	8.5
4/21/98	n/a	20
4/14/98	n/a	27
4/7/98	n/a	51
4/1/98	0.54	
3/31/98	n/a	18
3/24/98	n/a	42
3/17/98	n/a	42
3/17/98	1.5	31
3/10/98	n/a	32
3/9/98	0.5	27
3/3/98	1.107	23
2/24/98	1.558	29
2/19/98	2.82	47
2/13/98	2.435	41
2/12/98	0.0487	37
2/3/98	0.811	51
1/27/98	0.96	32
1/20/98	1.151	27
1/14/98	1.439	56
1/6/98	1.754	30
12/30/97	1.673	21
12/23/97	1.567	19
12/16/97	1.397	33
12/9/97	1.431	32
12/2/97	1.466	11
11/25/97	0.695	22
11/18/97	0.712	31
11/11/97	1.101	43
11/4/97	1.008	
10/28/97	1.711	
10/21/97	0.801	27
10/14/97	1.581	32
10/7/97	0.77	42
9/23/97	0.655	27
9/16/97	0.614	18
9/9/97	0.771	10
9/2/97	0.707	65
8/25/97	0.998	29
8/19/97	1.575	58
8/12/97	0.804	13
8/5/97	0.857	27
7/29/97	0.817	4
7/22/97	0.875	33
7/15/97	0.859	26
7/8/97	1.459	35
7/1/97	1.728	29
6/24/97	1.34	10
6/17/97	2.231	11

Date	Flow (MGD)	NFR (mg/L)
9/7/99	0.831	28
9/1/99	1.069	40
8/24/99	1.111	17
8/17/99	1.039	42
8/10/99	0.925	13
8/3/99	0.857	32
7/27/99	0.787	36
7/20/99	0.896	39
7/13/99	1.006	28
7/6/99	0.824	20
6/30/99	1.691	12
6/24/99	1.76	40
6/17/99	0.962	29
6/10/99	0.942	53
6/1/99	0.85	4.9
5/28/99	1.223	55
5/18/99	3.754	37
5/11/99	1.669	50
5/4/99	2.003	48
4/27/99	3.845	21
4/20/99	1.612	38
4/13/99	1.093	26
4/7/99	1.062	8
3/30/99	1.111	25
3/23/99	1.516	24
3/20/99	1.386	15
3/10/99	3.474	37
3/7/99		40

Date	Flow (MGD)	NFR (mg/L)
6/10/97	1.252	43
6/3/97	2.927	48
5/27/97	4.13	25
5/27/97	3.68	37
5/21/97	1.328	37
5/13/97	1.271	27
5/6/97	1.151	57
4/29/97	2.63	35
4/22/97	2.202	60
4/22/97	1.16	59
4/15/97	2.022	23
4/8/97	1.426	38
4/1/97	1.262	23
3/26/97	2.052	28
3/18/97	1.53	21
3/11/97	2.523	39
3/4/97	2.454	30
2/27/97	0.75	23
2/25/97	2.697	44
2/21/97	9.1	46
2/18/97	1.224	48
2/10/97	1.25	19
2/4/97	2.953	44
1/28/97	1.534	14
1/21/97	1.666	49
1/15/97	0.93	53
1/7/97	0.8	20
1/1/97	0.737	37

Appendix H

Figure 22. Locations of Instream Monitoring Sites for Sedalia Central WWTP



United States Environmental Protection Agency
Region 7
Total Maximum Daily Load
For Low Dissolved Oxygen, Ammonia and Organic Sediment

Big Bottom Creek (MO_1746)
Ste. Genevieve County, Missouri

William A. Spratlin
Director
Water, Wetlands and Pesticides Division

10/26/10
Date

(This page intentionally left blank)

Total Maximum Daily Loads (TMDL)
For Big Bottom Creek
Pollutant: Low Dissolved Oxygen, Ammonia and Organic Sediment

Name: Big Bottom Creek

Location: Near Rocky Ridge in Ste. Genevieve County, Missouri


State map showing location of watershed

Hydrologic Unit Code (HUC): 07140101-0907

Water Body Identification (WBID): 1746

Missouri Stream Class: Class C[1]

Designated Beneficial Uses:
- Livestock and Wildlife Watering
- Protection of Warm Water Aquatic Life
- Human Health Protection (Fish Consumption)
- Whole Body Contact Recreation – Category B (CSR, 2009)

Size of Classified Segment: 1.9 miles

Location of Classified Segment: Mouth to Lake Anne. Wholly contained in Land Grant 02046[2].

Location of Impaired Segment: Mouth to Lake Anne. Wholly contained in Land Grant 02046.

Impaired Use: Protection of Warm Water Aquatic Life

Size of Impaired Segment: 1.9 miles[3]

Length of Impairments within Segment: 0.5 miles for ammonia; 1.7 miles for low DO; 0.5 mile for organic sediment

Pollutants: Low Dissolved Oxygen (DO), Ammonia and Organic Sediment

Identified Source on 303(d) list: Lake Forest Estates Wastewater Treatment Plant (WWTP)

TMDL Priority Ranking: High

---

[1] Streams that maintain permanent flow even in drought periods. See Missouri Water Quality Standards (WQS) 10 Code of State Regulations (CSR) 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] Missouri's Public Land Survey System rectangular grid is interrupted by historic land grants that predated the surveying conducted for the Land Ordinance of 1785.

[3] The stream length listed corresponds to the EPA approved 2008 Missouri 303(d) List segment length. Due to the increased accuracy of Geographical Information System (GIS) data layers for analysis over previous methods of stream length measurements, the stream length used in the TMDL analysis may not correspond exactly to the 303(d) list. The descriptive start and end point of each segment remains the same and this TMDL addresses the impaired segment in its entirety.

Contents

Figures

Tables

List of Acronyms

Σ	Sum
µg	Micrograms
µgN/L	Micrograms of Nitrogen per Liter
AFO	Animal Feeding Operation
BOD	Biochemical Oxygen Demand
CAFO	Concentrated Animal Feeding Operation
CBOD and $CBOD_5$	Carbonaceous Biochemical Oxygen Demand and 5-day CBOD
CFR	Code of Federal Regulations
cfs	Cubic Feet per Second
cms	Cubic Meters per Second
CSR	Code of State Regulation
CWA	Clean Water Act
Deg C	Temperature in Degrees Celsius
DMRs	Daily Monitoring Reports
DO	Dissolved Oxygen
EDU	Ecological Drainage Unit
e.g.	For Example
EPA	Environmental Protection Agency
GIS	Geographic Information System
HUC	Hydrologic Unit Code
km	Kilometer
LA	Load Allocation
Lbs/day	Pounds per day
LC	Loading Capacity
LDC	Load Duration Curve
m	Meters
m/s	Meters per Second
MDNR	Missouri Department of Natural Resources
mg	Milligrams
mg/L	Milligrams per Liter
MGD	Million Gallons per Day
MO	Missouri
MoRAP	Missouri Resource Assessment Partnership
MOS	Margin of Safety
MS4	Municipal Separate Storm Sewer System
MSDIS	Missouri Spatial Data Information Service
MSOPS	Missouri State Operating Permit System
NA	Not Applicable
NASS	National Agricultural Statistics Service
NBOD	Nitrogenous Biochemical Oxygen Demand
NESC	National Environmental Service Center
NH_3	Ammonia Nitrogen
NO_2	Nitrite Nitrogen
NO_3	Nitrate Nitrogen

List of Acronyms (continued)

NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
°C	Temperature in Degrees Celsius
°F	Temperature in Degrees Fahrenheit
PBIAS	Percent Bias Statistic
PCS	Permit Compliance System
R^2	Coefficient of Determination
QAPP	Quality Assurance Project Plan
RAM	Resource Assessment and Monitoring Program
RMSE	Root Mean Square Error Statistic
RTI	RTI International Corporation
SOD	Sediment Oxygen Demand
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
URS	URS Group Inc.
U.S.	United States
USDA	United States Department of Agriculture
USGS	United States Geological Survey
VSS	Volatile Suspended Solids
WBID	Water Body Identification
WLA	Wasteload Allocation
WQS	Water Quality Standards
WWTP	Wastewater Treatment Plant

1 INTRODUCTION

The Big Bottom Creek Total Maximum Daily Load (TMDL) is being established in accordance with Section 303(d) of the Clean Water Act (CWA). The water quality limited segment is included on the United States (U.S.) Environmental Protection Agency (EPA) approved 2008 Missouri 303(d) List. EPA is establishing this TMDL to meet the milestones 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.

Section 303(d) of the CWA and federal Chapter 40 of the Code of Federal Regulations (CFR) Part 130 requires states to develop TMDLs for waters not meeting designated beneficial uses under technology-based controls for pollutants of concern. The TMDL process quantitatively assesses the impairment factors so that states can establish water-quality based controls to reduce pollutants and restore and protect the quality of their water resources. The purpose of a TMDL is to determine the maximum amount of a pollutant (the load) that a water body can assimilate without exceeding the water quality standards (WQS) for that pollutant. WQS are benchmarks used to assess the quality of streams, rivers and lakes. The TMDL also establishes the pollutant loading capacity (LC) necessary to meet the Missouri WQS established for each water body based on the relationship between pollutant sources and instream water quality conditions. The TMDL consists of a wasteload allocation (WLA), a load allocation (LA) and a margin of safety (MOS). The WLA is the portion of the allowable load that is allocated to point sources. The LA is the portion of the allowable load that is allocated to nonpoint sources. The MOS accounts for the uncertainty associated with linking pollutant loads to water quality conditions. This is sometimes related to the model assumption and data limitations.

The goal of the TMDL program is to restore impaired designated beneficial uses to water bodies. Thus, reduction strategies for point and nonpoint sources and implementation of source controls throughout the watershed will be necessary to restore the protection of warm water aquatic life use in Big Bottom Creek. In addition to establishing a TMDL for Big Bottom Creek, this report provides a summary of information, results and recommendations related to the impairment based on a broad analysis of watershed information, analysis of water quality data and computer modeling to support TMDL development.

Section 2 of this report provides background information on the Big Bottom Creek watershed and Section 3 describes potential sources of concern. Section 4 presents the applicable WQS, Section 5 describes the water quality problems and Section 6 describes the modeling that was done to support the TMDL. Sections 7 to 11 present the required TMDL elements (LC, WLA, LA, MOS, seasonal variation) and Sections 12 to 14 summarize the follow-up monitoring plan, reasonable assurances and public participation. A summary of the administrative record is presented in Section 15; Appendix A summarizes the available water quality data. Appendix B presents QUAL2K modeling conducted to support this TMDL. Methods and data used in the load duration curve (LDC) modeling are presented in Appendix C – Appendix E.

2 BACKGROUND

This section of the report provides information on Big Bottom Creek and its watershed.

2.1 The Setting

Big Bottom Creek is located in the Ozark/ Apple/ Joachim Ecological Drainage Unit (EDU). Big Bottom Creek flows north to Indian Creek which then flows into Establishment Creek. Establishment Creek flows north and eventually drains to the Mississippi River. The Big Bottom Creek watershed covers an area of approximately 4.86 square miles with a combined stream mileage distance of approximately 3.7 miles (Figure 1). Big Bottom Creek is impounded approximately 2 miles upstream with its confluence with Establishment Creek and forms Lake Anne (previously called Lake Forest), a 90 acre reservoir with 4.3 square mile drainage area. Lake Anne effectively splits the watershed into two distinct parts. The upper watershed drains to Lake Anne while the lower portion receives discharge from Lake Anne and runoff from the drainage area below Lake Anne (approximately 0.6 square miles).

The EPA-approved 2008 Missouri 303(d) List of impaired waters identifies the impaired segments of Big Bottom Creek at a length of 1.9 miles. Due to the increased accuracy of Geographic Information System (GIS) data layers for analysis over previous methods of stream length measurements, the stream length used in the TMDL analysis does not correspond exactly to the length shown in the 2008 Missouri 303(d) List. The descriptive start and end point of each segment remains the same. This TMDL addresses the impaired segment in its entirety and based on such improved estimates using GIS, the impaired segment is approximately 1.5 miles in length.

Big Bottom Creek, near Rocky Ridge in Ste. Genevieve County, Missouri, was on the Missouri 2002 303(d) List for Biochemical Oxygen Demand (BOD) and Volatile Suspended Solids (VSS). In 2004-2006 these listings were changed to low dissolved oxygen (DO) and organic sediment. In 2008 the listings were changed to DO, ammonia and organic sediment. The sole source of these impairments is the Lake Forest Estates Subdivision Wastewater Treatment Plant (WWTP), Missouri State Operating Permit (MSOP) number MO0035742. The Lake Forest Estates WWTP serves an established subdivision around Lake Anne with a population equivalent of 1,040 persons. A revised National Pollutant Discharge Elimination System (NPDES) permit was issued to the WWTP in order to correct the water quality exceedances of DO and scarcity of aquatic life observed downstream of the facility. In 2004, upgrades were made to the WWTP and monitoring was conducted in 2005, 2006 and 2009 to determine if plant upgrades had resolved the water quality issues. Big Bottom Creek remains on the 303(d) List due to DO criteria exceedances and reduced abundance and diversity of aquatic life.

The dam for Lake Anne, a classified lake (called Forest Lake in the current standards, WBID: 7267) is less than 0.2 mile upstream of the WWTP outfall. When Big Bottom Creek was assessed for the 1998 Missouri 303(d) List, there was no upstream flow and the poor condition of the creek was believed to be caused by the WWTP alone. In April 2005, all inspections found that water from the lake was not contributing to the impairment. Water only runs over the lake spillway during high flow periods. Otherwise there is no flow in Big Bottom Creek below the dam upstream of the WWTP. However, Lake Anne may contribute organic material to Big Bottom Creek during high flow periods which settle and affects DO via sediment oxygen demand (SOD).

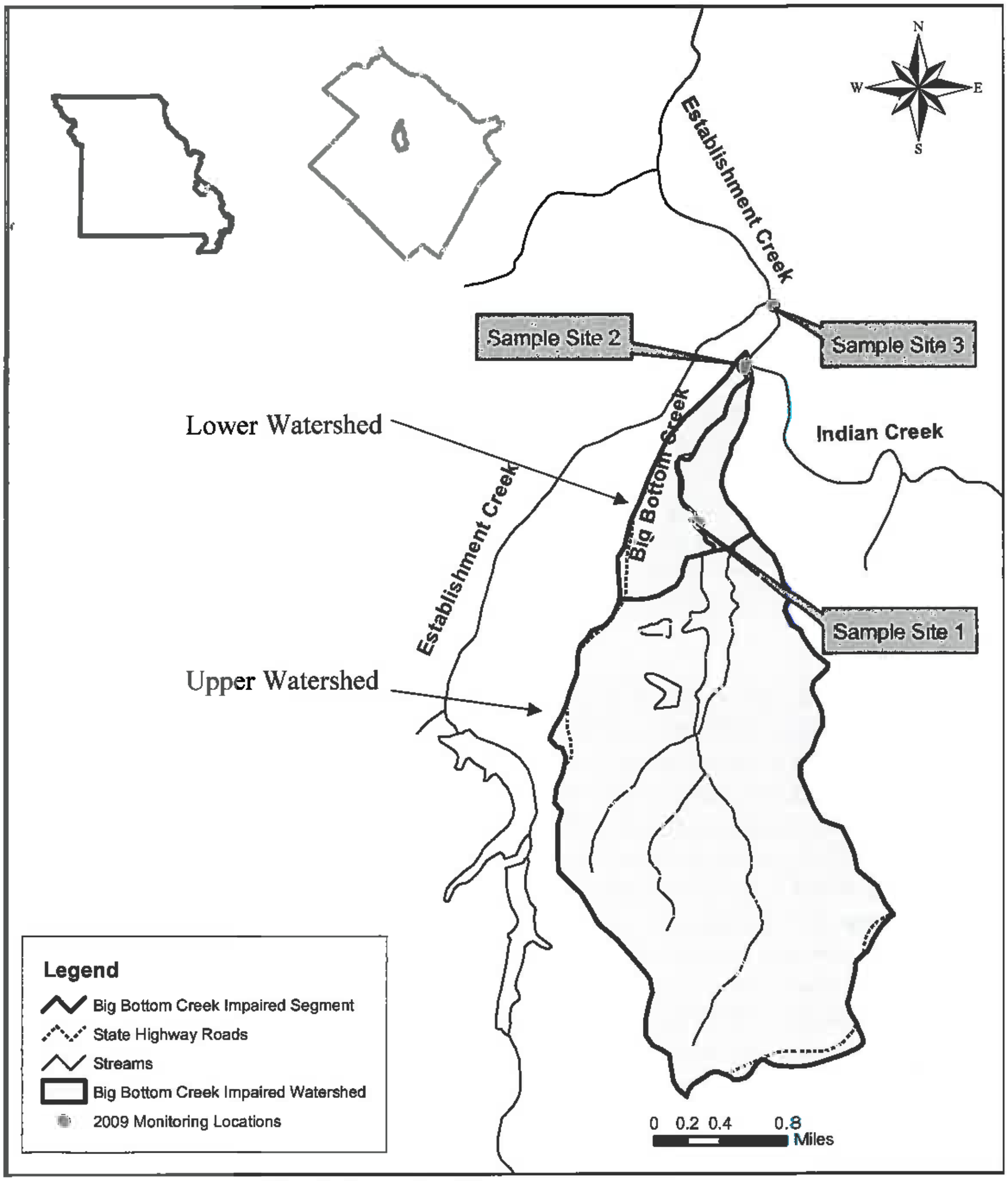


Figure 1. Big Bottom Creek Location Map

The current 303(d) listing for the impaired reach was based on visual inspections of Big Bottom Creek below the Lake Forest Estates WWTP during summer low flow conditions in 1995 and 2001. These inspections reported sludge deposits, green water, thick growths of prostrate algae, some filamentous algae and a scarcity of aquatic life. In addition, almost all of the life forms that were present during these surveys were known to have a high tolerance for pollution. These conditions are characteristic of streams suffering from impacts by wastewater treatment facilities. Big Bottom Creek was reassessed during the 2009 TMDL study (EPA, 2009) to determine whether conditions have changed since the WWTP upgrade and whether additional pollutant reductions are necessary.

2.2 Physiographic Location, Geology and Soils

Big Bottom Creek is located within the Interior Highlands; a division of the Springfield-Salem Plateau. The Springfield-Salem Plateau is a physiographic section of the Ozark Plateaus Province. Geologically, the Big Bottom Creek watershed is located in the Early Ordovician Ibexian Series. Predominant rock types include sandstone and dolostone (dolomite).

The soils hydrologic group relates to the rate at which surface water enters the soil profile, which in turn affects the amount of water that enters the stream as direct runoff. Table 1 and Figure 2 provide a summary of soil types in the impaired Big Bottom Creek watershed. The dominant soil type, C, covers approximately 86.2 percent of the watershed and 49.5 percent of the impaired watershed. Group C includes sandy clay loam soils that have a moderately fine to fine structure. These soils have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water. Soil type B covers approximately 5.8 percent of the Big Bottom Creek watershed and 20.6 percent of the impaired watershed. Group B includes silt loam and loam which have moderate infiltration rates. These soils consist of well drained soils with moderately fine to moderately coarse textures. Group D soil covers 4.7 percent of soils in the watershed and 28.8 percent of the impaired watershed. Group D soils include clay loam, silty clay loam, sandy clay, silty clay or clay. This soil group has the highest runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface and shallow soils over nearly impervious material (Purdue Research Foundation, 2009).

Table 1. Types and hydrologic group for soils in Big Bottom Creek.

		Lower Watershed (Impaired Reach)		Upper Watershed	
Soil Type	**Hydrologic Soil Group**	**Area Acres**	**Percent**	**Area Acres**	**Percent**
Bloomsdale silt loam	B	78.73	20.6	78.73	2.5
Midco gravelly silt loam	B	0.0	0	100.21	3.2
Subtotal	**B**	**78.73**	**20.6**	**178.95**	**5.8**
Caneyville silt loam	C	0.0	0.0	13.50	0.4
Goss very cobbly silt loam	C	110.31	28.9	1,223.88	39.3
Hildebrecht silt loam	C	0.0	0.0	28.12	0.9
Wrengart silt loam	C	78.52	20.6	1,418.83	45.6
Subtotal	**C**	**188.83**	**49.5**	**2,684.33**	**86.2**
Gasconade-Rock outcrop complex	D	109.96	28.8	145.75	4.7
Water	N/A	4.17	1.1	104.00	3.3

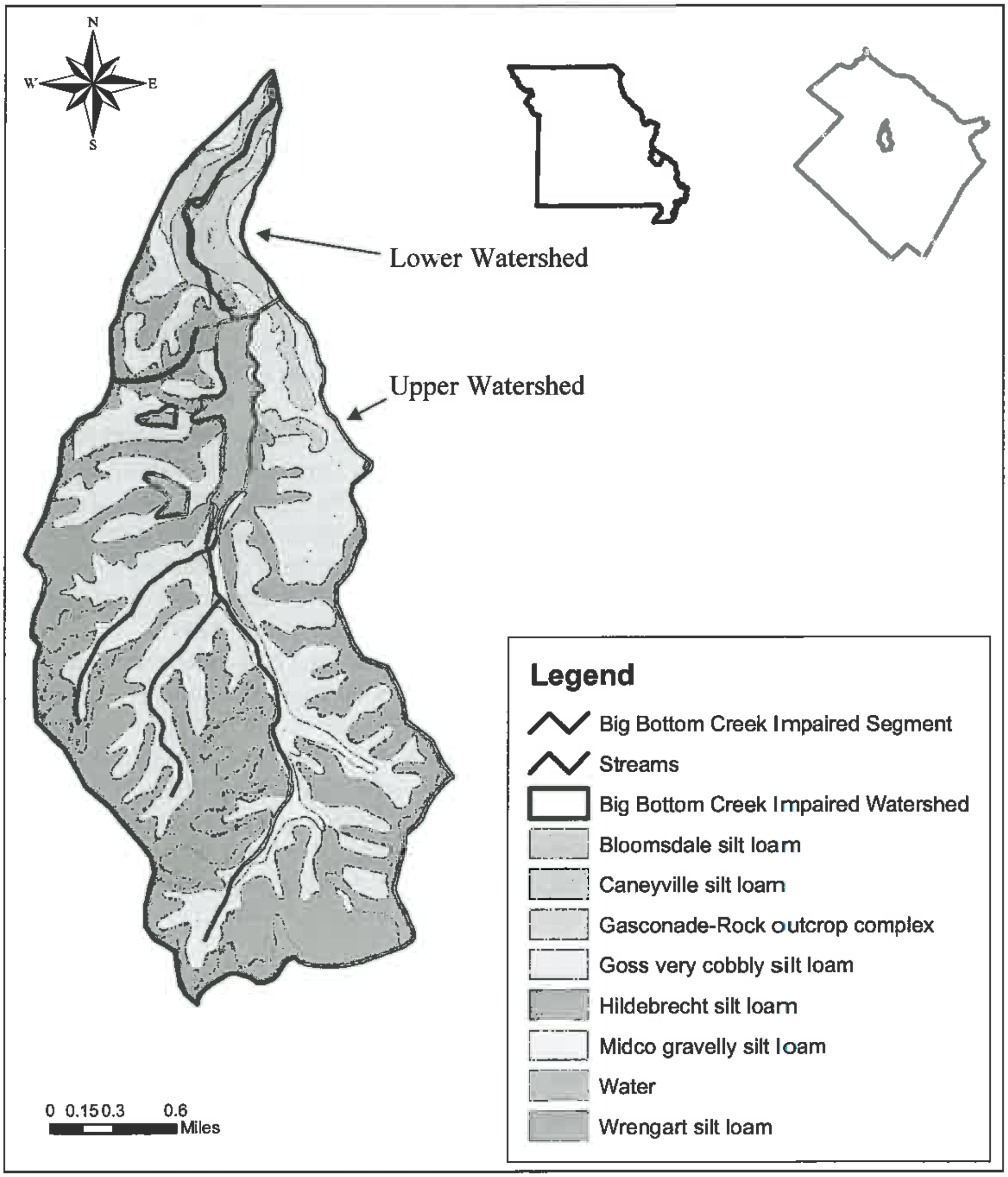


Figure 2. Big Bottom Creek Soils Map

2.3 Rainfall and Climate

Three weather stations are near the Big Bottom Creek watershed (Figure 3). These three stations record daily precipitation, maximum and minimum temperatures, snowfall, and snow depth. Figure 4 provides a summary of rainfall and climate data for Station 232850 (Festus, MO) based on 30 year totals (1971 – 2000) (NOAA, 2009). The annual average precipitation and temperature over the 30 year period is 39.91 inches and 53.7 degrees Fahrenheit, respectively. These nearby weather stations will provide useful information for simulating stream temperature which impacts the growth of algae, decay of Carbonaceous Biochemical Oxygen Demand (CBOD), transformations of nutrients and solubility of DO.

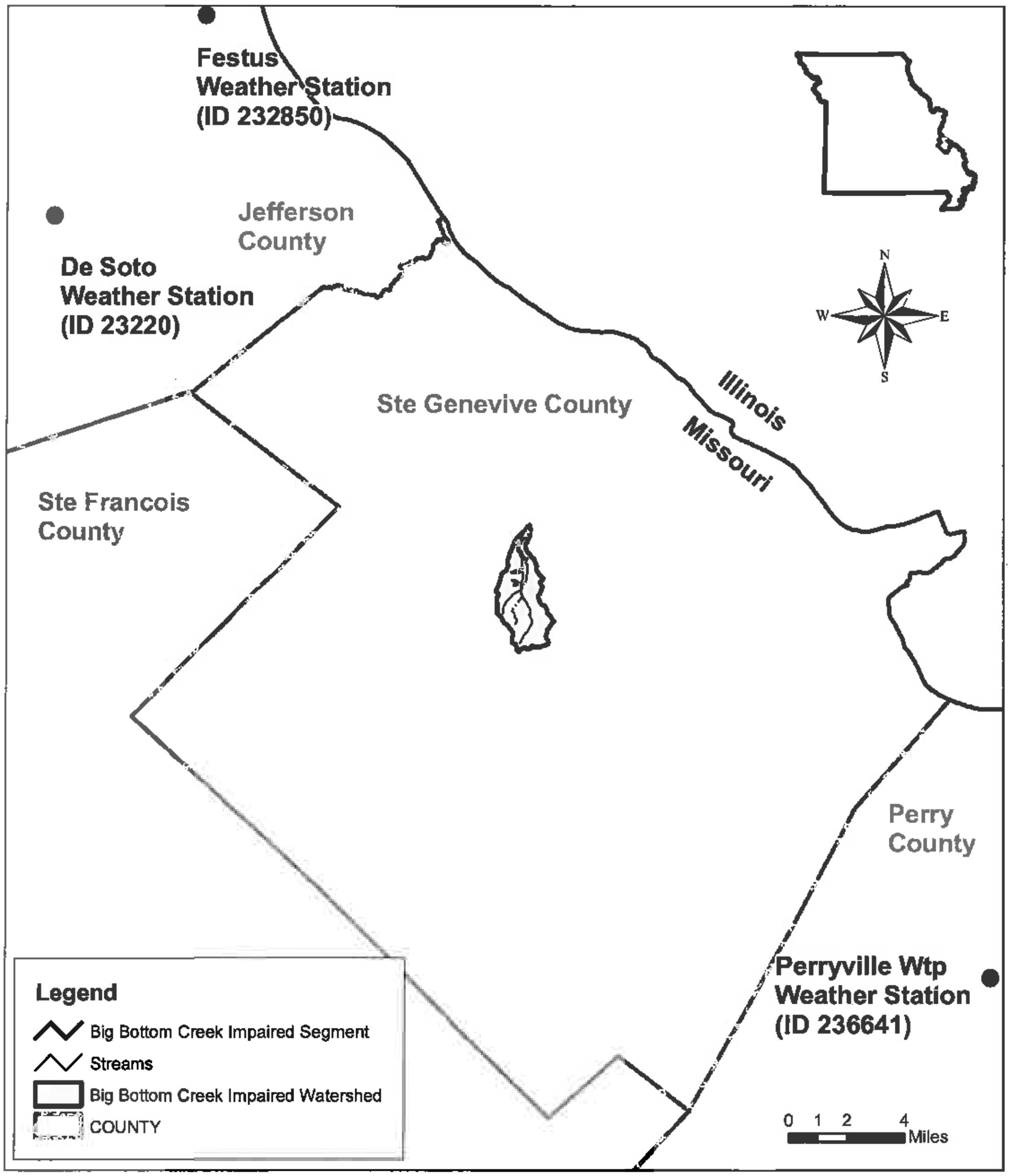


Figure 3. Location of Big Bottom Creek Watershed with weather stations

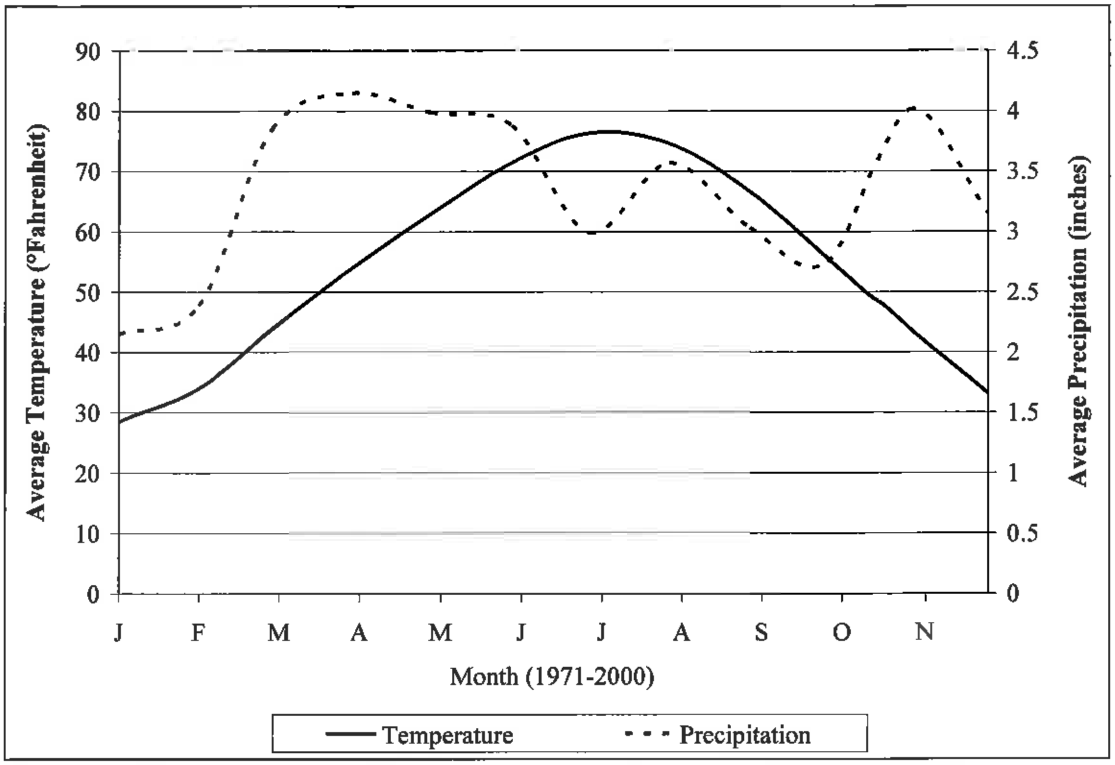


Figure 4. Thirty-year monthly temperature and precipitation averages for Station 232850 (Festus, MO) (NOAA, 2009)

2.4 Population

Population data for the Big Bottom Creek watershed is not directly available. However, the United States Census Bureau reports that the 2000 population for the cities of St. Mary's, Bloomsdale and Ste. Genevieve were 377, 419 and 4,476 persons, respectively (U. S. Census Bureau, 2000). The urban population of the Big Bottom Creek watershed is zero, as there are no urban areas within the watershed. Lake Forest Estates is a planned community surrounding Lake Anne. The community includes year-around homes, seasonal homes and vacation rentals.

The rural population of the watershed can be estimated based on the proportion of the watershed compared to Ste. Genevieve County. Ste. Genevieve County covers an area of 509.67 square miles and has a population of 17,842 persons. The rural population in Ste. Genevieve County is approximately 12,570 people (total county population minus St. Mary's, Bloomsdale and Ste. Genevieve population) and the rural county area is 503.29 square miles (total county area minus county urban area). The Big Bottom Creek watershed rural population was estimated to be 121 persons. This was calculated by dividing the rural watershed area (4.86 square miles) by the Ste. Genevieve County rural area (503.29 square miles) and multiplying the product by the Ste. Genevieve County rural population (12,750). The total estimated population of the Big Bottom Creek watershed is approximately 121 persons. An overall population density for the Big Bottom Creek watershed was calculated to be (121 persons divided by 4.86 square miles)

25 persons per square mile. Therefore, the impaired portion of the watershed has approximately 15 persons (25 persons per square mile multiplied by 0.6 square miles).

2.5 Land Use and Land Cover

The land use and land cover of the Big Bottom Creek watershed is summarized in Table 2 and is shown in Figure 5 (MoRAP, 2005). The primary land uses/land covers are forest (45.0 percent), grassland (28.6 percent) and herbaceous (14.6 percent) with impervious cover, low intensity urban areas, cropland and open water occupying the remaining area of the watershed.

Much of the Big Bottom Creek watershed is upstream of Lake Anne and the impaired segment. Since this watershed area drains to Lake Anne and influences conditions upstream of the impaired reach, it has been included in the land use assessment. Water from Lake Anne will have an effect on DO levels in the impaired segment because accumulated organics in the watershed are transported downstream and deposited in the impaired segment as runoff events occur. The deposited organics are the primary source of sediment oxygen demand (SOD) that can influence DO levels in the segment during critical (or low flow) periods. For completeness, land use for the total watershed area and the impaired lower watershed area has also been included in (Table 2).

Table 2. Land Use/Land Cover in the Big Bottom Creek Impaired Watershed (MoRAP, 2005)

Land Use/Land Cover	Lower (Impaired Reach) Watershed		Upper Watershed		Total Watershed Area	
	Square Miles	Percent	Square Miles	Percent	Square Miles	Percent
Impervious[4]	0.008	1.5	0.06	1.4	0.07	1.4
Low Intensity Urban[5]	0.003	0.5	0.15	3.5	0.15	3.1
Barren or Sparsely Vegetated	0.002	0.4	0.02	0.60	0.03	0.58
Cropland	0.046	8.0	0.05	1.1	0.09	1.9
Grassland	0.153	26.6	1.23	28.9	1.39	28.6
Forest	0.210	36.4	1.97	46.3	2.19	45.0
Herbaceous[6]	0.137	23.8	0.57	13.4	0.71	14.6
Wetland	0.001	0.24	0.0	0.0	0.00	0.04
Open Water	0.015	2.7	0.21	5.0	0.23	4.7
Total	0.57	100	4.3	100	4.9	100

Note: MoRAP = Missouri Resource Assessment Partnership

[4] Impervious land use includes non-vegetated, impervious surfaces including areas dominated by streets, parking lots and buildings (MoRAP, 2005).

[5] Low Intensity Urban land use includes vegetated urban environments with a low density of buildings (MoRAP, 2005).

[6] Herbaceous land use includes shrublands, young woodlots and open woodlands

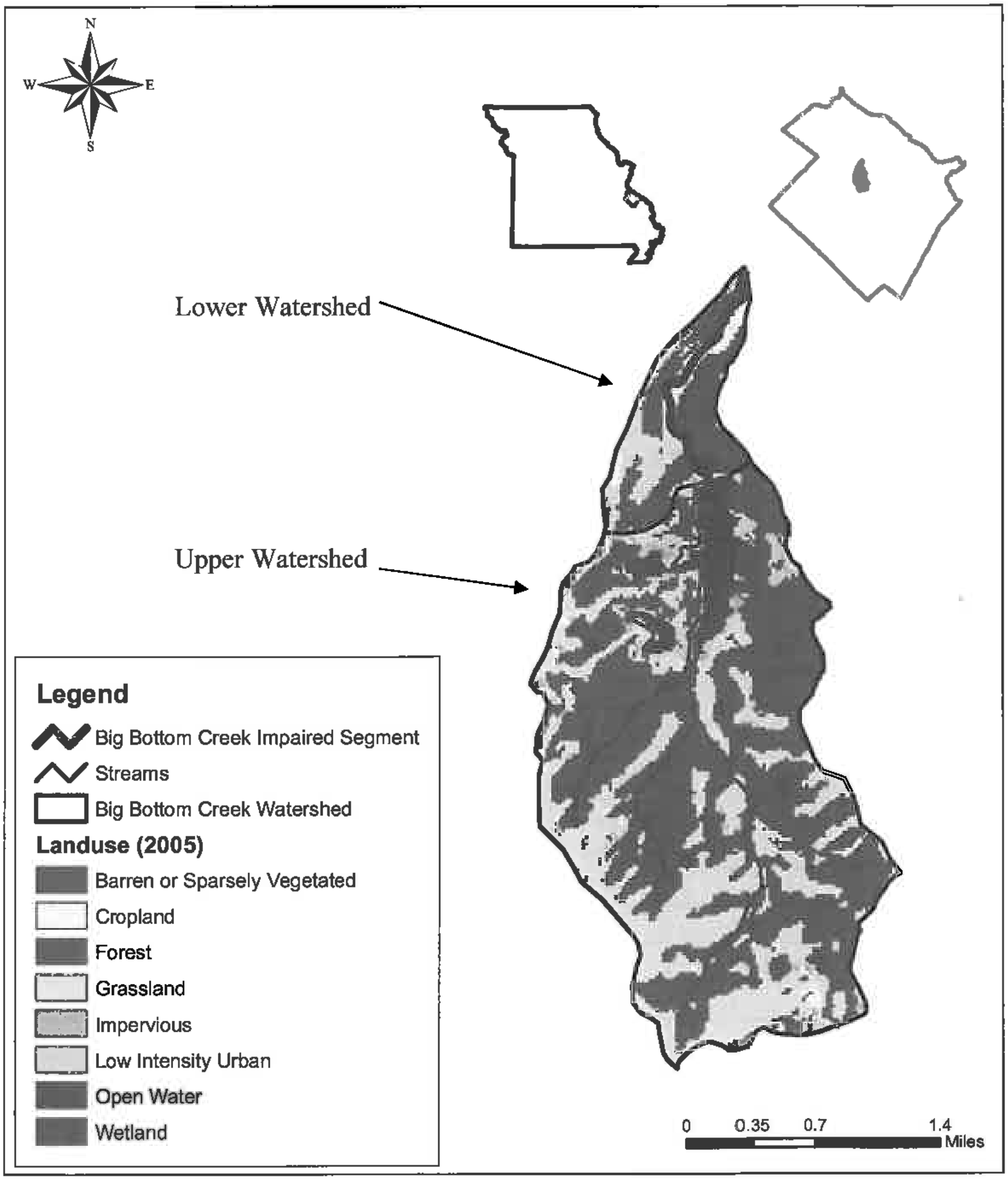


Figure 5. Land Use/Land Cover in the Big Bottom Creek Impaired Watershed (MoRAP, 2005)

3 DEFINING THE PROBLEM

Big Bottom Creek is impaired due to exceedances of Missouri's general water quality criteria for the protection of aquatic life and biological aquatic communities (10 CSR 20-7.031(3)). Historical water quality data collected from June 2004 to August 2007 show DO concentrations below 5 milligrams per liter (mg/L) in 17 of 34 samples collected at various locations in Big Bottom Creek (Table 3 and Appendix A). These data indicate Big Bottom Creek is not in compliance with the Missouri protection of aquatic life DO minimum water quality criterion of 5 mg/L for general warm water fisheries. Therefore, Big Bottom Creek is not in compliance with Missouri WQSs. Ammonia, CBOD and organic sediment from the Lake Forest Estates WWTP are the listed source of the impairment.

Table 3. Summary of Historical DO data for Big Bottom Creek.

Survey	Number of DO Samples	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	Percentage of Samples < 5 mg/L
June 2004	3	4.8	5.6	6.4	33
July 2004	8	1.1	4.7	7.4	62.5
April 2005	8	1.1	7.6	13	25
June 2005	8	0.8	4.6	12	75
August 2006	6	2.0	4.9	7.2	50
August 2007	1	6.2	6.2	6.2	0

Source: The Missouri Department of Natural Resources

DO in streams is affected by several factors including water temperature, the amount of decaying matter (i.e. organic sediment) in the stream, turbulence at the air-water interface and the amount of photosynthesis occurring in plants within the stream. Excessive nitrogen and phosphorus loading to water bodies can also contribute to DO problems because they can accelerate algal growth.

Algal growth in streams is most frequently assessed based on the amount of Chlorophyll-a in the water or attached to the stream bed. Algal growth is affected by numerous biotic and abiotic factors including light availability, flow and water velocity, nutrients (particularly phosphorus in freshwater systems), grazing and other influences. In the presence of light, respiration and photosynthesis can occur simultaneously in algae. However, the respiration rate is low compared with the photosynthesis rate, resulting in a net production of oxygen. In the absence of light, algal respiration continues while photosynthesis stops, resulting in a net consumption of oxygen. The breakdown of dead, decaying algae also removes oxygen from water. The most common approach to reducing excessive algal growth involves controls on activities that contribute nutrients to the water body.

Organic sediments can contribute to fluctuating DO concentrations. Decaying matter can come from wastewater effluent as well as agricultural and urban runoff and is typically measured instream as BOD. Decaying matter can also accumulate on the bottom of a stream and cause

SOD. SOD is a combination of all of the oxygen-consuming processes that occur at or just below the sediment/water interface. SOD is partly due to biological processes and partly due to chemical processes. Most of the SOD at the surface of the sediment is due to the biological decomposition of organic material and the bacterially facilitated nitrification of ammonia, while SOD found several centimeters into the sediment is often dominated by the chemical oxidation of species such as iron, manganese and sulfide (Wang, 1980; Walker and Snodgrass, 1986). Organic sediment can settle out of the water column and can smother aquatic invertebrates and fish eggs and cause offensive odors and unsightliness.

This TMDL study will characterize pollutant sources contributing to low DO through modeling temperature, nutrient dynamics, algal production and DO during critical, low-flow periods. Missouri's DO criterion for general warm water fisheries (5 mg/L) will be used as the TMDL target.

The DO impairment of Big Bottom Creek could be due to one or more of the following:

- Excessive loads of biodegradable matter, as measured by BOD and/or CBOD
- Excessive algae in the stream as a result of excessive nutrient loading
- High consumption of oxygen from decaying organic matter on the streambed
- Chemical oxygen demand from ammonia and other substances

To better determine the cause of the low DO impairment, additional data from Big Bottom Creek were collected and analyzed in 2009 by URS Corporation under contract with EPA. These data are of sufficient quality to evaluate compliance with WQSs and to support TMDL development because they were collected in accordance with required quality assurance procedures and the Missouri Department of Natural Resources'(MDNR's) sampling protocols (MDNR, 2005).

The location of the stream survey sampling sites in July and August 2009 are provided in Figure 6 and the data are summarized in Table 4, Table 5, Table 6 and Table 7. Monitoring was conducted on July 7 - 8, and August 12 – 13, 2009. For each daily sampling period, flow and water quality data were collected during a morning and afternoon period at seven monitoring locations.

There are several issues worth noting from a review of the data collected from Big Bottom Creek in July and August of 2009 (Sampling locations in Figure 6):

- Sample Location #2 had no flow during the August 12 - 13 sampling events. The stream was dry upstream for at least 100 meters but was flowing further upstream at Sample Location #1. The stream was dry downstream from Sample Location #2 to the confluence with Indian Creek. Indian Creek was flowing and flow was observed further downstream at Sample Location #3.
- Sample Location #1 had observed DO concentration below the 5 mg/L minimum criterion during all four sampling periods and Sample Location #3 had observed DO concentrations below the 5 mg/L minimum criterion during the August 13 sampling period.

- Headwater flow from the spillway at Lake Anne is intermittent. During dry periods, the only flow contributing to the impaired segment of Big Bottom Creek is the discharge from the Lake Forest Estates Subdivision WWTP.

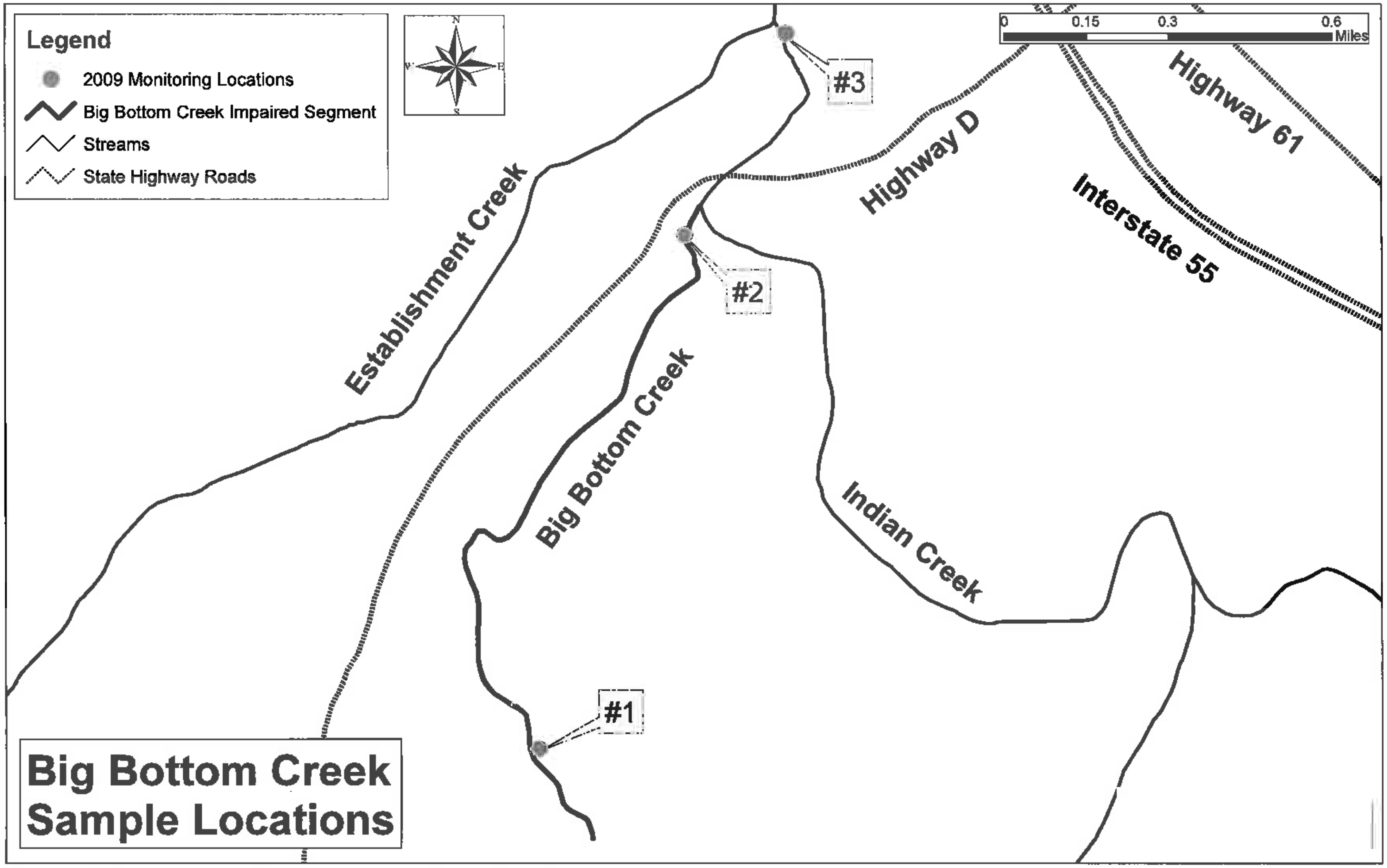


Figure 6. Location of July and August Sampling Sites

For these reasons, the Lake Forest Estates WWTP is listed as the main contributor to BOD and nutrient loads to Big Bottom Creek. Historical data (Appendix A) indicates DO concentrations greater than 5 mg/L upstream of the WWTP discharge (MDNR data: July 9, 2004 and August 7, 2007). The concentration of BOD in the WWTP effluent was below permit limits during both the July and August sampling events, with the exception of an August 9 sample result that reportedly had a CBOD of 174 mg/L (Allen Grass, Lake Forest Estates Manager, personal communication October 12, 2009).

Table 4. Summary of Big Bottom Creek water quality data collected on July 7, 2009

Sampling Station	Time	Flow (cms)	Velocity (m/sec)	$CBOD_5$ (mg/L)	Nitrogen, Ammonia (mg/L)	Nitrogen, TKN (mg/L)	Nitrogen, NO_2+NO_3 (mg/L)	DO (mg/L)	pH	Temp. (°C)	TP (mg/L)
1	7:20 AM	0.052	0.076	3.1	<0.5	1.301	0.615	4.97	6.14	22.55	0.157
1	1:15 PM	0.028	0.036	3.8	<0.5	0.978	0.144	7.25	8.20	26.30	0.0569
2	6:25 AM	0.054	0.061	2.6	<0.5	0.560	0.462	7.48	6.35	19.29	0.0735
2	12:35 PM	0.031	0.031	1.5	<0.5	0.446	0.319	10.06	8.48	22.84	0.0786
3	5:40 AM	0.337	0.077	1.7	<0.5	0.521	0.410	9.32	4.07	19.45	0.0599
3	12:02 PM	0.136	0.029	1.8	<0.5	0.547	0.385	8.44	7.92	21.03	0.0585

(See notes for Tables 4 – 7 after Table 7)

Table 5. Summary of Big Bottom Creek water quality data collected on July 8, 2009

Sampling Station	Time	Flow (cms)	Velocity (m/sec)	$CBOD_5$ (mg/L)	Nitrogen, Ammonia (mg/L)	Nitrogen, TKN (mg/L)	Nitrogen, NO_2+NO_3	DO (mg/L)	pH	Temp. (°C)	TP (mg/L)
1	6:45 AM	0.011	0.017	3.1	<0.5	1.630	0.930	3.68	7.21	23.27	0.330
1	1:30 PM	0.030	0.037	5.2	<0.5	0.897	0.397	4.64	7.21	26.08	0.0832
2	6:00 AM	0.010	0.012	1.3	<0.5	0.455	0.353	5.83	7.62	20.15	0.0667
2	12:50 PM	0.060	0.077	2.7	<0.5	0.264	0.297	8.08	7.40	23.92	0.0628
3	5:30 AM	0.109	0.024	1.15	<0.5	0.546	0.336	5.05	7.23	20.73	0.0591
3	12:10 PM	0.084	0.019	1.8	<0.5	0.295	0.339	6.66	7.01	21.97	0.0456

(See notes for Tables 4 – 7 after Table 7)

Table 6. Summary of Big Bottom Creek water quality data collected on August 12, 2009

Sampling Station	Time	Flow (cms)	Velocity (m/sec)	$CBOD_5$ (mg/L)	Nitrogen, Ammonia (mg/L)	Nitrogen, TKN (mg/L)	Nitrogen, NO_2+NO_3	DO (mg/L)	pH	Temp. (°C)	TP (mg/L)
1	6:55 AM	0.008	0.012	2.1	1.70	3.636	0.774	1.75	7.20	24.10	0.496
1	1:00 PM	0.008	0.012	1.2	1.05	1.307	0.546	3.68	7.34	25.30	0.272
3	5:20 AM	0.031	0.009	0.5	<0.50	0.445	0.117	4.72	7.20	21.80	0.046
3	12:05 PM	0.061	0.015	0.5	<0.50	0.441	0.099	6.51	7.46	23.50	0.044

(See notes for Tables 4 – 7 after Table 7)

Table 7. Summary of Big Bottom Creek water quality data collected on August 13, 2009

Sampling Station	Time	Flow (cms)	Velocity (m/sec)	$CBOD_5$ (mg/L)	Nitrogen, Ammonia (mg/L)	Nitrogen, TKN (mg/L)	Nitrogen, NO_2+NO_3	DO (mg/L)	pH	Temp. (°C)	TP (mg/L)
1	6:15 AM	0.010	0.015	5.5	2.05	3.462	0.598	1.84	7.07	23.30	0.548
1	1:15 PM	0.010	0.012	6.5	1.80	4.042	1.020	4.29	7.24	25.00	0.663
3	5:20 AM	0.041	0.009	0.7	<0.50	0.343	0.115	4.43	7.10	21.00	0.049
3	12:25 PM	0.045	0.012	0.6	<0.50	0.395	0.093	6.20	7.31	22.90	0.050

Notes for Tables 4 - 7:

cms = cubic meters per second
m/sec = meters per second
mg/L = milligrams per liter;
CBOD5 = Carbonaceous Biochemical Oxygen Demand (5 days)
TKN = Total Kjeldahl Nitrogen
NO2+NO3 = Nitrite + Nitrate
DO = Dissolved Oxygen
Temp. = Temperature in degrees Celsius
TP = Total Phosphorus

Method Detection Limits: $CBOD_5$ = 0.2 mg/L, NH_3 = 0.5 mg/L, TKN = 0.1 mg/L, $NO_2 + NO_3$ = 0.01 mg/L, TP = 0.003 mg/L.

4 SOURCE INVENTORY

A source assessment is used to identify and characterize the known and suspected pollutant sources contributing to the impairment in Big Bottom Creek. For the purpose of this report, sources have been divided into two broad categories; point sources and nonpoint sources. Point sources can be defined as sources, either constant or time transient, which occur at a fixed location in a watershed. Nonpoint sources are generally accepted to be diffuse sources not entering a water body at a specific location. Nutrients and oxygen consuming substances from both point and nonpoint sources are considered to be the primary contributors to impairment in Big Bottom Creek. It should be noted that the upper portion of the watershed drains into Lake Anne and does not have a direct impact on the water quality of the impaired segment; however, dams and impoundments are known to degrade water quality and aquatic life (FWS, 2009). The impacts of Lake Anne on the downstream aquatic life use of Big Bottom Creek include alteration of Big Bottom Creek hydrologic regime, increases to water temperature and greater nutrients loads during the summer months. Pollutant source information provided in this section encompasses the entire watershed (both upstream and downstream of Lake Anne). Historic water quality data used to identify and assess sources is presented in Appendix B of this document.

4.1 Point Sources

The term "point source" refers to any discernible, confined and discrete conveyance, such as a pipe, ditch, channel, tunnel or conduit, by which pollutants are transported to a water body. For the purposes of TMDL development, point sources are defined as sources regulated through the National Pollutant Discharge Elimination System (NPDES) program. Missouri has its own program for administering the NPDES program, referred to as the Missouri State Operating Permit system (MSOPS). The NPDES and MSOP programs are the same and for the purposes of this document the term "NPDES" will be used. The following NPDES-regulated entities are included in this source category:

- Municipal and industrial wastewater treatment facilities (e.g. WWTP),
- Concentrated animal feeding operations (CAFOs),
- Storm water runoff from Municipal Separate Storm Sewer System (MS4) and
- General permitted facilities (including storm water runoff from construction and industrial sites).

General permits (as opposed to site specific or individual permits) are issued to activities that are similar enough to be covered by a single set of requirements. Storm water permits are issued to activities that discharge only in response to precipitation events. Point sources in the Big Bottom Creek watershed were identified by consulting EPA's Permit Compliance System (PCS) website[7] and MDNR's GIS inventory[8] of NPDES permitted facilities covered under storm water or general permits. There are no permitted concentrated animal feeding operations in this watershed.

The single point source in Big Bottom Creek watershed is shown in Figure 7 and listed in Table 8. The Lake Forest Estates Subdivision WWTP is required to monitor and report effluent concentrations.

Lake Forest Estates upgraded their wastewater treatment facility in 2003. The community installed a new, three-cell, aerated lagoon adjacent to the existing lagoon site. The existing (old) three lagoons were converted to flow equalization basins to address infiltration and inflow to the subdivision collection system around the lake.

A draft operating permit with new effluent limits was public noticed October 28 through November 27, 2005. The draft included limits for BOD of 18 mg/L weekly average and 9 mg/L monthly average. The limits for total suspended solids (TSS) were 17 mg/L weekly average and 8 mg/L monthly average. These effluent limits were calculated from a WLA developed with a water quality model that used data collected in 2004 and 2005. The previous operating permit contained effluent limits of 60 mg /L weekly average and 30 mg/L monthly average for BOD, and 60 mg/L weekly average and 30 mg/L monthly average for TSS. The following ammonia limits were also included: a daily maximum of 3.4 mg/L and monthly average of 1.7 mg/L for summer (May through October), and daily maximum of 4.0 mg/L and monthly average of 2.0

---

7 www.epa.gov/enviro/html/pcs/index.html

8 http://msdis.missouri.edu/datasearch/ThemeList.jsp; GIS layers updated May 2009 and June 2009

mg/L for winter (November through April). A compliance schedule was included in the permit stating (in part) that the facility was required to submit its engineering report for construction upgrades to MDNR by March 1, 2006. The permit also included instream monitoring requirements.

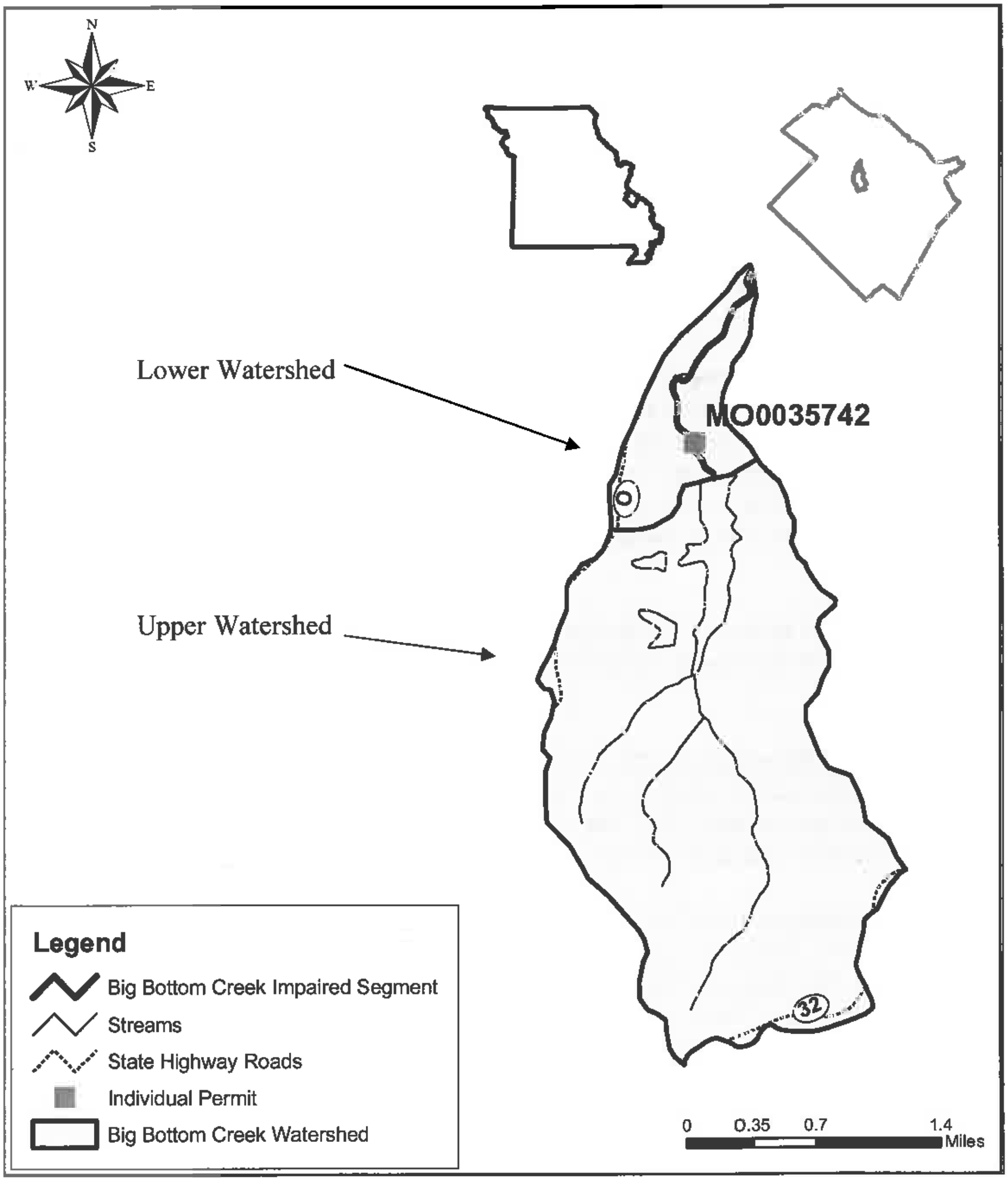


Figure 7. Location of permitted facilities in the Big Bottom Creek Watershed

Table 8. Permitted Facilities in the Big Bottom Creek Watershed

Facility ID	Facility Name	Receiving Stream	Classification/ Description	Reporting Requirements[1]	Design Flow (MGD)[2]	Permit Expiration Date
MO0035742	Lake Forest Estates Subdivision	Big Bottom Creek	Sewerage Systems	NH_3, Temperature, pH, DO, BOD, Flow, TSS	0.1183 (dry weather flow)	2011

[1] Where NH_3 = Ammonia, BOD = Biochemical Oxygen Demand, TSS = Total Suspended Solids, DO = Dissolved Oxygen

[2] MGD = Million Gallons per Day

The NPDES permit for the Lake Forest Estates WWTP was issued December 1, 2006 with existing effluent limitations for BOD, TSS and new seasonal effluent limits for ammonia. The reissued permit did not contain the proposed effluent limitations based upon the 2004-2005 water quality model. Subsequent to permit reissuance, MDNR inspected the stream and collected water quality data in 2007 and 2008 to evaluate water quality in Big Bottom Creek. These data were used to determine whether the operating permit effluent limits needed to be adjusted or if previous upgrades at the facility were sufficient to achieve water quality. In addition to water quality data collected by MDNR, twice per month permittee instream monitoring data for pH, ammonia as nitrogen, temperature and DO were also reviewed. The data indicates low DO persists below the 5 mg/L minimum criterion at critical flow conditions (Appendix A).

Illicit straight pipe discharges of household waste are also potential point sources in rural areas. These sources are discharges directly into streams or land areas and are different than illicitly connected sewers. There is no specific information on the number of illicit straight pipe discharges of household wastes in the Big Bottom Creek watershed and since a WWTP is located within the watershed, it is assumed that illicit straight pipe discharges are an insignificant load to the stream.

4.2 Nonpoint Sources

Nonpoint sources include all other categories of pollutant sources not classified as point sources. Potential nonpoint sources contributing to low DO problems in the Big Bottom Creek watershed include runoff from agricultural areas, runoff from urban areas, onsite wastewater treatment systems and various sources associated with riparian habitat conditions. Additional discussion on nonpoint sources is provided in the following sections.

Based on the information before us, the decision to apply discharges associated with unpermitted sources to the LA, as opposed to the WLA for purposes of this TMDL, is acceptable. The decision to allocate these sources to the LA does not reflect any determination by EPA as to whether these discharges are, in fact, unpermitted point source discharges within this watershed. In addition, by approving these TMDLs with some sources treated as LAs, EPA is not determining that these discharges are exempt from NPDES permitting requirements. If sources of the allocated pollutant in this TMDL are found to be, or become, NPDES-regulated discharges, their loads must be considered as part of the calculated sum of the WLA in this TMDL. WLA in addition to that allocated here is not available.

4.2.1 Runoff from Agricultural Areas

Lands used for agricultural purposes can be a source of nutrients and oxygen consuming substances. Accumulation of nitrogen and phosphorus on cropland occurs from decomposition of residual crop material, fertilization with chemical and manure fertilizers, atmospheric deposition, wildlife excreta, irrigation water and livestock excreta. The 2005 land use / land cover data indicates there are 0.09 square miles of cropland in the watershed, which comprises 2 percent of the entire watershed (Table 2). Cropland is concentrated in the lower watershed adjacent to the impaired reach (Figure 5) and comprises 8 percent of the lower watershed. An assessment of cropland in the riparian buffer of the impaired stream segment showed cropland to be approximately 24.3 percent (Table 9) of the entire watershed.

County wide data from the National Agricultural Statistics Service (NASS) (USDA, 2007) were combined with the land cover data for the Big Bottom Creek watershed to estimate approximately 364 cattle in the watershed[9]. The cattle are most likely located on the approximately 1.4 square miles acres of grassland/pastureland in the total watershed and the 0.153 square miles in the lower watershed. Runoff from these areas can be potential sources of nutrients and oxygen consuming substances. Animals grazing in pasture areas deposit manure directly upon the land surface and even though a pasture may be relatively large and animal densities low, the manure will often be concentrated near the feeding and watering areas in the field. These areas can quickly become barren of plant cover, increasing the possibility of erosion and contaminated runoff during a storm event. In addition, when pasture land is not fenced off from the stream, cattle or other livestock may contribute nutrients to the stream while walking in or adjacent to the water body. The density of cattle in the Big Bottom Creek watershed (74 cattle per square mile or 364 cattle in the entire watershed) suggests they are not a potential source of pollutants. The NASS also reports there were 10,567 hogs and pigs, 933 horses and ponies, 150 sheep and lambs and 1,795 layers in Ste. Genevieve County in 2007 (USDA, 2007).

Permitted CAFOs identified in this TMDL are part of the assigned WLA. At this time, animal feeding operations (AFOs) and unpermitted CAFOs are considered under the LA because we do not currently have enough detailed information to know whether these facilities are required to obtain NPDES permits. This TMDL does not reflect a determination by EPA that such facility does not meet the definition of a CAFO nor that the facility does not need to obtain a permit. To the contrary, a CAFO that discharges or proposes to discharge has a duty to obtain a permit. If it is determined that any such operation is an AFO or CAFO that discharges, any future WLA assigned to the facility must not result in an exceedance of the sum of the WLAs in this TMDL as approved.

---

[9] According to the NASS there are approximately 32,855 head of cattle in Ste. Genevieve County (USDA, 2007). There are 126 square miles of grasslands in Ste. Genevieve County (MoRAP, 2005). These two values result in a cattle density of approximately 261 cattle per square mile of grasslands. This density was multiplied by the number of grassland square miles in the Big Bottom Creek watershed to estimate the number of cattle in the watershed.

Any CAFO that does not obtain an NPDES permit must operate as a no discharge operation. Any discharge from an unpermitted CAFO is a violation of Section 301. It is EPA's position that all CAFOs should obtain an NPDES permit because it provides clarity of compliance requirements, authorization to discharge when the discharges are the result of large precipitation events (e.g., in excess of 25-year and 24-hour frequency/duration) or are from a man-made conveyance.

4.2.2 Runoff from Urban Areas

Storm water runoff from urban areas can also be a significant source of nutrients and oxygen consuming substances. Lawn fertilization can lead to high nutrient loads and pet wastes can contribute both nutrient loads and oxygen consuming substances. Phosphorus loads from residential areas can be comparable to or higher than loading rates from agricultural areas (Reckhow et al., 1980; Athayde et al., 1983). Leaking or illicitly connected sewers can also be a significant source of pollutant loads within urban areas. Storm runoff from urban areas such as parking lots and buildings is also warmer than runoff from grassy and woodland areas, which can lead to higher temperatures that lower the DO saturation capacity of the stream. Excessive discharge of suspended solids from urban areas can also lead to streambed siltation problems.

The areas within Big Bottom Creek watershed classified as urban land use are predominately composed of impervious surfaces (i.e., driveways, roads, rooftops, etc.). Since approximately 2.0 percent of the lower watershed and 4.5 percent of the total Big Bottom Creek watershed is classified as impervious and low intensity urban it is unlikely these areas are a major contributor of pollutants to the impaired reach.

4.2.3 Onsite Wastewater Treatment Systems

Onsite wastewater treatment systems (e.g., septic systems) that are properly designed and maintained should not serve as a source of contamination to surface waters. However, onsite systems do fail for a variety of reasons. When these septic systems fail hydraulically (surface breakouts) or hydrogeologically (inadequate soil filtration) there can be adverse effects to surface waters. Failing septic systems are sources of nutrients and pathogens that can reach nearby streams through both runoff and groundwater flows.

The exact number of onsite wastewater treatment systems in the Big Bottom Creek watershed is unknown. However, the National Environmental Service Center (NESC) reports that in 1998 there were 33,703 septic systems with an average population per septic system of 2.57 persons and a septic failure rate of 0.46 percent in the Cahokia-Joachim watershed (HUC 07140101). As discussed in Section 2.4, the estimated rural population of the lower Big Bottom Creek watershed, where the impaired reach is located, is approximately 15 persons. Based on this population and an average density of 2.57 persons per septic system, we can estimate that there are approximately six septic systems in the watershed. Based on a failure rate of 0.46 percent there is approximately one failing septic system within the Big Bottom Creek watershed (NESC 1998). EPA reports that the statewide failure rate of onsite wastewater systems in Missouri is 30 to 50 percent (EPA, 2002). If these higher numbers are more accurate there would be between 2 and 3 failing systems. Based on these estimates it is unlikely that failing onsite wastewater treatment systems are a contributor to water quality problems in Big Bottom Creek.

4.2.4 Riparian Habitat Conditions

Riparian[10] (streamside) habitat conditions can have a strong influence on in-stream DO. Wooded riparian buffers are a vital functional component of stream ecosystems and are instrumental in the detention, removal and assimilation of nutrients from or by the water column. Therefore, a stream with good riparian habitat is better able to moderate the impacts of high nutrient loads than a stream with poor habitat. Wooded riparian buffers can also provide shading that reduces stream temperatures and increases the DO saturation capacity of the stream.

Riparian buffers can also be sources of natural background material that contributes nutrients to the creek. For example, leaf fall from vegetation near the water's edge, aquatic plants and drainage from organically rich areas like swamps and wetlands are all natural sources of organic material that consume oxygen.

As indicated in Table 9, approximately 32 percent of the land in the lower Big Bottom Creek 30-meter riparian corridor is classified as forest (MoRAP, 2005). Grassland, including pasture areas, covers approximately 34 percent of the riparian corridor and cropland covers 24.3 percent. Compared to wooded areas, grasslands and cropland have the potential to provide much less shading and higher nutrient loads due to livestock activity and fertilization. Much of the riparian corridor is comprised of cropland and grassland. Since these land use types are associated with high nutrient loads their presence near Big Bottom Creek indicates that transport of pollutants from these areas is more likely to occur than similar land uses further from the creek.

Table 9. Percentage Land use / Land cover within 30-meter riparian buffer of lower Big Bottom Watershed (MoRAP, 2005)

Land Use/Land Cover	Percent Area
Barren or Sparsely Vegetated	0.4
Cropland	24.3
Deciduous Forest	32.4
Herbaceous	11.1
Grassland	23.5
Impervious	1.7
Low Intensity Urban	1.6
Open Water	2.1
Wetland	2.9
Total	100

[10] A riparian corridor (or zone or area) is the linear strip of land running adjacent to a stream bank.

5 APPLICABLE WQS AND NUMERIC WATER QUALITY TARGETS

Section 303(d) of the CWA and Chapter 40 of the CFR Part 130 require states to develop TMDLs for waters not meeting WQS. The TMDL process quantitatively assesses the impairment factors so that states can establish water-quality based controls to reduce pollutants of concern from both point and nonpoint sources and to restore and protect the quality of their water resources.

Under the CWA, every state must adopt WQS to protect, maintain and improve the quality of the nation's surface waters (US Code Title 33, Chapter 26, Subchapter III [US Code, 2009]). These standards represent a level of water quality that will support the CWA's goal of "fishable/swimmable" waters. Missouri's Surface WQS (10 Code of State Regulation [CSR, 2009] 20-7.031) consist of three components: designated uses, criteria (general and numeric) and an antidegradation policy.

Beneficial or designated uses for Missouri streams are found in the WQS at 10 CSR 20-7.031(1)(C), (1)(F) and Table H (CSR, 2009). Criteria for designated uses are found at 10 CSR 20-7.031, Tables A and B (CSR, 2009)). Missouri's antidegradation policy is outlined at 10 CSR 20-7.031(2) (CSR, 2009).

5.1 Designated Beneficial Uses

The designated beneficial uses of Big Bottom Creek (Water body ID [WBID]_1746) are:

- Livestock and Wildlife Watering
- Protection of Warm Water Aquatic Life
- Protection of Human Health (Fish Consumption)
- Whole Body Contact Recreation – Category B (CSR, 2009)

The use that is impaired is Protection of Warm Water Aquatic Life. The designated beneficial uses and stream classifications for Missouri may be found in the WQS at 10 CSR 20-7.031(1)(C), (1)(F) and Table H available from the Missouri Secretary of State (CSR, 2009).

5.2 Criteria

Missouri's water quality criteria that relate to DO, ammonia and organic sediment are presented in the following sections. The sections also provide brief descriptions of why DO, organic sediment and ammonia are important to water quality, how they are measured and how they are related to other water quality parameters.

5.2.1 Dissolved Oxygen

The amount of DO in water is one of the most commonly used indicators of river and stream health. Under extended hypoxic (low DO) or anoxic (no DO) conditions, many higher forms of life are driven off or die. Fish, mussels, macroinvertebrates and all other aquatic life utilize DO to create energy and metabolize food. The WQS for all Missouri streams except cold water fisheries require a daily minimum of 5 mg/L DO (10 CSR 20-7.031 Table A [CSR, 2009]).

DO in streams is affected by several factors including water temperature, the amount of decaying matter (i.e. organic sediment) in the stream, turbulence at the air-water interface and the amount of photosynthesis occurring in plants within the stream. Excessive nitrogen and phosphorus loading to water bodies can also contribute to DO problems because they can accelerate algal growth.

Algal growth in streams is most frequently assessed based on the amount of chlorophyll-a in the water. Algal growth is affected by numerous biotic and abiotic factors including light availability, flow and water velocity, nutrients (particularly nitrogen and phosphorus), grazing and other influences. Algae contribute DO during photosynthesis and consume DO during respiration. This typically results in a net gain of DO during the day and net loss of DO during the night. The breakdown of dead, decaying algae also removes oxygen from water. The most common approach to reducing excessive algal growth involves controls on activities that contribute phosphorus to the water body.

5.2.2 Organic Sediment

As previously mentioned, organic sediments can contribute to fluctuating DO concentrations. Decaying matter can come from wastewater effluent, as well as agricultural and urban runoff and is typically measured in stream as BOD. Decaying matter can also accumulate on the bottom of a stream and cause SOD. SOD is a combination of all of the oxygen-consuming processes that occur at or just below the sediment/water interface. SOD is partly due to biological processes and partly due to chemical processes. Most of the SOD at the surface of the sediment is due to the biological decomposition of organic material and the bacterially facilitated nitrification of NH_3, while SOD found several centimeters into the sediment is often dominated by the chemical oxidation of species such as iron, manganese and sulfide (Wang, 1980; Walker and Snodgrass, 1986).

High levels of organic sediment can contribute to sludge production along stream beds which smother aquatic invertebrates and fish eggs and cause offensive odors and unsightliness. Missouri's WQS do not include specific numeric criteria for organic sediment, but given the natural effects of excessive organic sediment on aquatic life, Missouri's narrative criteria are applicable [10 CSR 20-7.031(3)(A), (C), (D) and (G)] (CSR, 2009). Included in the narrative criteria are the following requirements:

- 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.
- Waters shall be free from substances or conditions in sufficient amounts to result in toxicity to human, animal or aquatic life.

- Waters shall be free from physical, chemical or hydrologic changes that would impair the natural biological community.

There are many quantitative indicators of sediment, such as TSS, turbidity and bedload sediment, which are appropriate to describe sediment in rivers and streams (EPA, 2006). A concentration of TSS was selected to represent the numeric target for this TMDL because it enables the use of the highest quality available data and is included in monitoring data. A detailed discussion of the method used to develop the TSS target is provided in Appendix D.

5.2.3 Ammonia

Ammonia is an important consideration in Big Bottom Creek because of its influence on DO concentrations and toxicity to aquatic life. Nitrogenous biochemical oxygen demand (NBOD) is the result of ammonia oxidation, which is a conversion of ammonia to nitrate in the aqueous environment. The consumption of nitrogen usually occurs more slowly than that of carbon. Nitrifying bacteria grow more slowly than the heterotrophic bacteria, which is one of the reasons why NBOD occurs at a slower rate than CBOD. The Missouri WQS contain acute and chronic numeric criteria for ammonia that are pH and temperature dependent. The numeric ammonia criteria are in 10 CSR 20-7 Table B1, B2 and B3 (CSR, 2009). These tables are also included in Appendix C.

5.2.4 Total Nitrogen and Total Phosphorus

An overabundance of nutrients, in particular nitrogen and phosphorus, is a serious threat to aquatic ecosystems. Excess nutrients support rapid algal growth, also referred to as algal blooms, which will cause significant changes to the water body. This phenomenon is called eutrophication. Eutrophication is the natural aging of lakes or streams caused by nutrient enrichment. Cultural eutrophication is the accelerated aging of the natural condition caused by human activities. Nutrient related water quality issues include the following:

- Proliferation of nuisance algae and the resulting unsightly and harmful bottom deposits;
- Turbidity due to suspended algae and the resulting green color;
- Organic enrichment when algal blooms die off, which perpetuates the cycle of excessive plant growth;
- Low DO caused by extreme swings in oxygen production by over abundant plant life and oxygen depletion resulting from decomposition of algae and other plants, which can have a negative impact on aquatic organisms.

Missouri does not have a numeric criterion for total nitrogen (TN) or total phosphorus (TP) in freshwater streams; therefore, targets and LCs are based on EPA-recommended Ecoregion 39 criteria and water quality observations at locations throughout the ecoregion (EPA, 2000). Reference conditions for TN and TP in level III Ecoregion 39 streams are as follows: TN = 0.289 milligrams per liter (mg/L) and TP = 0.007 mg/L. For this TMDL, recommended TN and TP ecoregion criteria are used directly in developing LCs for TN and TP. A detailed discussion of the method used to develop the TN and TP targets is provided in Appendix E of this report.

5.3 Antidegradation Policy

Missouri's WQS include EPA's "three-tiered" approach to antidegradation, which may be found at 10 CSR 20-7.031(2) (CSR, 2009).

Tier 1 – Protects existing in-stream uses and a level of water quality necessary to maintain and protect those uses. Tier 1 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 28, 1975, the date of EPA's first WQS Regulation.

Tier 2 – Protects and maintains the existing level of water quality where it is better than applicable water quality criteria. 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 economic and 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 or beneficial uses.

Tier 3 – Protects the quality of outstanding national and state resource waters, such as waters of national and state parks, wildlife refuges and 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.

6 MODELING APPROACH

DO in streams is determined by the factors of photosynthetic productivity, respiration (autotrophic and heterotrophic), reaeration and temperature. These factors are influenced by natural and anthropogenic conditions within a watershed. Generally, reaeration is based on the physical properties of the stream and on the capacity of water to hold DO. This capacity is mainly determined by water temperature with colder water having a higher saturation concentration for DO. In a review of variables and their importance in DO modeling, Nijboer and Verdonschot (2004) categorized the impact of a number of variables on oxygen depletion. For this TMDL, the effects of temperature and the physical aspects of the stream itself were discounted. Even though the hydrological regime of historic alluvial streams was modified by changes in land cover and channelization, manipulation of these parameters does not address a pollutant and so is not the goal of a TMDL. Pollutants which result in oxygen concentrations below saturation are:

- fine particle size of bottom sediment
- high nutrient levels (nitrogen and phosphorus)
- turbidity

Because the influence of these three pollutants on DO varies to a large extent based on anthropogenic factors, they are appropriate targets for a TMDL written to address an impairment of low DO.

An essential component of developing a TMDL is establishing a relationship between the source loadings and the resulting water quality. For this TMDL, two modeling approaches are used. The LDC method is used to develop TMDLs for TSS, TN and TP under all flow conditions and the QUAL2K model is used to assess DO under low flow conditions. The relationship between the source loadings of CBOD, nutrients (NH_3, TN and TP) and algal dynamics on DO is generated by the water quality model QUAL2K (Chapra et al., 2008) under steady low flow conditions.

Since fine particle sized sediment and turbidity are derived from similar loading conditions of terrestrial and stream bank erosion, this TMDL establishes an allocation for TSS (see Appendix C for discussion of development of TSS targets). This target was derived based on a reference approach by targeting the 25th percentile of TSS measurements (U.S. Geological Survey [USGS], non-filterable residue) in the geographic region in which Big Bottom Creek is located. To address nutrient levels, the EPA nutrient ecoregion reference concentrations were used. For the ecoregion where Big Bottom Creek is located, the reference concentration for TN is 0.289 mg/L and the reference concentration for TP is 0.007 mg/L. This TMDL will not specifically target chlorophyll as a WLA, but will use a linkage between nutrient concentrations and chlorophyll response to achieve the ecoregion reference concentrations.

6.1 Load Duration Curves

The sediment target for this TMDL was derived using a reference approach. In this approach, the target for pollutant loading is the 25th percentile of the current EDU condition calculated from all TSS data available (USGS, non-filterable residue) within the EDU in which the water body is located (see Appendix C for a list of sites and data). Therefore, the 25th percentile (10mg/L) is targeted as the TMDL LDC (See Appendices D and F).

To develop LDCs for TN and TP, a method similar to that used for TSS was employed. First, TN and TP measurements were collected from USGS sites in the vicinity of the impaired stream. These data were adjusted such that the median of the measured data was equal to the ecoregion reference concentration. This was accomplished by subtracting the difference of the data median and the reference concentration. Where this would result in a negative concentration, the data point in question was replaced with the minimum concentration seen in the measured data. This resulted in a modeled data set which retained much of the original variability seen in the measured data. This modeled data was then regressed as instantaneous load versus flow. The resultant regression equation was used to develop the LDC. Allowable pollutant loads were calculated for all flow conditions by multiplying flow by either the EPA-recommended ecoregion reference concentration or the concentration established using the regional streams, whichever concentration is higher.

To develop the TMDL expression of maximum daily loads, the background discharge at the stream outlet was modified from the traditional approach using synthetic flow estimation.

Since the design flow from permitted facilities would overwhelm the background natural low flow, the sum of permitted volumes was added to the derived stream discharge at all percentiles of flow to take into account the increases in flow volume as well as pollutant load. The TMDL curves in the LDCs flatten at low flow because at these lower flows the TMDL target is dominated by the point source flow.

6.2 QUAL2K

QUAL2K and its predecessor models have been used extensively for permitting of wastewater treatment discharges and TMDL development across the country. QUAL2K is supported by EPA and is well accepted within the scientific community because of its proven ability to simulate the processes important to DO conditions within streams. QUAL2K is suitable for simulating the hydraulics and water quality conditions of a small river. It is a one-dimensional model with the assumption of a completely mixed system for each computational cell. QUAL2K assumes that the major pollutant transport mechanisms, advection and dispersion, are significant only along the longitudinal direction of flow. The model allows for multiple waste discharges, water withdrawals, tributary flows and incremental inflows and outflows. The processes employed in QUAL2K address nutrient cycles, algal growth and DO dynamics. QUAL2K links plant respiration and photosynthesis as well as other oxygen demanding substances such as CBOD, the nitrification process (which uses oxygen to reduce organic nitrogen to NH_3 and then to NO_3+NO_2) and sediment demands of organic substances to instream oxygen levels.

Flow and water quality data collected on July 7 - 8, August 12 - 13 were used to calibrate and validate the QUAL2K model. Once the QUAL2K model was set up and calibrated for Big Bottom Creek, a series of scenarios were run to evaluate the pollutant load reductions needed to achieve the minimum DO criterion. These results are summarized in Section 7 and a detailed discussion of the QUAL2K model is included in Appendix B.

7 CALCULATION OF LOADING CAPACITY

LC is defined as the greatest amount of pollutant that a water body can assimilate without violating WQS. This load is then divided among the point source (WLA) and nonpoint source (LA) contributions to the stream, with an allowance for an explicit MOS. The MOS accounts for uncertainty in the relationship between pollutant loads and the quality of the receiving water body. If the MOS is implicit, no numeric allowance is necessary. Conceptually, this definition is represented by the equation:

$$LC = \sum WLA + \sum LA + MOS \quad \textbf{Equation 1}$$

Where:

LC = Loading Capacity

WLA = Wasteload Allocations (point source)

LA = Load Allocations (non point source)

MOS = Margin of Safety (may be implicit and factored into a conservative WLA or LA, or explicit)

The objective of the TMDL is to estimate allowable pollutant loads and to allocate these loads to known pollutant sources within the watershed so appropriate control measures can be implemented and the WQS achieved. The WLA and LA are calculated by multiplying the appropriate flow in cubic feet per second (cfs) by the appropriate pollutant concentration in milligrams per liter (mg/L). A conversion factor of 5.395 is used to convert to pounds per day (lbs/day).

Critical conditions are considered when the LC is calculated. DO levels that threaten the integrity of aquatic communities generally occur during low flow periods, so these periods are considered the critical condition. Mixing zones and zones of initial dilution are not allowed in regulation for Class C streams [10 CSR 20-7.031(4)(A)4.B.(I)]. Therefore, in order to ensure attainment of applicable WQS, all water quality criteria must be met end of pipe for permitted facilities.

The QUAL2K model was set up and calibrated to the 2009 July and August sampling dates to further investigate the DO issues. The August 12, 2009, model was used to identify the LC since it represented a more critical condition (i.e., reduced DO and lower flows). The following steps were taken during the modeling process:

- Step 1: Application of the Model to Existing Conditions
  - This application forms the current condition that is used to evaluate the magnitude of load reductions that are needed to meet WQS. Nonpoint source loads are set equal to the calibrated conditions.

- Step 2: Application of the Model to Existing Conditions with Point Sources at Permit Limits
  - This application forms the baseline condition that will be reduced to meet the allowable load. The Lake Forest Estates WWTP was set at its permit limits using the permitted flow and mean daily concentration allowed for in the permit. For pollutants not included in the permit, the observed effluent data were used.

- Step 3: Develop and Test Allocation Scenarios
  - Working from the baseline condition and considering the primary pollutant sources, sample allocation scenarios were developed and applied. For example, if existing BOD or ammonia effluent limits for the Lake Forest Estates WWTP in Step 2 are not protective of the instream DO WQS, the QUAL2K model is iteratively run at reduced BOD and ammonia concentrations until compliance with the WQS is met. The difference between the baseline condition and BOD and ammonia WLA required to achieve the standard is the percent reduction needed at the facility.

The TMDL, summarized in Table 10, is based on 7Q10 flows[11] of 0.01 cfs (0.00028 cubic meters per second) and the environmental conditions (air temperature, dew point temperature and cloud cover) that were present on the August 12, 2009 model. For the purposes of QUAL2K modeling, MDNR assigns a 7Q10 flow of 0.01 cfs for Class C waters. The results of the modeling analysis indicate that the effluent needs to be aerated to above 8.0 mg/L DO in addition to the specified load reductions. Lower DO concentrations will require greater reductions in BOD, CBOD and/or ammonia. Based on the QUAL2K modeling the load reductions from baseline conditions required to meet 5 mg/L of DO are:

- 78 percent reduction in BOD,
- 72 percent reduction in SOD,
- 84 percent reduction in ammonia.

The SOD assumed for the impaired reach in the TMDL scenarios is a low value for enriched sediments and is a reasonable value downstream of a WWTP. The effluent characteristics of the Lake Forest Estates WWTP that results in a minimum DO of 5 mg/L are provided in Table 10. These values represent the daily load that will result in a DO of 5 mg/L during low flow critical conditions. During this period flow in the stream is almost entirely from the WWTP.

The treatment technology required to meet the BOD limits corresponding to the WLAs shown below should result in corresponding reductions of organic sediment that will eliminate the organic sediment impairment and reduce the SOD in Big Bottom Creek.

To meet the targeted nutrient and TSS critical condition targets outlined in this TMDL, the sum of the WLA was calculated by using nutrient ecoregion reference concentrations and 25th percentile EDU TSS concentrations and the sum of the design flows of permitted facilities in the watershed. The nonpoint sources or LA TMDL targets for TSS, TP and TN were calculated using nutrient ecoregion reference concentrations and 25th percentile EDU TSS concentrations and the sum of the headwater and tributary flows. For tributary loading (Indian Creek), the ecoregion target for nitrogen (289 micrograms nitrogen per liter [µgN/L]) was assigned as 289 µgN/L in the organic nitrogen fraction because there are no wastewater treatment facilities on the tributary and nitrogen from nonpoint sources is expected to be largely represented by the organic nitrogen fraction. For point source loading, the ecoregion target for nitrogen was assigned as 289 µgN/L ammonia, based on the assumption that ammonia is the primary parameter of concern, with respect to nitrogen, in treated WWTP effluent. For both point and nonpoint sources, the ecoregion criteria target for TP (7 ug/L) was split 80:20 between organic and inorganic phosphorus fractions, respectively, such that the organic phosphorus target was set equal to 5.6 micrograms per liter [µg/L] and the inorganic phosphorus target was set equal to 1.4 µg/L. TP and TN nonpoint source baseline flow conditions were obtained using existing loads sampled on August 12, 2009. The LDCs for the targeted pollutants are depicted in Figure 8, Figure 9 and Figure 10, where the TMDL line represents the total LC of all point and

[11] For the purposes of QUAL2K modeling, MDNR assigns a 7Q10 flow of 0.01 cfs for Class C waters (personal communication with John Hoke, MDNR TMDL Unit Chief, October 15, 2009).

nonpoint sources of pollutants. The pollutant allocations under a range of flow conditions are presented in Table 11, Table 12 and Table 13.

Table 10. TMDL Summary for Big Bottom Creek at 7Q10 Low Flow Critical Conditions

Pollutant	Baseline Conditions (based on monthly average limits and design flow)			TMDL			WLA Percent Reduction	LA Percent Reduction
	Point Sources	Nonpoint Sources	Total	Point Sources (WLA)	Nonpoint Sources (LA)	Total		
Flow (MGD)	0.118	0.001	0.119	0.118	0.001	0.119	0%	0%
BOD_5 (lbs/day)	29.6	0.23	29.9	6.4	0.26	6.7	78%	0%
$CBOD_{ult}$ (lbs/day)	No limit	0.12	Not applicable	10.9	0.34	11.2	Not applicable	0%
$NBOD_{ult}$ (lbs/day)	No limit	0.33	Not applicable	1.3	0.15	1.49	Not applicable	55%
NH_3 (lbs/day)	1.9	0.05	1.927	0.3	0.00	0.29	84%	100%
TSS (lbs/day)	29.6	1.3	30.9	9.9	1.1	11.0	67%	16%
TN (lbs/day)	No limit	0.57	Not applicable	0.285	0.031	0.317	Not applicable	94%
TP (lbs/day)	No limit	0.004	Not applicable	0.007	0.001	0.008	Not applicable	81%

Note: The WLA and LA specified in Table 10 results in a minimum DO of 5.0 mg/L when the effluent is aerated to at least 8.0 mg/L DO. Baseline conditions for point sources are based on permitted flow and concentration at the Lake Forest Estates Subdivision WWTP. Baseline conditions for nonpoint sources are based on inputs used in the August 12, 2009, QUAL2K model. Monthly average permit limits were used for baseline point source conditions. The Lake Forest Estates Subdivision WWTP has numeric limits for BOD_5, which are 60 mg/L weekly average and 30 mg/L monthly average and ammonia which are 3.7 mg/L daily maximum and 1.9 mg/L monthly average from May through October. Numeric limits for TSS are 60 mg/L weekly average and 30 mg/L monthly average. Point and nonpoint TMDL values for flow, BOD_5, $CBOD_{ult}$, $NBOD_{ult}$ and NH_3, are based on the August 12, 2009, QUAL2K TMDL model in which background and point source nutrient concentrations are set to ecoregion criteria (TN = 0.289 mg/L and TP = 0.007 mg/L), flows are adjusted to 7Q10 conditions and aeration (to 8.0 mg/L DO) is used at the Lake Forest Estates Subdivision WWTP. In developing the TMDL scenarios, the ecoregion target for nitrogen (289 µgN/L) was fully assigned to the organic nitrogen fraction for tributary loading because there are no wastewater treatment facilities on the tributary and nitrogen from nonpoint sources is expected to be largely represented by the organic nitrogen fraction. For point source loading, the ecoregion target for nitrogen was assigned as 289 µgN/L ammonia, based on the assumption that ammonia is the primary parameter of concern, with respect to nitrogen, in treated WWTP effluent.

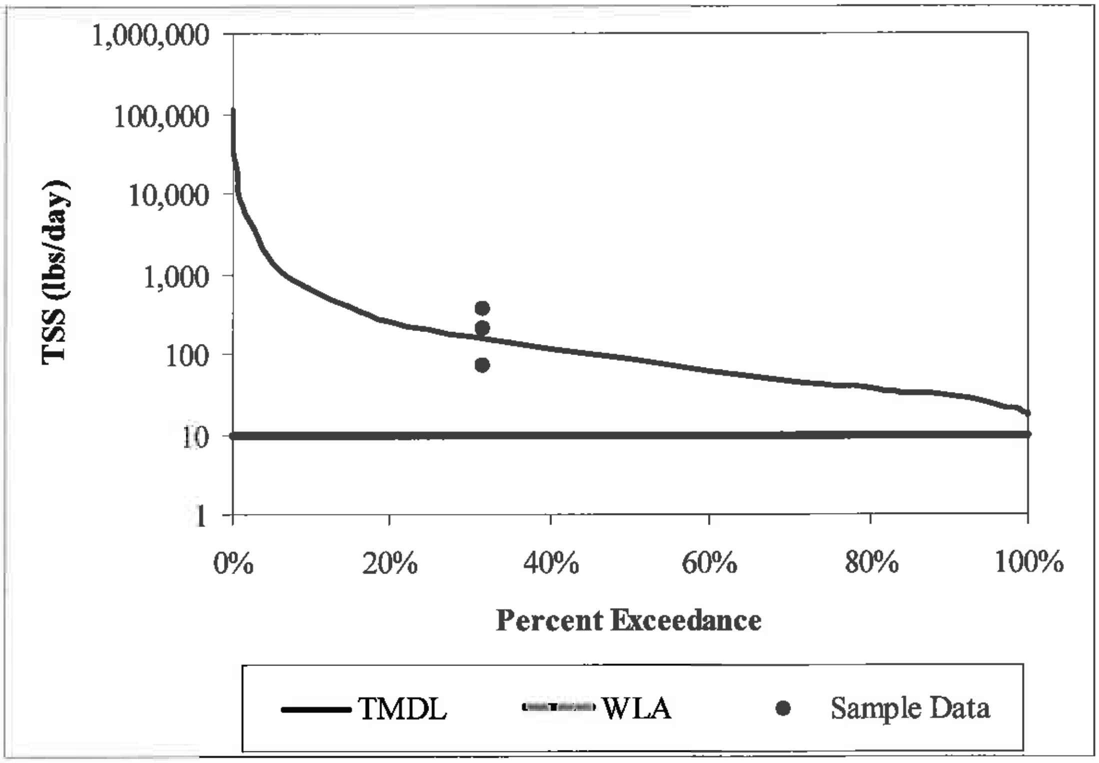


Figure 8. TSS LDC for Big Bottom Creek

Table 11. TSS TMDL under a range of flow conditions in Big Bottom Creek

Percent Flow Exceedance	Estimated Flow (cfs)	TMDL (lbs/day)	MOS[1] (lbs/day)	LA (lbs/day)	Lake Forest WWTP (lbs/day)
95%	0.46	25	--	15	10
90%	0.54	29	--	19	10
70%	0.86	47	--	37	10
50%	1.58	85	--	75	10
30%	3.05	164	--	154	10
10%	7.97	623	--	613	10
5%	12.98	1,370	--	1,360	10

[1] The TSS MOS is implicit.

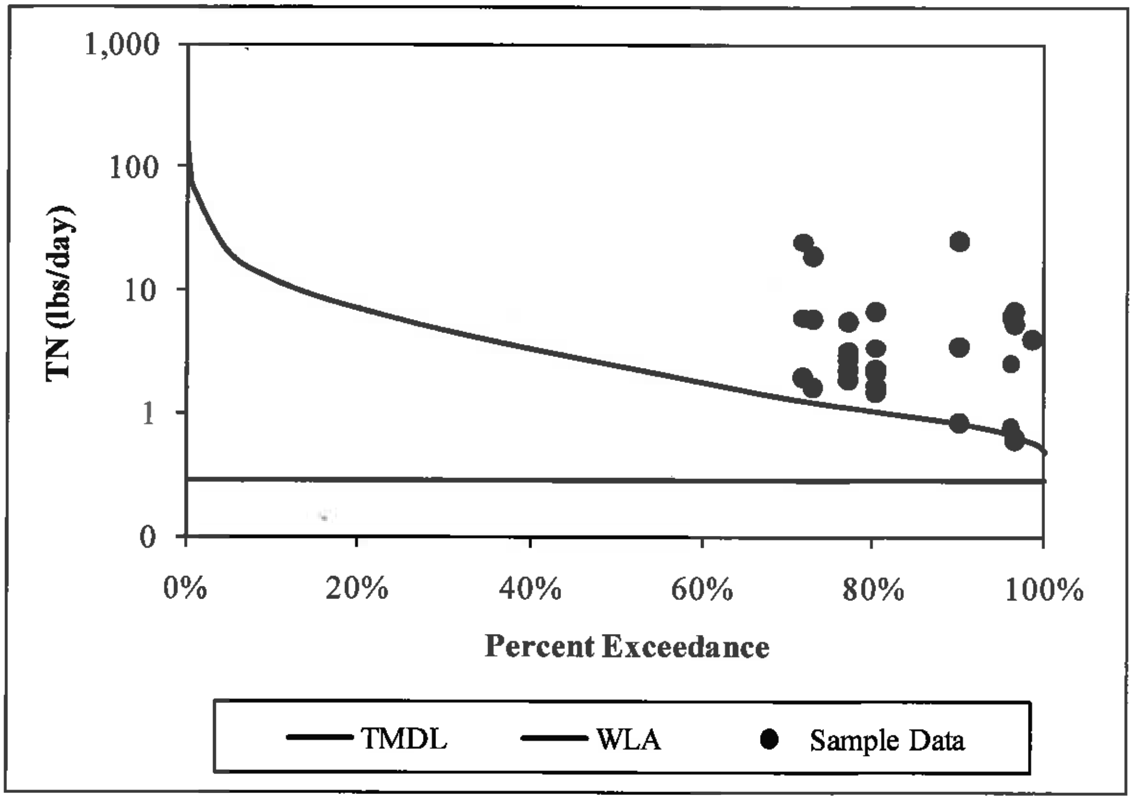


Figure 9. TN LDC for Big Bottom Creek

Table 12. TN TMDL under a range of flow conditions in Big Bottom Creek

Percent Flow Exceedance	Estimated Flow (cfs)	TMDL (lbs/day)	MOS[1] (lbs/day)	LA (lbs/day)	Lake Forest WWTP (lbs/day)
95%	0.46	0.72	--	0.43	0.29
90%	0.54	0.85	--	0.56	0.29
70%	0.86	1.35	--	1.06	0.29
50%	1.58	2.47	--	2.18	0.29
30%	3.05	4.75	--	4.46	0.29
10%	7.97	12.42	--	12.13	0.29
5%	12.98	20.24	--	19.95	0.29

[1] The TN MOS is implicit.

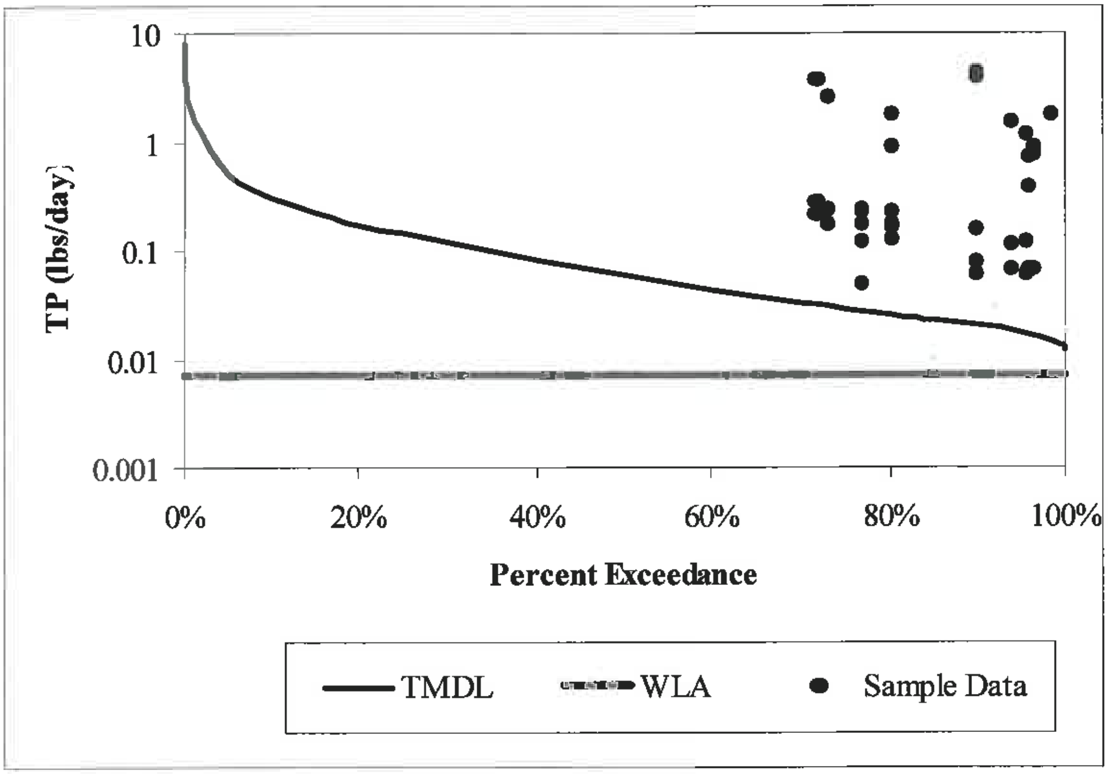


Figure 10. TP LDC for Big Bottom Creek

Table 13. TP TMDL under a range of flow conditions in Big Bottom Creek

Percent Flow Exceedance	Estimated Flow (cfs)	TMDL (lbs/day)	MOS[1] (lbs/day)	LA (lbs/day)	Lake Forest WWTP (lbs/day)
95%	0.46	0.02	--	0.01	0.01
90%	0.54	0.02	--	0.01	0.01
70%	0.86	0.03	--	0.02	0.01
50%	1.58	0.06	--	0.05	0.01
30%	3.05	0.12	--	0.11	0.01
10%	7.97	0.30	--	0.29	0.01
5%	12.98	0.49	--	0.48	0.01

[1] The TP MOS is implicit.

8 WASTELOAD ALLOCATION (POINT SOURCE LOADS)

The WLA is the portion of the LC that is allocated to existing or future point sources of pollutants. New WLAs for the Lake Forest Estates Subdivision WWTP were calculated through the modeling process and are shown in Table 14. The WLAs for CBOD and ammonia should ensure attainment of the DO water quality criterion in Big Bottom Creek if SOD is reduced by 72 percent and DO is increased to 8.0 mg/L. The treatment technology required to meet the CBOD limits corresponding to the WLAs should result in corresponding reductions of organic sediments that will reduce the SOD in Big Bottom Creek. To meet the WLAs, a reduction below existing permit limits is required. The existing and reduced permit limits are summarized in Table 14.

Table 14. WLAs for Lake Forest Estates Subdivision WWTP (MO0035742) in the Big Bottom Creek Watershed

Effluent Parameter	Design Flow (MGD)	Existing Permit Limit (mg/L)		WLA at Design Flow based on QUAL2K and LDC modeling (mg/L)		Percent Reduction
		Concentration (mg/L)	Load (lbs/day)	Concentration (mg/L)	Load (lbs/day)	
$CBOD_5$	0.1183	No limit	No limit	5.04	4.99	Not applicable
$NBOD_5$	0.1183	No limit	No limit	1.46	1.45	Not applicable
TN	0.1183	No limit	No limit	0.289	0.29	Not applicable
TP	0.1183	No limit	No limit	0.007	0.01	Not applicable
NH_3	0.1183	Daily Maximum = 3.7[12] - 7.5[13] Monthly Average = 1.9[14] - 3.7[15]	3.7 - 7.4 1.9 – 3.7	0.3	0.9	50
TSS	0.1183	Weekly Average = 60 Monthly Average = 30	= 59.2 = 29.6	10.0	9.9	67

Notes: $CBOD_5$ is calculated using simulated BOD_5 divided by 1.29, based on 1998 EPA modeling guidance for NH3 toxicity and DO modeling. $NBOD_5$ is the difference between BOD_5 and $CBOD_5$. TN target loading for point sources was based on 289 µgN/L, Ecoregion 39 TN value. TP target loading for point sources was based on 7 µgP/L, Ecoregion 39 TP value. Existing permit limit loads (lbs/day) are based on existing design flow and monthly average limits.

9 LOAD ALLOCATION (NONPOINT SOURCE LOADS)

The LA includes all existing and future nonpoint sources and natural background contributions (40 CFR § 130.2(g)). The LA for the Big Bottom Creek TMDL is for all nonpoint sources of CBOD, NBOD, TSS, TP and TN, which could include loads from agricultural lands, runoff from urban areas, livestock and failing onsite wastewater treatment systems. The LAs provided in Table 11, Table 12 and Table 13 are expected to be protective of water quality in Big Bottom Creek during critical low flow periods. During periods of higher flow, such as when Lake Anne overflows, low DO has not been identified as a water quality problem.

---

[12] Represents limits from May 1 – October 31
[13] Represents limits from November 1 – April 30
[14] Represents limits from May 1 – October 31
[15] Represents limits from November 1 – April 30

10 MARGIN OF SAFETY

A 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 numeric portion of the LC as a separate term in the TMDL.
2) Implicit - Incorporate the MOS as part of the critical conditions for the WLA and LA calculations by making conservative assumptions in the analysis.

An implicit MOS was incorporated into the BOD, CBOD and ammonia TMDLs by identifying a LC that achieves a minimum DO concentration of 5 mg/L at the 7Q10 low flow by using conservative modeling assumptions within QUAL2K. The conservative modeling assumptions included focusing calibration on the measured low DO concentrations, critical low flow conditions and DO concentrations under critical low flow conditions in deriving applicable CBOD, NBOD, NH3 and TSS targets.

For TSS, TN and TP, an implicit MOS was incorporated into the TMDL based on conservative assumptions used in the development of the TMDL LDCs. Among the conservative approaches used was to calculate WLAs by targeting the 25th percentile of TSS concentrations in the geographic region in which Big Bottom Creek is located and to establish WLAs for the Lake Forest Estates WWTP under critical low flow conditions when discharge from this facility will dominate the stream flow. The TN and TP targets for this TMDL are also conservative because they are based on the 25th percentile of all TN and TP data gathered from the Subecoregion 39 of Aggregate Nutrient Ecoregion IX. These targets were derived by EPA to represent conditions of surface waters that are minimally impacted by human activities and protective of aquatic life and recreational uses (EPA, 2000). The 25th percentile is considered a surrogate for establishing a reference population of the pristine systems (EPA 2000).

11 SEASONAL VARIATION

A TMDL must consider seasonal variation in the derivation of the allocations. The pollutants that the TMDL addresses (DO, ammonia and organic sediment) are all affected by temperature and flow. DO levels that threaten the integrity of aquatic communities generally occur during low flow periods and warm temperatures, so these periods are considered the critical condition for the TMDL targets. Annual low-flow conditions in Missouri typically occur between July 1 and September 15. In this TMDL report, summer low flow is defined as a 7-day average flow of the 10-year return frequency (7Q10) dry-weather condition. This TMDL addresses seasonal variation and critical conditions by identifying a LC that would be protective of the DO target during the 7Q10 low flow period.

DO in streams is affected by several factors including water temperature, the amount of decaying matter (i.e. organic sediment) in the stream, turbulence at the air-water interface and the amount of photosynthesis occurring in plants within the stream. Organic sediments and SOD can also contribute to fluctuating DO concentrations in the water column. The effects of high nutrient and BOD concentrations on DO swings and low DO conditions (discussed in Section

5.2) are typically amplified under circumstances in which flow is low and water temperature is relatively high (for example, summer months).

The TMDL LDCs for TSS, TN and TP represent flow under all conditions. Because the WLA, LA and TMDL are applicable at all flow conditions, they are also applicable and protective over all seasons. The advantage of the LDC approach is that all flow conditions are considered and the constraints associated with using a single-flow critical condition are avoided.

12 MONITORING PLAN FOR TMDLS DEVELOPED UNDER PHASED APPROACH

Post-TMDL monitoring will be scheduled by MDNR after new effluent limits in the Lake Forest Estates WWTP permit have gone into effect. In the interim, instream monitoring required by the facility operating permit for pH, temperature, ammonia, and DO upstream and downstream of the facility outfall will be reviewed by MDNR. MDNR will also routinely examine physical habitat, water quality, invertebrate 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.

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.

13 REASONABLE ASSURANCES

MDNR has the authority to issue and enforce Missouri State Operating Permits. Inclusion of effluent limits determined from WLAs established by TMDL modeling into a state permit and monitoring of the effluent and receiving stream reported to MDNR, should provide reasonable assurance that instream WQS will be met. In most cases, "Reasonable Assurance" in reference to TMDLs relates only to point sources. As a result, any assurances that nonpoint source contributors of oxygen consuming substances, ammonia and organic sediment will implement measures to reduce their contribution in the future will not be found in this section.

14 PUBLIC PARTICIPATION

EPA regulations require that TMDLs be subject to public review (40 CFR 130.7). EPA is providing public notice of this draft TMDL for Big Bottom Creek 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 Big Bottom Creek in Ste. Genevieve County, Missouri, is included on the EPA-approved 2008 Missouri 303(d) List. This TMDL is being established 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 meet the *American Canoe* consent decree milestones. Missouri may submit and EPA may approve another TMDL for this water at a later time.

Before finalizing EPA established TMDLs (such as this TMDL), the public is notified that a comment period is open on the EPA Region 7 website for at least 30 days. EPA's public notices to comment on draft TMDLs are also distributed via mail and electronic mail to major stakeholders in the watershed or other potentially impacted parties. After the comment period closes, EPA reviews all comments, edits the TMDL as is appropriate, writes a Summary of Response to Comments and establishes the TMDL. For Missouri TMDLs, groups receiving the public notice announcement include a distribution list provided by MDNR, the Missouri Clean Water Commission, the Missouri Water Quality Coordinating Committee, stream team volunteers, state legislators, County Commissioners, the County Soil and Water Conservation District and potentially impacted cities, towns and facilities. EPA followed this public notice process for this TMDL. Links to active public notices for draft TMDLs, final (approved and established) TMDLs and Summary of Response to Comments are posted on the EPA website: http://www.epa.gov/region07/water/tmdl.htm.

15 ADMINISTRATIVE RECORD AND SUPPORTING DOCUMENTATION

An administrative record on the Big Bottom Creek TMDL has been assembled and is being kept on file with EPA.

References

Athayde, D., P. Shelley, E. Driscoll, D. Gaboury and G. Boyd, 1983. Results of the Nationwide Urban Runoff Program, Volume I.

Chapra, S.C., G. J. Pelletier, and H. Tao, 2008. QUAL2K: A Modeling Framework for Simulating River and Stream Water Quality, Version 2.11: Documentation and Users Manual.

Code of State Regulations (CSR), 2009. Missouri Secretary of State Web page. Title 10 - Department of Natural Resources. Division 20 – Clean Water Commission. Chapter 7 – Water Quality. 10 CSR 20-7.031 - Water Quality Standards. http://www.sos.mo.gov/adrules/csr/current/10csr/10c20-7.pdf

United States Environmental Protection Agency (EPA), 2000. Ambient Water Quality Criteria Recommendations. Information Supporting the Development of State and Tribal Nutrient Criteria. Rivers and Streams in Nutrient Ecoregion XI. EPA 822-B-00-020.

EPA, 2002. Onsite Wastewater Treatment System Manual. EPA/625/R-00/008. U.S. Environmental Protection Agency, Office of Water, Washington, D.C. and Office of Research and Development, Cincinnati, OH. February 2002.

EPA, 2006. Framework for Developing Suspended and Bedded Sediments (SABS) Water Quality Criteria. EPA-822-R-06-001, May 2006.

EPA, 2009. Permit Compliance System (PCS). Accessed July 17, 2009. http://www.epa.gov/enviro/html/pcs/index.html.

Missouri Department of Natural Resources (MDNR), 2009. Northeast Missouri Groundwater Providence. Accessed July 17, 2009. http://dnr.mo.gov/env/wrc/groundwater/education/provinces/nemissouriprovince.htm.

Missouri Resource Assessment Partnership (MoRAP), 2005. Land Use/Land Cover Data. Accessed July 1, 2009, from www.msdis.missouri.edu

Missouri Spatial Data Information Service (MSDIS), 2009. GIS Layers Downloaded May 2009. http://msdis.missouri.edu/datasearch/ThemeList.jsp.

National Environmental Service Center (NESC), 1998. Accessed July 28, 2009. http://bering.tetratech-ffx.com/website/stepl/viewer.htm

National Oceanic and Atmospheric Administration (NOAA), 2009. NNDC Climate Data Online. Accessed July 17, 2009. http://cdo.ncdc.noaa.gov/climatenormals/clim20/mo/234544.pdf.

Natural Resources Conservation Service (NRCS). Accessed July 17, 2009. http://soildatamart.nrcs.usda.gov/Survey.aspx?County=MO001.

Nijboer, R.C. and P.F.M. Verdonschot, 2004. Variable selection for modeling effects of eutrophication on stream and river ecosystems. Ecol. Model. 177, 17-39.

Purdue Research Foundation, 2009. Hydrologic Soil Groups. Accessed July 17, 2009. http://www.ecn.purdue.edu/runoff/documentation/hsg.html, Hydrologic Soil Groups.

Reckhow, K. H., M. N. Beaulac and J. R. Simpson, 1980. Modeling Phosphorous Loading and Lake Response Under Uncertainty: A Manual and Compilation of Export Coefficients. EPA-440/5-8-011, U.S. Environmental Protection Agency, Washington, D.C.

United States Census Bureau. 2000. 2000 Population Estimates. Accessed July 20, 2009. http://www.census.gov/

U.S. Code, 2009. Title 33 of the US Code. Accessed February 19, 2009. http://www.gpoaccess.gov/uscode/

U.S. Department of Agriculture (USDA), 2002. Census of Agriculture. Accessed July 28, 2009. http://bering.tetratech-ffx.com/website/stepl/viewer.htmwww.nass.usda.gov/

U.S. Department of the Interior (USDOI), U.S. Geological Survey, 1997, Standards for Digital Raster Graphics, Reston, VA.

Walker, R.R. and W. J. Snodgrass, 1986. Model for sediment oxygen demand in lakes: Journal of Environmental Engineering, v. 112, no. 1, p. 25-43.

Wang, W., 1980. Fractionation of sediment oxygen demand: *Water Research*. v. 14, p. 603-612.

APPENDIX A – BIG BOTTOM CREEK WATER QUALITY DATA

Table A-1. Historic Water Quality Data in Big Bottom Creek (See Sec 3, Tables 6 and 7 for 2009 data)

Org	Site	Site Name	Date	Temperature (°C)	DO (mg/L)	pH	NH_3-N (mg/L)	CBOD (mg/L)
MDNR	1746/1.1	Big Bottom Cr. just ab. Lake Forest Lgn.	6/9/2004		5.7	7.8		
MDNR	1746/1.1	Lake Forest Lgn Effluent	6/9/2004		6.4	7.6		
MDNR	1746/1.1	Big Bottom Cr. just bl. Lake Forest Lgn.	6/9/2004		4.8	7.7		
MDNR	1746/1.1	Big Bottom Cr. just bl. Lake Forest Lgn.	7/1/2004	26	4.4	7.5	2.65	3.17
MDNR	1746/1.1	Big Bottom Cr. just bl. Lake Forest Lgn.	7/2/2004	23.5	1.1	7.5	5.58	2.91
MDNR	1746/1.1	Big Bottom Cr. just bl. Lake Forest Lgn.	4/19/2005	17	1.1			
MDNR	1746/1.1	Big Bottom Cr. just bl. Lake Forest Lgn.	4/19/2005	20	8.2			
MDNR	1746/1.1	Big Bottom Cr. just bl. Lake Forest Lgn.	6/9/2005	23.9	0.8	7.4	12.4	8
MDNR	1746/1.1	Big Bottom Cr. just bl. Lake Forest Lgn.	6/9/2005	24.9	1.9	7.5	12.5	6.5
MDNR	1746/1.1	Big Bottom Cr. just bl. Lake Forest Lgn.	8/18/2006	24.8	4.7			
MDNR	1746/1.1	Big Bottom Cr. just bl. Lake Forest Lgn.	8/18/2006	28.3	7.2			
MDNR	1746/1.1	Big Bottom Cr. just ab. Lake Forest Lgn.	8/2/2007	26	6.2	7.7	0.76	2.09
MDNR	1746/0.5	Big Bottom Cr. just ab. Indian Cr.	7/1/2004	18	4.7	7.5	0.01499	0.99
MDNR	1746/0.5	Big Bottom Cr. just ab. Indian Cr.	7/2/2004	17	4.2	7.5	0.01499	0.99
MDNR	1746/0.5	Big Bottom Cr. just ab. Indian Cr.	4/19/2005	13	4.2			
MDNR	1746/0.5	Big Bottom Cr. just ab. Indian Cr.	4/19/2005	17	9			
MDNR	1746/0.5	Big Bottom Cr. just ab. Indian Cr.	6/9/2005	14.1	2.4	7.3	0.01499	0.99
MDNR	1746/0.5	Big Bottom Cr. just ab. Indian Cr.	6/9/2005	14.2	2.6	7.4	0.01499	0.99
MDNR	1746/0.5	Big Bottom Cr. just ab. Indian Cr.	8/18/2006	20.7	5			
MDNR	1746/0.5	Big Bottom Cr. just ab. Indian Cr.	8/18/2006	26.8	6.9			
MDNR	1747/0.01	Indian Cr. nr. Mouth	7/1/2004	22	6.3	7.7	0.01499	0.99
MDNR	1747/0.01	Indian Cr. nr. Mouth	7/2/2004	19.5	5.5	7.5	0.01499	0.99
MDNR	1747/0.01	Indian Cr. nr. Mouth	4/19/2005	13	6.3			
MDNR	1747/0.01	Indian Cr. nr. Mouth	4/19/2005	21	13			
MDNR	1747/0.01	Indian Cr. nr. Mouth	6/9/2005	19.8	4.6	7.7	0.01499	0.99
MDNR	1747/0.01	Indian Cr. nr. Mouth	6/9/2005	25	12	8.4		

Org	Site	Site Name	Date	Temperature (°C)	DO (mg/L)	pH	NH_3-N (mg/L)	CBOD (mg/L)
MDNR	1747/0.01	Indian Cr. nr. Mouth	8/18/2006					
MDNR	1746/0.03	Big Bottom Cr. nr. Mouth	7/1/2004	23	7.4	7.7	0.01499	0.99
MDNR	1746/0.03	Big Bottom Cr. nr. Mouth	7/2/2004	22	4.4	7.7	0.01499	0.99
MDNR	1746/0.03	Big Bottom Cr. nr. Mouth	4/19/2005	14	6			
MDNR	1746/0.03	Big Bottom Cr. nr. Mouth	4/19/2005	21	13			
MDNR	1746/0.03	Big Bottom Cr. nr. Mouth	6/9/2005	21.3	2.8	7.7	0.01499	0.99
MDNR	1746/0.03	Big Bottom Cr. nr. Mouth	6/9/2005	24	9.3	8		
MDNR	1746/0.03	Big Bottom Cr. nr. Mouth	8/18/2006	20.9	2			
MDNR	1746/0.03	Big Bottom Cr. nr. Mouth	8/18/2006	24.3	3.4			

Blank cells indicate that no sample was collected for that parameter and date.

Lgn = Lagoon; Cr = Creek; nr = near
C = temperature in degrees Celsius
DO = Dissolved Oxygen
NH_3N = Ammonia as Nitrogen
CBOD = Carbonaceous Biochemical Oxygen Demand (5 days)
MDNR = Missouri Department of Natural Resources

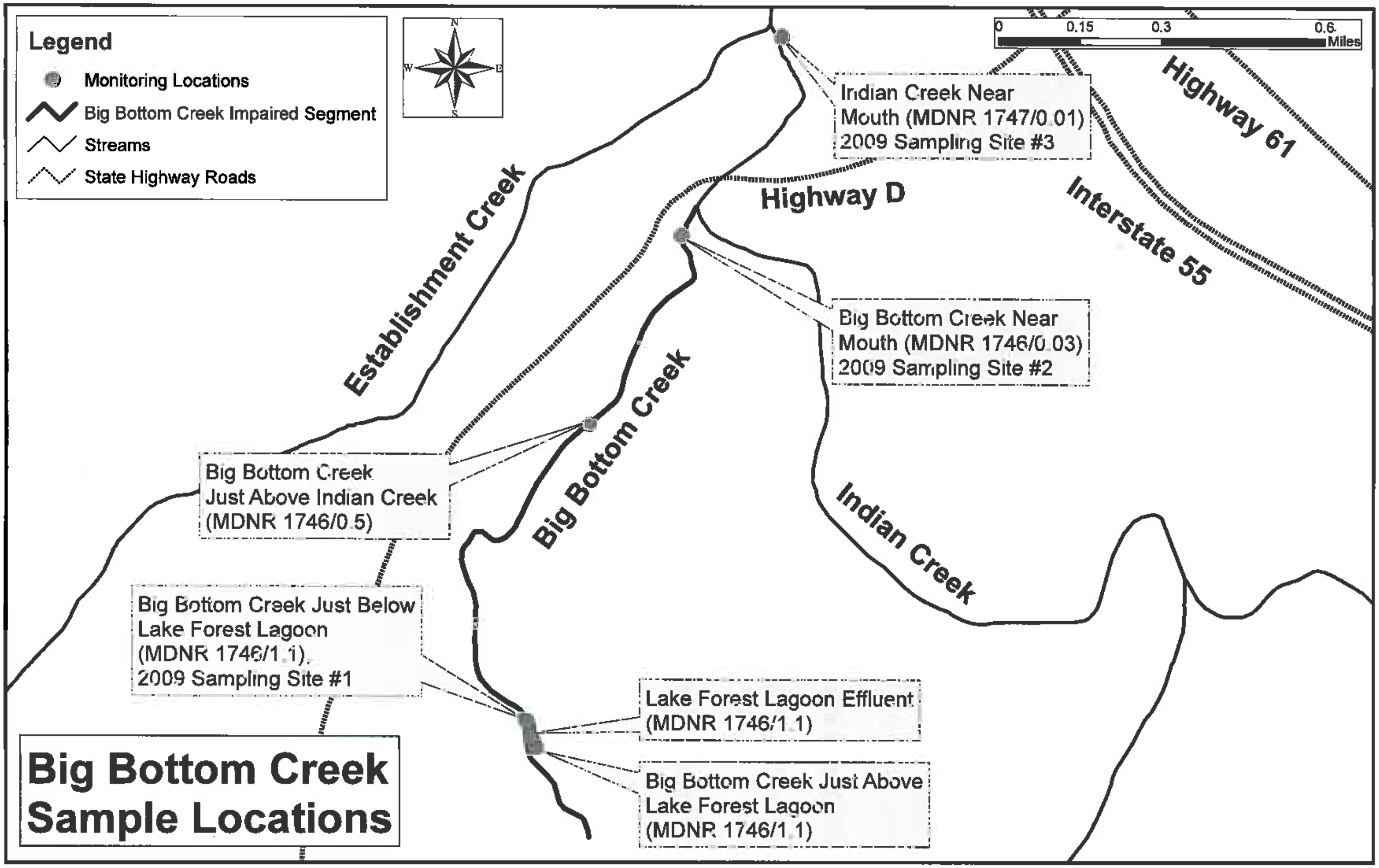


Figure A-1. Location of Big Bottom Creek 2009 Water Quality Monitoring Stations

APPENDIX B - BIG BOTTOM CREEK QUAL2K MODELING

B.1 Overview of QUAL2K

The QUAL2K water quality model, version 2.11b8, was selected for the development of the Big Bottom Creek Dissolved Oxygen (DO) Total Maximum Daily Load (TMDL). QUAL2K is supported by the U. S. Environmental Protection Agency (EPA) and has been used extensively for TMDL development and point source permitting issues across the country, especially for issues related to DO concentrations. The QUAL2K model is suitable for simulating hydraulics and water quality conditions of small rivers and creeks. It is a one-dimensional uniform flow model with the assumption of a completely mixed system for each computational cell. QUAL2K assumes that the major pollutant transport mechanisms, advection and dispersion, are significant only along the longitudinal direction of flow. The model allows for multiple waste discharges, water withdrawals, nonpoint source loading, tributary flows and incremental inflows and outflows. The processes employed in QUAL2K can address nutrient cycles, algal growth, particulate settling, Sediment Oxygen Demand (SOD) and DO dynamics.

B.2 QUAL2K Model Setup

This section of the appendix describes the process that was used to setup the QUAL2K models for the Big Bottom Creek watershed.

B.2.1 Stream Segmentation

Figure B-1 and Figure B-2 provide a visual description of the Big Bottom Creek QUAL2K model structure; including locations of monitoring stations, point sources, nonpoint sources and boundaries. The impaired water body segment is divided into seven reaches; reach lengths are provided in Table B-1. The stream segment was divided into reaches based on the location of water quality monitoring stations, stream hydrology, National Pollutant Discharge Elimination System (NPDES) discharges, shading estimates and point/nonpoint sources. Reaches are further segmented into elements as identified in Table B-1. One wastewater treatment facility, the Lake Forest Estates Subdivision Wastewater Treatment Plant (WWTP), is represented as a point source in reach one and a tributary; Indian Creek is represented as a point source to reach seven.

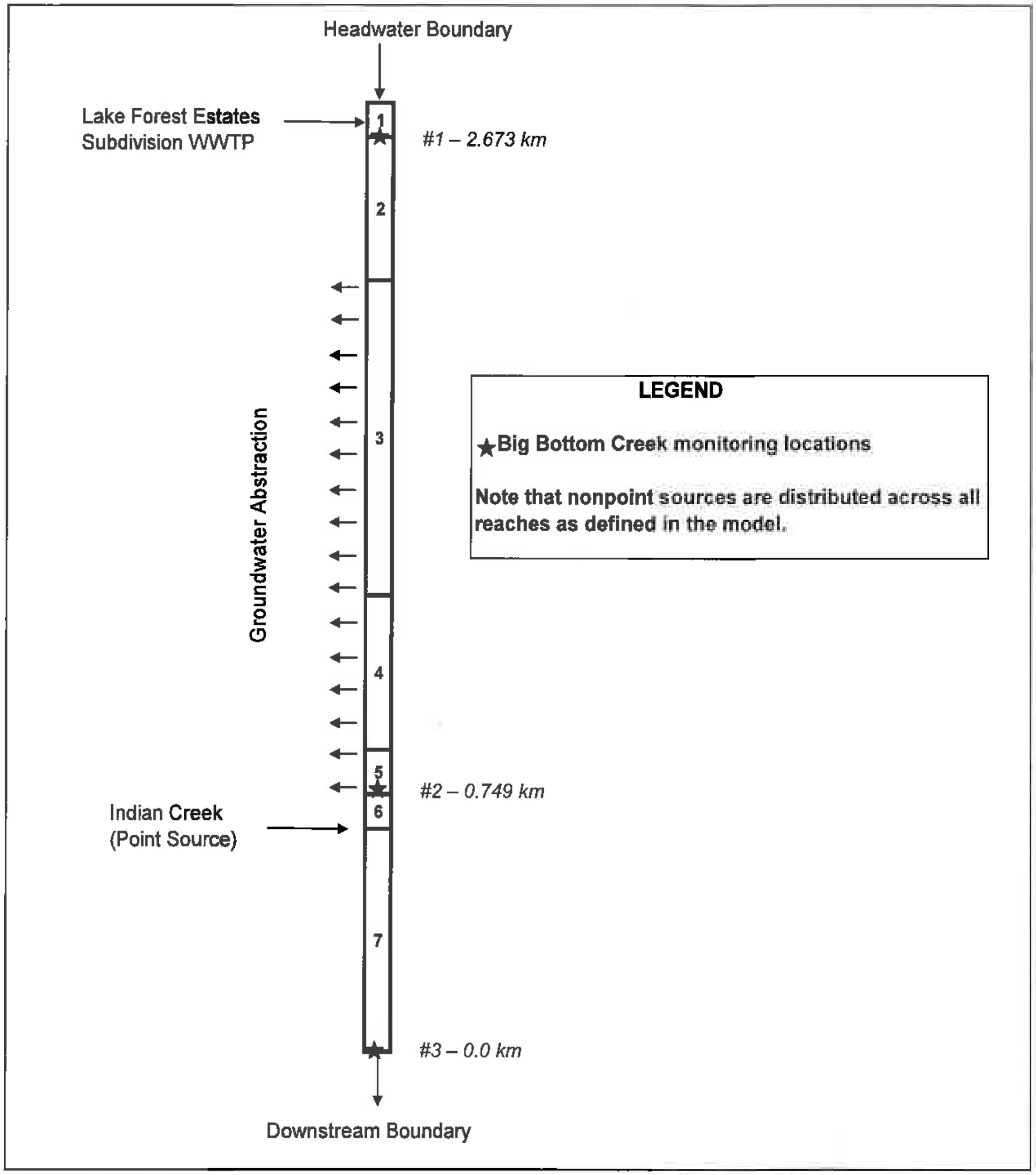


Figure B-1. Diagram of Big Bottom Creek QUAL2K Watershed Model

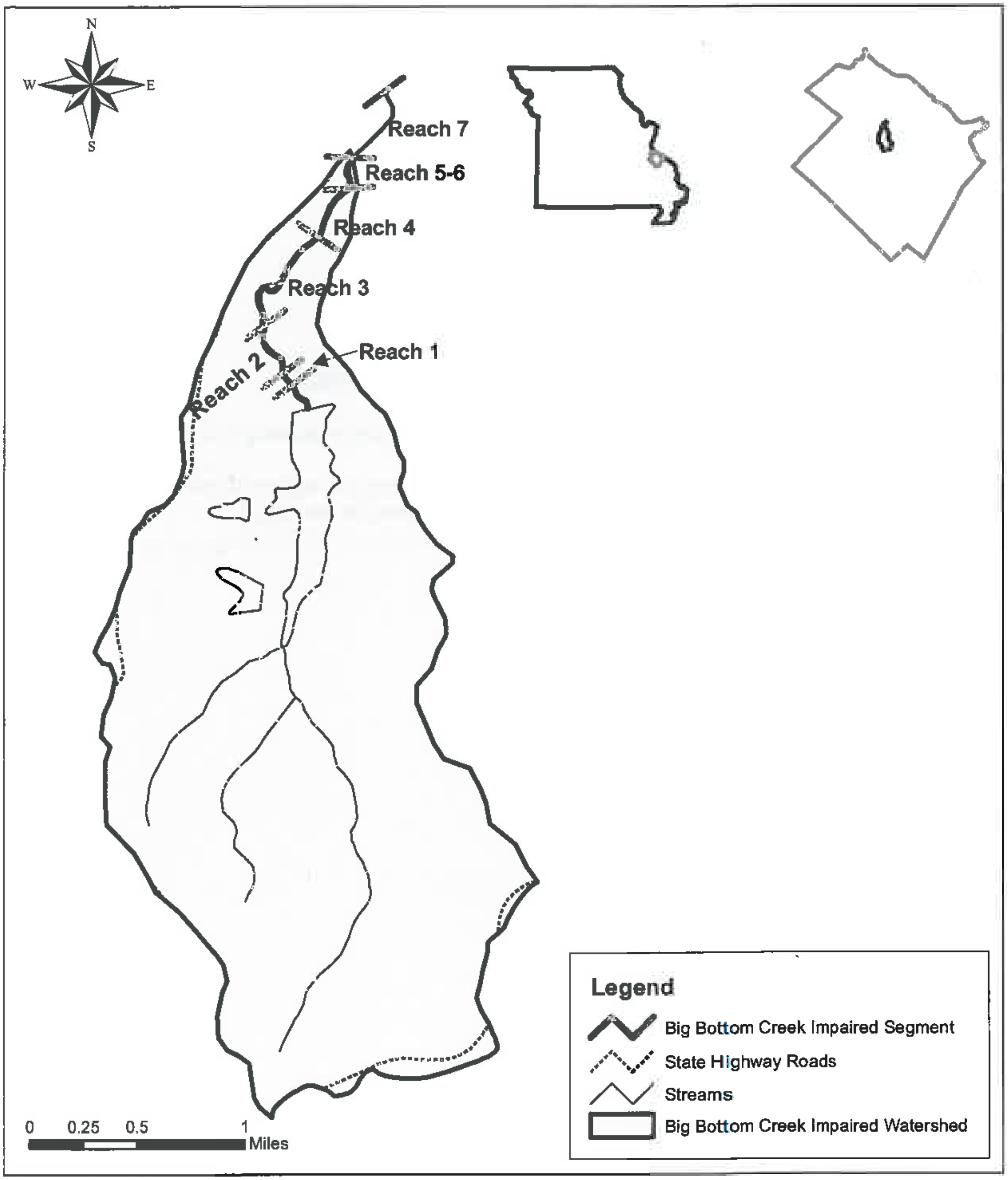


Figure B-2. Reaches in Big Bottom Creek QUAL2K Model

Table B-1. Number of Reaches and Elements Associated with Each Reach In Big Bottom Creek

Reach Number	Reach Length (kilometers)	Number of Elements	Element Length (meters)
1	0.10	1	100
2	0.42	6	70
3	0.92	8	115
4	0.45	5	90
5	0.13	2	65
6	0.10	1	100
7	0.65	7	93

B.2.2 Geometry, Elevation and Weather Data

Measurement of stream velocities, widths and depths collected at three locations in Big Bottom Creek were used to calculate flow rates at each location. QUAL2K allows the user to calculate the flow balance using one of three approaches: weirs, rating curves and Manning equations. The rating curve method was selected and applied to each QUAL2K simulation for Big Bottom Creek. Inputs for velocity and depth were developed from Equations 1 and 2, which are further described in the QUAL2K User's Manual (Chapra, 2008):

$$U = aQ^b$$ **Equation 2**

Where,
U = Velocity (m/s)
a = Empirical Coefficient
b = Empirical Coefficient
Q = Flow (m3/s)

$$H = \alpha Q^\beta$$ **Equation 3**

Where,
H = Depth (m)
α = Empirical Coefficient
β = Empirical Coefficient

a, b, α and β are empirical coefficients that are determined from velocity-discharge and stage-discharge rating curves. Within QUAL2K the values of velocity and depth are used to estimate reach average cross-sectional area and width by:

$$A_c = \frac{Q}{U}$$ **Equation 4**

Where,

A_c = average cross-sectional area (m^2)
Q = flow (m^3/s)
U = velocity (m/s)

$$B = \frac{A_c}{H}$$ **Equation 5**

Where,

B = width (m)
A_c = average cross-sectional area (m^2)
H = depth (m)

The surface area and volume of the element can then be computed as:

$$A_s = B\Delta x$$ **Equation 6**

Where,

A_s = surface area (m^2)
B = width (m)
Δx = length of element

$$V = BH\Delta x$$ **Equation 7**

Where,

V = volume (m^3)
B = width (m)
H = depth (m)
Δx = length of element

The measured hydraulic characteristics collected during the spring and summer of 2009 are included in Table B-2 and the rating curves calculated from this data are included in Table B-3.

Table B-2. Stream characteristics for Big Bottom Creek used to develop QUAL2K model hydraulic inputs

Time	Site	Date	Width (meters)	Average Depth (meters)	Area (square meters)	Velocity (m/s)	Flow (cms)	Event
AM	Big Bottom 1	07/07/09	3.659	0.185	0.68	0.07626	0.052	July WLA
PM	Big Bottom 1	07/07/09	3.659	0.208	0.76	0.03614	0.028	July WLA
AM	Big Bottom 1	07/08/09	3.659	0.165	0.6	0.01754	0.011	July WLA
PM	Big Bottom 1	07/08/09	3.659	0.216	0.79	0.03737	0.03	July WLA
AM	Big Bottom 1	08/12/09	3.582	0.174	0.63	0.0123	0.008	Aug WLA
PM	Big Bottom 1	08/12/09	3.659	0.175	0.64	0.01206	0.008	Aug WLA
AM	Big Bottom 1	08/13/09	3.659	0.165	0.6	0.01707	0.01	Aug WLA
PM	Big Bottom 1	08/13/09	3.811	0.175	0.67	0.01436	0.01	Aug WLA
AM	Big Bottom 2	07/07/09	3.659	0.241	0.88	0.06098	0.054	July WLA
PM	Big Bottom 2	07/07/09	3.354	0.294	0.99	0.03101	0.031	July WLA

Time	Site	Date	Width (meters)	Average Depth (meters)	Area (square meters)	Velocity (m/s)	Flow (cms)	Event
AM	Big Bottom 2	07/08/09	3.354	0.255	0.86	0.01223	0.01	July WLA
PM	Big Bottom 2	07/08/09	3.354	0.238	0.8	0.00773	0.006	July WLA
AM	Big Bottom 3	07/07/09	10.823	0.406	4.39	0.0768	0.337	July WLA
PM	Big Bottom 3	07/07/09	12.652	0.371	4.69	0.02894	0.136	July WLA
AM	Big Bottom 3	07/08/09	12.652	0.36	4.56	0.02397	0.109	July WLA
PM	Big Bottom 3	07/08/09	12.652	0.358	4.53	0.01862	0.084	July WLA
AM	Big Bottom 3	08/12/09	12.652	0.289	3.66	0.00857	0.031	Aug WLA
PM	Big Bottom 3	08/12/09	12.576	0.3	3.78	0.01617	0.061	Aug WLA
AM	Big Bottom 3	08/13/09	12.652	0.292	3.69	0.01115	0.041	Aug WLA
PM	Big Bottom 3	08/13/09	12.652	0.295	3.73	0.0121	0.045	Aug WLA

Table B-3. Rating Curve QUAL2K Model Inputs

Reach	Velocity		Depth	
	Coefficient	Exponent	Coefficient	Exponent
1	0.9979	0.9035	0.2746	0.0976
2	0.8867	0.9377	0.2877	0.0297
3	0.8867	0.9377	0.2877	0.0297
4	0.8867	0.9377	0.2877	0.0297
5	0.8867	0.9377	0.2877	0.0297
6	0.8867	0.9377	0.2877	0.0297
7	0.1837	0.8891	0.5036	0.1650

Hourly weather data for air temperature, dew point temperature and wind speed were retrieved from the National Climatic Data Center (NCDC). Weather data from the Farmington Regional Airport weather station (ID FAM) were used because this was the closest NCDC station with the appropriate data. Table B-4 displays the hourly weather data for July 7 - 8, and August 12 - 13, 2009, that was used during the calibration.

Table B-4. Hourly Weather Data for July 7 - 8, and August 12 - 13, 2009, from the Farmington Regional Airport weather station (ID FAM)

Date/Time	Air temperature C	Dew point temperature C	Wind speed (meters/second)	Cloud cover
July 7, 2009				
12:00 AM	18	17	0.0	0%
1:00 AM	16	14	0.0	0%
2:00 AM	16	14	0.0	0%
3:00 AM	15	14	0.0	0%
4:00 AM	14	13	0.0	0%
5:00 AM	14	13	0.0	0%
6:00 AM	14	13	0.0	0%
7:00 AM	14	14	0.0	0%
8:00 AM	18	16	0.0	0%
9:00 AM	23	17	2.0	0%
10:00 AM	25	15	2.0	0%

Date/Time	Air temperature C	Dew point temperature C	Wind speed (meters/second)	Cloud cover
11:00 AM	26	15	2.0	6%
12:00 PM	26	16	2.0	44%
1:00 PM	27	14	0.0	56%
2:00 PM	27	16	2.0	36%
3:00 PM	29	15	2.0	31%
4:00 PM	29	15	3.0	54%
5:00 PM	29	15	3.0	6%
6:00 PM	28	16	2.0	0%
7:00 PM	28	16	2.0	0%
8:00 PM	26	16	0.0	0%
9:00 PM	23	17	0.0	0%
10:00 PM	22	17	0.0	0%
11:00 PM	19	17	0.0	0%
July 8, 2009				
12:00 AM	18	17	0.0	0%
1:00 AM	17	16	0.0	0%
2:00 AM	17	16	0.0	0%
3:00 AM	17	16	0.0	0%
4:00 AM	16	16	0.0	0%
5:00 AM	16	15	0.0	72.9%
6:00 AM	16	15	0.0	64.6%
7:00 AM	16	16	0.0	20.9%
8:00 AM	19	17	0.0	0.0%
9:00 AM	23	18	0.0	0.0%
10:00 AM	26	16	2.2	0.0%
11:00 AM	28	16	3.1	0.0%
12:00 PM	28	15	2.7	0.0%
1:00 PM	29	14	0.0	14.6%
2:00 PM	29	15	3.1	6.3%
3:00 PM	30	15	1.3	6.3%
4:00 PM	30	14	0.0	64.6%
5:00 PM	30	14	2.2	12.5%
6:00 PM	29	14	2.7	14.6%
7:00 PM	29	15	1.3	6.3%
8:00 PM	27	17	2.7	0.0%
9:00 PM	24	18	2.2	0.0%
10:00 PM	21	18	0.0	0.0%
11:00 PM	20	18	0.0	0.0%
August 12, 2009				
12:00 AM	17	16	0.0	0.0%
1:00 AM	19	18	0.0	0.0%
2:00 AM	18	17	0.0	0.0%
3:00 AM	18	17	0.0	0.0%
4:00 AM	17	17	0.0	0.0%
5:00 AM	17	16	0.0	0.0%

Date/Time	Air temperature C	Dew point temperature C	Wind speed (meters/second)	Cloud cover
6:00 AM	18	16	0.0	0.0%
7:00 AM	17	16	0.0	0.0%
8:00 AM	20	18	0.0	0.0%
9:00 AM	23	19	2.0	0.0%
10:00 AM	24	19	0.0	0.0%
11:00 AM	26	18	2.0	14.6%
12:00 PM	27	17	3.0	75.0%
1:00 PM	28	16	4.0	56.3%
2:00 PM	28	16	2.0	64.6%
3:00 PM	28	16	3.0	35.5%
4:00 PM	29	16	4.0	20.9%
5:00 PM	28	17	5.0	18.8%
6:00 PM	28	16	4.0	12.5%
7:00 PM	26	17	3.0	0.0%
8:00 PM	23	17	3.0	0.0%
9:00 PM	21	17	3.0	0.0%
10:00 PM	19	16	0.0	0.0%
11:00 PM	18	16	0.0	0.0%
August 13, 2009				
12:00 AM	17	16	0.0	0.0%
1:00 AM	16	14	0.0	0.0%
2:00 AM	16	15	0.0	0.0%
3:00 AM	15	14	0.0	0.0%
4:00 AM	15	14	0.0	0.0%
5:00 AM	14	13	0.0	0.0%
6:00 AM	14	13	0.0	0.0%
7:00 AM	14	13	7.0	0.0%
8:00 AM	17	15	0.0	0.0%
9:00 AM	21	17	0.0	0.0%
10:00 AM	24	17	2.0	0.0%
11:00 AM	25	16	2.0	0.0%
12:00 PM	27	15	2.0	0.0%
1:00 PM	28	14	0.0	0.0%
2:00 PM	28	15	3.0	0.0%
3:00 PM	29	13	3.0	0.0%
4:00 PM	29	13	4.0	0.0%
5:00 PM	29	14	4.0	0.0%
6:00 PM	29	15	4.0	0.0%
7:00 PM	27	16	4.0	0.0%
8:00 PM	24	16	3.0	0.0%
9:00 PM	22	16	3.0	0.0%
10:00 PM	20	16	0.0	0.0%
11:00 PM	18	16	0.0	0.0%

B.2.3 Boundary Conditions

Headwater boundary conditions for the July QUAL2K model runs were estimated using data collected at site #3 and the point source loads were estimated by conducting a mass balance. Since there was flow above the WWTP during July and no data collected at this location water quality data from site #3 was used because it was far downstream and is relatively unimpacted by point sources. For the July events flows were known for the Lake Forest WWTP and site #1; therefore flows from the head waters were calculated using a flow balance approach. Water quality concentrations were known for sampling site #1 and estimated for the headwaters (from site #3 data); therefore the loads from the Lake Forest WWTP could be calculated using a simple mass balance approach.

Ammonia was assumed to be zero for the headwaters concentration because all measured concentrations were below the detection limit and total kjeldahl nitrogen (TKN) values were low at site #3. This assumption allowed the permitted ammonia limit to be used in the model for the July events.

Time-variable diel temperature and DO fluctuations were employed for headwater conditions. The diel output from initial model runs was used to calculate the magnitude and timing of headwater temperature and DO fluctuations. No headwater flow was observed during the August sampling events. Table B-5 summarizes each of the model headwater inputs.

Table B-5. Big Bottom Creek QUAL2K headwater model input values for July and August simulations

Constituent	QUAL2K Headwater Model Input values			
	July 7, 2009	July 8, 2009	August 12, 2009	August 13, 2009
Flow (cms)	0.0365	0.0156	No flow was present above the Lake Forest WWTP during the August sampling events. The Lake Forest WWTP discharge is the most upstream flow in the model.	
Temperature (Deg C)	22.87 – 26.22	24.80 – 27.80		
Dissolved Oxygen (mg/l)	4.00-7.25	2.50-3.30		
CBOD Ultimate (mg/L)	3.3	2.8		
Organic Nitrogen (μg/L)	284.0	490		
NH_4-Nitrogen (μg/L)	0.0	0.0		
NO_3-Nitrogen (μg/L)	398.0	340.0		
Organic Phosphorus (μg/L)	41.7	36.7		
Inorganic Phosphorus (μg/L)	17.9	15.71		
Total Alkalinity as $CaCO_3$ (mg/L)	50	25		
pH	7.9	7.00		

Notes: cms = cubic meters per second; temperature varies hourly; mg/L = milligrams per liter; μg/L = micrograms per liter; Deg C = degrees celsius

B.2.4 Point Sources

Two point sources are represented in the Big Bottom Creek QUAL2K models: 1) Lake Forest WWTP at 2.67 kilometers (km), and 2) Indian Creek tributary at 0.65 km. The Lake

Forest WWTP point source is the only known "end of pipe" discharge within the impaired reach and the only source identified on the CWA 303(d) list. Indian Creek tributary was modeled as a point source rather than a discrete stream segment, since little data is available on Indian Creek and the model only needs to account for its flow and estimated pollutant loads.

The Lake Forest WWTP point source boundary conditions were based upon a simple mass balance between assumed headwater concentrations and sampling site #1.and instream data collected at sample site #1 during the August event. During August there was no flow upstream of the Lake Forest WWTP; therefore, sampling Location #1, located approximately 15 meters downstream of the WWTP discharge, was used to represent WWTP discharge characteristics. Because there was no headwater flow during the August sample dates and the stream flow at this location was comprised entirely of the WWTP discharge. Point source input data used for the July and August modeling events are summarized in Table B-6.

Table B-6. Point Source Input Data Summary

Facility Name & NPDES	Date	Discharge Point (km)	Flow (cms)	$CBOD_u$ (mg/L)	NH_3 N (µg/L)	Organic N (µg/L)	Nitrate+Nitrite N (µg/L)	Organic P (µg/L)	Inorganic P (µg/L)	DO (mg/L)
Lake Forest Estates Subdivision WWTP	July 7, 2009	2.69	0.0044	33.5	1900	4400	871	394	169	2.20
Lake Forest Estates Subdivision WWTP	July 8, 2009	2.69	0.0044	33.5	1900	1885	871	394	169	2.20
Lake Forest Estates Subdivision WWTP	August 12, 2009	2.69	0.0033	5.2	1400	2500	700	450	182	2.72
Lake Forest Estates Subdivision WWTP	August 13, 2009	2.69	0.0033	6.05	1126	1827	809	424	182	3.07

Notes: Discharge location is based on the distance to the end of the stream; Inorganic P estimated to be 70 percent of TP and Organic P estimated to be 30 percent of TP based on EPA, 1997.

B.2.5 Critical Conditions

Critical conditions for developing the TMDL were selected based upon the available data. As shown in Table B-7, the August 12, 2009, sampling event included a DO measurement of 1.75 mg/L. This date was therefore adopted as the critical condition.

Table B-7. Minimum measured DO (mg/L) at each sampling location

Sampling Location	Stream distance (km)	7/7/2009	7/8/2009	8/12/2009	8/13/2009
1	2.673	4.97	3.65	1.75	1.84
2	0.749	7.48	5.83	ND	ND
3	0.000	8.44	5.05	4.72	4.43

Notes: Stream distance is measured from the most downstream sampling station.
ND = No data was measured at this site

B.3 Model Calibration

This section of the appendix describes the process that was used to calibrate the QUAL2K model for the Big Bottom Creek watershed and presents the calibration results.

B.3.1 Flow and Water Depth Simulations

The QUAL2K model for Big Bottom Creek was calibrated for flow, stream velocities and depths for the data collected on July 7 - 8, and August 12 - 13, 2009. The power function included in the QUAL2K model was selected for the flow simulation method. The flow and its related parameters (velocity and depth) can be reasonably simulated using this method.

QUAL2K addresses boundary headwater flows and point source flows during calibration. Flow can also be "lost" from the model through the simulation of losing reaches or water withdrawals. Measured flow was not available for the upstream boundary headwater, so headwater flows were calibrated to flows measured at Sample Location #1 after allowing for the Lake Forest WWTP point source flow.

Point source flow data for the Lake Forest WWTP was obtained from daily monitoring reports (DMRs) that were provided by MDNR. The July and August daily flow data was obtained directly from the Lake Forest WWTP operator, since it had not yet been reported to MDNR when the models were constructed.

Field observations showed that portions of Big Bottom Creek ran dry during the August sampling events and flow decreased during the July sampling events. The streambed within the dry sections was largely composed of gravel. Since there was no headwater flow observed during this period, the only source of stream flow between Sample Location #1 and the dry stream bed was the Lake Forest WWTP. The reported WWTP flow data was used to estimate a groundwater withdrawal (abstraction) rate of 0.0033 cms between the 0.75 and 2.25 km segment of Big Bottom Creek during the August events. Because of the uncertainty associated with flow measurements this abstraction rate was used for all periods simulated.

Depths, widths and velocities for each reach were related to flow using the power equations. Stream velocity, depth, discharge and time of travel are all critical to the water quality simulation because they influence reaeration and DO, biogeochemical reactions and deposition rates, growth of algal species and the influence of SOD in the stream.

Figure B-3 shows the comparisons of flow, depth and velocity between the modeled results and the observed data for the July 7 - 8, 2009 simulations.

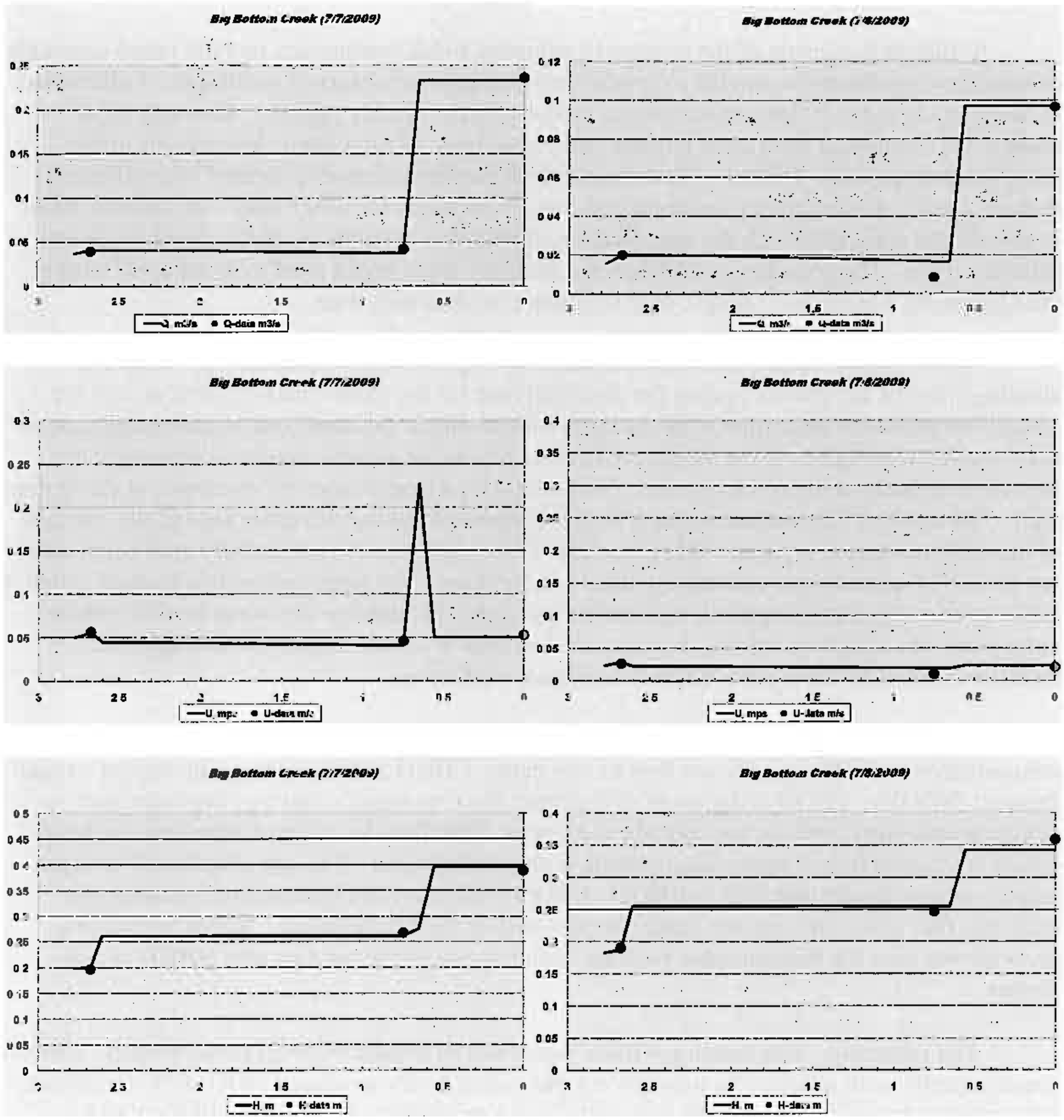


Figure B-3. Comparisons of observed and simulated flow (Q), velocity (U) and depth (H) in Big Bottom Creek

B.3.2 Water Quality Calibration

Calibration consists of the process of adjusting model parameters and the initial estimates of boundary conditions to provide a suitable representation of observed conditions. Calibration is necessary because of the semi-empirical nature of water quality models. Although these models are formulated from mass balance principles, most of the kinetic descriptions in the models are empirically derived. These empirical derivations contain a number of coefficients that are usually determined by calibration to data collected in the water body. In addition, there is uncertainty associated with the specification of boundary conditions, point source loads and tributary loads. The boundary conditions and tributary loads might need to be adjusted within the uncertainty bounds of available data to achieve model calibration.

Water quality models are often evaluated through visual comparisons, in which the simulated results are plotted against the observed data for the same location and time and are visually evaluated to determine if the model is able to mimic the trend and overall magnitude of the observed conditions. If the model predictions follow the general trend and reproduce the overall magnitude of the observed data, the model is said to represent the dynamics of the system well. The merit of this method is that it is straightforward, taking full advantage of the strength of human intelligence in pattern identification. This method works particularly well when data are limited in quantity and contain significant uncertainty. The limitation of this method is that it relies on the subjective judgment of modelers and lacks quantitative measures to differentiate among sets of calibration results. Because of this, both a visual comparison and quantitative measures were used during the Big Bottom Creek calibration.

BOD is an important calibration parameter because of its influence on DO concentrations. BOD typically consists of two parts: CBOD and nitrogenous biological oxygen demand (NBOD). CBOD is the result of the breakdown of organic carbon molecules such as cellulose and sugars into carbon dioxide and water. NBOD is the result of ammonia oxidation, which is a conversion of ammonia to nitrate in the environment. The consumption of nitrogen usually occurs slower than that of CBOD. CBOD is the oxygen consumed by heterotrophic microbes that utilize the organic matter of the waste in their metabolism. Nitrifying bacteria grow slower than the heterotrophic bacteria, which is one of the reasons why NBOD occurs slower.

The parameter "fast reacting CBOD" was used to simulate CBOD in the models. $CBOD_5$ measurements were adjusted by multiplying each value by the average $CBOD_5$:CBOD-ultimate ratio observed at all stations on the July and August monitoring dates. The $CBOD_5$:CBOD-ultimate ratio was calculated to be 1.9. This approach to adjusting $CBOD_5$ model inputs was used for headwater, tributary and WWTP source loads. The first order kinetic reaction rates for biogeochemical reactions are influenced from the various flow and chemical conditions in streams. Kinetic rates may be estimated from the observed data, stream distance and velocity. However, the estimated rates based on the field data are a function of different physical and chemical mechanisms such as mixing and turbulence, the particulate and dissolved chemical components ratio, physical settling, biochemical decompositions and sorption by biological slimes on river bottom. The final selections were made as a result of sensitivity analyses to compare the model results to the observed value using the range from the literature values

(Brown and Barnwell, 1987; EPA, 1997; EPA, 1985). Reaction rates producing the best match to the observed data were selected for the final calibration.

Water quality calibration for the Big Bottom Creek QUAL2K model relied on comparison of model predictions to observations at three stations on the main stem of the system. The July 7 - 8, 2009, data sets were selected for model calibration. Model validation was subsequently performed with the August 12 - 13, 2009 data set. A single set of kinetic parameters was selected that resulted in the best fit for both the calibration and validation periods. This final calibration and validation parameter set was used in the TMDL model runs.

Lateral inflow concentrations representing the lone tributary were initially set equal to the observed headwater concentrations but were then adjusted to best match the observed data. The Indian Creek point source concentrations were initially estimated from the average Sampling Location #3 lab results for August, since there was no flow observed upstream at Sampling Location #2 and Indian Creek was the only source during the August sampling events. The BOD and nutrient concentrations were then calibrated to match the Sampling Location #3 observed data for each simulation. Temperature and DO inputs for Indian Creek were also calibrated to field observations at Sampling Location #3.

SOD by benthic sediments and organisms can be a large fraction of oxygen consumption in the stream. Benthic sediments can be composed of inorganic minerals and organic material such as leaf litter, particulate and dissolved BOD, detritus from phytoplankton/periphyton and macrophytes. Reduced inorganic and organic materials can exert SOD by diffused oxygen into sediments or oxygen consumption in water columns after the inorganic and organic materials are suspended from the sediments. In addition to physical and chemical characteristics of sediments, the impact that SOD has on water column DO can be affected by water depth, stream velocity and water temperature.

SOD is primarily a function of oxidation of dissolved ammonium, methane and decomposition of organic matter by bacteria. Additionally, dissolved hydrogen sulfide and reduced iron and manganese could consume DO once they diffuse into the aerobic sediment layers. The amount of organic matter can be related to SOD consumption.

Organic matter can be described by Redfield ratio, $C_{106}H_{263}O_{110}N_{16}P$. As this ratio suggests, the bacterial conversion (decomposition) of the organic matter can generate the rapidly reactive dissolved N and C species. These species eventually exert SOD from both in sediments and at the interface between water column and sediments. SOD can be measured using the respiration chamber but the method can have high uncertainty and the data was not collected for Big Bottom Creek. SOD values were estimated using the QUAL2K sediment diagenesis routines. Percent bottom SOD coverage was based on the percent fine material identified in the stream reach during the 2009 sampling events.

Benthic algae (periphyton) kinetics also has a marked effect on DO concentrations and diurnal swings (EPA, 1985). Periphyton dynamics were included in model calibration to account for the current observation and historical presence (e.g., Environmental Resources Coalition, 2005) of bottom algae and for the observed diurnal variation in DO. Algal growth, respiration, death and related nutrient kinetics were adjusted within typical ranges reported by the literature (EPA, 1985; Ambrose, 2006) to best match the observed DO variations and nutrient concentrations from the July sampling events.

The Tsivoglou-Neal reaeration model was selected for Big Bottom Creek because it is the most appropriate model to predict reaeration for flows less than 10 cfs (Tsivoglou and Neal, 1972; Thomann and Mueller, 1987). Under low flow (Q = 0.0283 to 0.4247 cms (1 to 15 cfs)), the reaeration model formula is as follows:

$$k_{ah}(20) = 31{,}183US \qquad \textbf{Equation 9}$$

Where,

k_{ah} = the reaeration rate at 20 °C
U = velocity (m/s)
S = channel slope (m/m)

A sensitivity analysis showed that this method better accounted for the relatively shallow stream. Other methods tended to overestimate reaeration.

The final rates used for the Big Bottom Creek calibration are presented in Table B-8. Figures B-4 through B-10 show the results of the model calibrations, including temperature, DO, CBOD, TKN, NH_4-N, NO_3-N, TN, TP and bottom algae. A visual inspection of the plots indicates that the model predictions follow the general trend and reproduce the overall magnitude of the observed data reasonably well.

The quantitative calibration metrics that were used to assess the calibration include the evaluation of average error, residual error, root mean squared error (RSME), coefficient of determination (R^2), relative error and percent bias. Table B-9 reports the statistical measure and equation for each quantitative calibration metrics used to evaluate the calibration. Table B-10 presents statistical results for calibration and validation model runs for flow, DO, TN, NO_3, TKN and TP.

Table B-8. Rates used for the Big Bottom Creek QUAL2K calibration and validation

Parameter	*Value*	*Typical Range*	*Units*	*Symbol*
Stoichiometry:				
Carbon	40		gC	gC
Nitrogen	7.2		gN	gN
Phosphorus	1		gP	gP
Dry weight	100		gD	gD
Chlorophyll	1		gA	gA
Inorganic suspended solids:				
Settling velocity	0.5	0.2 – 30 (4)	m/d	v_i
Oxygen:				
Reaeration model	Tsivoglou-Neal			
User reaeration coefficient α	0			α
User reaeration coefficient β	0			β

Parameter	Value	Typical Range	Units	Symbol
Oxygen (continued)				
User reaeration coefficient γ	0			γ
Temp correction	1.024			$\square_{a}$
Reaeration wind effect	Banks-Herrera			
O2 for carbon oxidation	2.69		gO_2/gC	r_{oc}
O2 for NH4 nitrification	4.57		gO_2/gN	r_{on}
Oxygen inhib model CBOD oxidation	Exponential			
Oxygen inhib parameter CBOD oxidation	0.60		L/mgO2	K_{socf}
Oxygen inhib model nitrification	Exponential			
Oxygen inhib parameter nitrification	0.60		L/mgO2	K_{sona}
Oxygen enhance model denitrification	Exponential			
Oxygen enhance parameter denitrification	0.60		L/mgO2	K_{sodn}
Oxygen inhib model phyto resp	Exponential			
Oxygen inhib parameter phyto resp	0.60		L/mgO2	K_{sop}
Oxygen enhance model bot alg resp	Exponential			
Oxygen enhance parameter bot alg resp	0.60		L/mgO2	K_{sob}
Slow CBOD:				
Hydrolysis rate	0.25		/d	k_{hc}
Temp correction	1.047			$\square_{hc}$
Oxidation rate	0.6	0.02 – 3.4 (1)	/d	k_{dcs}
Temp correction	1.047	1.02 – 1.15 (3)		$\square_{dcs}$
Fast CBOD:				
Oxidation rate	0.8	0.02 – 3.4 (1)	/d	k_{dc}
Temp correction	1.047	1.02 – 1.15 (3)		$\square_{dc}$
Organic N:				
Hydrolysis	0.1	0.02 – 0.4 (1)	/d	k_{hn}
Temp correction	1.07	1.02 – 1.08 (2)		$\square_{hn}$
Settling velocity	0.5	0.2 – 30 (4)	m/d	v_{on}
Ammonium:				
Nitrification	0.1	0.1 – 1.0 (1)	/d	k_{na}
Temp correction	1.07			θ_{na}
Nitrate				
Denitrification	0.1	0.002 – 1.0 (2)	/d	k_{dn}
Temp correction	1.07	1.02 – 1.09 (2)		$\square_{dn}$
Sed denitrification transfer coeff	0		m/d	v_{di}
Temp correction	1.07			$\square_{di}$
Organic P:				
Hydrolysis	0.1	0.03 – 0.8 (2)	/d	k_{hp}
Temp correction	1.07	1.02 – 1.09 (2)		$\square_{hp}$
Settling velocity	0.25	0.2 – 30 (4)	m/d	v_{op}
Inorganic P:				
Settling velocity	0.25	0.2 – 30 (4)	m/d	v_{ip}
Inorganic P sorption coefficient	0.073		L/mgD	K_{dpi}
Sed P oxygen attenuation half sat constant	1.831		mgO_2/L	k_{spi}

Parameter	Value	Typical Range	Units	Symbol
Bottom Algae:				
Growth model	First-order			
Max Growth rate	1.1	0.2 – 1.5 (2)	$mgA/m^2/d$ or /d	C_{gb}
Temp correction	1.07	1.07 (3)		$\square_{gb}$
First-order model carrying capacity	1000	1500 (3)	mgA/m^2	$a_{b,max}$
Respiration rate	0.18	0.02 – 0.44 (2)	/d	k_{rb}
Temp correction	1.07	1.07 (3)		$\square_{rb}$
Excretion rate	0.09	0.09 (3)	/d	k_{eb}
Temp correction	1.07	1.07 (3)		$\square_{db}$
Death rate	0.05	0.05 (3)	/d	k_{db}
Temp correction	1.07	1.07 (3)		$\square_{db}$
External nitrogen half sat constant	100	100 (3)	µgN/L	k_{sPb}
External phosphorus half sat constant	40	40 (3)	µgP/L	k_{sNb}
Inorganic carbon half sat constant	1.30E-05	1.30E-05 (3)	moles/L	k_{sCb}
Light model	Steele			
Light constant	225	200 – 300 (2)	langleys/d	K_{Lb}
Ammonia preference	25	25 (3)	µgN/L	k_{hnxb}
Subsistence quota for nitrogen	0.72	0.72 (3)	mgN/mgA	q_{0N}
Subsistence quota for phosphorus	0.1	0.1 (3)	mgP/mgA	q_{0P}
Maximum uptake rate for nitrogen	72	72 (3)	mgN/mgA/d	$\square_{mN}$
Maximum uptake rate for phosphorus	5	5 (3)	mgP/mgA/d	$\square_{mP}$
Internal nitrogen half sat constant	0.9	0.9 (3)	mgN/mgA	K_{qN}
Internal phosphorus half sat constant	0.13	0.13 (3)	mgP/mgA	K_{qP}
Detritus (POM):				
Dissolution rate	0.2		/d	k_{dt}
Temp correction	1.07			$\square_{dt}$
Fraction of dissolution to fast CBOD	0.50			F_f
Settling velocity	0.25		m/d	v_{dt}
Pathogens:				
Decay rate	0.8		/d	k_{dx}
Temp correction	1.07			$\square_{dx}$
Settling velocity	1		m/d	v_x
Light efficiency factor	1.00			$\square_{path}$
pH:				
Partial pressure of carbon dioxide	347		ppm	p_{CO2}

(1) QUAL2E Manual
(2) Rates, Constants and Kinetic Formulations in Surface Water Quality (2nd Edition, June 1985)
(3) WASP 7 Benthic Algae – Model Theory and User Guide (EPA, 2006)
(4) Surface Water Quality Modeling (Chapra, 1997)

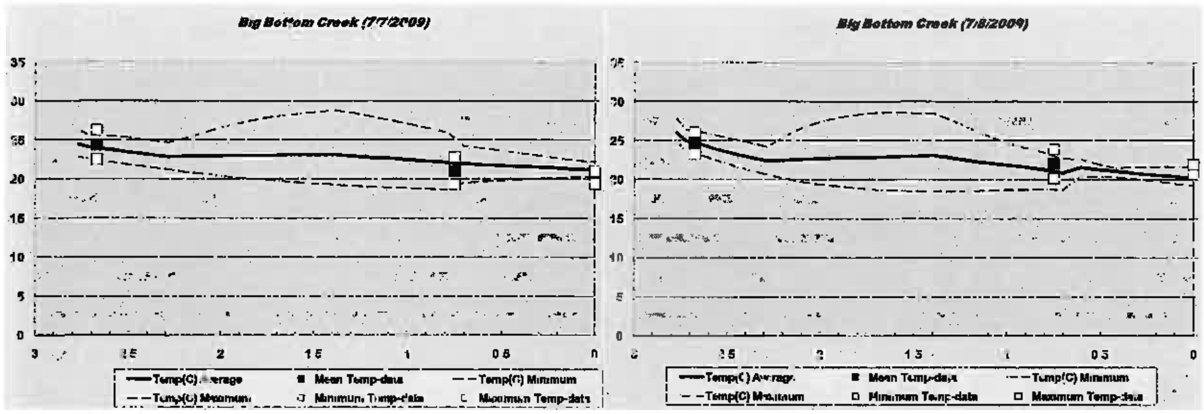


Figure B-4. Temperature calibration in Big Bottom Creek

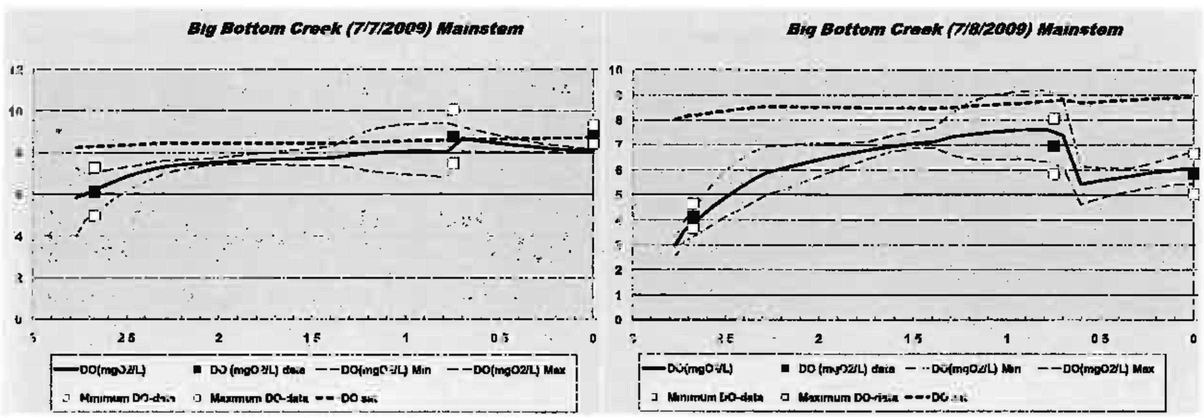


Figure B-5. DO calibration in Big Bottom Creek

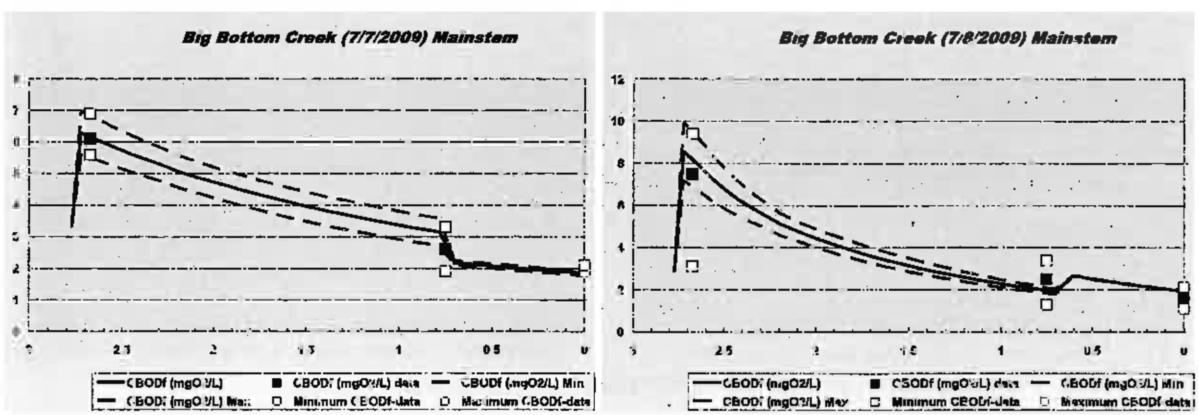


Figure B-6. CBOD calibration in Big Bottom Creek

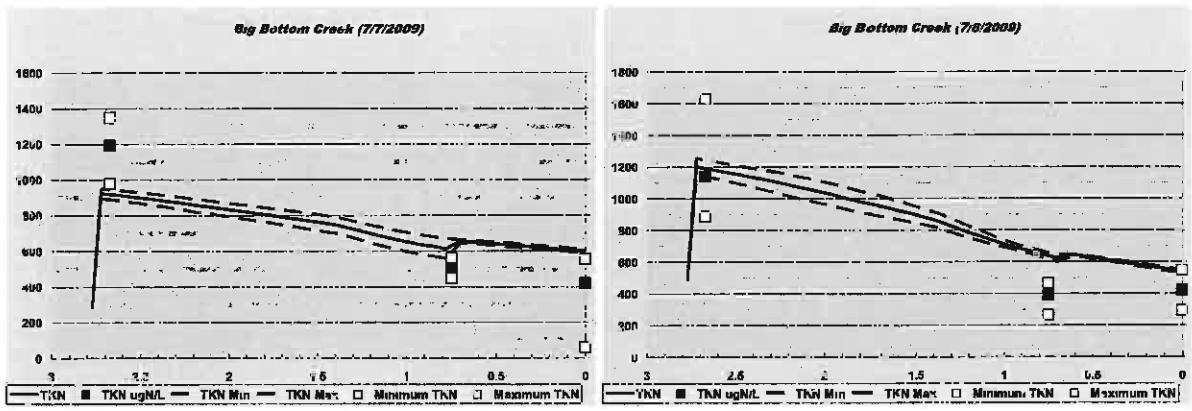


Figure B-7. TKN calibration in Big Bottom Creek

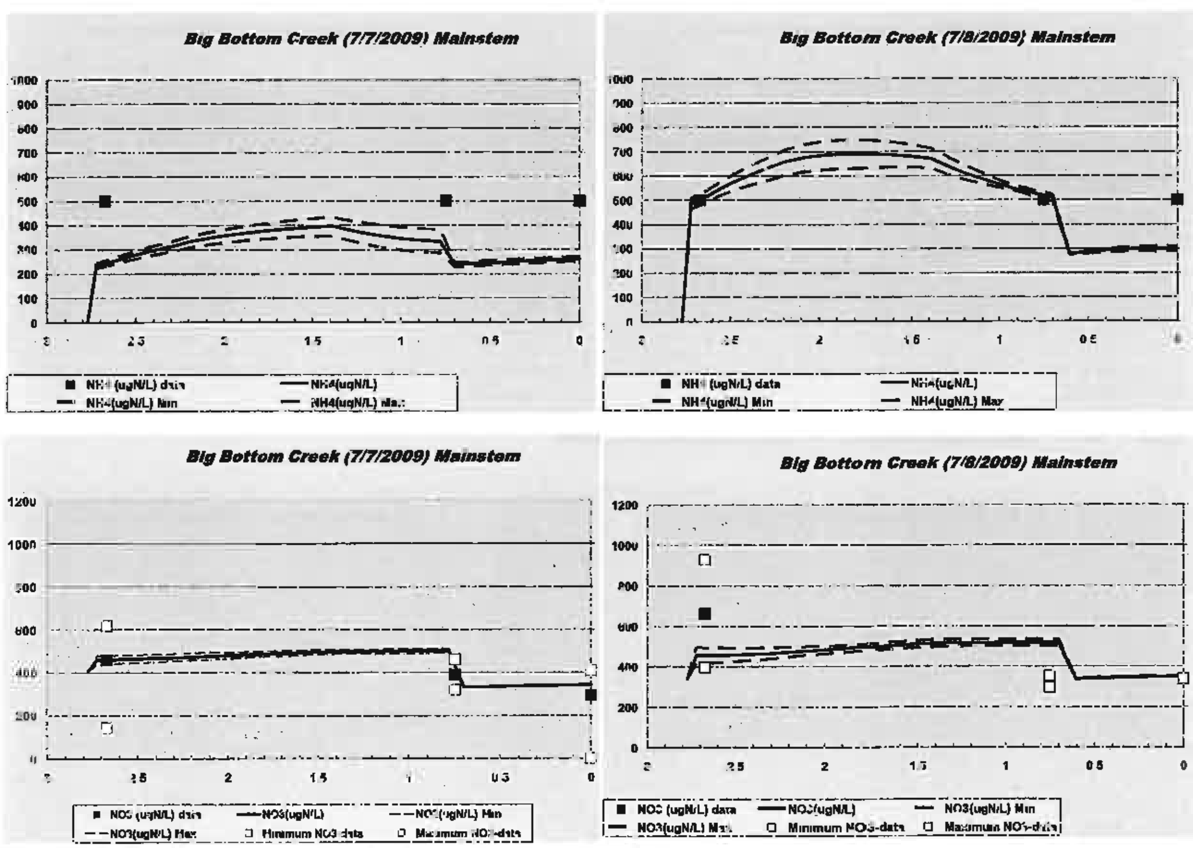


Figure B-8. Ammonium and nitrate calibration in Big Bottom Creek

Note: Ammonium was below laboratory detection limits of 0.5 mg/L in the majority of samples. Based on four samples that had both NH_4-N and TKN results, a NH_4-N:TKN ratio of 0.49 was calculated. Because TKN had a lower detection limit (0.3 mg/L), the NH_4-N:TKN ratio was used to estimate the remaining NH_4-N observed data.

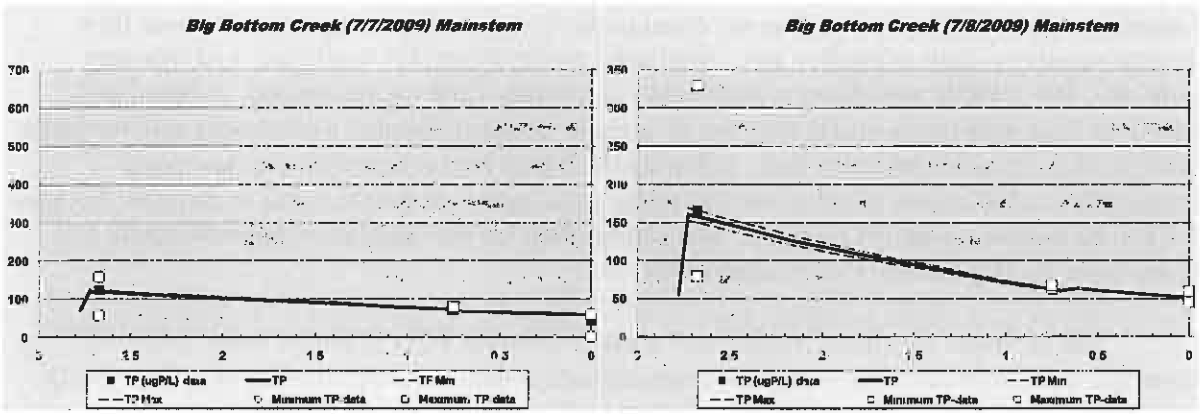


Figure B-9. Total Phosphorus calibration in Big Bottom Creek

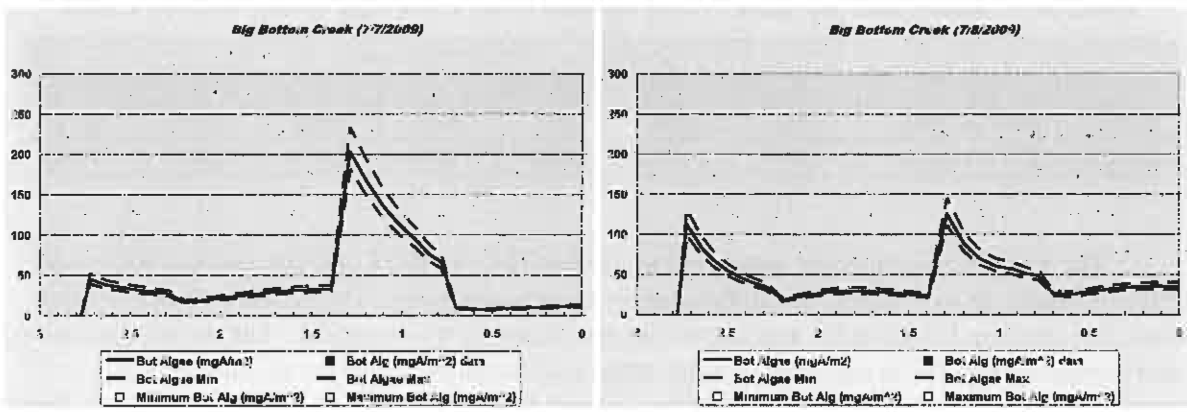


Figure B-10. Bottom algae from calibration runs in Big Bottom Creek

Note: Bottom algae were not sampled in 2009 but were calibrated to diurnal DO variations measured in stream.

B.4 Model Validation

Typically, the performance of a calibrated model is evaluated through "validation." Model validation is defined as "subsequent testing of a pre-calibrated model to additional field data, usually under different external conditions, to further examine the model's ability to predict future conditions" (EPA, 1997). Its purpose is to ensure that the calibrated model properly assesses all the variables and conditions that can affect model results and demonstrate the ability to predict field observations for periods separate from the calibration effort (Donigian, 2003).

Validation of the Big Bottom Creek model was conducted using the data collected on August 12 - 13, 2009. System rates and coefficients were initially set equal to the values selected in the calibration runs. Minor adjustments were made to nutrient rates (oxidation, hydrolysis, sorption and settling rates) and bottom algae (growth and respiration rates). These adjustments were made using best professional judgment based on previous experience with similar modeling projects. All adjustments in validation runs were incorporated in the calibration model runs so that all four models contained the same system rates and coefficients.

Headwater and tributary flows were set equal to the average of morning and afternoon flow measurements on each respective day. Similarly, model inputs for headwater and tributary nutrients, DO, CBOD and pH were also based on average field measurements or calculated based on field measurements (in the case of organic nitrogen, organic phosphorus and inorganic phosphorus) on each respective day. Initial model inputs for air temperature, dew point temperature, wind speed, cloud cover and shade were based on weather station data (see Section 2.3 for discussion on station location. The station used for this analysis is approximately 22 miles from the Big Bottom Creek watershed).

The sediment digenesis routine was used to estimate SOD. Percent reach with SOD coverage was estimated from sediment characterization data collected during sampling. SOD coverage was set at the percent of creek bottom with sand, silt, or clay (Table B-9).

Table B-9. Rates used for the Percent Bottom SOD Coverage in Big Bottom Creek

	Reach Number						
	1	2	3	4	5	6	7
Bottom Algae Coverage	0%	40%	40%	50%	50%	50%	50%
Bottom SOD Coverage	100%	100%	100%	100%	100%	100%	100%

The validation results are presented in Figures B-11 to B-15 and suggest that the model performs nearly as well as for the calibration for most parameters. The absence of observation points at Sampling Location #2 was due to the dry stream at this location. The model validation was complicated by the occurrence of a dry stream at Sampling Location #2 and for some distance upstream (at least 100 m) during the August 12 - 13 sampling period. In addition, there was no headwater flow during the August sampling events. The dry conditions, however, made it easier to assign flows and concentration to the two point sources, Lake Forest WWTP and Indian Creek.

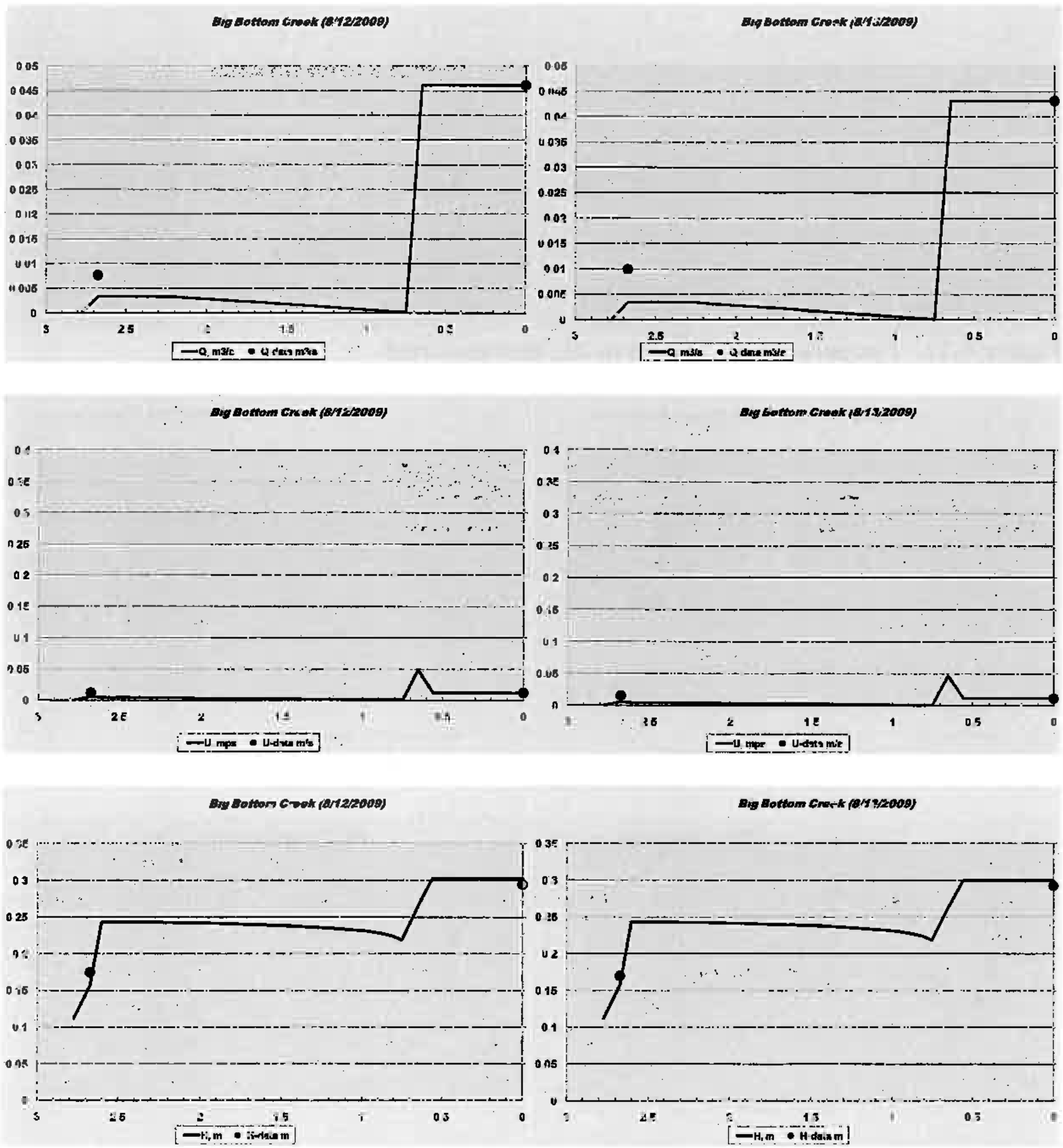


Figure B-11. Validations of observed and simulated flow (Q), velocity (U) and depth (H) in Big Bottom Creek

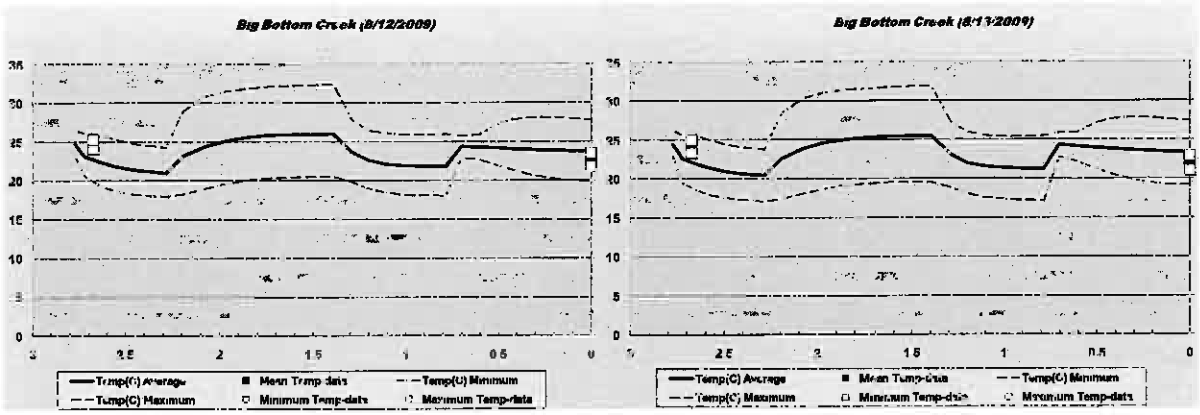


Figure B-12. Temperature validation in Big Bottom Creek

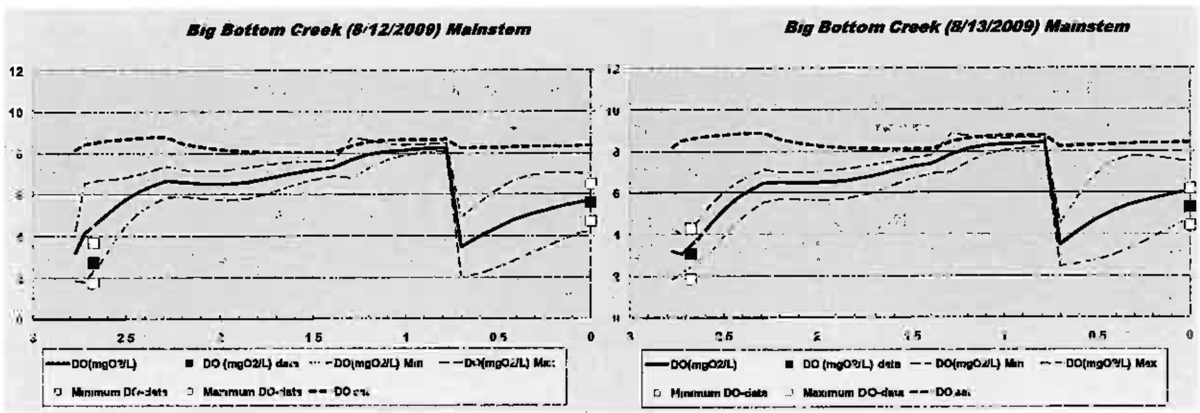


Figure B-13. DO validation in Big Bottom Creek

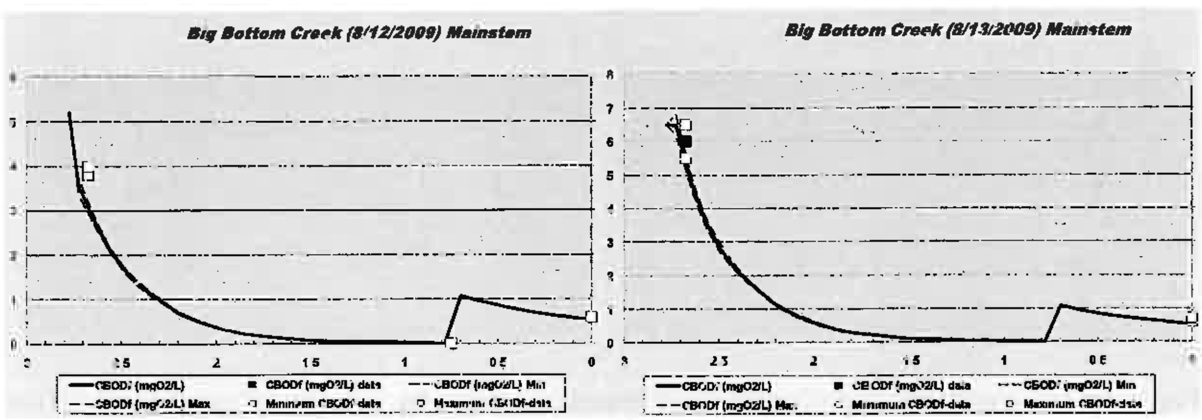


Figure B-14. CBOD validation in Big Bottom Creek

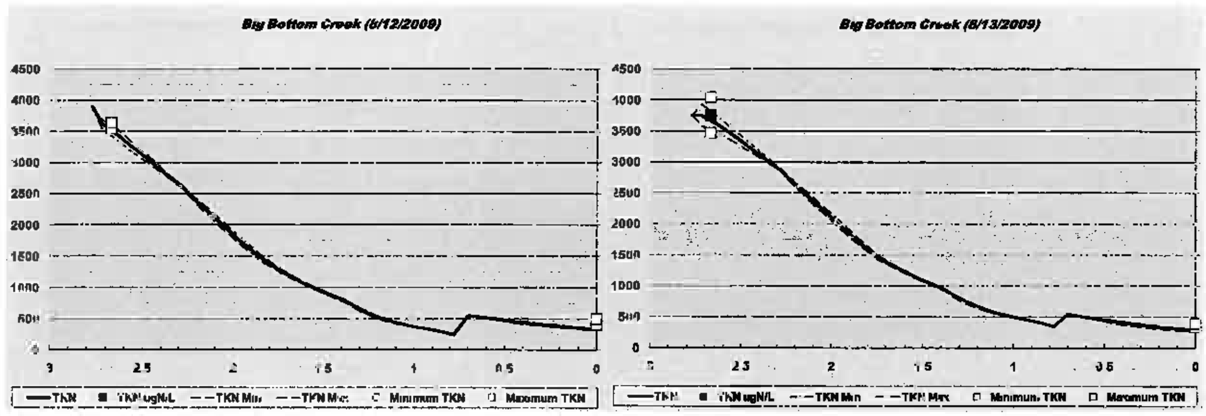


Figure B-15. TKN validation in Big Bottom Creek

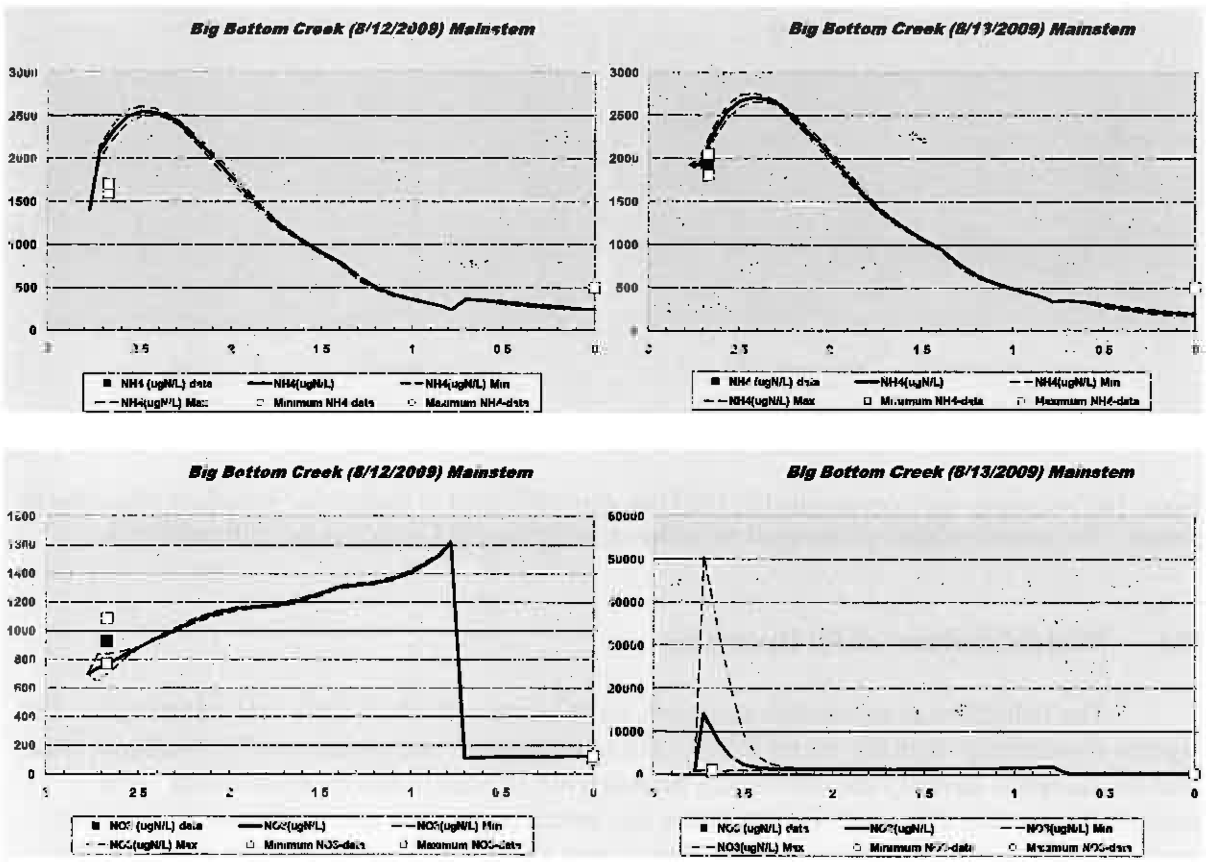


Figure B-16. Ammonium and nitrate validation in Big Bottom Creek

Note: Ammonium was below laboratory detection limits of 0.5 mg/L in the majority of samples. Based on four samples that had both NH_4-N and TKN results, a NH_4-N:TKN ratio of 0.49 was calculated. Because TKN had a lower detection limit (0.3 mg/L), the NH_4-N:TKN ratio was used to estimate the remaining NH_4-N observed data.

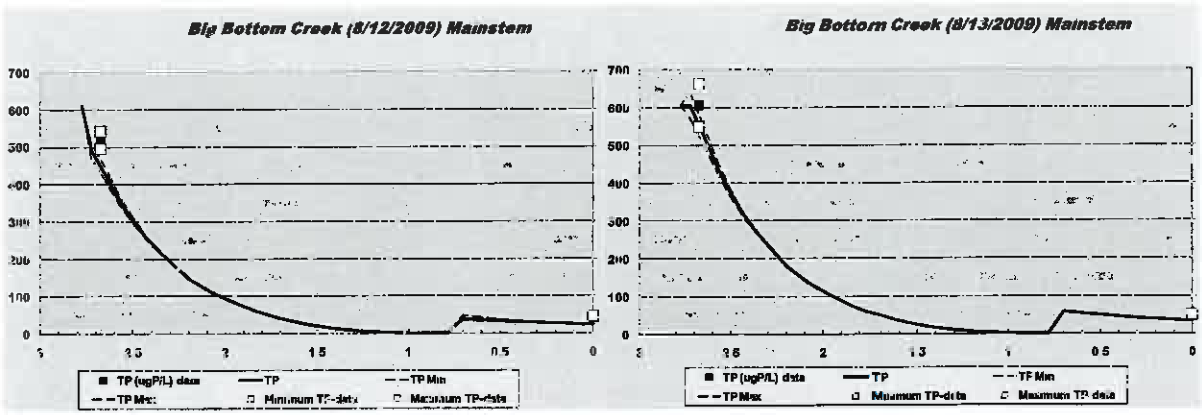


Figure B-17. TP validation in Big Bottom Creek

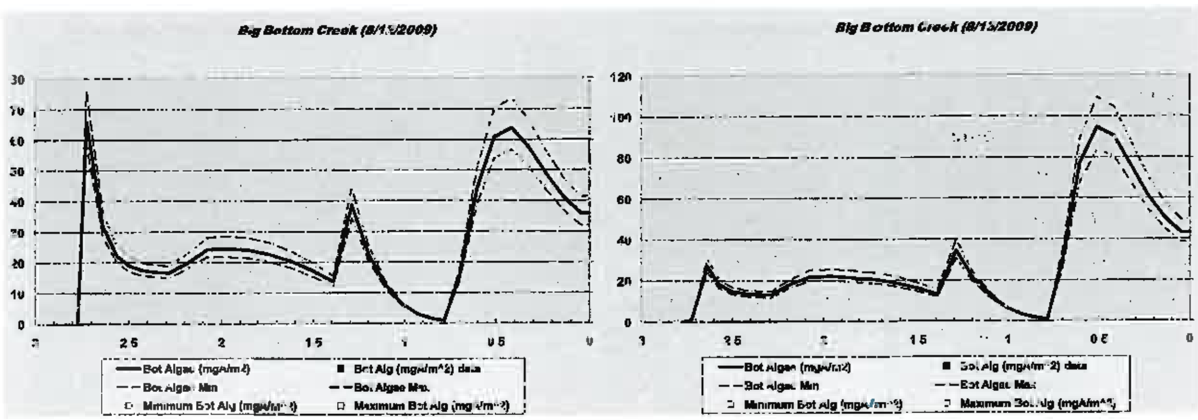


Figure B-18. Bottom algae from validation runs in Big Bottom Creek

Note: Bottom algae were not sampled in 2009 but were calibrated to diurnal DO variations measured in stream. The model validation runs used the same algae inputs and kinetics as the calibration runs.

B.5 Model Goodness of Fit Discussion

The calibration and validation periods were assessed both visually and statistically. The figures demonstrate that the model follows the same patterns and trends and the measured data and the statistics quantify the differences between the simulated and measured data. The statistical measures that were used to assess the model calibration and validation include the evaluation of coefficient of determination (R^2), root mean square error, percent bias, average error, relative error and residual error. Table B-10 reports the statistical measure and equation for each quantitative calibration metrics used to evaluate the calibration, and Table B-11 reports the calculated error statistics for the periods simulated.

The statistics demonstrate that the model results in prediction similar to those measured in the field. Specifically, the following statistics demonstrate a good model fit:

- Coefficient of determination (r^2) is high for all parameters and suggests a high degree of correlation between the simulated model results and observed water quality data.

- The root mean square error statistic (RMSE) for DO is near 1 mg/L for the average, minimum and maximum for all periods.

The model calibration and validation runs use the same kinetic parameters to achieve a good comparison of measured data. This is supported with a visual and statistical comparison. Based on this comparison the QUAL2K model for Big Bottom Creek is suitable for assessing DO problems and for TMDL development.

Table B-10. Quantitative metrics for calibration and validation

Calibration Metric	Equation
Root Mean Squared Error (RMSE)	$\sqrt{\frac{\sum(Predicted - Observed)^2}{n-1}}$
Coefficient of determination (r^2)	$1 - \frac{\sum(Squared\ Errors)}{\sum(Total\ Sum\ of\ Squares)}$
Percent Bias (pBias)	$\frac{\sum(Predicted - Observed)}{\sum Observed} * 100$
Absolute Average Error	$\sum_{i=1}^{n} \frac{\lvert Predicted - Observed \rvert}{n_{obs}}$
Residual Error	$\sum_{i=1}^{n} \frac{(Simulated\ Value - Observed\ Value)}{n_{obs}}$

Table B-11. Summary statistics for calibration and validation runs

Statistic	Model Period	Flow	Avg. DO	Min DO	Max DO	CBOD	TN	TKN	NO_3	TP
RMSE	Calibration	0.004	0.6	1.0	1.0	2.1	0.5	0.4	0.3	0.1
	Validation	0.005	1.1	1.6	1.2	1.7	1.5	0.4	1.5	0.3
	Entire Period	0.004	0.8	1.2	1.0	1.8	1.0	0.4	0.9	0.2
R2	Calibration	1.00	0.9	0.9	0.8	1.0	0.9	1.0	0.1	1.0
	Validation	1.00	0.7	0.8	0.1	1.0	0.7	1.0	0.3	1.0
	Entire Period	1.00	0.9	0.9	0.7	0.9	0.7	1.0	0.3	1.0
PBIAS	Calibration	0.60	-0.3	-11.7	2.2	2.4	-6.5	-22.5	2.0	5.2
	Validation	-10.24	-20.4	-58.6	-17.9	23.7	-61.9	5.9	-344.5	18.9
	Entire Period	-1.51	-6.2	-24.1	-4.1	9.5	-40.1	-3.6	-150.7	14.8
Abs. Average Error	Calibration	0.003	0.3	0.8	0.8	3.6	0.2	0.2	0.1	0.0
	Validation	0.003	0.9	1.9	1.0	2.1	1.8	0.1	1.8	0.1
	Entire Period	0.003	0.6	1.2	0.9	3.0	0.9	0.1	0.8	0.0
Residual Error	Calibration	0.000	0.0	-0.7	0.2	3.6	-0.1	-0.2	0.0	0.0
	Validation	-0.003	-0.9	-1.9	-0.9	2.1	-1.6	0.1	-1.7	0.1
	Entire Period	-0.001	-0.4	-1.2	-0.3	3.0	-0.7	0.0	-0.7	0.0

References – Appendix B

Ambrose, R.B., J. L. Martin, and T. Wool, 2006. WASP7 Benthic Algae – Model Theory and User's Guide, EPA 600/R-06/106. Office of Research and Development.

Brown, L.C. and T. O. Barnwell, Jr., 1987. The Enhanced Stream Water Quality Models QUAL2E and QUAL2E-UNCAS: Documentation and User Manual. EPA 600/3-87/007. Office of Research and Development.

Chapra, S.C., G. J. Pelletier, and H. Tao, 2007. QUAL2K: A Modeling Framework for Simulating River and Stream Water Quality, Version 2.07: Documentation and Users Manual.

Donigian. A.S., 2003. Watershed Model Calibration and Validation: The HSPF Experience. WEF National TMDL Science and Policy 2002, November 13-16, 2002. Phoenix, AZ. WEF Specialty Conference Proceedings on CD-ROM.

United States Environmental Protection Agency (EPA), 1985. Rates, Constants and Kinetics Formulations In Surface Water Quality Modeling. Second Edition. EPA/600/3-85/040. Prepared by Tetra Tech, Inc. and Humboldt State University.

EPA, 1997. Technical Guidance Manual for Developing Total Maximum Daily Loads, Book 2: Streams and River. Part 1: Biochemical Oxygen Demand/Dissolved Oxygen And Nutrients/Eutrophication. EPA 823-B-97-002. Office of Water.

EPA, 2005. Use Attainability Analysis for Water Body Identification #1746 Big Bottom Creek. Missouri Department of Natural Resources Water Protection Program.

Melching, C. and H. E. Flores, 1999. Reaeration Equations derived from U.S. Geological Survey Database. Journal of Environmental Engineering. American Society of Civil Engineers. 125(5): 407-414.

Thomann, R. V., J. A. Mueller, 1987. "Principles of Surface Water Quality Modeling and Control." Harper Collins Publishers Inc.

Tsivoglou, E.C. and L. A. Neal, 1976. "Tracer Measurement of Reaeration. III. Predicting the Reaeration Capacity of Inland Streams." Journal of the Water Pollution Control Federation, 48(12): 2669-2689.

APPENDIX C - AMMONIA CRITERIA

Table B1. Acute Criteria for Total Ammonia Nitrogen (mg N/L)

pH	Cold-Water Fisheries (1)	Cool & Warm-Water Fisheries (2)
6.5	32.6	48.8
6.6	31.3	46.8
6.7	29.8	44.6
6.8	28.1	42.0
6.9	26.2	39.1
7.0	24.1	36.1
7.1	22.0	32.8
7.2	19.7	29.5
7.3	17.5	26.2
7.4	15.4	23.0
7.5	13.3	19.9
7.6	11.4	17.0
7.7	9.6	14.4
7.8	8.1	12.1
7.9	6.7	10.1
8.0	5.6	8.4
8.1	4.6	6.9
8.2	3.8	5.7
8.3	3.1	4.7
8.4	2.5	3.8
8.5	2.1	3.2
8.6	1.7	2.6
8.7	1.4	2.2
8.8	1.2	1.8
8.9	1.0	1.5
9.0	0.8	1.3

Table B2. Chronic Criteria for Total Ammonia Nitrogen (mg N/L); Early Life Stage absent(3)(4)

	Temperature (°C)																
pH	0-7	8	9	10	11	12	13	14	15	16	18	20	22	24	26	28	30
6.5	10.8	10.1	9.5	8.9	8.3	7.8	7.3	6.8	6.4	6.0	5.3	4.6	4.1	3.6	3.1	2.8	2.4
6.6	10.7	9.9	9.3	8.7	8.2	7.7	7.2	6.7	6.3	5.9	5.2	4.6	4.0	3.5	3.1	2.7	2.4
6.7	10.5	9.8	9.2	8.6	8.0	7.5	7.1	6.6	6.2	5.8	5.1	4.5	3.9	3.5	3.0	2.7	2.3
6.8	10.2	9.5	8.9	8.4	7.9	7.4	6.9	6.5	6.1	5.7	5.0	4.4	3.8	3.4	3.0	2.6	2.3
6.9	9.9	9.3	8.7	8.1	7.6	7.2	6.7	6.3	5.9	5.5	4.8	4.3	3.7	3.3	2.9	2.5	2.2
7.0	9.6	9.0	8.4	7.9	7.4	6.9	6.5	6.1	5.7	5.3	4.7	4.1	3.6	3.2	2.8	2.4	2.1
7.1	9.2	8.6	8.0	7.5	7.1	6.6	6.2	5.8	5.4	5.1	4.5	3.9	3.5	3.0	2.7	2.3	2.0
7.2	8.7	8.2	7.6	7.2	6.7	6.3	5.9	5.5	5.2	4.9	4.3	3.7	3.3	2.9	2.5	2.2	1.9
7.3	8.2	7.7	7.2	6.7	6.3	5.9	5.6	5.2	4.9	4.6	4.0	3.5	3.1	2.7	2.4	2.1	1.8
7.4	7.6	7.2	6.7	6.3	5.9	5.5	5.2	4.8	4.5	4.3	3.7	3.3	2.9	2.5	2.2	1.9	1.7
7.5	7.0	6.6	6.2	5.8	5.4	5.1	4.8	4.5	4.2	3.9	3.4	3.0	2.6	2.3	2.0	1.8	1.6
7.6	6.4	6.0	5.6	5.3	5.0	4.6	4.3	4.1	3.8	3.6	3.1	2.7	2.4	2.1	1.9	1.6	1.4
7.7	5.8	5.4	5.1	4.7	4.0	4.2	3.9	3.7	3.4	3.2	2.8	2.5	2.2	1.9	1.7	1.5	1.3
7.8	5.1	4.8	4.5	4.2	4.4	3.7	3.5	3.2	3.0	2.8	2.5	2.2	1.9	1.7	1.5	1.3	1.1
7.9	4.5	4.2	3.9	3.7	3.5	3.2	3.1	2.8	2.7	2.5	2.2	1.9	1.7	1.5	1.3	1.1	1.0
8.0	3.9	3.7	3.4	3.2	3.0	2.8	2.6	2.5	2.3	2.2	1.9	1.7	1.5	1.3	1.1	1.0	0.8
8.1	3.4	3.1	2.9	2.8	2.6	2.4	2.3	2.1	2.0	1.8	1.6	1.4	1.2	1.1	1.0	0.8	0.7
8.2	2.9	2.7	2.5	2.4	2.2	2.1	1.9	1.8	1.7	1.6	1.4	1.2	1.1	0.9	0.8	0.7	0.6
8.3	2.4	2.3	2.1	2.0	1.9	1.7	1.6	1.5	1.4	1.3	1.2	1.0	0.9	0.8	0.7	0.6	0.5
8.4	2.0	1.9	1.8	1.7	1.6	1.5	1.4	1.3	1.2	1.1	1.0	0.9	0.7	0.7	0.6	0.5	0.4
8.5	1.7	1.6	1.5	1.4	1.3	1.2	1.2	1.1	1.0	0.9	0.8	0.7	0.6	0.5	0.5	0.4	0.4
8.6	1.4	1.4	1.3	1.2	1.1	1.0	1.0	0.9	0.8	0.8	0.7	0.6	0.5	0.4	0.4	0.3	0.3
8.7	1.2	1.1	1.1	1.0	0.9	0.9	0.8	0.8	0.7	0.7	0.6	0.5	0.4	0.4	0.3	0.3	0.2
8.8	1.0	1.0	0.9	0.8	0.8	0.7	0.7	0.6	0.6	0.6	0.5	0.4	0.4	0.3	0.3	0.2	0.2
8.9	0.9	0.8	0.8	0.7	0.7	0.6	0.6	0.5	0.5	0.5	0.4	0.3	0.3	0.2	0.2	0.2	0.2
9.0	0.7	0.7	0.6	0.6	0.6	0.5	0.5	0.5	0.4	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.1

Table B3. Chronic Criteria for Total Ammonia Nitrogen (mg N/L): Early Life Stages present (5)

	Temperature (°C)									
pH	0	14	16	18	20	22	24	26	28	30
6.5	6.6	6.6	6.0	5.3	4.6	4.1	3.6	3.1	2.8	2.4
6.6	6.5	6.5	5.9	5.2	4.6	4.0	3.5	3.1	2.7	2.4
6.7	6.4	6.4	5.8	5.1	4.5	3.9	3.5	3.0	2.7	2.3
6.8	6.2	6.2	5.7	5.0	4.4	3.8	3.4	3.0	2.6	2.3
6.9	6.1	6.1	5.5	4.8	4.3	3.7	3.3	2.9	2.5	2.2
7.0	5.9	5.9	5.3	4.7	4.1	3.6	3.2	2.8	2.4	2.1
7.1	5.6	5.6	5.1	4.5	3.9	3.5	3.0	2.7	2.3	2.0
7.2	5.3	5.3	4.9	4.3	3.7	3.3	2.9	2.5	2.2	1.9
7.3	5.0	5.0	4.6	4.0	3.5	3.1	2.7	2.4	2.1	1.8
7.4	4.7	4.7	4.3	3.7	3.3	2.9	2.5	2.2	1.9	1.7
7.5	4.3	4.3	3.9	3.4	3.0	2.6	2.3	2.0	1.8	1.6
7.6	3.9	3.9	3.6	3.1	2.7	2.4	2.1	1.9	1.6	1.4
7.7	3.5	3.5	3.2	2.8	2.5	2.2	1.9	1.7	1.5	1.3
7.8	3.1	3.1	2.8	2.5	2.2	1.9	1.7	1.5	1.3	1.1
7.9	2.8	2.8	2.5	2.2	1.9	1.7	1.5	1.3	1.1	1.0
8.0	2.4	2.4	2.2	1.9	1.7	1.5	1.3	1.1	1.0	0.8
8.1	2.1	2.1	1.9	1.6	1.4	1.2	1.1	1.0	0.8	0.7
8.2	1.7	1.7	1.6	1.4	1.2	1.1	0.9	0.8	0.7	0.6
8.3	1.5	1.5	1.3	1.2	1.0	0.9	0.8	0.7	0.6	0.5
8.4	1.2	1.2	1.1	1.0	0.9	0.7	0.7	0.6	0.5	0.4
8.5	1.0	1.0	0.9	0.8	0.7	0.6	0.5	0.5	0.4	0.4
8.6	0.9	0.9	0.8	0.7	0.6	0.5	0.4	0.4	0.3	0.3
8.7	0.7	0.7	0.7	0.6	0.5	0.4	0.4	0.3	0.3	0.2
8.8	0.6	0.6	0.6	0.5	0.4	0.4	0.3	0.3	0.2	0.2
8.9	0.5	0.5	0.5	0.4	0.3	0.3	0.2	0.2	0.2	0.2
9.0	0.4	0.4	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.1

(1) *Salmonids present:* $CMC = [0.275 / (1+10^{7.204-pH})] + [39.0 / (1+10^{pH-7.204})]$

(2) *Salmonids absent:* $CMC = [0.411 / (1+10^{7.204-pH})] + [58.4 / (1+10^{pH-7.204})]$

(3) Without sufficient and reliable data, it is assumed that Early Life Stages are present and must be protected at all times of the year.

(4) Early Life Stages absent

$CCC = [0.0577 / (1+10^{7.688-pH})]+[2.487 / (1+10^{pH-7.688})] * 1.45 * 10^{0.028 * (25-MAX(T, 7))}$

(5) Early Life Stages present

$CCC = [0.0577 / (1+10^{7.688-pH})]+[2.487 / (1+10^{pH-7.688})] * MIN(2.85, 1.45 * 10^{0.028 * (25-T)})$

APPENDIX D - DEVELOPMENT OF TSS TARGETS USING REFERENCE LDC

Overview

This procedure is used when a lotic system is placed on the 303(d) 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 water body is located excluding large rivers that originate outside of the EDU, such as the Mississippi River. 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. Selection of these gages is based on location, land use/soil/topography similarities to the Big Bottom Creek watershed and the availability of flow data of sufficient age and duration. From this synthetic record a flow duration curve was developed which was used to build a load duration curve (LDC) for the pollutant.

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 total maximum daily load (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 LDC. 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 LDC uses the 25th percentile of EDU concentration at flows where surface runoff is less than 1 percent of the stream flow. This result in an inflection point in the curve below which the TMDL is calculated using load calculated with 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 (typically 20 years or more).

Figure B-1 shows the application of the approach in the Big Bottom Creek EDU (Ozark/Apple/Joachim EDU). Watershed-size normalized data for the individual gages in the EDU were calculated and compared to a pooled data set of all the gages (Figure D-1, Table D-1). Table D-1 demonstrates the pooled data set can confidently be used as a surrogate for the EDU analyses.

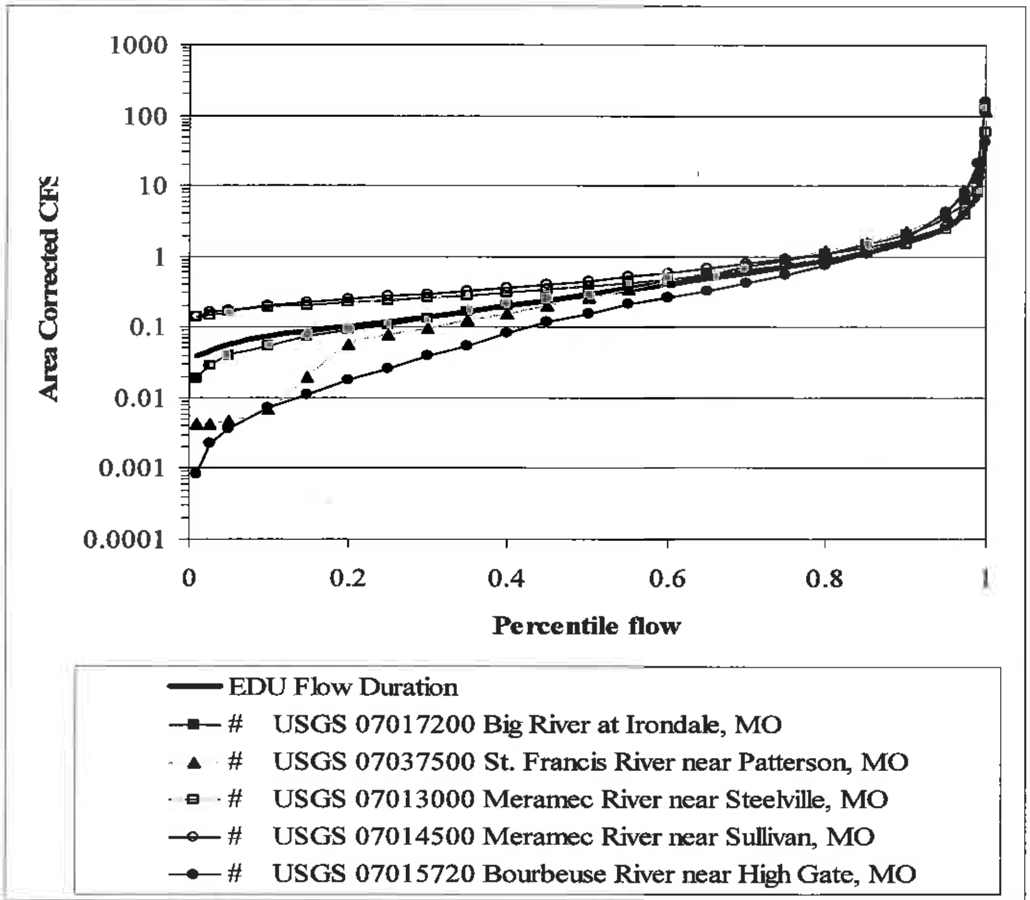


Figure D-1. Synthetic Flow Development in the Ozark/Apple/Joachim EDU

Table D-1. Stream Flow Stations Used to Estimate Flows in Big Bottom Creek

River/Station Name	Data Source	Station Number	Drainage Area (mi^2)	Lognormal Nash-Sutcliffe
Big River at Irondale, MO	USGS	07017200	175	63%
St. Francis River near Patterson, MO	USGS	07037500	956	68%
Meramec River near Steelville, MO	USGS	07013000	781	98%
Meramec River near Sullivan, MO	USGS	07014500	1,475	96%
Bourbeuse River near High Gate, MO	USGS	07015720	135	51%

The next step is to calculate pollutant-discharge relationships for the EDU, these are log transformed data for the yield (tons/mi^2/day) and the instantaneous flow (cfs/mi^2). Figure D-2 shows the EDU relationship. Further statistical analyses on this relationship are included in Table D-2.

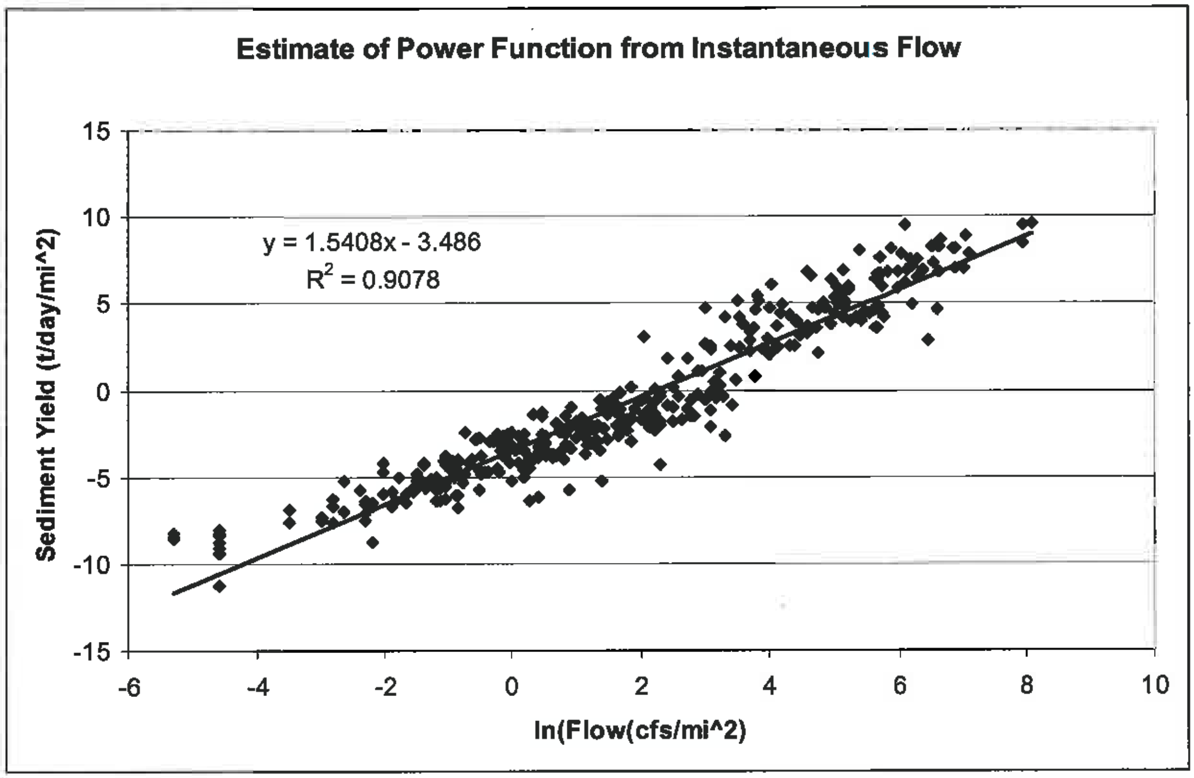


Figure D-2. Estimate of Power Function from Instantaneous Flow in the Ozark/Apple/Joachim EDU

Table D-2. Ozark/Apple/Joachim EDU Flow and Sediment Statistics

m	1.54079899	b	-3.485986392
Standard Error (m)	0.02549522	Standard Error (b)	0.082872781
r2	0.90778871	Standard Error (y)	1.377724534
F	3652.36846	DF	371
SSreg	6932.65148	SSres	704.2043347

The standard error of y was used to estimate the 25th percentile level for the TMDL line. This was done by adjusting the intercept (b) by subtracting the product of the one-sided Z_{75} statistic times the standard error of (y). The resulting TMDL equation is the following:

Sediment yield (t/day/mi2) = exp (1.54079899 * ln (flow) -3.485986392)

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

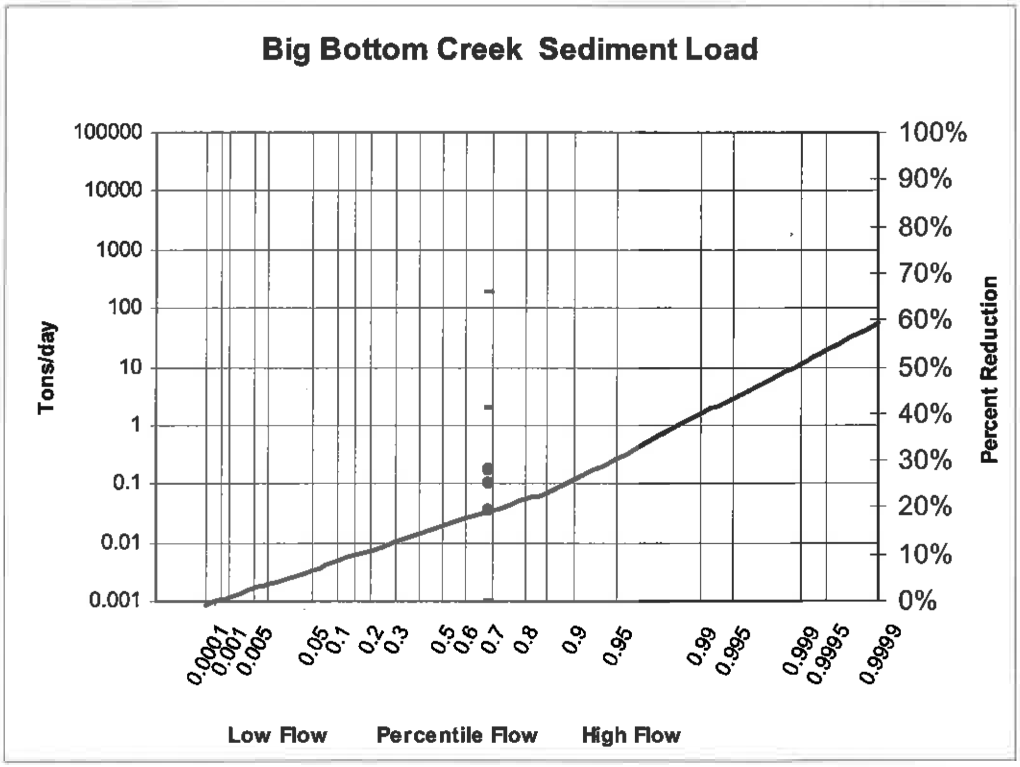


Figure D-3. TMDL LDC for TSS

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 Big Bottom Creek the 25th percentile TSS concentration target is 10 mg/L. The TMDL, LA and WLA were calculated based on this concentration.

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 E -DEVELOPMENT OF NUTRIENT TARGETS USING ECOREGION NUTRIENT CRITERIA WITH LDCS

Overview

This procedure is used when a lotic system is placed on the 303(d) impaired water body list for nutrient pollutants and the designated use being addressed is aquatic life. In cases where EPA-approved state numeric criteria for the impaired stream is not available a reference approach is used. The target for pollutant loading is the U. S. Environmental Protection Agency (EPA) recommended ecoregion nutrient criterion for the specific ecoregion in which the water body is located (EPA, 2000). If a flow record for the impaired stream is not available a synthetic flow record is needed. To develop a synthetic flow record a user should calculate an average of the log discharge per square mile of U. S. Geological Survey (USGS) gaged rivers for which the drainage area is contained within the Ecological Drainage Unit (EDU). Selection of these gages is based on location, land use/soil/topography similarities to the Big Bottom Creek watershed and the availability of flow data of sufficient age and duration. From this synthetic record develop a flow duration and build a load duration curve (LDC) for the pollutant within the EDU.

See EPA (2000) for more detailed information as to how recommended ecoregion nutrient criteria were developed. This appendix describes how the nutrient criteria (TN and TP) are expressed in this TMDL.

Methodology

The first step in this procedure is to gather available nutrient data within the ecoregion of interest. These data along with the instantaneous flow measurement taken at the time of sample collection for the specific date are required to develop the LDC. Both dates and nutrient concentrations are needed in order to match the measured data used with the synthetic EDU flow record.

Secondly, collect average daily flow data from gages with a variety of drainage areas for a period of time to cover the nutrient 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 the synthetic flow record calculate the Nash-Sutcliffe value 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 then used to develop the LDC for the EDU. The flow record should be of sufficient length to be able to calculate percentiles of flow (typically 20 years or more).

The following example shows the application of the approach for the Ozark/Apple/ Joachim EDU. Watershed-size normalized data for the individual gages in the EDU were calculated and compared to a pooled data set of all the gages (Figure E-1, Table E-1). Table E-1 demonstrates the pooled data set can confidently be used as a surrogate for the EDU analyses.

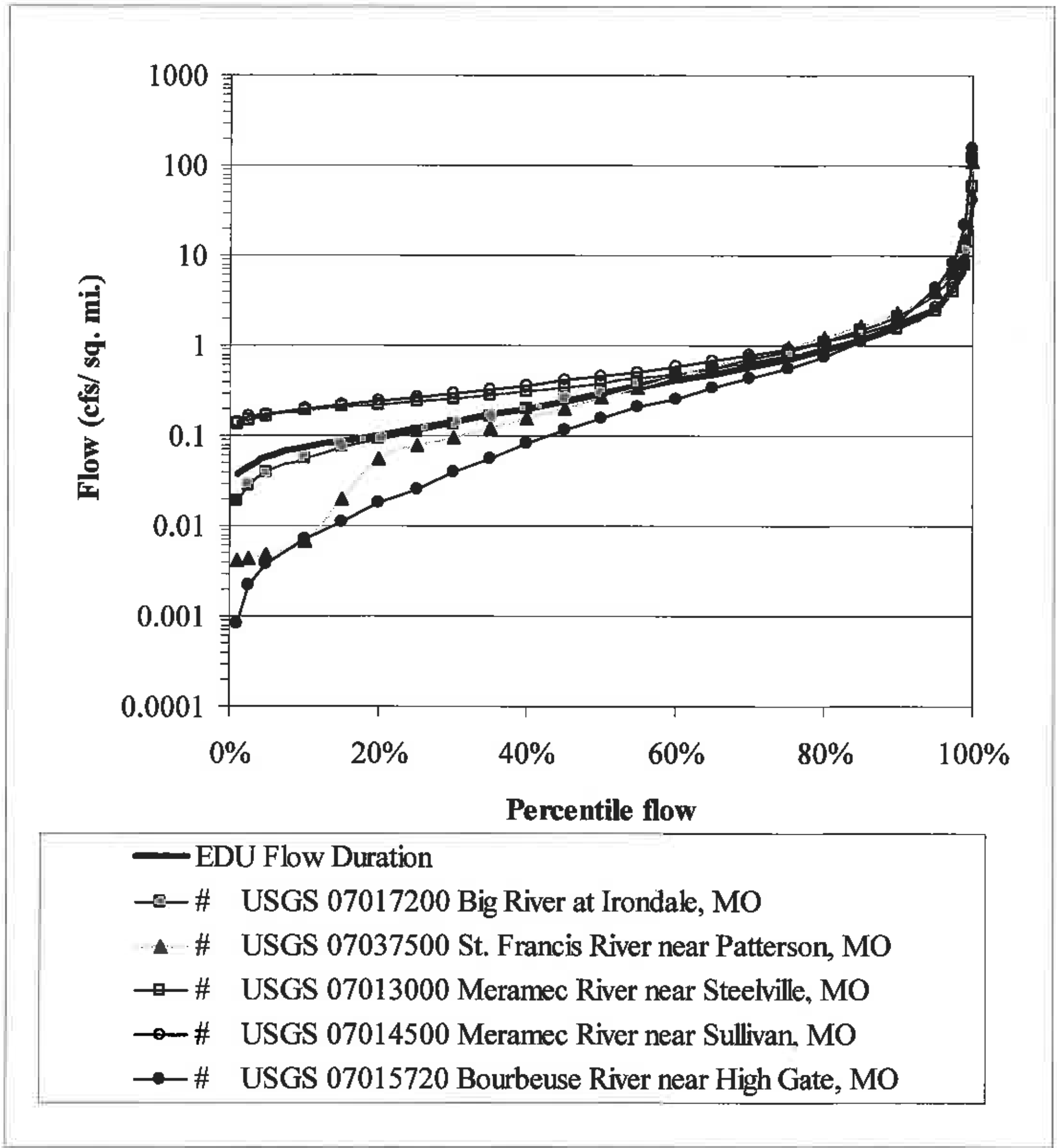


Figure E-1. Synthetic Flow Development in the Ozark/Apple/Joachim EDU

Table E-1. Stream Flow Stations Used to Estimate Flows in Big Bottom Creek

River/Station Name	Data Source	Station Number	Drainage Area (mi2)	Lognormal Nash-Sutcliffe
Big River at Irondale, MO	USGS	07017200	175	63%
St. Francis River near Patterson, MO	USGS	07037500	956	68%
Meramec River near Steelville, MO	USGS	07013000	781	98%
Meramec River near Sullivan, MO	USGS	07014500	1,475	96%
Bourbeuse River near High Gate, MO	USGS	07015720	135	51%

The next step was to collect previously measured water quality data from within the ecoregion. Measured total nitrogen (TN) concentrations are adjusted so their median is equal to the EPA recommended ecoregion TN criterion. This is accomplished by subtracting the difference between the EPA recommended ecoregion TN criterion and the median from the measured data. This results in the data retaining most of its natural variability yet having a median which meets the EPA recommended ecoregion TN criterion. Where this adjustment would result in a negative concentration the minimum measured concentration is substituted. Figure E-2 shows an example of this process where the solid line is the measured distribution of the natural log TN concentration with the natural log flow and the dashed line represents a data distribution (the adjusted data) which would comply with the EPA recommended ecoregion TN criterion.

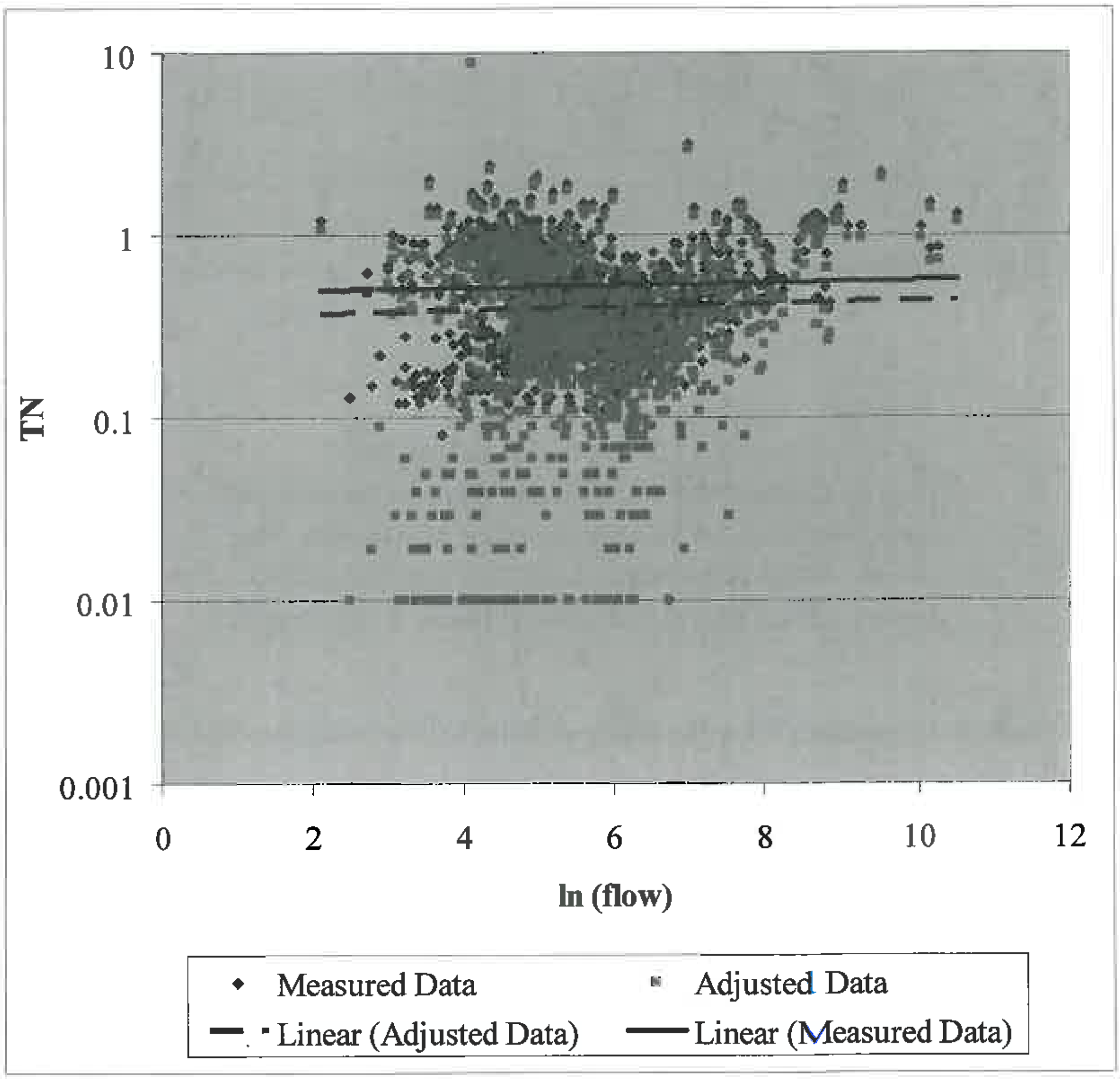


Figure E-2. Graphic Representation of Data Adjustment in Ozark/Apple/Joachim EDU

The next step was to calculate the TN-discharge relationship for the ecoregion using the adjusted data; this is natural log transformed data for the yield (pounds/mi^2/day) and the instantaneous flow (cfs/mi^2). Figure E-3 shows this relationship for this TMDL.

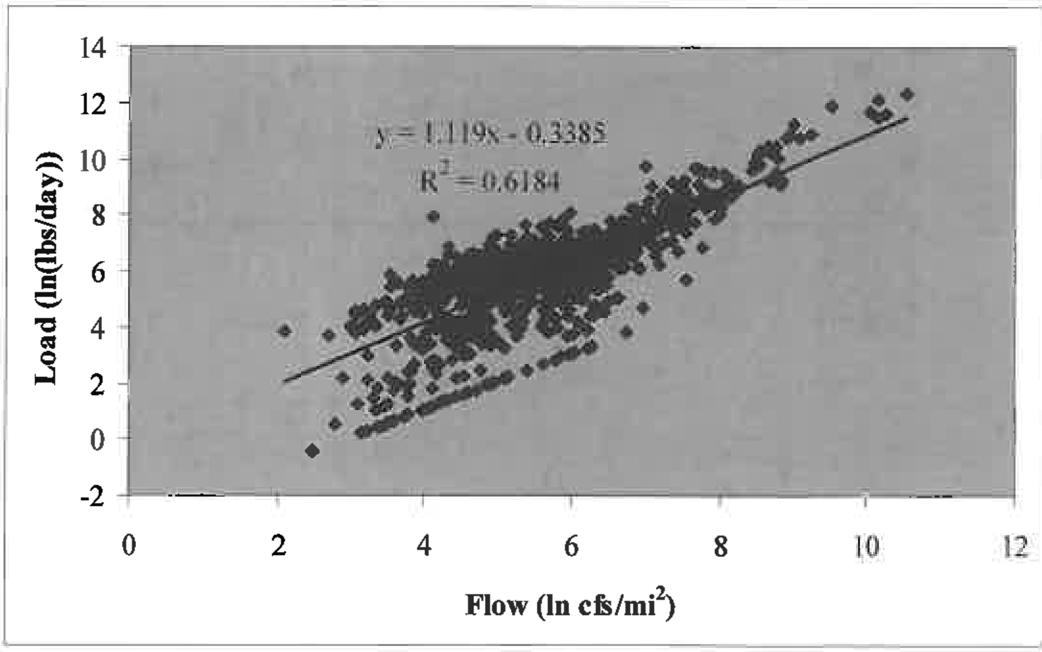


Figure E-3. TN Load and Flow Relationship Used to Set TN TMDL Targets

This relationship was used to develop a LDC for which the relationship between flow and nutrient distribution is taken into account. In this LDC the targeted concentration is allowed to change at different percentiles of flow exceedance. However, meeting the LDC will result in a water body in which the median concentration is equal to the EPA recommended ecoregion criterion.

To apply this process to a specific watershed entails using the individual watershed data compared to the TMDL curve that has been multiplied by the watershed area (mi^2). Data from the impaired segment is then plotted as a load (pounds/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. These data points do not have to be collected at the segment outlet. The spreadsheet applies an outlet flow (percentile exceedance) to the concentration based on the synthetic flow estimate for the specific date the sample was taken (Figure E-4).

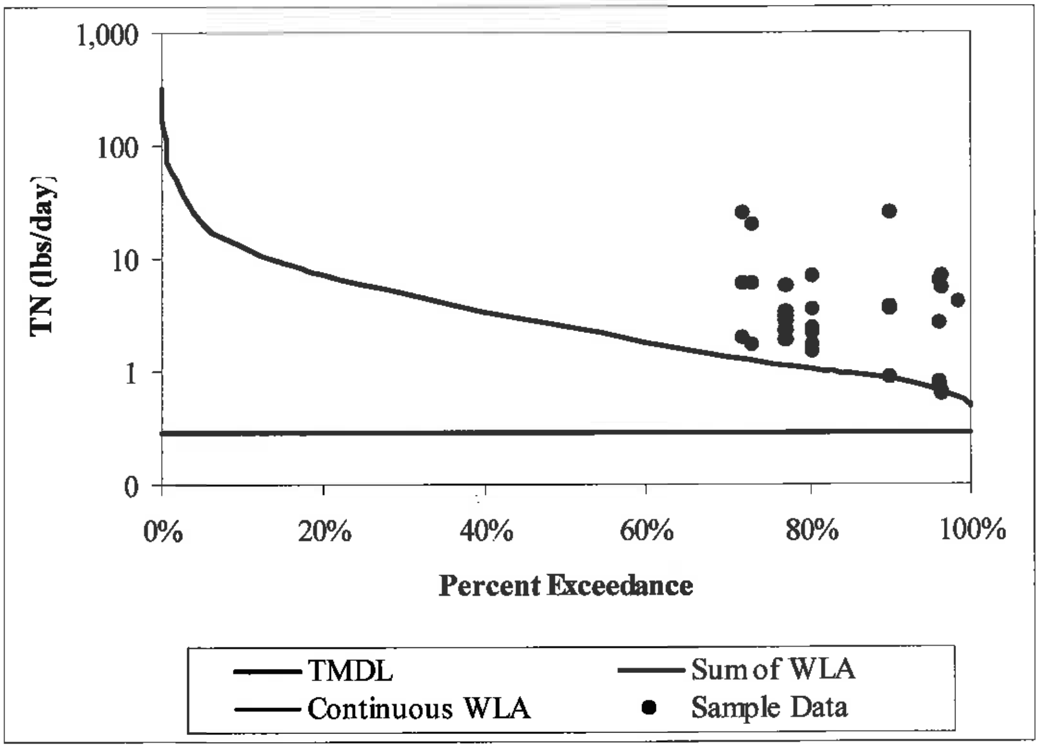


Figure E-4. Example of TMDL LDC Using This Method

The resulting LDC with plotted site specific measured data can now be used to target implementation by identifying flows in which TN concentrations are higher than would be expected in a stream meeting the EPA recommended ecoregion TN criterion.

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 F - STREAM FLOW AND WATER QUALITY STATIONS USED TO DEVELOP TMDLS IN THE BIG BOTTOM CREEK WATERSHED

Table F-1. Stations Used to Develop Water Quality Data Targets in Big Bottom Creek

USGS/ MDNR Station	Station Name
06930800	Gasconade River above Jerome, MO
7010500	Maramec Spring near St. James, MO
7014000	Huzzah Creek near Steelville, MO
7014200	Courtois Creek at Berryman, MO
7014500	Meramec River near Sullivan, MO
7064400	Montauk Springs at Montauk, MO
7064440	Current River at Montauk State Park, MO
7064530	Welch Spring near Akers, MO
7064555	Pulltite Spring near Round Spring, MO
7065000	Round Spring at Round Spring, MO
7065500	Alley Spring at Alley, MO
7066000	Jacks Fork at Eminence, MO
7066110	Jacks Fork above Two River, MO
7066510	Current River above Powder Mill, MO
7066550	Blue Spring near Eminence, MO
370857091265901	Jacks Fork River above Alley Spring, MO
370901091262001	Alley Spring Below Alley, MO
370905091204001	Jacks Fork Above 2nd Unnamed Hollow below Eminence, MO
371014091201301	Jacks Fork above Lick Log Hollow below Eminence, MO
371026091183301	Jacks Fork above Powell Springs above Two Rivers, MO
371054091173501	Jacks Fork below 3rd Hollow above Two Rivers, MO
1708/1.2/0.6	Watkins Creek @ Fry Lane
1709/1.0	Maline Creek @ Bellefontaine Rd.
1711/1.0/7.0	River des Peres @ Harlan Park
1711/1.2	River des Peres @ St. Louis
1711/1/3.5/1.5/0.5	Black Creek near Brentwood
1711/1/3.7/0.6	Deer Creek @ Maplewood, MO
1711/1/3.7/4	Deer Creek @ LaDue
1711/1/5.3/1.9	Engelholm Creek near Wellston
1713/1.7	Gravois Creek @ Green Park Rd, Mehlville
1714/0.8	Rock Creek @ Hwy K in Kimmswick
1716/3.4	Glaize Creek near Barnhardt
1755/1.8	Pickle Creek @ Hawn State Park

Table F-2. Water Quality Data Used in TMDL Development

USGS Gage	Sample Date	TN (mg/L)	Flow (cfs)
370901091262001	5/10/1999	0.8	208
370901091262001	6/22/1999	0.85	136
370901091262001	11/8/1999	0.71	89
370901091262001	2/29/2000	0.83	173
370901091262001	6/6/2000	0.64	75
370901091262001	6/28/2000	0.62	99
370901091262001	8/22/2000	0.62	73
370901091262001	2/22/2001	0.85	208
370901091262001	3/21/2001	0.95	123
370901091262001	5/25/2001	0.65	75
370901091262001	5/27/2001	0.65	80
370901091262001	8/9/2001	0.6	69
370901091262001	10/11/2001	0.98	66
370901091262001	4/2/2002	0.76	200
370901091262001	4/30/2002	0.59	250
370901091262001	5/29/2002	0.7	293
370901091262001	6/28/2002	0.77	145
370901091262001	6/29/2002	0.79	142
370901091262001	10/8/2002	1.1	89
370901091262001	10/9/2002	0.74	89
370901091262001	6/2/2003	0.71	113
370901091262001	6/9/2003	0.81	117
370901091262001	9/23/2003	0.71	87
370901091262001	7/13/2004	0.31	108
370901091262001	9/21/2004	0.72	88
6930800	2/1/1999	0.89	3060
6930800	3/16/1999	0.92	4780
6930800	4/12/1999	0.45	2900
6930800	5/26/1999	0.35	1700
6930800	6/24/1999	0.42	921
6930800	7/12/1999	0.44	826
6930800	8/12/1999	0.32	642
6930800	9/2/1999	0.27	482
6930800	10/5/1999	0.47	492
6930800	11/16/1999	0.25	516
6930800	12/8/1999	0.36	879
6930800	1/13/2000	0.6	722
6930800	2/9/2000	0.31	560
6930800	3/13/2000	0.49	1010
6930800	4/4/2000	0.32	935
6930800	5/16/2000	0.3	504
6930800	6/13/2000	0.44	481
6930800	7/5/2000	0.48	493
6930800	8/1/2000	0.36	541
6930800	9/5/2000	0.23	350
6930800	10/24/2000	0.2	463
6930800	11/21/2000	0.1	535
6930800	12/6/2000	0.24	523
6930800	1/9/2001	0.35	475
6930800	2/15/2001	1.3	1570

USGS Gage	Sample Date	TP (mg/L)	Flow (cfs)
370901091262001	5/10/1999	0.026	208
370901091262001	6/22/1999	0.008	136
370901091262001	8/10/1999	0.015	128
370901091262001	11/8/1999	0.01	89
370901091262001	12/14/1999	0.009	94
370901091262001	1/18/2000	0.009	85
370901091262001	2/29/2000	0.011	173
370901091262001	4/4/2000	0.006	87
370901091262001	5/10/2000	0.006	77
370901091262001	5/23/2000	0.009	80
370901091262001	5/25/2000	0.01	85
370901091262001	6/6/2000	0.011	75
370901091262001	6/28/2000	0.008	99
370901091262001	7/10/2000	0.009	82
370901091262001	7/28/2000	0.009	76
370901091262001	8/11/2000	0.009	73
370901091262001	8/22/2000	0.007	73
370901091262001	9/20/2000	0.012	74
370901091262001	10/4/2000	0.009	66
370901091262001	11/9/2000	0.009	79
370901091262001	12/20/2000	0.009	73
370901091262001	1/24/2001	0.01	79
370901091262001	2/22/2001	0.012	208
370901091262001	3/21/2001	0.011	123
370901091262001	4/25/2001	0.011	88
370901091262001	5/25/2001	0.009	75
370901091262001	5/26/2001	0.008	80
370901091262001	5/26/2001	0.01	80
370901091262001	5/27/2001	0.01	80
370901091262001	5/27/2001	0.01	80
370901091262001	6/7/2001	0.01	74
370901091262001	8/1/2001	0.009	64
370901091262001	8/8/2001	0.008	69
370901091262001	8/8/2001	0.009	69
370901091262001	8/9/2001	0.006	69
370901091262001	8/9/2001	0.01	69
370901091262001	9/18/2001	0.009	68
370901091262001	10/2/2001	0.009	66
370901091262001	10/10/2001	0.008	66
370901091262001	10/10/2001	0.009	66
370901091262001	10/11/2001	0.009	66
370901091262001	10/11/2001	0.01	66
370901091262001	11/20/2001	0.002	62
370901091262001	4/2/2002	0.015	200
370901091262001	4/30/2002	0.013	250
370901091262001	5/29/2002	0.021	293
370901091262001	6/4/2002	0.019	226
370901091262001	6/28/2002	0.012	145
370901091262001	6/29/2002	0.012	142
370901091262001	7/29/2002	0.013	118

USGS Gage	Sample Date	TN (mg/L)	Flow (cfs)
6930800	3/28/2001	0.91	894
6930800	4/9/2001	0.62	1400
6930800	5/3/2001	0.32	681
6930800	6/13/2001	0.43	1150
6930800	7/18/2001	0.36	547
6930800	8/14/2001	0.32	429
6930800	9/6/2001	0.25	381
6930800	10/22/2001	0.21	504
6930800	11/19/2001	0.19	469
6930800	12/4/2001	0.71	1820
6930800	1/28/2002	0.8	1630
6930800	2/13/2002	1.5	2100
6930800	3/26/2002	1.1	8780
6930800	4/9/2002	0.54	2100
6930800	5/20/2002	0.84	26100
6930800	6/11/2002	0.37	1670
6930800	7/16/2002	0.27	729
6930800	8/12/2002	0.29	547
6930800	9/3/2002	0.26	598
6930800	10/1/2002	0.12	498
6930800	11/13/2002	0.17	547
6930800	12/5/2002	0.16	547
6930800	1/15/2003	0.88	952
6930800	2/4/2003	0.53	631
6930800	3/5/2003	1.1	2660
6930800	4/8/2003	0.44	2720
6930800	5/8/2003	1.1	4900
6930800	6/9/2003	0.42	952
6930800	7/28/2003	0.19	475
6930800	9/5/2003	1.2	5300
6930800	10/29/2003	0.17	665
6930800	11/21/2003	2.2	13600
6930800	12/22/2003	1.2	2410
6930800	1/20/2004	1.1	5910
6930800	2/4/2004	1	2730
6930800	3/10/2004	1.3	5690
6930800	4/20/2004	0.28	1410
6930800	5/19/2004	0.42	1680
6930800	6/14/2004	0.44	864
6930800	7/8/2004	0.3	787
6930800	9/21/2004	0.2	481
6930800	10/13/2004	0.36	467
6930800	11/18/2004	1.2	1820
6930800	12/10/2004	1.4	7740
6930800	1/19/2005	1.2	5130
6930800	2/1/2005	1	1710
6930800	3/2/2005	0.49	1990
6930800	4/5/2005	0.27	1320
6930800	5/23/2005	0.31	763
6930800	6/9/2005	0.47	580
6930800	7/7/2005	0.28	484
6930800	8/1/2005	0.23	344
6930800	8/11/2005	0.27	343
6930800	9/1/2005	0.3	473
6930800	10/13/2005	0.17	554

USGS Gage	Sample Date	TP (mg/L)	Flow (cfs)
370901091262001	8/6/2002	0.011	105
370901091262001	8/7/2002	0.012	105
370901091262001	10/8/2002	0.01	89
370901091262001	10/9/2002	0.01	89
370901091262001	6/2/2003	0.011	113
370901091262001	6/9/2003	0.007	117
370901091262001	6/28/2003	0.01	91
370901091262001	7/26/2003	0.009	86
370901091262001	8/6/2003	0.01	86
370901091262001	9/23/2003	0.011	87
370901091262001	10/8/2003	0.01	74
370901091262001	6/15/2004	0.012	127
370901091262001	6/26/2004	0.013	127
370901091262001	7/13/2004	0.009	108
370901091262001	8/11/2004	0.01	103
370901091262001	8/21/2004	0.009	108
370901091262001	9/21/2004	0.012	88
370901091262001	10/5/2004	0.01	85
370901091262001	6/14/2005	0.011	100
370901091262001	7/5/2005	0.01	94
370901091262001	8/9/2005	0.009	88
6930800	3/16/1999	0.03	4780
6930800	4/12/1999	0.03	2900
6930800	7/12/1999	0.04	826
6930800	10/5/1999	0.04	492
6930800	4/4/2000	0.03	935
6930800	6/13/2000	0.04	481
6930800	7/5/2000	0.04	493
6930800	8/1/2000	0.05	541
6930800	4/9/2001	0.03	1400
6930800	6/13/2001	0.03	1150
6930800	8/14/2001	0.03	429
6930800	12/4/2001	0.03	1820
6930800	3/26/2002	0.07	8780
6930800	5/20/2002	0.13	26100
6930800	3/5/2003	0.02	2660
6930800	5/8/2003	0.09	4900
6930800	6/9/2003	0.03	952
6930800	9/5/2003	0.11	5300
6930800	11/21/2003	0.3	13600
6930800	12/22/2003	0.03	2410
6930800	1/20/2004	0.07	5910
6930800	2/4/2004	0.02	2730
6930800	3/10/2004	0.05	5690
6930800	6/14/2004	0.02	864
6930800	7/8/2004	0.03	787
6930800	10/13/2004	0.04	467
6930800	11/18/2004	0.05	1820
6930800	12/10/2004	0.1	7740
6930800	1/19/2005	0.04	5130
6930800	2/1/2005	0.03	1710
6930800	6/9/2005	0.03	580
6930800	8/1/2005	0.02	344
6930800	8/11/2005	0.02	343
6930800	11/22/2005	0.06	1340

USGS Gage	Sample Date	TN (mg/L)	Flow (cfs)
6930800	11/22/2005	1	1340
6930800	12/20/2005	0.49	611
6930800	1/10/2006	0.28	117
6930800	2/6/2006	0.31	1180
6930800	3/22/2006	0.78	1660
6930800	4/25/2006	0.35	943
6930800	5/8/2006	1	5860
6930800	6/6/2006	0.31	871
6930800	7/5/2006	0.3	481
6930800	8/1/2006	0.27	463
6930800	9/7/2006	0.25	424
6930800	10/4/2006	0.23	404
6930800	11/2/2006	0.22	637
6930800	12/11/2006	1.5	2200
6930800	1/23/2007	1.3	7240
6930800	2/7/2007	1	1680
6930800	3/14/2007	0.4	1300
6930800	4/25/2007	0.45	3360
6930800	5/8/2007	0.32	2930
6930800	6/4/2007	0.5	1540
6930800	7/11/2007	0.63	1360
6930800	8/16/2007	0.22	487
6930800	9/10/2007	0.81	1890
6930800	10/17/2007	0.24	542
6930800	11/19/2007	0.17	557
6930800	12/4/2007	0.23	580
6930800	1/9/2008	1.9	8130
6930800	2/6/2008	1.3	7290
6930800	3/18/2008	1.5	25800
6930800	4/2/2008	1.1	22900
6930800	5/14/2008	0.52	6400
6930800	6/3/2008	0.42	2470
6930800	7/31/2008	0.44	1000
6930800	8/4/2008	0.36	1080
6930800	9/3/2008	0.37	874
6930800	10/16/2008	0.31	1160
6930800	11/4/2008	0.26	927
6930800	12/1/2008	0.36	795
6930800	1/26/2009	0.66	787
6930800	2/2/2009	0.54	825
6930800	3/16/2009	0.27	1560
6930800	4/6/2009	0.55	3230
6930800	5/18/2009	0.79	6440
6930800	6/1/2009	0.21	2320
6930800	7/6/2009	0.46	1150
6930800	8/17/2009	0.38	625
6930800	9/2/2009	0.49	592
6930800	10/5/2009	0.46	856
6930800	11/2/2009	1.3	37400
371054091173501	11/10/1999	0.37	169
371054091173501	12/16/1999	0.47	276
371054091173501	3/2/2000	0.72	470
371054091173501	4/6/2000	0.45	241
371054091173501	5/12/2000	0.36	146
371054091173501	5/25/2000	0.58	225

USGS Gage	Sample Date	TP (mg/L)	Flow (cfs)
6930800	3/22/2006	0.03	1660
6930800	4/25/2006	0.03	943
6930800	5/8/2006	0.12	5860
6930800	6/6/2006	0.03	871
6930800	7/5/2006	0.02	481
6930800	8/1/2006	0.03	463
6930800	11/2/2006	0.02	637
6930800	12/11/2006	0.04	2200
6930800	1/23/2007	0.04	7240
6930800	3/14/2007	0.02	1300
6930800	4/25/2007	0.04	3360
6930800	5/8/2007	0.03	2930
6930800	6/4/2007	0.02	1540
6930800	7/11/2007	0.06	1360
6930800	9/10/2007	0.07	1890
6930800	12/4/2007	0.03	580
6930800	1/9/2008	0.31	8130
6930800	2/6/2008	0.11	7290
6930800	3/18/2008	0.21	25800
6930800	4/2/2008	0.13	22900
6930800	5/14/2008	0.03	6400
6930800	6/3/2008	0.03	2470
6930800	7/31/2008	0.03	1000
6930800	8/4/2008	0.02	1080
6930800	9/3/2008	0.02	874
6930800	1/26/2009	0.04	787
6930800	2/2/2009	0.02	825
6930800	4/6/2009	0.02	3230
6930800	5/18/2009	0.06	6440
6930800	7/6/2009	0.03	1150
6930800	9/2/2009	0.03	592
6930800	10/5/2009	0.03	856
6930800	11/2/2009	0.21	37400
371054091173501	3/2/2000	0.005	470
371054091173501	5/12/2000	0.004	146
371054091173501	5/25/2000	0.014	225
371054091173501	6/8/2000	0.005	177
371054091173501	6/30/2000	0.004	250
371054091173501	7/12/2000	0.008	171
371054091173501	7/26/2000	0.005	165
371054091173501	8/9/2000	0.014	132
371054091173501	9/19/2000	0.004	113
371054091173501	12/12/2000	0.003	195
371054091173501	1/24/2001	0.002	186
371054091173501	2/21/2001	0.003	475
371054091173501	4/25/2001	0.004	235
371054091173501	5/26/2001	0.009	218
371054091173501	5/27/2001	0.006	193
371054091173501	5/27/2001	0.006	193
371054091173501	8/1/2001	0.008	150
371054091173501	8/8/2001	0.005	122
371054091173501	8/8/2001	0.006	122
371054091173501	8/9/2001	0.007	122
371054091173501	8/9/2001	0.008	122
371054091173501	9/19/2001	0.006	125

USGS Gage	Sample Date	TN (mg/L)	Flow (cfs)
371054091173501	6/8/2000	0.48	177
371054091173501	6/30/2000	0.3	250
371054091173501	7/12/2000	0.4	171
371054091173501	7/26/2000	0.31	165
371054091173501	8/9/2000	0.43	132
371054091173501	8/21/2000	0.35	128
371054091173501	12/12/2000	0.42	195
371054091173501	1/24/2001	0.41	186
371054091173501	2/21/2001	0.63	475
371054091173501	4/25/2001	0.34	235
371054091173501	5/26/2001	0.33	218
371054091173501	5/27/2001	0.31	193
371054091173501	5/27/2001	0.33	193
371054091173501	8/1/2001	0.33	150
371054091173501	8/8/2001	0.33	122
371054091173501	8/8/2001	0.35	122
371054091173501	8/9/2001	0.36	122
371054091173501	8/9/2001	0.37	122
371054091173501	9/19/2001	0.33	125
371054091173501	10/10/2001	0.3	129
371054091173501	10/10/2001	0.49	129
371054091173501	10/11/2001	0.33	129
371054091173501	4/3/2002	0.46	551
371054091173501	5/1/2002	0.31	728
371054091173501	5/30/2002	0.37	738
371054091173501	6/5/2002	0.39	548
371054091173501	6/28/2002	0.48	310
371054091173501	6/29/2002	0.45	298
371054091173501	8/7/2002	0.39	226
371054091173501	10/9/2002	0.38	167
371054091173501	6/4/2003	0.4	344
371054091173501	7/26/2003	0.3	185
371054091173501	8/6/2003	0.35	229
371054091173501	9/23/2003	0.37	210
371054091173501	10/8/2003	0.35	158
371054091173501	6/15/2004	0.42	342
371054091173501	6/26/2004	0.35	266
371054091173501	7/13/2004	0.36	228
371054091173501	8/11/2004	0.37	181
371054091173501	8/21/2004	0.38	184
371054091173501	6/14/2005	0.4	186
371054091173501	7/6/2005	0.38	120
371054091173501	8/10/2005	0.37	149
371014091201301	11/9/1999	0.39	151
371014091201301	12/15/1999	0.51	298
371014091201301	1/19/2000	0.77	173
371014091201301	3/1/2000	0.73	524
371014091201301	4/5/2000	0.46	234
371014091201301	5/11/2000	0.42	138
371014091201301	5/24/2000	0.4	133
371014091201301	5/25/2000	0.4	221
371014091201301	6/7/2000	0.52	168
371014091201301	6/29/2000	0.29	265
371014091201301	7/11/2000	0.4	144
371014091201301	7/27/2000	0.38	143

USGS Gage	Sample Date	TP (mg/L)	Flow (cfs)
371054091173501	10/3/2001	0.004	110
371054091173501	10/10/2001	0.004	129
371054091173501	10/10/2001	0.004	129
371054091173501	10/11/2001	0.004	129
371054091173501	10/11/2001	0.006	129
371054091173501	4/3/2002	0.005	551
371054091173501	5/1/2002	0.006	728
371054091173501	5/30/2002	0.008	738
371054091173501	6/5/2002	0.005	548
371054091173501	6/28/2002	0.007	310
371054091173501	6/29/2002	0.006	298
371054091173501	7/30/2002	0.006	268
371054091173501	8/6/2002	0.004	226
371054091173501	8/7/2002	0.006	226
371054091173501	10/8/2002	0.004	167
371054091173501	10/9/2002	0.005	167
371054091173501	6/4/2003	0.003	344
371054091173501	6/28/2003	0.006	209
371054091173501	7/26/2003	0.007	185
371054091173501	8/6/2003	0.009	229
371054091173501	9/23/2003	0.005	210
371054091173501	10/8/2003	0.006	158
371054091173501	6/15/2004	0.007	342
371054091173501	6/26/2004	0.005	266
371054091173501	7/13/2004	0.005	228
371054091173501	8/11/2004	0.008	181
371054091173501	8/21/2004	0.003	184
371054091173501	9/21/2004	0.005	150
371054091173501	10/5/2004	0.004	146
371054091173501	6/14/2005	0.007	186
371054091173501	7/6/2005	0.007	120
371054091173501	8/10/2005	0.007	149
371014091201301	11/9/1999	0.004	151
371014091201301	3/1/2000	0.006	524
371014091201301	5/11/2000	0.006	138
371014091201301	5/24/2000	0.005	133
371014091201301	5/25/2000	0.008	221
371014091201301	6/7/2000	0.01	168
371014091201301	6/29/2000	0.004	265
371014091201301	7/11/2000	0.008	144
371014091201301	7/27/2000	0.006	143
371014091201301	8/10/2000	0.013	127
371014091201301	8/22/2000	0.004	122
371014091201301	10/4/2000	0.005	111
371014091201301	11/8/2000	0.003	227
371014091201301	1/23/2001	0.003	204
371014091201301	3/21/2001	0.005	272
371014091201301	4/24/2001	0.005	226
371014091201301	5/25/2001	0.006	220
371014091201301	5/26/2001	0.006	208
371014091201301	5/26/2001	0.007	208
371014091201301	5/27/2001	0.005	208
371014091201301	5/27/2001	0.009	208
371014091201301	6/7/2001	0.014	192
371014091201301	7/31/2001	0.009	140

USGS Gage	Sample Date	TN (mg/L)	Flow (cfs)
371014091201301	8/10/2000	0.41	127
371014091201301	8/22/2000	0.42	122
371014091201301	10/4/2000	0.37	111
371014091201301	11/8/2000	0.28	227
371014091201301	3/21/2001	0.64	272
371014091201301	4/24/2001	0.36	226
371014091201301	5/25/2001	0.32	220
371014091201301	5/26/2001	0.33	208
371014091201301	5/26/2001	0.35	208
371014091201301	5/27/2001	0.36	208
371014091201301	5/27/2001	0.38	208
371014091201301	6/7/2001	0.33	192
371014091201301	7/31/2001	0.35	140
371014091201301	8/8/2001	0.4	97
371014091201301	8/9/2001	0.4	97
371014091201301	8/9/2001	0.4	97
371014091201301	10/2/2001	0.33	106
371014091201301	10/10/2001	0.37	109
371014091201301	10/11/2001	0.39	116
371014091201301	10/11/2001	0.48	116
371014091201301	4/2/2002	0.43	590
371014091201301	4/30/2002	0.28	760
371014091201301	5/29/2002	0.39	657
371014091201301	6/4/2002	0.39	488
371014091201301	6/28/2002	0.5	309
371014091201301	6/29/2002	0.47	297
371014091201301	7/29/2002	0.41	266
371014091201301	8/6/2002	0.42	220
371014091201301	8/7/2002	0.39	216
371014091201301	10/8/2002	0.47	168
371014091201301	10/9/2002	0.48	171
371014091201301	6/3/2003	0.46	308
371014091201301	6/10/2003	0.52	296
371014091201301	6/28/2003	0.41	220
371014091201301	7/26/2003	0.36	170
371014091201301	8/6/2003	0.37	253
371014091201301	9/23/2003	0.4	208
371014091201301	10/8/2003	0.44	157
371014091201301	6/15/2004	0.45	355
371014091201301	6/26/2004	0.39	279
371014091201301	7/13/2004	0.39	223
371014091201301	8/21/2004	0.42	182
371014091201301	10/5/2004	0.4	151
371014091201301	6/15/2005	0.47	179
371014091201301	7/6/2005	0.44	164
371014091201301	8/10/2005	0.43	144
371026091183301	6/24/1999	0.49	267
371026091183301	8/12/1999	0.48	186
371026091183301	11/10/1999	0.39	164
371026091183301	12/15/1999	0.46	298
371026091183301	3/2/2000	0.76	489
371026091183301	4/5/2000	0.45	258
371026091183301	5/11/2000	0.38	144
371026091183301	5/24/2000	0.36	137
371026091183301	6/7/2000	0.45	191

USGS Gage	Sample Date	TP (mg/L)	Flow (cfs)
371014091201301	8/8/2001	0.012	97
371014091201301	8/9/2001	0.009	97
371014091201301	8/9/2001	0.013	97
371014091201301	9/18/2001	0.005	115
371014091201301	10/2/2001	0.004	106
371014091201301	10/10/2001	0.004	109
371014091201301	10/10/2001	0.009	109
371014091201301	10/11/2001	0.009	116
371014091201301	10/11/2001	0.015	116
371014091201301	11/21/2001	0.004	114
371014091201301	4/2/2002	0.005	590
371014091201301	4/30/2002	0.006	760
371014091201301	5/29/2002	0.007	657
371014091201301	6/4/2002	0.005	488
371014091201301	6/28/2002	0.008	309
371014091201301	6/29/2002	0.009	297
371014091201301	7/29/2002	0.007	266
371014091201301	8/6/2002	0.009	220
371014091201301	8/7/2002	0.007	216
371014091201301	10/8/2002	0.005	168
371014091201301	10/9/2002	0.007	171
371014091201301	6/3/2003	0.007	308
371014091201301	6/10/2003	0.022	296
371014091201301	6/28/2003	0.006	220
371014091201301	7/26/2003	0.009	170
371014091201301	8/6/2003	0.012	253
371014091201301	9/23/2003	0.005	208
371014091201301	10/8/2003	0.009	157
371014091201301	6/15/2004	0.008	355
371014091201301	6/26/2004	0.006	279
371014091201301	7/13/2004	0.009	223
371014091201301	8/11/2004	0.006	195
371014091201301	8/21/2004	0.003	182
371014091201301	9/21/2004	0.011	135
371014091201301	10/5/2004	0.004	151
371014091201301	6/15/2005	0.011	179
371014091201301	7/6/2005	0.008	164
371014091201301	8/10/2005	0.012	144
371026091183301	5/12/1999	0.004	582
371026091183301	8/12/1999	0.005	186
371026091183301	3/2/2000	0.005	489
371026091183301	5/24/2000	0.005	137
371026091183301	6/7/2000	0.008	191
371026091183301	6/29/2000	0.005	246
371026091183301	7/11/2000	0.007	155
371026091183301	7/27/2000	0.006	147
371026091183301	8/10/2000	0.006	133
371026091183301	9/20/2000	0.005	114
371026091183301	10/4/2000	0.004	114
371026091183301	12/20/2000	0.002	164
371026091183301	3/20/2001	0.006	302
371026091183301	4/24/2001	0.004	235
371026091183301	5/25/2001	0.008	235
371026091183301	5/26/2001	0.007	207
371026091183301	5/26/2001	0.007	207

USGS Gage	Sample Date	TN (mg/L)	Flow (cfs)
371026091183301	6/29/2000	0.3	246
371026091183301	7/11/2000	0.34	155
371026091183301	7/27/2000	0.37	147
371026091183301	8/10/2000	0.34	133
371026091183301	8/22/2000	0.37	125
371026091183301	10/4/2000	0.33	114
371026091183301	12/20/2000	0.4	164
371026091183301	3/20/2001	0.64	302
371026091183301	4/24/2001	0.37	235
371026091183301	5/25/2001	0.38	235
371026091183301	5/26/2001	0.3	207
371026091183301	5/26/2001	0.33	207
371026091183301	5/27/2001	0.28	207
371026091183301	5/27/2001	0.32	207
371026091183301	6/7/2001	0.31	201
371026091183301	7/31/2001	0.36	147
371026091183301	8/8/2001	0.33	121
371026091183301	8/8/2001	0.43	121
371026091183301	8/9/2001	0.36	121
371026091183301	8/9/2001	0.38	121
371026091183301	9/18/2001	0.3	118
371026091183301	10/10/2001	0.3	109
371026091183301	10/11/2001	0.33	116
371026091183301	10/11/2001	0.34	116
371026091183301	6/28/2002	0.49	314
371026091183301	6/29/2002	0.45	312
371026091183301	7/29/2002	0.4	249
371026091183301	8/7/2002	0.4	216
371026091183301	10/8/2002	0.4	168
371026091183301	10/9/2002	0.55	171
371026091183301	6/3/2003	0.45	308
371026091183301	6/10/2003	0.43	296
371026091183301	6/28/2003	0.36	220
371026091183301	7/26/2003	0.34	170
371026091183301	8/6/2003	0.35	253
371026091183301	9/23/2003	0.35	208
371026091183301	10/8/2003	0.41	157
371026091183301	6/15/2004	0.43	355
371026091183301	6/26/2004	0.36	279
371026091183301	7/13/2004	0.41	223
371026091183301	8/11/2004	0.39	195
371026091183301	8/21/2004	0.4	182
371026091183301	9/21/2004	0.37	135
371026091183301	6/15/2005	0.42	179
371026091183301	7/6/2005	0.39	164
371026091183301	8/10/2005	0.4	144
370857091265901	5/10/1999	0.24	307
370857091265901	6/22/1999	0.22	82
370857091265901	8/10/1999	0.17	61
370857091265901	12/14/1999	0.37	233
370857091265901	2/29/2000	0.79	359
370857091265901	4/4/2000	0.3	117
370857091265901	5/10/2000	0.22	52
370857091265901	5/23/2000	0.16	42
370857091265901	5/25/2000	0.24	129

USGS Gage	Sample Date	TP (mg/L)	Flow (cfs)
371026091183301	5/27/2001	0.006	207
371026091183301	5/27/2001	0.006	207
371026091183301	6/7/2001	0.009	201
371026091183301	7/31/2001	0.01	147
371026091183301	8/8/2001	0.005	121
371026091183301	8/8/2001	0.008	121
371026091183301	8/9/2001	0.007	121
371026091183301	8/9/2001	0.01	121
371026091183301	9/18/2001	0.004	118
371026091183301	10/2/2001	0.004	108
371026091183301	10/10/2001	0.005	109
371026091183301	10/10/2001	0.005	109
371026091183301	10/11/2001	0.006	116
371026091183301	10/11/2001	0.006	116
371026091183301	11/21/2001	0.003	119
371026091183301	4/2/2002	0.007	590
371026091183301	4/30/2002	0.006	751
371026091183301	5/29/2002	0.008	657
371026091183301	6/4/2002	0.006	492
371026091183301	6/28/2002	0.005	314
371026091183301	6/29/2002	0.007	312
371026091183301	7/29/2002	0.007	249
371026091183301	8/6/2002	0.005	216
371026091183301	8/7/2002	0.005	216
371026091183301	10/8/2002	0.004	168
371026091183301	10/9/2002	0.006	171
371026091183301	6/3/2003	0.004	308
371026091183301	6/10/2003	0.003	296
371026091183301	6/28/2003	0.007	220
371026091183301	7/26/2003	0.008	170
371026091183301	8/6/2003	0.013	253
371026091183301	9/23/2003	0.004	208
371026091183301	10/8/2003	0.007	157
371026091183301	6/15/2004	0.008	355
371026091183301	6/26/2004	0.005	279
371026091183301	7/13/2004	0.008	223
371026091183301	8/11/2004	0.005	195
371026091183301	8/21/2004	0.005	182
371026091183301	9/21/2004	0.004	135
371026091183301	10/5/2004	0.004	151
371026091183301	6/15/2005	0.007	179
371026091183301	7/6/2005	0.007	164
371026091183301	8/10/2005	0.008	144
370905091204001	5/11/1999	0.006	616
370905091204001	6/23/1999	0.005	239
370905091204001	8/11/1999	0.008	190
370905091204001	3/1/2000	0.006	547
370905091204001	5/11/2000	0.005	142
370905091204001	5/24/2000	0.007	129
370905091204001	6/7/2000	0.007	177
370905091204001	7/11/2000	0.009	155
370905091204001	7/27/2000	0.007	144
370905091204001	8/10/2000	0.006	128
370905091204001	8/21/2000	0.007	124
370905091204001	10/2/2001	0.008	104

USGS Gage	Sample Date	TN (mg/L)	Flow (cfs)
370857091265901	6/6/2000	0.22	73
370857091265901	6/28/2000	0.18	123
370857091265901	7/28/2000	0.15	44
370857091265901	8/11/2000	0.16	36
370857091265901	8/22/2000	0.18	33
370857091265901	9/20/2000	0.12	25
370857091265901	11/9/2000	0.18	121
370857091265901	2/22/2001	0.54	328
370857091265901	3/21/2001	0.34	127
370857091265901	4/25/2001	0.2	107
370857091265901	5/25/2001	0.17	102
370857091265901	5/26/2001	0.15	94
370857091265901	5/26/2001	0.17	94
370857091265901	5/27/2001	0.14	85
370857091265901	5/27/2001	0.15	85
370857091265901	6/7/2001	0.15	94
370857091265901	8/1/2001	0.16	45
370857091265901	8/8/2001	0.12	30
370857091265901	8/8/2001	0.18	33
370857091265901	8/9/2001	0.14	33
370857091265901	8/9/2001	0.15	33
370857091265901	9/18/2001	0.13	30
370857091265901	4/30/2002	0.15	382
370857091265901	5/29/2002	0.21	303
370857091265901	6/4/2002	0.23	201
370857091265901	6/28/2002	0.23	99
370857091265901	6/29/2002	0.22	90
370857091265901	10/8/2002	0.11	53
370857091265901	10/9/2002	0.26	54
370857091265901	6/2/2003	0.24	112
370857091265901	6/9/2003	0.2	101
370857091265901	8/6/2003	0.13	128
370857091265901	9/23/2003	0.21	94
370857091265901	10/8/2003	0.18	62
370857091265901	6/15/2004	0.26	162
370857091265901	6/26/2004	0.18	117
370857091265901	8/21/2004	0.16	64
370857091265901	6/14/2005	0.21	75
370857091265901	7/5/2005	0.18	59
370857091265901	8/9/2005	0.13	44
370905091204001	5/11/1999	0.34	616
370905091204001	6/23/1999	0.5	239
370905091204001	8/11/1999	0.52	190
370905091204001	11/9/1999	0.38	154
370905091204001	12/15/1999	0.56	299
370905091204001	1/19/2000	0.45	172
370905091204001	3/1/2000	0.76	547
370905091204001	4/5/2000	0.47	240
370905091204001	5/24/2000	0.41	129
370905091204001	6/7/2000	0.5	177
370905091204001	6/29/2000	0.36	244
370905091204001	7/27/2000	0.46	144
370905091204001	8/10/2000	0.31	128
370905091204001	8/21/2000	0.43	124
370905091204001	10/2/2001	0.41	104

USGS Gage	Sample Date	TP (mg/L)	Flow (cfs)
370905091204001	10/10/2001	0.007	109
370905091204001	10/10/2001	0.009	109
370905091204001	10/11/2001	0.01	116
370905091204001	10/11/2001	0.018	116
370905091204001	11/20/2001	0.002	112
370905091204001	4/2/2002	0.006	590
370905091204001	5/29/2002	0.008	657
370905091204001	6/4/2002	0.006	488
370905091204001	6/28/2002	0.008	309
370905091204001	6/29/2002	0.009	297
370905091204001	7/29/2002	0.008	266
370905091204001	8/6/2002	0.004	220
370905091204001	8/7/2002	0.007	216
370905091204001	10/8/2002	0.007	161
370905091204001	10/9/2002	0.009	164
370905091204001	6/3/2003	0.007	270
370905091204001	6/10/2003	0.014	263
370905091204001	6/28/2003	0.022	185
370905091204001	7/26/2003	0.009	169
370905091204001	8/6/2003	0.011	226
370905091204001	9/23/2003	0.006	201
370905091204001	10/8/2003	0.009	151
370905091204001	6/15/2004	0.007	368
370905091204001	6/26/2004	0.005	266
370905091204001	7/13/2004	0.008	216
370905091204001	8/11/2004	0.005	186
370905091204001	8/21/2004	0.005	174
370905091204001	9/21/2004	0.012	147
370905091204001	10/5/2004	0.006	135
370905091204001	6/14/2005	0.008	156
370905091204001	7/6/2005	0.005	164
370905091204001	4/30/2002	0.006	760
7066110	6/20/1973	0.03	478
7066110	8/1/1973	0.02	288
7066110	10/17/1973	0.04	439
7066110	1/18/1974	0.03	560
7066110	4/17/1974	0.03	680
7066110	7/10/1974	0.01	326
7066110	10/22/1974	0.02	233
7066110	1/21/1975	0.01	490
7066110	5/4/1977	0.01	242
7066110	5/16/1979	0.01	980
7066110	9/5/1979	0.01	293
7066110	5/6/1980	0.09	279
7066110	6/10/1981	0.01	395
7066110	9/22/1981	0.02	127
7066110	6/30/1982	0.04	464
7066110	5/25/1983	0.01	700
7066110	5/16/1984	0.01	775
7066110	5/7/1986	0.01	300
7066110	5/12/1987	0.01	220
7066110	5/18/1988	0.02	282
7066110	10/12/1988	0.01	172
7066110	10/24/1989	0.01	159
7066110	11/20/1990	0.03	126

USGS Gage	Sample Date	TN (mg/L)	Flow (cfs)
370905091204001	10/10/2001	0.39	109
370905091204001	10/10/2001	0.4	109
370905091204001	10/11/2001	0.37	116
370905091204001	4/2/2002	0.43	590
370905091204001	4/30/2002	0.34	760
370905091204001	5/29/2002	0.36	657
370905091204001	6/4/2002	0.42	488
370905091204001	6/28/2002	0.51	309
370905091204001	6/29/2002	0.46	297
370905091204001	7/29/2002	0.42	266
370905091204001	8/7/2002	0.42	216
370905091204001	10/8/2002	0.47	161
370905091204001	10/9/2002	0.48	164
370905091204001	6/3/2003	0.47	270
370905091204001	6/10/2003	0.5	263
370905091204001	6/28/2003	0.43	185
370905091204001	7/26/2003	0.36	169
370905091204001	8/6/2003	0.35	226
370905091204001	9/23/2003	0.47	201
370905091204001	10/8/2003	0.45	151
370905091204001	6/15/2004	0.47	368
370905091204001	6/26/2004	0.4	266
370905091204001	7/13/2004	0.42	216
370905091204001	8/11/2004	0.44	186
370905091204001	8/21/2004	0.46	174
370905091204001	9/21/2004	0.5	147
370905091204001	6/14/2005	0.45	156
370905091204001	7/6/2005	0.43	164
370905091204001	8/10/2005	0.46	138
7066110	6/20/1973	0.37	478
7066110	8/1/1973	0.45	288
7066110	10/17/1973	0.58	439
7066110	1/18/1974	0.39	560
7066110	4/17/1974	0.46	680
7066110	7/10/1974	0.46	326
7066110	10/22/1974	0.35	233
7066110	1/21/1975	0.48	490
7066110	4/15/1975	0.53	530
7066110	9/23/1976	0.3	132
7066110	5/4/1977	0.53	242
7066110	9/22/1977	0.69	210
7066110	5/11/1978	0.53	626
7066110	9/13/1978	0.56	140
7066110	5/16/1979	0.29	980
7066110	9/5/1979	0.34	293
7066110	5/6/1980	0.54	279
7066110	8/27/1980	0.73	121
7066110	6/10/1981	1.7	395
7066110	9/22/1981	0.6	127
7066110	6/30/1982	0.76	464
7066110	5/25/1983	0.6	700
7066110	9/14/1983	0.6	180
7066110	5/16/1984	0.7	775
7066110	5/15/1985	0.6	1140
7066110	9/11/1985	0.6	329

USGS Gage	Sample Date	TP (mg/L)	Flow (cfs)
7066110	10/23/1991	0.01	166
7066110	11/12/1992	0.13	2200
7066110	12/8/1992	0.01	344
7066110	1/22/1993	0.02	1200
7066110	4/7/1993	0.05	1100
7066110	4/14/1993	0.02	702
7066110	6/3/1993	0.03	366
7066110	4/14/1994	0.04	4140
7066110	10/20/1994	0.06	251
7066110	5/22/1995	0.02	680
7066110	8/7/1995	0.12	262
7066110	10/11/1995	0.02	189
7066110	4/1/1996	0.03	1340
7066110	4/7/1997	0.03	3200
7066110	11/13/2000	0.17	215
7066110	5/13/2002	0.06	2400
7066110	2/14/2007	0.04	2400
7064555	4/3/1973	0.007	151
7064555	6/18/1973	0.04	164
7064555	7/30/1973	0.02	93
7064555	5/5/1977	0.02	55
7064555	5/11/1978	0.01	105
7064555	5/15/1979	0.01	110
7064555	9/5/1979	0.01	57
7064555	5/7/1980	0.02	61
7064555	8/26/1980	0.01	21
7064555	6/11/1981	0.02	98
7064555	9/21/1981	0.02	9.8
7064555	7/1/1982	0.05	119
7064555	5/26/1983	0.02	132
7064555	5/15/1984	0.01	141
7064555	5/6/1986	0.01	101
7064555	10/14/1986	0.01	70
7064555	5/11/1987	0.01	85
7064555	10/13/1987	0.01	23
7064555	5/17/1988	0.02	75
7064555	10/11/1988	0.01	32
7064555	10/23/1989	0.01	28
7064555	10/22/1991	0.02	34
7064555	4/13/1993	0.04	124
7064555	10/19/1993	0.03	112
7064555	10/10/1995	0.04	49
7064555	10/1/1996	0.18	126
7064530	4/2/1973	0.004	500
7064530	6/18/1973	0.02	232
7064530	7/30/1973	0.03	272
7064530	5/5/1977	0.03	130
7064530	5/12/1978	0.01	299
7064530	5/15/1979	0.01	387
7064530	9/4/1979	0.01	127
7064530	5/8/1980	0.03	158
7064530	8/26/1980	0.01	103
7064530	6/11/1981	0.19	144
7064530	9/21/1981	0.02	111
7064530	6/29/1982	0.05	337

USGS Gage	Sample Date	TN (mg/L)	Flow (cfs)
7066110	10/15/1986	1.1	205
7066110	5/12/1987	0.8	220
7066110	10/14/1987	0.5	145
7066110	5/18/1988	0.6	282
7066110	10/12/1988	0.5	172
7066110	5/24/1989	0.9	1380
7066110	11/20/1990	0.6	126
7066110	11/12/1992	0.9	2200
7066110	1/22/1993	0.52	1200
7066110	7/9/1993	0.59	274
7066110	8/7/1995	0.58	262
7066110	4/1/1996	0.69	1340
7066110	11/6/1996	0.54	123
7066110	6/10/1997	0.49	410
7066110	1/26/1999	0.45	530
7066110	3/2/1999	0.52	390
7066110	4/5/1999	0.29	860
7066110	6/17/1999	0.51	220
7066110	8/18/1999	0.5	196
7066110	11/1/1999	0.41	179
7066110	3/20/2000	0.66	333
7066110	5/8/2000	0.43	180
7066110	7/17/2000	0.4	170
7066110	9/11/2000	0.35	145
7066110	11/13/2000	1.2	215
7066110	5/10/2001	0.39	225
7066110	7/17/2001	0.29	152
7066110	9/4/2001	0.31	110
7066110	1/22/2002	0.51	144
7066110	3/5/2002	0.4	504
7066110	5/13/2002	0.5	2400
7066110	7/15/2002	0.37	304
7066110	9/5/2002	0.48	288
7066110	3/11/2003	0.48	398
7066110	5/19/2003	0.37	1170
7066110	7/7/2003	0.41	271
7066110	9/5/2003	0.53	761
7066110	11/17/2003	0.33	340
7066110	1/22/2004	0.42	853
7066110	5/5/2004	0.44	1020
7066110	7/6/2004	0.35	404
7066110	9/7/2004	0.42	230
7066110	11/22/2004	0.54	425
7066110	1/25/2005	0.62	760
7066110	3/15/2005	0.45	428
7066110	5/19/2005	0.37	310
7066110	7/18/2005	0.38	210
7066110	9/1/2005	0.33	206
7066110	1/4/2006	0.5	165
7066110	3/1/2006	0.34	170
7066110	5/8/2006	0.29	1170
7066110	7/10/2006	0.39	166
7066110	11/15/2006	0.49	384
7066110	1/24/2007	0.29	984
7066110	2/14/2007	0.69	2400

USGS Gage	Sample Date	TP (mg/L)	Flow (cfs)
7064530	5/24/1983	0.01	356
7064530	9/15/1983	0.01	90
7064530	5/15/1984	0.01	271
7064530	9/18/1984	0.01	172
7064530	9/10/1985	0.01	244
7064530	5/6/1986	0.01	209
7064530	10/14/1986	0.01	176
7064530	5/11/1987	0.01	173
7064530	10/13/1987	0.01	97
7064530	5/17/1988	0.02	240
7064530	10/11/1988	0.01	115
7064530	10/23/1989	0.01	101
7064530	11/19/1990	0.01	171
7064530	10/22/1991	0.01	117
7064530	10/19/1994	0.18	169
7064530	10/10/1995	0.02	138
7065500	9/23/1976	0.01	78
7065500	5/10/1978	0.01	189
7065500	9/5/1979	0.01	118
7065500	8/27/1980	0.01	73
7065500	9/22/1981	0.01	82
7065500	5/16/1984	0.01	297
7065500	5/7/1986	0.01	139
7065500	5/12/1987	0.01	115
7065500	10/25/1989	0.01	88
7065500	5/30/1991	0.01	163
7065500	10/16/1973	0.02	201
7065500	5/4/1977	0.02	148
7065500	5/16/1979	0.02	320
7065500	5/6/1980	0.02	138
7065500	6/10/1981	0.02	137
7065500	5/25/1983	0.02	197
7065500	5/18/1988	0.02	129
7065500	10/12/1988	0.02	96
7065500	10/22/1991	0.02	87
7065500	10/10/1995	0.02	103
7065500	10/8/2002	0.02	98
7065500	4/4/1973	0.021	309
7065500	6/19/1973	0.03	179
7065500	7/31/1973	0.03	141
7065500	7/10/1974	0.03	169
7065500	4/14/1993	0.03	204
7065500	6/30/1982	0.04	147
7066550	6/21/1973	0.03	176
7066550	8/1/1973	0.02	155
7066550	10/17/1973	0.02	180
7066550	5/4/1977	0.01	154
7066550	5/16/1979	0.01	273
7066550	9/5/1979	0.01	103
7066550	5/6/1980	0.03	102
7066550	6/10/1981	0.01	114
7066550	6/30/1982	0.04	128
7066550	5/25/1983	0.02	237
7066550	5/16/1984	0.01	254
7066550	9/11/1985	0.01	121

USGS Gage	Sample Date	TN (mg/L)	Flow (cfs)
7066110	4/3/2007	0.31	440
7066110	5/2/2007	0.34	530
7066110	6/11/2007	0.38	282
7066110	7/16/2007	0.44	206
7066110	9/4/2007	0.36	162
7066110	5/5/2008	0.35	650
7066110	7/7/2008	0.39	340
7066110	10/6/2008	0.4	230
7066110	1/12/2009	0.5	250
7066110	3/2/2009	0.49	322
7066110	5/28/2009	0.38	613
7066110	7/6/2009	0.48	310
7066110	9/9/2009	0.42	334
7066110	10/28/2009	0.51	1600
7064555	6/18/1973	0.76	164
7064555	7/30/1973	0.63	93
7064555	10/15/1973	0.68	114
7064555	9/24/1976	0.51	24
7064555	5/5/1977	0.67	55
7064555	9/22/1977	0.62	15
7064555	5/11/1978	0.69	105
7064555	9/14/1978	1	21
7064555	5/15/1979	0.48	110
7064555	9/5/1979	0.66	57
7064555	5/7/1980	0.9	61
7064555	8/26/1980	0.87	21
7064555	6/11/1981	1	98
7064555	7/1/1982	1	119
7064555	5/26/1983	0.8	132
7064555	9/15/1983	0.9	49
7064555	5/14/1985	0.8	153
7064555	9/10/1985	0.9	77
7064555	10/14/1986	1.1	70
7064555	5/11/1987	0.7	85
7064555	10/11/1988	0.9	32
7064555	10/23/1989	0.9	28
7064555	5/30/1991	0.63	115
7064555	5/2/2000	0.62	26
7064555	5/8/2001	0.58	24
7064555	5/30/2002	0.42	150
7064555	10/8/2002	0.6	33
7064555	5/6/2003	0.54	113
7064530	6/18/1973	0.81	232
7064530	7/30/1973	0.87	272
7064530	10/15/1973	0.91	284
7064530	9/24/1976	0.58	65
7064530	5/5/1977	0.86	130
7064530	9/23/1977	0.8	75
7064530	5/12/1978	1.5	299
7064530	9/14/1978	1.1	113
7064530	5/15/1979	0.96	387
7064530	9/4/1979	1.1	127
7064530	5/8/1980	0.82	158
7064530	8/26/1980	1	103
7064530	6/11/1981	2.1	144

USGS Gage	Sample Date	TP (mg/L)	Flow (cfs)
7066550	5/12/1987	0.01	118
7066550	5/18/1988	0.02	118
7066550	10/12/1988	0.01	96
7066550	10/23/1991	0.01	108
7066550	10/20/1994	0.02	98
7066550	5/23/1995	0.03	242
7066550	10/2/1996	0.02	232
7066550	10/7/2002	0.02	96
7014000	11/23/1993	0.03	244
7014000	3/11/1994	0.02	266
7014000	3/11/1994	0.02	266
7014000	6/23/1994	0.02	175
7014000	8/29/1994	0.09	115
7014000	1/13/1995	0.03	352
7014000	3/20/1995	0.02	245
7014000	8/7/1995	0.02	127
7014000	4/9/1996	0.02	245
7014000	6/24/1996	0.02	310
7014000	3/10/1997	0.03	330
7014000	11/15/2000	0.078	105
7014000	5/9/2002	0.06	3050
7014500	1/19/1993	0.02	1450
7014500	4/8/1993	0.03	2090
7014500	5/19/1993	0.08	5020
7014500	6/1/1993	0.02	870
7014500	7/6/1993	0.05	833
7014500	8/12/1993	0.17	6830
7014500	9/30/1993	0.03	3210
7014500	10/6/1993	0.02	1640
7014500	11/3/1993	0.02	1070
7014500	12/2/1993	0.04	1840
7014500	2/14/1994	0.03	703
7014500	3/1/1994	0.04	1580
7014500	3/8/1994	0.02	1190
7014500	5/25/1994	0.02	1660
7014500	6/23/1994	0.02	966
7014500	8/31/1994	0.02	811
7014500	9/12/1994	0.02	669
7014500	3/22/1995	0.02	1270
7014500	5/9/1995	0.07	5890
7014500	6/12/1995	0.03	4620
7014500	7/18/1995	0.02	727
7014500	9/11/1995	0.02	405
7014500	10/3/1995	0.03	392
7014500	2/27/1996	0.02	500
7014500	7/24/1996	0.02	505
7014500	1/14/1997	0.02	670
7014500	2/5/1997	0.02	3450
7014500	3/13/1997	0.03	2230
7014500	4/7/1997	0.02	3800
7014500	1/19/1999	0.04	3180
7014500	2/9/1999	0.16	7760
7014500	4/26/1999	0.07	4540
7014500	5/20/1999	0.04	1260
7014500	8/10/1999	0.08	1380

USGS Gage	Sample Date	TN (mg/L)	Flow (cfs)
7064530	9/21/1981	1.1	111
7064530	6/29/1982	1.2	337
7064530	5/24/1983	1.4	356
7064530	9/15/1983	1.1	90
7064530	5/15/1984	1.4	271
7064530	9/10/1985	0.9	244
7064530	10/14/1986	1.7	176
7064530	5/11/1987	1.2	173
7064530	10/13/1987	0.9	97
7064530	10/11/1988	1	115
7064530	5/30/1991	0.83	300
7064530	10/1/1996	1.1	241
7065500	6/19/1973	0.74	179
7065500	7/31/1973	0.74	141
7065500	10/16/1973	0.97	201
7065500	7/10/1974	0.7	169
7065500	9/23/1976	0.57	78
7065500	5/4/1977	0.96	148
7065500	9/21/1977	0.82	105
7065500	5/10/1978	1	189
7065500	9/13/1978	0.77	96
7065500	5/16/1979	0.62	320
7065500	9/5/1979	0.79	118
7065500	5/6/1980	0.86	138
7065500	8/27/1980	0.68	73
7065500	6/10/1981	2	137
7065500	9/22/1981	1	82
7065500	6/30/1982	1.2	147
7065500	5/25/1983	1.1	197
7065500	9/14/1983	1	93
7065500	5/16/1984	1	297
7065500	5/15/1985	0.8	213
7065500	9/11/1985	1.1	139
7065500	5/7/1986	0.9	139
7065500	10/15/1986	1.5	100
7065500	5/12/1987	1.1	115
7065500	10/12/1988	1.1	96
7065500	5/25/1989	0.8	202
7065500	5/29/2002	0.68	311
7065500	5/6/2003	0.7	175
7065500	5/18/2004	0.66	262
7065500	5/9/2006	0.62	350
7066550	6/21/1973	0.45	176
7066550	8/1/1973	0.68	155
7066550	10/17/1973	0.63	180
7066550	9/23/1976	0.37	91
7066550	5/4/1977	0.58	154
7066550	9/22/1977	0.54	104
7066550	5/11/1978	0.66	115
7066550	9/13/1978	1	93
7066550	5/16/1979	0.63	273
7066550	9/5/1979	0.9	103
7066550	5/6/1980	0.86	102
7066550	8/27/1980	0.78	92
7066550	6/10/1981	1.1	114

USGS Gage	Sample Date	TP (mg/L)	Flow (cfs)
7014500	10/6/1999	0.03	267
7014500	11/16/1999	0.04	302
7014500	6/13/2000	0.04	274
7014500	8/2/2000	0.03	242
7014500	11/7/2000	0.04	322
7014500	7/25/2001	0.03	226
7014500	3/28/2002	0.04	3000
7014500	5/23/2002	0.03	2800
7014500	8/12/2002	0.03	373
7014500	4/8/2003	0.02	1870
7014500	5/5/2003	0.06	2450
7014500	8/6/2003	0.03	373
7014500	12/17/2003	0.02	772
7014500	1/21/2004	0.02	1770
7014500	5/4/2004	0.05	3140
7014500	9/1/2004	0.03	642
7014500	11/3/2004	0.07	1570
7014500	12/14/2004	0.02	1180
7014500	5/17/2006	0.03	1710
7014500	4/2/2007	0.05	2660
7014500	7/10/2007	0.02	425
7014500	2/6/2008	0.02	1950
7014500	3/25/2008	0.04	3270
7014500	4/15/2008	0.04	3310
7014500	6/3/2008	0.02	903
7014500	7/22/2008	0.02	415
7014500	9/2/2008	0.03	440
7014500	4/20/2009	0.18	10400
7014500	10/29/2009	0.04	3870
7010500	11/17/1993	0.04	1100
7010500	1/20/1994	0.02	135
7010500	3/8/1994	0.03	255
7010500	6/23/1994	0.03	135
7010500	8/29/1994	0.02	80
7010500	11/3/1994	0.04	130
7010500	1/13/1995	0.02	285
7010500	3/22/1995	0.05	90
7010500	8/8/1995	0.02	140
7010500	3/5/1996	0.18	55
7010500	4/10/1996	0.04	163
7010500	6/25/1996	0.03	170
7010500	11/13/1996	0.02	207
7010500	3/10/1997	0.04	318
7010500	11/16/1999	0.05	92
7010500	3/14/2000	0.03	114
7010500	5/17/2000	0.04	95
7010500	9/14/2000	0.04	75
7010500	11/8/2000	0.05	115
7010500	5/14/2001	0.04	72
7010500	7/20/2001	0.04	63
7010500	11/2/2001	0.04	72
7010500	9/5/2002	0.03	103
7010500	11/13/2002	0.03	105
7010500	1/14/2003	0.03	92
7010500	3/4/2003	0.02	129

USGS Gage	Sample Date	TN (mg/L)	Flow (cfs)
7066550	9/22/1981	1.1	116
7066550	6/30/1982	1.1	128
7066550	5/25/1983	1	237
7066550	9/14/1983	0.9	88
7066550	5/16/1984	0.9	254
7066550	9/11/1985	0.6	121
7066550	10/15/1986	1.2	119
7066550	5/12/1987	0.6	118
7066550	5/29/1991	1.9	214
7066550	5/7/2001	0.43	100
7066550	5/28/2002	0.65	239
7066550	5/9/2006	0.31	154
7014000	11/23/1993	0.48	244
7014000	8/7/1995	0.39	127
7014000	3/4/1999	0.36	200
7014000	4/8/1999	0.28	394
7014000	6/14/1999	0.36	153
7014000	8/19/1999	0.73	66
7014000	11/15/1999	0.25	56
7014000	1/11/2000	0.26	92
7014000	3/14/2000	0.26	100
7014000	5/17/2000	0.25	47
7014000	7/6/2000	0.24	76
7014000	9/7/2000	0.17	29
7014000	11/15/2000	0.76	105
7014000	3/22/2001	0.64	110
7014000	5/10/2001	0.36	66
7014000	7/11/2001	0.27	37
7014000	11/1/2001	0.11	57
7014000	1/23/2002	0.35	70
7014000	3/28/2002	0.37	469
7014000	5/9/2002	0.55	3050
7014000	9/3/2002	0.3	77
7014000	11/12/2002	0.19	84
7014000	1/13/2003	0.47	127
7014000	3/3/2003	0.34	255
7014000	5/6/2003	0.28	478
7014000	7/29/2003	0.31	69
7014000	9/11/2003	0.28	56
7014000	1/8/2004	0.38	88
7014000	3/17/2004	0.43	63
7014000	5/5/2004	0.31	438
7014000	7/27/2004	0.28	64
7014000	9/2/2004	0.28	163
7014000	11/9/2004	0.28	101
7014000	3/1/2005	0.28	175
7014000	5/18/2005	0.22	135
7014000	7/6/2005	0.23	58
7014000	9/7/2005	0.28	67
7014000	11/22/2005	0.38	139
7014000	1/10/2006	0.28	86
7014000	3/21/2006	0.43	408
7014000	5/9/2006	0.24	238
7014000	11/8/2006	0.24	163
7014000	2/14/2007	0.46	659

USGS Gage	Sample Date	TP (mg/L)	Flow (cfs)
7010500	5/5/2003	0.04	215
7010500	7/30/2003	0.03	129
7010500	11/10/2003	0.03	141
7010500	1/6/2004	0.03	287
7010500	3/15/2004	0.04	208
7010500	5/5/2004	0.03	190
7010500	7/27/2004	0.03	205
7010500	9/2/2004	0.02	197
7066000	5/11/1999	0.068	627
7066000	8/11/1999	0.004	194
7066000	11/8/1999	0.006	154
7066000	3/1/2000	0.004	542
7066000	5/24/2000	0.005	130
7066000	5/25/2000	0.01	235
7066000	7/11/2000	0.004	160
7066000	7/27/2000	0.004	143
7066000	8/10/2000	0.005	129
7066000	12/20/2000	0.002	160
7066000	2/21/2001	0.005	410
7066000	3/21/2001	0.004	242
7066000	4/24/2001	0.004	218
7066000	5/25/2001	0.006	215
7066000	5/26/2001	0.003	202
7066000	5/26/2001	0.006	202
7066000	5/27/2001	0.003	190
7066000	5/27/2001	0.003	186
7066000	6/6/2001	0.007	211
7066000	7/31/2001	0.005	136
7066000	8/8/2001	0.004	112
7066000	8/8/2001	0.005	112
7066000	8/9/2001	0.005	116
7066000	8/9/2001	0.008	116
7066000	9/18/2001	0.003	112
7066000	10/2/2001	0.003	104
7066000	10/10/2001	0.002	109
7066000	10/10/2001	0.007	109
7066000	10/11/2001	0.003	116
7066000	10/11/2001	0.004	116
7066000	11/20/2001	0.002	112
7066000	4/2/2002	0.005	590
7066000	4/30/2002	0.006	760
7066000	5/29/2002	0.009	657
7066000	6/4/2002	0.005	488
7066000	6/28/2002	0.006	309
7066000	6/29/2002	0.01	297
7066000	7/29/2002	0.006	266
7066000	8/6/2002	0.004	220
7066000	8/7/2002	0.004	216
7066000	10/8/2002	0.005	161
7066000	10/9/2002	0.004	164
7066000	6/3/2003	0.003	270
7066000	6/9/2003	0.019	263
7066000	6/28/2003	0.004	185
7066000	7/26/2003	0.005	169
7066000	8/6/2003	0.005	226

USGS Gage	Sample Date	TN (mg/L)	Flow (cfs)
7014000	4/2/2007	0.28	579
7014000	5/22/2007	0.24	114
7014000	6/5/2007	0.26	86
7014000	7/13/2007	0.24	57
7014000	3/24/2008	0.54	629
7014000	5/19/2008	0.18	394
7014000	7/21/2008	0.28	70
7014000	9/2/2008	0.28	81
7014000	10/27/2008	0.14	141
7014000	5/26/2009	0.15	494
7014000	7/21/2009	0.24	221
7014000	10/27/2009	0.46	255
7014500	1/19/1993	0.82	1450
7014500	5/19/1993	0.81	5020
7014500	7/6/1993	0.67	833
7014500	11/3/1993	0.35	1070
7014500	3/1/1994	0.64	1580
7014500	3/21/1994	0.34	854
7014500	8/31/1994	0.68	811
7014500	9/12/1994	0.41	669
7014500	10/12/1994	0.41	480
7014500	4/24/1995	0.44	3490
7014500	5/9/1995	0.45	5890
7014500	6/12/1995	0.92	4620
7014500	7/5/1995	0.42	1260
7014500	7/18/1995	0.48	727
7014500	9/11/1995	0.4	405
7014500	10/3/1995	0.3	392
7014500	1/9/1996	0.56	500
7014500	1/22/1996	0.7	1440
7014500	4/16/1996	0.48	1470
7014500	5/22/1996	0.46	1450
7014500	7/24/1996	0.51	505
7014500	10/7/1996	0.6	592
7014500	12/5/1996	0.56	2460
7014500	2/5/1997	0.59	3450
7014500	4/7/1997	0.57	3800
7014500	6/17/1997	0.54	2220
7014500	7/9/1997	0.27	812
7014500	1/19/1999	0.85	3180
7014500	2/9/1999	1.3	7760
7014500	3/24/1999	0.37	1800
7014500	4/26/1999	0.72	4540
7014500	5/20/1999	0.24	1260
7014500	6/29/1999	0.42	1170
7014500	7/21/1999	0.24	381
7014500	8/10/1999	0.95	1380
7014500	9/9/1999	0.28	272
7014500	10/6/1999	1.5	267
7014500	11/16/1999	0.16	302
7014500	12/8/1999	0.25	494
7014500	1/11/2000	0.16	517
7014500	2/8/2000	0.22	338
7014500	3/15/2000	0.22	662
7014500	4/4/2000	0.2	576

USGS Gage	Sample Date	TP (mg/L)	Flow (cfs)
7066000	9/23/2003	0.004	201
7066000	10/8/2003	0.004	151
7066000	6/15/2004	0.01	368
7066000	6/26/2004	0.005	266
7066000	7/13/2004	0.005	216
7066000	8/11/2004	0.002	186
7066000	8/21/2004	0.003	174
7066000	9/21/2004	0.005	147
7066000	10/5/2004	0.004	125
7066000	6/14/2005	0.005	150
7066000	7/5/2005	0.005	127
7066000	8/9/2005	0.005	142
7065000	4/3/1973	0.013	158
7065000	6/19/1973	0.04	60
7065000	7/31/1973	0.02	48
7065000	10/16/1973	0.02	71
7065000	5/5/1977	0.04	28
7065000	5/16/1979	0.01	118
7065000	9/5/1979	0.01	40
7065000	5/7/1980	0.03	31
7065000	6/9/1981	0.03	34
7065000	9/23/1981	0.01	20
7065000	7/1/1982	0.06	38
7065000	5/24/1983	0.02	100
7065000	5/17/1984	0.01	52
7065000	5/6/1986	0.01	58
7065000	10/14/1986	0.02	34
7065000	5/11/1987	0.01	52
7065000	5/17/1988	0.02	38
7065000	10/11/1988	0.01	21
7065000	10/22/1991	0.01	25
7065000	4/14/1993	0.04	214
7065000	10/21/1993	0.1	47
7065000	5/23/1995	0.02	82
7065000	10/1/1996	0.08	65
7064440	4/2/1973	0.013	253
7064440	6/18/1973	0.04	139
7064440	7/30/1973	0.04	107
7064440	10/15/1973	0.01	152
7064440	1/18/1974	0.04	160
7064440	4/17/1974	0.04	204
7064440	7/9/1974	0.03	146
7064440	10/21/1974	0.13	109
7064440	1/22/1975	0.04	153
7064440	4/15/1975	0.01	165
7064440	9/24/1976	0.03	64
7064440	5/6/1977	0.07	74
7064440	9/23/1977	0.03	45
7064440	5/12/1978	0.02	155
7064440	9/14/1978	0.02	58
7064440	5/15/1979	0.01	181
7064440	9/4/1979	0.04	90
7064440	5/8/1980	0.03	76
7064440	8/26/1980	0.03	62
7064440	6/9/1981	0.09	75

USGS Gage	Sample Date	TN (mg/L)	Flow (cfs)
7014500	6/13/2000	0.59	274
7014500	7/5/2000	0.27	288
7014500	1/24/2001	0.16	333
7014500	2/15/2001	0.6	895
7014500	3/27/2001	0.35	489
7014500	4/18/2001	0.4	1000
7014500	5/14/2001	0.23	324
7014500	6/13/2001	0.21	523
7014500	7/25/2001	0.28	226
7014500	8/14/2001	0.23	355
7014500	9/6/2001	0.19	175
7014500	12/5/2001	0.34	673
7014500	1/23/2002	0.3	312
7014500	2/12/2002	0.66	821
7014500	3/28/2002	0.53	3000
7014500	4/10/2002	0.29	1860
7014500	5/23/2002	0.53	2800
7014500	6/20/2002	0.26	729
7014500	7/30/2002	0.24	419
7014500	8/12/2002	0.39	373
7014500	9/3/2002	0.3	411
7014500	11/14/2002	0.15	411
7014500	12/2/2002	0.11	351
7014500	1/14/2003	0.32	580
7014500	2/4/2003	0.29	388
7014500	3/4/2003	0.4	1050
7014500	4/8/2003	0.39	1870
7014500	5/5/2003	0.6	2450
7014500	6/9/2003	0.28	621
7014500	7/30/2003	0.29	351
7014500	8/6/2003	0.28	373
7014500	9/4/2003	0.46	626
7014500	10/20/2003	0.14	396
7014500	12/17/2003	0.41	772
7014500	1/21/2004	0.48	1770
7014500	2/9/2004	0.3	766
7014500	3/2/2004	0.23	506
7014500	4/20/2004	0.28	637
7014500	5/4/2004	0.54	3140
7014500	6/1/2004	0.24	784
7014500	7/19/2004	0.26	358
7014500	9/1/2004	0.53	642
7014500	10/14/2004	0.27	367
7014500	11/3/2004	0.67	1570
7014500	12/14/2004	0.47	1180
7014500	1/3/2005	0.31	465
7014500	2/2/2005	0.6	877
7014500	3/10/2005	0.24	754
7014500	4/5/2005	0.17	760
7014500	5/4/2005	0.15	1050
7014500	6/8/2005	0.37	386
7014500	7/25/2005	0.2	353
7014500	8/17/2005	0.39	896
7014500	9/1/2005	0.22	283
7014500	10/12/2005	0.17	381

USGS Gage	Sample Date	TP (mg/L)	Flow (cfs)
7064440	9/21/1981	0.03	52
7064440	6/29/1982	0.06	114
7064440	5/24/1983	0.01	172
7064440	9/13/1983	0.01	90
7064440	5/15/1984	0.02	181
7064440	9/18/1984	0.01	100
7064440	5/14/1985	0.01	196
7064440	9/10/1985	0.02	125
7064440	5/6/1986	0.02	130
7064440	10/14/1986	0.02	113
7064440	5/11/1987	0.02	114
7064440	10/13/1987	0.03	77
7064440	5/17/1988	0.02	116
7064440	10/11/1988	0.03	82
7064440	5/23/1989	0.02	221
7064440	10/23/1989	0.02	76
7064440	11/19/1990	0.01	90
7064440	5/30/1991	0.01	167
7064440	10/22/1991	0.03	81
7064440	4/14/1992	0.01	122
7064440	9/30/1992	0.03	100
7064440	4/29/1993	0.02	173
7064440	10/21/1993	0.02	122
7064440	10/19/1994	0.02	91
7064440	5/22/1995	0.03	164
7064440	10/10/1995	0.07	98
7064440	5/8/2001	0.03	53
7064440	10/3/2001	0.03	48
7064440	10/9/2002	0.02	71
7064440	10/7/2004	0.03	51
7064440	5/8/2006	0.02	120
7066510	6/20/1973	0.03	1560
7066510	8/1/1973	0.02	1240
7066510	1/18/1974	0.03	1820
7066510	4/17/1974	0.03	2420
7066510	7/10/1974	0.02	1260
7066510	10/22/1974	0.02	850
7066510	1/21/1975	0.01	1870
7066510	5/4/1977	0.01	928
7066510	9/22/1977	0.01	738
7066510	5/16/1979	0.01	3000
7066510	9/5/1979	0.01	894
7066510	5/6/1980	0.01	798
7066510	6/10/1981	0.01	1190
7066510	9/22/1981	0.01	462
7066510	6/30/1982	0.04	1150
7066510	5/25/1983	0.02	2240
7066510	9/14/1983	0.04	680
7066510	5/12/1987	0.01	985
7066510	5/18/1988	0.02	932
7066510	10/12/1988	0.01	639
7066510	10/23/1991	0.01	659
7066510	4/13/1993	0.03	3500
7066510	5/23/1995	0.05	2400
7066510	10/7/2002	0.02	1000

USGS Gage	Sample Date	TN (mg/L)	Flow (cfs)
7014500	11/9/2005	0.21	581
7014500	12/5/2005	0.33	760
7014500	1/9/2006	0.23	425
7014500	2/7/2006	0.16	620
7014500	3/6/2006	0.2	415
7014500	4/12/2006	0.17	742
7014500	5/17/2006	0.49	1710
7014500	6/14/2006	0.29	420
7014500	7/20/2006	0.22	214
7014500	9/5/2006	0.19	206
7014500	10/11/2006	0.12	222
7014500	11/7/2006	0.14	401
7014500	12/4/2006	0.7	1910
7014500	1/8/2007	0.33	522
7014500	2/15/2007	0.59	1690
7014500	3/13/2007	0.22	642
7014500	4/2/2007	0.55	2660
7014500	5/21/2007	0.2	648
7014500	6/5/2007	0.53	565
7014500	7/10/2007	0.25	425
7014500	8/13/2007	0.33	214
7014500	9/5/2007	0.13	218
7014500	10/23/2007	0.2	278
7014500	11/5/2007	0.11	274
7014500	1/24/2008	0.57	396
7014500	2/6/2008	0.62	1950
7014500	3/25/2008	0.81	3270
7014500	4/15/2008	0.58	3310
7014500	5/21/2008	0.22	1710
7014500	6/3/2008	0.28	903
7014500	7/22/2008	0.36	415
7014500	8/5/2008	0.2	425
7014500	9/2/2008	0.33	440
7014500	10/28/2008	0.13	430
7014500	11/13/2008	0.2	559
7014500	12/8/2008	0.31	363
7014500	1/20/2009	0.37	363
7014500	2/3/2009	0.19	460
7014500	3/23/2009	0.16	548
7014500	4/20/2009	1.1	10400
7014500	6/1/2009	0.35	1580
7014500	7/21/2009	0.24	815
7014500	8/24/2009	0.28	614
7014500	9/2/2009	0.22	543
7014500	10/29/2009	0.5	3870
7010500	11/17/1993	0.78	1100
7010500	8/8/1995	0.93	140
7010500	11/13/1996	0.88	207
7010500	6/19/1997	0.76	384
7010500	11/16/1999	0.87	92
7010500	1/12/2000	0.88	102
7010500	5/17/2000	0.72	95
7010500	7/5/2000	0.64	79
7010500	9/14/2000	0.84	75
7010500	11/8/2000	0.77	115

USGS Gage	Sample Date	TP (mg/L)	Flow (cfs)
7061600	1/13/2009	0.02	136
7061600	8/10/1995	0.01	248
7061600	9/8/2009	0.02	280
7061600	2/15/1994	0.01	360
7061600	2/12/2007	0.03	370
7061600	3/22/1995	0.02	416
7061600	7/11/1995	0.02	565
7061600	5/7/2008	0.03	735
7061600	1/29/2006	0.04	1140
7061600	5/21/2003	0.02	1320
7061600	11/18/2003	0.17	6280
7061600	5/14/2002	0.06	6630
7061600	5/11/2006	0.07	6830
7061600	4/12/1994	0.17	28800
7064400	9/24/1976	0.01	51
7064400	5/6/1977	0.03	60
7064400	5/12/1978	0.01	112
7064400	5/15/1979	0.01	140
7064400	9/4/1979	0.02	70
7064400	8/26/1980	0.01	43
7064400	6/9/1981	0.02	64
7064400	9/21/1981	0.01	46
7064400	6/29/1982	0.07	106
7064400	5/24/1983	0.01	132
7064400	9/13/1983	0.05	70
7064400	5/15/1984	0.01	123
7064400	9/18/1984	0.01	77
7064400	5/14/1985	0.05	151
7064400	9/10/1985	0.02	95
7064400	5/6/1986	0.01	102
7064400	10/14/1986	0.02	83
7064400	5/11/1987	0.01	8.2
7064400	10/13/1987	0.02	61
7064400	5/17/1988	0.02	93
7064400	10/11/1988	0.02	68
7064400	10/23/1989	0.02	62
7064400	5/30/1991	0.01	132
7064400	10/22/1991	0.02	69
7064400	4/29/1993	0.02	92
7064400	10/21/1993	0.02	70
7064400	10/19/1994	0.04	78
7064400	10/10/1995	0.03	81
7014200	11/23/1993	0.04	240
7014200	8/7/1995	0.02	45
7014200	4/9/1996	0.02	140
7014200	6/24/1996	0.02	47
7014200	3/10/1997	0.03	240
7014200	8/19/1999	0.03	68
7014200	11/15/2000	0.09	39
7014200	5/9/2002	0.07	3250
7014200	2/14/2007	0.04	264

USGS Gage	Sample Date	TN (mg/L)	Flow (cfs)
7010500	1/9/2001	0.89	58
7010500	3/27/2001	1	104
7010500	5/14/2001	0.75	72
7010500	7/20/2001	0.76	63
7010500	9/6/2001	0.66	72
7010500	11/2/2001	0.75	72
7010500	1/28/2002	0.87	77
7010500	5/21/2002	0.6	411
7010500	7/29/2002	0.88	135
7010500	9/5/2002	0.91	103
7010500	11/13/2002	0.47	105
7010500	1/14/2003	0.89	92
7010500	5/5/2003	0.7	215
7010500	7/30/2003	0.92	129
7010500	9/4/2003	0.84	123
7010500	1/6/2004	0.78	287
7010500	3/15/2004	0.89	208
7010500	5/5/2004	0.63	190
7010500	9/2/2004	0.96	197
7066000	5/11/1999	0.37	627
7066000	6/23/1999	0.5	227
7066000	8/11/1999	0.59	194
7066000	11/8/1999	0.35	154
7066000	12/15/1999	0.45	305
7066000	3/1/2000	0.75	542
7066000	4/5/2000	0.46	241
7066000	5/25/2000	0.36	235
7066000	6/7/2000	0.41	172
7066000	6/29/2000	0.34	245
7066000	7/27/2000	0.4	143
7066000	8/10/2000	0.36	129
7066000	8/22/2000	0.41	127
7066000	9/19/2000	0.4	113
7066000	2/21/2001	0.63	410
7066000	3/21/2001	0.6	242
7066000	5/25/2001	0.33	215
7066000	5/26/2001	0.31	202
7066000	5/26/2001	0.34	202
7066000	5/27/2001	0.22	186
7066000	5/27/2001	0.33	190
7066000	6/6/2001	0.29	211
7066000	7/31/2001	0.34	136
7066000	8/8/2001	0.32	112
7066000	8/8/2001	0.34	112
7066000	8/9/2001	0.34	116
7066000	8/9/2001	0.38	116
7066000	10/11/2001	0.35	116
7066000	10/11/2001	0.36	116
7066000	4/2/2002	0.44	590
7066000	4/30/2002	0.26	760
7066000	5/29/2002	0.37	657
7066000	6/28/2002	0.49	309
7066000	6/29/2002	0.31	297
7066000	8/7/2002	0.38	216
7066000	10/8/2002	0.44	161

USGS Gage	Sample Date	TN (mg/L)	Flow (cfs)
7066000	6/3/2003	0.46	270
7066000	6/9/2003	0.46	263
7066000	6/28/2003	0.4	185
7066000	7/26/2003	0.35	169
7066000	8/6/2003	0.32	226
7066000	9/23/2003	0.37	201
7066000	10/8/2003	0.39	151
7066000	6/15/2004	0.46	368
7066000	6/26/2004	0.42	266
7066000	8/21/2004	0.44	174
7066000	9/21/2004	0.45	147
7066000	7/5/2005	0.39	127
7066000	8/9/2005	0.46	142
7065000	6/19/1973	0.47	60
7065000	7/31/1973	0.53	48
7065000	10/16/1973	0.5	71
7065000	9/22/1976	0.28	25
7065000	5/5/1977	0.51	28
7065000	9/22/1977	0.94	24
7065000	5/11/1978	0.47	39
7065000	9/13/1978	0.73	26
7065000	5/16/1979	0.5	118
7065000	9/5/1979	0.51	40
7065000	5/7/1980	0.89	31
7065000	8/26/1980	0.64	20
7065000	6/9/1981	2	34
7065000	9/23/1981	0.68	20
7065000	7/1/1982	1.4	38
7065000	5/24/1983	0.8	100
7065000	9/13/1983	0.7	34
7065000	5/17/1984	0.7	52
7065000	5/16/1985	0.5	97
7065000	9/11/1985	0.7	43
7065000	5/6/1986	0.5	58
7065000	10/14/1986	1.4	34
7065000	5/11/1987	0.9	52
7065000	10/11/1988	0.5	21
7065000	5/23/1989	0.8	179
7065000	5/8/2001	0.54	27
7065000	5/29/2002	0.5	153
7065000	5/5/2003	0.45	53
7065000	5/18/2004	0.5	88
7065000	5/10/2006	0.42	250
7064440	6/18/1973	1.2	139
7064440	7/30/1973	0.97	107
7064440	10/15/1973	0.93	152
7064440	1/18/1974	0.66	160
7064440	4/17/1974	0.79	204
7064440	7/9/1974	0.86	146
7064440	10/21/1974	0.84	109
7064440	1/22/1975	0.82	153
7064440	4/15/1975	0.84	165
7064440	9/24/1976	0.9	64
7064440	5/6/1977	1.1	74
7064440	9/23/1977	0.91	45

	Sample	TP	Flow

USGS Gage	Sample Date	TN (mg/L)	Flow (cfs)
7064440	5/12/1978	0.9	155
7064440	9/14/1978	1.2	58
7064440	5/15/1979	0.55	181
7064440	9/4/1979	0.89	90
7064440	5/8/1980	2.4	76
7064440	8/26/1980	1	62
7064440	6/9/1981	1.9	75
7064440	9/21/1981	1.1	52
7064440	6/29/1982	1.1	114
7064440	5/24/1983	1	172
7064440	9/13/1983	1.3	90
7064440	5/15/1984	1	181
7064440	5/14/1985	0.9	196
7064440	5/6/1986	1	130
7064440	10/14/1986	1.3	113
7064440	5/11/1987	1.3	114
7064440	10/11/1988	1.1	82
7064440	5/23/1989	1.3	221
7064440	4/29/1993	0.86	173
7064440	5/29/1996	0.79	182
7064440	10/6/1999	0.96	96
7064440	5/3/2000	0.87	72
7064440	5/8/2001	0.79	53
7064440	10/3/2001	0.58	48
7064440	5/30/2002	0.56	189
7064440	10/9/2002	0.85	71
7064440	5/7/2003	0.64	151
7064440	10/7/2003	0.79	57
7064440	5/17/2004	0.62	186
7064440	10/7/2004	0.82	51
7064440	5/25/2005	0.83	80
7064440	5/8/2006	0.59	120
7066510	6/20/1973	0.38	1560
7066510	8/1/1973	0.5	1240
7066510	10/17/1973	0.52	1480
7066510	1/18/1974	0.34	1820
7066510	4/17/1974	0.49	2420
7066510	7/10/1974	0.46	1260
7066510	10/22/1974	0.01	850
7066510	1/21/1975	0.16	1870
7066510	4/15/1975	0.58	1880
7066510	9/23/1976	0.25	533
7066510	5/4/1977	0.36	928
7066510	9/22/1977	0.49	738
7066510	5/11/1978	0.51	2050
7066510	9/13/1978	0.58	532
7066510	5/16/1979	0.38	3000
7066510	9/5/1979	0.42	894
7066510	5/6/1980	0.48	798
7066510	8/27/1980	0.35	441
7066510	6/10/1981	1.4	1190
7066510	9/22/1981	0.59	462
7066510	6/30/1982	0.97	1150
7066510	5/25/1983	1.4	2240
7066510	9/14/1983	0.8	680

	Sample	TP	Flow

USGS Gage	Sample Date	TN (mg/L)	Flow (cfs)
7066510	5/16/1984	0.6	2350
7066510	5/15/1985	0.6	2480
7066510	9/11/1985	0.7	1080
7066510	5/7/1986	0.5	1290
7066510	10/15/1986	3.1	1080
7066510	5/12/1987	0.7	985
7066510	5/29/1991	0.66	1750
7066510	5/1/2000	0.32	600
7066510	5/7/2001	0.38	720
7066510	10/7/2002	0.37	1000
7066510	5/5/2003	0.43	2500
7066510	10/6/2003	0.32	552
7066510	5/17/2004	0.33	2100
7066510	5/24/2005	0.31	713
7066510	5/8/2006	0.31	2800
7061600	4/12/1994	0.85	28800
7061600	11/2/1999	0.13	172
7061600	1/10/2000	0.39	316
7061600	7/24/2000	0.21	121
7061600	9/14/2000	0.12	99
7061600	1/16/2001	0.21	599
7061600	3/12/2001	0.58	271
7061600	5/8/2001	0.38	164
7061600	7/16/2001	0.18	95
7061600	9/4/2001	0.13	93
7061600	5/14/2002	0.39	6630
7061600	9/5/2002	0.12	163
7061600	3/10/2003	0.29	329
7061600	5/21/2003	0.2	1320
7061600	7/7/2003	0.19	203
7061600	9/2/2003	0.26	468
7061600	11/18/2003	1.2	6280
7061600	5/5/2004	0.22	1000
7061600	11/23/2004	0.27	374
7061600	1/25/2005	0.34	444
7061600	3/15/2005	0.19	136
7061600	5/16/2005	0.13	322
7061600	9/6/2005	0.12	133
7061600	11/2/2005	0.21	501
7061600	1/4/2006	0.38	203
7061600	1/29/2006	0.34	1140
7061600	2/2/2006	0.24	802
7061600	2/13/2006	0.25	305
7061600	3/7/2006	0.24	225
7061600	4/18/2006	0.17	268
7061600	5/11/2006	0.42	6830
7061600	6/20/2006	0.17	191
7061600	7/12/2006	0.18	204
7061600	8/3/2006	0.17	134
7061600	10/23/2006	0.25	287
7061600	11/13/2006	0.34	348
7061600	12/19/2006	0.38	422
7061600	1/4/2007	0.23	614
7061600	3/29/2007	0.29	866
7061600	4/3/2007	0.21	990

	Sample	TP	Flow

USGS Gage	Sample Date	TN (mg/L)	Flow (cfs)
7061600	9/10/2007	0.5	1020
7061600	5/7/2008	0.17	735
7061600	10/7/2008	0.14	110
7061600	3/3/2009	0.28	430
7061600	5/26/2009	0.15	497
7061600	7/6/2009	0.18	312
7061600	9/8/2009	0.18	280
7061600	10/27/2009	0.39	936
7064400	7/9/1974	1	101
7064400	9/23/1975	0.82	42
7064400	9/24/1976	0.84	51
7064400	5/6/1977	1	60
7064400	9/23/1977	0.82	42
7064400	5/12/1978	0.89	112
7064400	9/14/1978	1	51
7064400	5/15/1979	0.67	140
7064400	9/4/1979	1	70
7064400	5/8/1980	8.8	60
7064400	8/26/1980	1.1	43
7064400	6/9/1981	1.6	64
7064400	9/21/1981	1.3	46
7064400	6/29/1982	1.5	106
7064400	5/24/1983	1.6	132
7064400	9/13/1983	1.5	70
7064400	5/15/1984	1.2	123
7064400	5/14/1985	0.9	151
7064400	9/10/1985	1.2	95
7064400	10/14/1986	1.6	83
7064400	5/11/1987	1.2	8.2
7064400	10/13/1987	1.7	61
7064400	10/11/1988	1.2	68
7064400	10/6/1999	1.1	75
7064400	5/3/2000	0.89	61
7064400	5/30/2002	0.5	155
7064400	5/7/2003	0.63	111
7064400	5/17/2004	0.62	113
7064400	5/8/2006	0.59	90
7014200	8/7/1995	0.29	45
7014200	6/24/1996	0.52	47
7014200	6/19/1997	0.29	313
7014200	3/4/1999	0.24	88
7014200	4/8/1999	0.21	359
7014200	6/14/1999	0.19	90
7014200	8/19/1999	0.31	68
7014200	3/14/2000	0.14	68
7014200	5/17/2000	0.16	27
7014200	7/6/2000	0.19	25
7014200	9/7/2000	0.13	12
7014200	11/15/2000	0.75	39
7014200	3/22/2001	0.32	60
7014200	5/10/2001	0.16	43
7014200	7/11/2001	0.22	18
7014200	11/1/2001	0.13	29
7014200	1/23/2002	0.19	47
7014200	3/28/2002	0.17	328

	Sample	TP	Flow

USGS Gage	Sample Date	TN (mg/L)	Flow (cfs)
7014200	5/9/2002	0.62	3250
7014200	7/30/2002	0.15	31
7014200	9/3/2002	0.14	32
7014200	11/12/2002	0.14	57
7014200	1/13/2003	0.27	97
7014200	3/3/2003	0.17	150
7014200	5/6/2003	0.16	441
7014200	9/11/2003	0.14	61
7014200	1/8/2004	0.21	210
7014200	3/17/2004	0.2	114
7014200	5/5/2004	0.16	289
7014200	7/27/2004	0.17	37
7014200	9/2/2004	0.18	46
7014200	11/9/2004	0.17	68
7014200	1/4/2005	0.15	61
7014200	3/1/2005	0.15	117
7014200	7/6/2005	0.16	22
7014200	9/7/2005	0.15	16
7014200	11/22/2005	0.24	82
7014200	3/21/2006	0.29	311
7014200	5/9/2006	0.16	162
7014200	11/8/2006	0.14	75
7014200	2/14/2007	0.34	264
7014200	4/2/2007	0.15	414
7014200	5/22/2007	0.12	72
7014200	6/5/2007	0.18	43
7014200	7/10/2007	0.15	28
7014200	3/24/2008	0.32	355
7014200	7/21/2008	0.17	80
7014200	10/27/2008	0.08	41
7014200	5/26/2009	0.28	73
7014200	7/21/2009	0.12	23
7014200	9/1/2009	0.13	36
7014200	10/27/2009	0.31	228

	Sample	TP	Flow

MDNR Site ID	Date	TSS (mg/L)	Flow (cfs)		MDNR Site ID	Date	TSS (mg/L)	Flow (cfs)
1708/1.2/0.6	12/09/1999	160	40		1711/1.2	06/09/2003	0.499	2.4
1708/1.2/0.6	01/06/2000	20	0.25		1711/1.2	08/11/2003	2	0.32
1708/1.2/0.6	02/29/2000	13	0.54		1711/1.2	10/09/2003	588	2860
1708/1.2/0.6	05/26/2000	280	40		1711/1.2	12/04/2003	14	8.6
1708/1.2/0.6	06/19/2000	17	0.42		1711/1.2	02/18/2004	9	7.9
1708/1.2/0.6	08/01/2000	32	0.86		1711/1.2	03/04/2004	433	969
1708/1.2/0.6	12/01/1998	10	1.7		1711/1.2	05/17/2004	4	9
1708/1.2/0.6	02/10/1999	12	3.6		1711/1.2	08/03/2004	4.99	2.1
1708/1.2/0.6	02/11/1999	1400	47		1711/1.2	10/04/2004	4.99	14
1708/1.2/0.6	04/15/1999	80	50		1711/1.2	10/12/2004	147	177
1708/1.2/0.6	06/17/1999	22	0.82		1711/1.2	04/25/2005	14	3.2
1708/1.2/0.6	08/03/1999	25	0.13		1711/1.2	06/21/2005	27	23
1708/1.2/0.6	12/15/1997	2	0.32		1711/1.2	08/10/2005	11	26
1708/1.2/0.6	02/24/1998	2	1		1711/1.2	10/04/2005	4.99	1.7

MDNR Site ID	Date	TSS (mg/L)	Flow (cfs)		MDNR Site ID	Date	TSS (mg/L)	Flow (cfs)
1708/1.2/0.6	04/03/1998	350	75		1711/1.2	10/31/2005	108	489
1708/1.2/0.6	04/13/1998	1500	142		1711/1.2	04/04/2006	12	7.7
1708/1.2/0.6	06/23/1998	22	2.72		1711/1.2	04/06/2006	168	289
1708/1.2/0.6	08/26/1997	31	1		1711/1.2	06/06/2006	4.99	1.9
1708/1.2/0.6	09/02/1997	3300	100		1711/1.2	08/22/2006	4.99	3.8
1708/1.2/0.6	12/18/2000	16	0.87		1711/1.2	10/03/2006	4.99	0.62
1708/1.2/0.6	02/09/2001	760	55		1711/1.2	10/16/2006	58	81
1708/1.2/0.6	02/27/2001	16	2.1		1711/1.2	01/16/2007	19	24
1708/1.2/0.6	04/10/2001	11160	439		1711/1.2	02/05/2007	4.99	8.4
1708/1.2/0.6	05/30/2001	15	0.39		1711/1.2	03/19/2007	15	22
1708/1.2/0.6	08/27/2001	44	0.13		1711/1.2	04/23/2007	51	731
1708/1.2/0.6	10/23/2001	37	12		1711/1.2	04/24/2007	9.99	635
1708/1.2/0.6	12/11/2001	2	0.43		1711/1.2	05/22/2007	49.99	280
1708/1.2/0.6	02/05/2002	3	3.1		1711/1.2	06/19/2007	19	6.7
1708/1.2/0.6	03/09/2002	937	158		1711/1.2	07/23/2007	4.99	1.3
1708/1.2/0.6	05/29/2002	43	4.4		1711/1.2	08/08/2007	10	1.2
1708/1.2/0.6	08/08/2002	49	1.6		1711/1.2	09/12/2007	4.99	1.1
1708/1.2/0.6	10/29/2002	131	54		1711/1/3.5/1.5/0.5	12/03/2003	4	0.35
1708/1.2/0.6	12/17/2002	4	0.32		1711/1/3.5/1.5/0.5	02/17/2004	6	0.4
1708/1.2/0.6	02/04/2003	16	1.2		1711/1/3.5/1.5/0.5	03/26/2004	298	43
1708/1.2/0.6	03/28/2003	131	34		1711/1/3.5/1.5/0.5	04/24/2004	239	61
1708/1.2/0.6	06/09/2003	14	0.62		1711/1/3.5/1.5/0.5	05/18/2004	13	0.84
1708/1.2/0.6	08/12/2003	23	0.25		1711/1/3.5/1.5/0.5	08/03/2004	4.99	1.1
1708/1.2/0.6	10/14/2003	162	30		1711/1/3.7/0.6	05/21/2001	150	100
1708/1.2/0.6	12/04/2003	4	1.9		1711/1/3.7/0.6	05/30/2001	10	1.2
1708/1.2/0.6	02/10/2004	26	10		1711/1/3.7/0.6	08/27/2001	3	1.2
1708/1.2/0.6	03/26/2004	2830	57		1711/1/3.7/0.6	10/05/2001	133	247
1708/1.2/0.6	05/17/2004	9	2.8		1711/1/3.7/0.6	12/10/2001	3	1.3
1708/1.2/0.6	08/04/2004	4.99	1.5		1711/1/3.7/0.6	02/04/2002	6	5.3
1709/1.0	12/09/1999	99	307		1711/1/3.7/0.6	03/09/2002	337	392
1709/1.0	01/06/2000	67	0.47		1711/1/3.7/0.6	05/29/2002	19	13
1709/1.0	02/29/2000	25	3		1711/1/3.7/0.6	08/05/2002	27	0.75
1709/1.0	04/07/2000	2600	300		1711/1/3.7/0.6	10/25/2002	114	143
1709/1.0	06/15/2000	22	5.4		1711/1/3.7/0.6	12/17/2002	25	1.1
1709/1.0	08/01/2000	31	4.2		1711/1/3.7/0.6	02/04/2003	17	2.9
1709/1.0	12/01/1998	12	6.3		1711/1/3.7/0.6	03/28/2003	27	118
1709/1.0	02/10/1999	12	12		1711/1/3.7/0.6	06/09/2003	7	1.7
1709/1.0	02/11/1999	2000	749		1711/1/3.7/0.6	08/11/2003	20	0.89
1709/1.0	05/04/1999	970	492		1711/1/3.7/0.6	10/09/2003	378	1110
1709/1.0	06/17/1999	19	2.7		1711/1/3.7/0.6	12/03/2003	2	1.2
1709/1.0	08/03/1999	19	1.6		1711/1/3.7/0.6	12/09/2003	50	55
1709/1.0	12/15/1997	9	2.7		1711/1/3.7/0.6	02/17/2004	5	3.5
1709/1.0	02/24/1998	9	5.4		1711/1/3.7/0.6	03/03/2004	134	98

MDNR Site ID	Date	TSS (mg/L)	Flow (cfs)		MDNR Site ID	Date	TSS (mg/L)	Flow (cfs)
1709/1.0	04/15/1998	1400	478		1711/1/3.7/0.6	04/23/2004	76	52
1709/1.0	06/23/1998	28	7		1711/1/3.7/0.6	05/18/2004	3	3.9
1709/1.0	12/11/1996	10	5		1711/1/3.7/0.6	08/03/2004	4.99	1.4
1709/1.0	03/05/1997	9	8		1711/1/3.7/4	05/21/2001	80	62
1709/1.0	05/25/1997	2900	779		1711/1/3.7/4	05/30/2001	10	0.01
1709/1.0	06/10/1997	30	5		1711/1/3.7/4	08/28/2001	6	0.01
1709/1.0	08/26/1997	28	2		1711/1/3.7/4	10/05/2002	64	18
1709/1.0	09/02/1997	2300	1150		1711/1/3.7/4	12/10/2002	9	0.01
1709/1.0	08/01/1996	24	4.6		1711/1/3.7/4	02/05/2002	8	0.28
1709/1.0	09/23/1996	1300	940		1711/1/3.7/4	03/09/2002	221	85
1709/1.0	12/18/2000	19	2.2		1711/1/3.7/4	05/30/2002	31	1
1709/1.0	02/09/2001	2100	173		1711/1/3.7/4	08/05/2002	12	0.01
1709/1.0	02/27/2001	43	9		1711/1/3.7/4	10/25/2002	40	25
1709/1.0	04/10/2001	3700	351		1711/1/3.7/4	12/17/2002	19	0.00499
1709/1.0	05/29/2001	18	0.34		1711/1/3.7/4	02/04/2003	6	1.3
1709/1.0	08/27/2001	37	0.56		1711/1/3.7/4	04/06/2003	18	44
1709/1.0	10/24/2001	69	61		1711/1/3.7/4	06/09/2003	15	0.00499
1709/1.0	12/10/2001	15	1.7		1711/1/3.7/4	08/11/2003	14	0.00499
1709/1.0	02/05/2002	68	6.4		1711/1/3.7/4	10/09/2003	437	536
1709/1.0	03/09/2002	575	171		1711/1/3.7/4	12/03/2003	0.499	0.01
1709/1.0	05/30/2002	6	6		1711/1/3.7/4	12/10/2003	235	180
1709/1.0	08/08/2002	56	3.9		1711/1/3.7/4	02/17/2004	3	0.1
1709/1.0	10/29/2002	305	180		1711/1/3.7/4	03/04/2004	450	307
1709/1.0	12/17/2002	7	3.2		1711/1/3.7/4	04/24/2004	97	90
1709/1.0	02/04/2003	22	9		1711/1/3.7/4	05/18/2004	38	0.6
1709/1.0	04/16/2003	2300	416		1711/1/3.7/4	08/03/2004	4.99	0.1
1709/1.0	06/09/2003	11	6		1711/1/5.3/1.9	01/06/2000	2	0.3
1709/1.0	08/12/2003	29	0.84		1711/1/5.3/1.9	02/18/2000	5000	224
1709/1.0	10/09/2003	1300	541		1711/1/5.3/1.9	02/29/2000	6	0.21
1709/1.0	12/04/2003	5	17		1711/1/5.3/1.9	05/07/2000	1000	7.7
1709/1.0	02/09/2004	6	9.9		1711/1/5.3/1.9	06/15/2000	14	0.17
1709/1.0	03/04/2004	2190	706		1711/1/5.3/1.9	07/31/2000	11	0.37
1709/1.0	05/17/2004	6	9		1711/1/5.3/1.9	12/01/1998	6	0.95
1709/1.0	08/04/2004	13	3.5		1711/1/5.3/1.9	02/11/1999	4	1.2
1709/1.0	10/05/2004	25	0.35		1711/1/5.3/1.9	02/11/1999	2700	105
1709/1.0	10/26/2004	465	127		1711/1/5.3/1.9	05/12/1999	450	36
1709/1.0	03/22/2005	872	398		1711/1/5.3/1.9	06/17/1999	5	0.26
1709/1.0	04/25/2005	4.99	5.2		1711/1/5.3/1.9	08/03/1999	3	0.19
1709/1.0	06/20/2005	20	2.4		1711/1/5.3/1.9	12/16/1997	4	0.16
1709/1.0	08/08/2005	14	3		1711/1/5.3/1.9	02/24/1998	11	0.51
1709/1.0	10/03/2005	15	5.3		1711/1/5.3/1.9	04/13/1998	1900	33
1709/1.0	10/31/2005	118	256		1711/1/5.3/1.9	06/22/1998	6	0.6
1709/1.0	04/04/2006	49	4.8		1711/1/5.3/1.9	08/19/1997	85	40

MDNR Site ID	Date	TSS (mg/L)	Flow (cfs)		MDNR Site ID	Date	TSS (mg/L)	Flow (cfs)
1709/1.0	05/01/2006	404	441		1711/1/5.3/1.9	08/26/1997	8	0.3
1709/1.0	06/06/2006	13	2.3		1711/1/5.3/1.9	12/19/2000	7	0.13
1709/1.0	08/21/2006	4.99	1.1		1711/1/5.3/1.9	02/24/2001	880	27
1709/1.0	10/02/2006	10	0.88		1711/1/5.3/1.9	02/27/2001	13	0.42
1709/1.0	10/16/2006	114	214		1711/1/5.3/1.9	04/03/2001	211	22
1709/1.0	01/16/2007	62	13		1711/1/5.3/1.9	05/29/2001	6	0.1
1709/1.0	02/05/2007	11	8.5		1711/1/5.3/1.9	08/27/2001	3	0.06
1709/1.0	03/19/2007	20	4.4		1711/1/5.3/1.9	10/24/2001	825	44
1709/1.0	04/03/2007	785	1220		1711/1/5.3/1.9	12/11/2001	0.499	0.11
1709/1.0	04/10/2007	10	6.2		1711/1/5.3/1.9	02/05/2002	4	0.46
1709/1.0	05/21/2007	61	5.3		1711/1/5.3/1.9	04/08/2002	169	22
1709/1.0	06/18/2007	10	3.6		1711/1/5.3/1.9	05/29/2002	38	0.79
1709/1.0	07/26/2007	61	1.6		1711/1/5.3/1.9	08/08/2002	2	0.1
1709/1.0	08/08/2007	32	0.93		1711/1/5.3/1.9	10/25/2002	213	11
1709/1.0	09/12/2007	65	1.4		1711/1/5.3/1.9	12/17/2002	3	0.15
1711/1.0/7.0	01/06/2000	6	0.03		1711/1/5.3/1.9	02/04/2003	6	0.22
1711/1.0/7.0	02/18/2000	1400	964		1711/1/5.3/1.9	04/20/2003	255	20
1711/1.0/7.0	02/29/2000	12	0.06		1711/1/5.3/1.9	06/09/2003	2	0.35
1711/1.0/7.0	06/15/2000	12	0.06		1711/1/5.3/1.9	08/12/2003	7	0.15
1711/1.0/7.0	08/01/2000	5	0.35		1711/1/5.3/1.9	10/09/2003	697	34
1711/1.0/7.0	12/01/1998	6	0.47		1711/1/5.3/1.9	12/03/2003	1	0.42
1711/1.0/7.0	02/11/1999	5	0.68		1711/1/5.3/1.9	02/18/2004	2	0.59
1711/1.0/7.0	02/11/1999	1000	333		1711/1/5.3/1.9	03/26/2004	1990	45
1711/1.0/7.0	06/17/1999	4	0.11		1711/1/5.3/1.9	05/18/2004	5	0.64
1711/1.0/7.0	08/03/1999	4	0.01		1711/1/5.3/1.9	08/03/2004	4.99	0.31
1711/1.0/7.0	12/16/1997	9	0.22		1713/1.7	12/09/1999	320	117
1711/1.0/7.0	02/24/1998	4	0.05		1713/1.7	01/05/2000	17	2.4
1711/1.0/7.0	04/03/1998	84	231		1713/1.7	02/28/2000	19	2.1
1711/1.0/7.0	06/22/1998	10	0.41		1713/1.7	05/26/2000	210	151
1711/1.0/7.0	08/19/1997	60	75		1713/1.7	11/30/1998	21	32
1711/1.0/7.0	08/26/1997	12	0.03		1713/1.7	02/07/1999	1600	3300
1711/1.0/7.0	12/19/2000	14	0.35		1713/1.7	02/10/1999	14	11
1711/1.0/7.0	02/27/2001	4	0.81		1713/1.7	05/12/1999	810	460
1711/1.0/7.0	03/15/2001	610	190		1713/1.7	06/16/1999	54	2.5
1711/1.0/7.0	04/09/2001	1000	288		1713/1.7	08/03/1999	25	1.2
1711/1.0/7.0	05/29/2001	13	0.09		1713/1.7	10/13/1997	61	19
1711/1.0/7.0	08/27/2001	3	0.01		1713/1.7	12/16/1997	4	2
1711/1.0/7.0	10/24/2001	633	593		1713/1.7	02/23/1998	3	6.4
1711/1.0/7.0	12/11/2001	28	0.07		1713/1.7	04/15/1998	2200	679
1711/1.0/7.0	02/04/2002	0.499	1.3		1713/1.7	06/22/1998	28	7.9
1711/1.0/7.0	03/09/2002	380	157		1713/1.7	08/01/1996	34	2.32
1711/1.0/7.0	05/30/2002	4	0.81		1713/1.7	09/23/1996	1800	2800
1711/1.0/7.0	08/08/2002	12	0.06		1713/1.7	06/19/2000	21	2.4

MDNR Site ID	Date	TSS (mg/L)	Flow (cfs)		MDNR Site ID	Date	TSS (mg/L)	Flow (cfs)
1711/1.0/7.0	10/29/2002	159	15		1713/1.7	08/23/2000	13	3.8
1711/1.0/7.0	12/17/2002	13	0.22		1713/1.7	11/06/2000	93	100
1711/1.0/7.0	02/04/2003	27	0.71		1713/1.7	12/18/2000	14	3.4
1711/1.0/7.0	03/19/2003	322	161		1713/1.7	02/24/2001	530	153
1711/1.0/7.0	06/09/2003	4	0.3		1713/1.7	02/27/2001	16	18
1711/1.0/7.0	08/12/2003	8	0.06		1713/1.7	05/29/2001	14	1.6
1711/1.0/7.0	10/09/2003	784	691		1713/1.7	08/27/2001	5	0.3
1711/1.0/7.0	12/17/2003	2	0.41		1713/1.7	10/15/2001	118	115
1711/1.0/7.0	02/18/2004	11	1.04		1713/1.7	12/10/2001	0.499	1.5
1711/1.0/7.0	03/03/2004	721	68		1713/1.7	02/04/2002	9	7.4
1711/1.0/7.0	05/18/2004	7	1.5		1713/1.7	03/09/2002	982	297
1711/1.0/7.0	08/03/2004	4.99	0.19		1713/1.7	05/28/2002	28	7.4
1711/1.0/7.0	10/05/2004	4.99	0.07		1713/1.7	08/05/2002	12	1.1
1711/1.0/7.0	10/12/2004	383	177		1713/1.7	10/03/2002	778	191
1711/1.0/7.0	03/22/2005	375	109		1713/1.7	12/17/2002	9	1.5
1711/1.0/7.0	04/25/2005	13	1		1713/1.7	02/03/2003	7	2.3
1711/1.0/7.0	06/22/2005	4.99	0.26		1713/1.7	04/04/2003	325	133
1711/1.0/7.0	08/08/2005	4.99	1.3		1713/1.7	06/24/2003	10	3.2
1711/1.0/7.0	10/03/2005	4.99	0.29		1713/1.7	08/11/2003	15	1
1711/1.0/7.0	10/20/2005	610	184		1713/1.7	10/09/2003	790	278
1711/1.0/7.0	04/02/2006	2030	20		1713/1.7	12/04/2003	14	8.5
1711/1.0/7.0	04/03/2006	4.99	1.9		1713/1.7	02/18/2004	10	4.1
1711/1.0/7.0	06/06/2006	4.99	0.68		1713/1.7	03/03/2004	231	85
1711/1.0/7.0	08/22/2006	4.99	0.68		1713/1.7	05/17/2004	15	5.4
1711/1.0/7.0	10/02/2006	4.99	0.05		1713/1.7	08/02/2004	4.99	4.4
1711/1.0/7.0	10/16/2006	104	193		1714/0.8	03/12/2007	4.99	9.8
1711/1.0/7.0	01/16/2007	4.99	3.4		1714/0.8	05/21/2007	31	9.8
1711/1.0/7.0	02/05/2007	4.99	1.3		1716/3.4	03/12/2007	4.99	12
1711/1.0/7.0	03/19/2007	4.99	1.8		1716/3.4	05/21/2007	4.99	10
1711/1.0/7.0	04/03/2007	475	65		1755/1.8	01/28/1997	3	2
1711/1.0/7.0	04/10/2007	4.99	16		1755/1.8	06/18/1997	2	13
1711/1.0/7.0	05/21/2007	4.99	0.8		1755/1.8	01/17/1996	0.499	2.8
1711/1.0/7.0	06/18/2007	8.499	0.24		1755/1.8	06/24/1996	1	0.73
1711/1.0/7.0	07/23/2007	4.99	0.21		1755/1.8	01/11/1995	4	5.5
1711/1.0/7.0	08/08/2007	4.99	0.26		1755/1.8	05/08/1995	10	2.7
1711/1.0/7.0	09/12/2007	4.99	0.11		1755/1.8	01/27/1994	32	27
1711/1.2	10/29/2002	79	314		1755/1.8	06/24/1994	10	1
1711/1.2	12/17/2002	6	2.4		1755/1.8	11/10/1992	10	1.6
1711/1.2	02/03/2003	5	3.2		1755/1.8	01/20/1993	10	10
1711/1.2	03/19/2003	444	752		1755/1.8	03/16/1993	0.499	7.5
					1755/1.8	05/18/1993	13	6.2
					1755/1.8	07/07/1993	5	3.6
					1755/1.8	09/29/1993	8	1.7

Appendix G – Supplemental Implementation Plan

States are not required under Section 303(d) of the CWA to develop TMDL implementation plans and EPA does not approve or disapprove them. However, MDNR included an implementation plan in this TMDL to provide information regarding how point and nonpoint sources can or should be controlled to ensure implementation efforts achieve the loading reductions identified in this TMDL. EPA recognizes that technical guidance and support are critical to determining the feasibility of and achieving the goals outlined in this TMDL. Therefore, this informational plan is included to be used by local professionals, watershed managers and citizens for decision-making support and planning purposes. It should not be considered to be a part of the established Big Bottom Creek TMDL.

This TMDL will be implemented through permit action. The current Lake Forest Estates Subdivision WWTP (MO0035742) permit was issued December 1, 2006, with limits for BOD of 60/30 mg/L (weekly/monthly averages) and monitoring only for ammonia. New limits for ammonia went into effect Nov 30, 2009. They are 3.7 mg/L daily maximum/1.9 mg/L monthly average for summer and 7.5/3.7 mg/L in the winter. However, the permit also states that a new water quality review will be conducted after three years to determine if recent upgrades were sufficient to bring about a recovery of the receiving stream. The permit also includes instream monitoring requirements, as stated above in Section 12. Monitoring Plan. Due to the development of new WLAs for the Lake Forest Estates WWTP, future permit renewals will contain the requirements found in this TMDL to ensure attainment of the protection of aquatic life designated use.

This TMDL was developed using the most recent and accurate data available. Should new data, information, criteria, targets or WQS become available, that may change the LC or allocations contained within this TMDL, the TMDL may be revised or modified by MDNR at any time (40 CFR 130.7).

Missouri Department of Natural Resources
Water Pollution Control Program

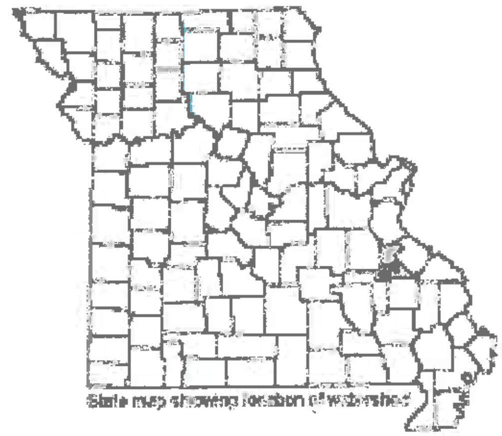
Total Maximum Daily Loads (TMDLs)

for

St. Francis River
St. Francois County, Missouri

Completed: December 22, 2005
Approved: February 1, 2006

Two Total Maximum Daily Loads (TMDLs)
For the St. Francis River
Pollutants: Biochemical Oxygen Demand (BOD) and Ammonia (NH_3)



State map showing location of watershed

Name: **St. Francis River**

Location: Near Farmington in St. Francois County, Missouri

Hydrologic Unit Code (HUC): 8020202-010003

Water Body Identification (WBID): 2835

Missouri Stream Class: P [1]

Beneficial Uses:

- Livestock and Wildlife Watering
- Irrigation
- Protection of Aquatic Life
- Protection of Human Health associated with Fish Consumption
- Cool Water Fishery
- Whole Body Contact Recreation (e.g., Swimming)
- Boating and Canoeing (This will be renamed "Secondary Contact Recreation" by 1/1/06)

Size of Impaired Segment: 3 miles

Location of Impaired Segment: From SE ¼ Section 11, T35N, R5E (upstream) to NW ¼ NE ¼ Section 19, T35N, R6E (downstream)

Pollutants: Biochemical Oxygen Demand (BOD) and Ammonia

Pollutant Source: Farmington West Wastewater Treatment Plant

Permit Number: Missouri State Operating Permit No. MO-0040312 [2]

TMDL Priority Ranking: High

---

[1] Class P streams maintain flow even during drought conditions. See Missouri Water Quality Standards (WQS) 10 CSR 20-7.031(1)(F). The WQS can be found at the following uniform resource locator (URL): http://www.dnr.mo.gov/env/wpp/rules/index.html#Chap7

[2] The state permitting system is Missouri's program for administering the National Pollution Discharge Elimination System (NPDES) program.

1. Background and Water Quality Problems

Area History[3]:

Farmington's roots go back to 1798 when William Murphy crossed the Mississippi River into Spanish Territory looking for a place to bring his family. Native Americans familiar with the area guided him to a perfect spot next to a spring. His decision made, he obtained a Spanish land grant and permission to start a settlement along the St. Francois River (now spelled St. Francis). Unfortunately, Murphy died while returning to Kentucky for his wife, their children and grandchildren.

Sarah Barton Murphy and her sons decided to go ahead with her husband's plans and Murphy's Settlement was established a year or so later. Despite many hardships and difficulties, the new community thrived. Sarah Barton Murphy is also credited with organizing the first Protestant Sunday school west of the Mississippi. Descendents of the Murphy family still live in Farmington and are active in the community.

The Louisiana Purchase brought the territory into the United States. When the state of Missouri was created, David Murphy donated 52 acres for the development of a county seat for the about-to-be-formed St. Francois County. This same tract of land is currently the heart of Farmington's downtown business district.

St. Francois County was coveted for its lead production by both sides during the Civil War. It was also used as a staging area for troops out of St. Louis. Despite the heavy concentration of Union soldiers, a notorious Confederate guerilla leader, Sam Hildebrand, managed to commandeer the St. Joe Lead Mines. The guerillas held out for several weeks while manufacturing lead for General Sterling Price's invasion of Missouri. Afterwards, Price ordered the furnaces blown up so that they would not fall into federal hands. One of Hildebrand's many local hideouts, a cave in St. Francois State Park, still bears his name.

Land Use and Soils:

The upper portion of the St. Francis River flows across relatively flat terrain developed in Cambrian-aged dolomites. Land use is primarily forests and pasture (see Land Use Appendix A). Stream gradients are low and streams are characterized by relatively long, deep pools. During dry weather, water movement in the St. Francis is exceedingly slow. Most of the riparian zone along this portion of the St. Francis is forested, so nutrient levels and algal production are fairly low. The river flows through the Crider-Fourche-Nicholson soil association that is part of the Farmington Plain. This is a broad rolling plain that separates the drainage areas of the north flowing Big River from the south flowing St. Francis (Appendix B – Upper St. Francis River Watershed). The soil association is deep, gently to strongly sloping, and well to moderately-well drained.

Defining the Problem:

The Farmington West Wastewater Treatment Plant (WWTP) discharges wastewater into a 0.4 mile long unnamed tributary of the St. Francis River. The tributary is unclassified and drains an area of approximately 3,500 acres. The land use in the tributary is about 21 percent urban, 64 percent agricultural and 15 percent forest. In 1990, the WWTP was upgraded from 0.72 to 1.2 million

---

[3] Farmington-City of Tradition and Progress, http://fxnet.missouri.org/econdev/lochist/htm and The Civil War, St. Francois county, Missouri, http://rosecity.net/civilwar.stfc.html

gallons per day (MGD or 1.86 cubic feet per second) to accommodate greater influent loads. The Missouri Department of Natural Resources (the department) was concerned that the increased volume of effluent might cause exceedences of the instream water quality standards applicable to the St. Francis River during low flow conditions.

As a result, water quality monitoring was conducted in July 1992, and exceedences of both dissolved oxygen and ammonia water quality standards were found in the St. Francis River below the Farmington West WWTP. The department's Environmental Services Program (ESP) conducted intensive water quality studies of the Farmington West WWTP receiving stream and the St. Francis River on Aug. 6-8, 1996 and July 23-24, 1997 (see Water Quality Data in Appendix C.2). These studies documented exceedences of dissolved oxygen and ammonia standards in at least one mile of the St. Francis River downstream of the Farmington West WWTP and also low dissolved oxygen concentrations on the St. Francis just upstream of the wastewater plant. In August 1999, the department conducted an investigation of possible sources for the low dissolved oxygen (DO) levels in the St. Francis River. No nonpoint sources of low DO were found upstream of the confluence of the tributary conveying the WWTP effluent and the St. Francis River. One small discharge was identified, but is not considered to contribute to the problem (See Section 5 for information on Farmington Manor Lagoon). Initially, the observed upstream DO levels were believed to be normal for this river during summer low flow periods. However, sampling results from 2001 did not support this assumption. On the tributary upstream of the wastewater treatment outfall, dissolved oxygen ranged from 4.1 to 9.4 mg/L (Appendix C.2 Site #2), and on the St. Francis above the confluence with the tributary (Site #1), it ranged from 4.7 to 6.8 mg/L.

The results of the 1996 and 1997 field studies were used to derive new permit limits and the WWTP was again upgraded. This upgrade was completed Nov. 22, 2001, at a cost of $4.8 million dollars. The design capacity of the new facility is 2.4 MGD compared to the old capacity of 1.2 MGD. Construction permit details may be found in Appendix F. The new permit limits went into effect March 1, 2002 and were based on achieving water quality standards in St. Francis River. More data were gathered in a regularly scheduled water quality study in 2001 and the model rerun in 2002. The results of this were modeling were considered inconclusive since they were based on data gathered before the new upgrades went into effect. Therefore, data were collected yet again in 2004. See Section 3. Load Capacity for the discussion.

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

Beneficial Uses:
The beneficial uses of the St. Francis River, WBID 2835, are:

- Livestock and Wildlife Watering
- Irrigation
- Protection of Aquatic Life
- Protection of Human Health associated with Fish Consumption
- Cool Water Fishery
- Whole Body Contact Recreation (e.g., Swimming)
- Boating and Canoeing (This will be renamed "Secondary Contact Recreation" by 1/1/06)

The use that is impaired is Protection of Aquatic Life. The designated (beneficial) uses and stream classifications may be found in the Water Quality Standards at 10 CSR 20-7.031(1)(C), (1)(F) and table H.

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 Nov. 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 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).

Specific Criteria:

Biochemical Oxygen Demand (BOD)

Dissolved oxygen (DO) is the water quality standard that is exceeded in the St. Francis River. In this case the DO has been found to be too low (i.e., below the required minimum of 5 mg/L). DO is not a "pollutant" and so cannot be allocated in a TMDL. As a result, we use Biochemical Oxygen Demand (BOD) as the parameter to determine the impact that wastewater will have 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 oxygen demand (CBOD) and nitrogenous 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, which is supported by U. S. Environmental Protection Agency (EPA). The QUAL2E model calculates BOD by using 5-day CBOD ($CBOD_5$), organic nitrogen, and ammonia nitrogen data from actual sample analyses. The present state water quality standards for all Missouri streams except cold water fisheries call for a daily minimum of 5 milligrams per liter (mg/L or parts per million) dissolved oxygen[4] or the natural upstream concentration of dissolved oxygen as determined on a regional or watershed basis.[5] The data in Table 1 was used to look at the background level of DO in the St. Francis River.

Table 1: Dissolved Oxygen concentration in the St. Francis River, 0.25 mile above the confluence with the tributary

	Flow (cfs)	Early Morning DO (mg/L)	Early Afternoon DO (mg/L)	Daily Fluctuation
August 7-8, 1996	0	2.7, 2.0	4.0, 3.7	1.3, 1.7
July 23-24, 1997	0.55	3.7, 3.4	4.4, 4.5	0.7, 1.1
August 8-10, 2001	2.7	4.7, 5.4	6.6, 6.8	1.9, 1.4
July 22, 2004	0.01	2.0	3.7	1.7

The small daily fluctuation values in Table 1 indicate photosynthesis has only a small effect on dissolved oxygen levels in this portion of the river and thus algal respiration is not responsible for the low DO values observed in 1996 and 1997. The major source of oxygen demand is believed to be bacterial respiration of terrestrial organic matter in bottom sediments. This portion of the St. Francis has not been developed, nor are there crops and livestock being raised. It has a low gradient and flows through a heavily wooded area. The combination of terrestrial vegetation inputs to streams, warm water temperatures and lack of water movement through large pools can cause substantial loss of dissolved oxygen. A site visit in August 2005 verified these observations, finding very warm water temperatures, sluggish or no flow and low DO (3.3 mg/L). These facts lead the department to conclude that the low DO upriver of the effluent tributary is a natural condition. However, since no regional or watershed site specific criteria have been adopted by the state, **the dissolved oxygen criterion remains a minimum of 5.0 mg/L for the St. Francis River**.

Ammonia

The specific criteria found in Missouri's Water Quality Standards (WQS) at 10 CSR 20-7.031(4) apply to all classified waters. The specific criteria for ammonia are found in 10 CSR 20-7.031 Table B. Cool water fisheries have the same chronic ammonia criteria as warm water fisheries and these criteria appear in Table B under the heading "General Warm Water Fishery." These criteria are pH and water temperature dependent. Seasonal **ammonia criteria** from the standards 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 2.0 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.

Numeric Water Quality Targets:

The water quality targets for this TMDL are the water quality standards criteria stated in the two paragraphs just above.

---

4 10 CSR 20-7.031(4)(J)

5 10 CSR 20-7.031(4)(A)(3)

3. Calculation of Load Capacity

Load capacity (LC) is defined as the greatest amount of loading of a pollutant that a waterbody can receive without violating water quality standards. This load is then divided among the point source (waste load allocation) and nonpoint source (load allocation) contributions to the stream, with an allowance for an explicit margin of safety. If the margin of safety is implicit, no numeric allowance is necessary. This is expressed in the following manner:

$$LC = WLA + LA + MOS$$

Critical conditions are considered when the LC is calculated. Dissolved oxygen levels that threaten the integrity of aquatic communities generally occur during low flow periods, so these periods are considered the critical conditions. The critical conditions for ammonia are also low flow conditions, which are most likely to accompany exceedences of ammonia standards. Under low flow conditions there is less water available to dilute pollutant loads. The 7Q10 flow is the lowest average flow for seven consecutive days that have a recurrence interval of once in 10 years. This represents the worse case flow scenario reasonably expected to occur. Allocations developed under 7Q10 conditions are believed to be protective during other seasons and expected flow scenarios, so they were chosen as the critical conditions. The 7Q10 flow for the St. Francis River is 0.1 cubic feet per second (cfs)[6].

Using the QUAL2E model, ammonia nitrogen (NH_3-N) and 5-day carbonaceous oxygen demand ($CBOD_5$) criteria and loads were developed for summer and winter periods. Model inputs that vary by season (climatology, headwater characteristics) were adjusted accordingly. The model contains six stream reaches, two of which represent the tributary. The reaches are subdivided into sub-reaches, or computational units, of 0.2 mile each. After calibration and validation, numerous simulations were modeled with varying point source loads of $CBOD_5$ and NH_3-N. The modeled maximum allowable loads (the loading capacity) are those loads that allow maintenance of in-stream WQS where the effluent meets classified water, or where the tributary joins the St. Francis.

Expressed as pounds per day (lbs/day), the Load Capacity (LC) is dependent on the WWTP discharge because nonpoint source contributions from the tributary upstream of the WWTP are considered to be zero (see Section 4). The LC for the river was calculated using the concentrations from the model results in the formula below. The 2.4 MGD design flow translates to 3.72 cubic feet per second (cfs). The figure 5.395 is the constant used to convert cfs times milligrams per liter (mg/L) to lbs/day.

Load Capacity = (design flow in cfs)(calculated concentration in mg/L)(5.395 conversion factor)

Summer: $LC_{NH3\text{-}N}$ = (3.72 cfs)**(2.0 mg/L)**(5.395) = **40.1 lbs/day**

Winter: $LC_{NH3\text{-}N}$ = (3.72 cfs)**(2.5 mg/L)**(5.395) = **50.2 lbs/day**

[6] Water Resources Report Number 32, USGS 1976

To calculate the load capacity for BOD_5, the nonpoint source load (or LA) must be added in (See Section 4.):

LC_{BOD5} = (3.72 cfs)**(10 mg/L)**(5.395) + 1.1 lbs./day = 200.7 + 1.1 = **201.8 lbs/day**

4. Load Allocation (Nonpoint Source Load)

Load Allocation (LA) includes all existing and future nonpoint sources and natural background contributions (40 CFR § 130.2(g)). The existing nonpoint source $CBOD_5$ concentrations in the tributary above the WWTP were as high as 6 mg/L in 2001 but were only 2 mg/L in the St. Francis River above the tributary. This may suggest a potential contribution from urban runoff. Likewise, NH_3-N concentrations in the same period were as high as 0.12 mg/L in the tributary and non-detect in the St. Francis River.

Because the critical flow conditions **in the tributary** above the WWTP are zero flow, no load would be contributed and **the LA is assigned as zero pounds per day**. However, the potential for urban runoff into the tributary should continue to be evaluated. If any problems are found based on future monitoring, they will be addressed in the next phase of this TMDL.

As already stated, the critical flow conditions in the St. Francis River are 0.1 cfs, so a LA can be calculated. In actuality, at summer low flows there is no flow in the river starting about 0.25 mile upstream of the confluence with the tributary (at the Rt. 67 bridge). The 2.0 mg/L $CBOD_5$ in the LA calculation below is the result of samples taken in the St. Francis River just upstream of the Farmington West WWTP effluent tributary in 2001. No NH_3-N was detected. The flow used is the same for both summer and winter to represent the worse case flow scenario. Thus the **nonpoint source loads (LAs) for the St. Francis** are calculated as follows:

Load Allocation = (stream flow in cfs)(instream pollutant concentration in mg/L)(5.395)

Summer and winter:
$LA_{NH3\text{-}N}$: (0.1 cfs)(0.0 mg/L)(5.395) = **0.0 pounds/day**
LA_{CBOD5}: (0.1 cfs)(2 mg/L)(5.395) = **1.1 pounds/day**

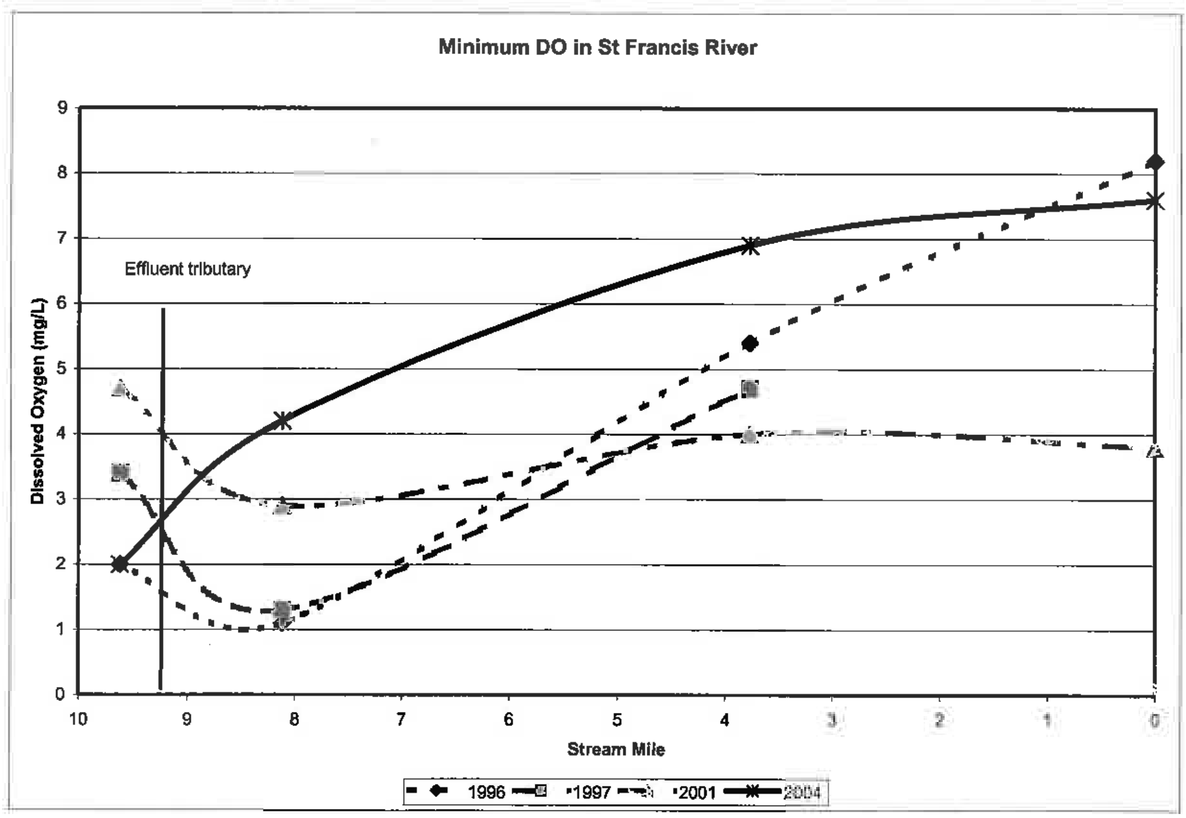
5. Waste Load Allocation (Point Source Loads)

The Waste Load Allocation (WLA) is the portion of a receiving water's load capacity that is allocated to its existing or future point sources of pollution. Aside from Farmington West WWTP, the Farmington Manor nursing home has a small lagoon that discharges to the St. Francis River about 0.5 miles upstream of the impaired segment. The impaired segment's upstream end begins where the Farmington West WWTP tributary enters the river. Water quality data taken upstream of the tributary in the St. Francis River showed very low levels of nutrients and non-detectable instream BOD, suggesting that the lagoon was either not discharging or the discharge was so small it was not having a discernable impact on instream water quality. In August 1999, this small lagoon was discharging less than 0.01 cfs into a large pool of the St. Francis River. The river at this point and time had no flow between the nursing home discharge and the upstream end of the impaired segment. During design conditions (0.1 cfs of flow in the St. Francis River) there would be an extremely long residence time (estimated at 3-4 days) for the Farmington Manor discharge in that upstream 0.5-mile segment of the river. It is expected that the very small $CBOD_5$ and NH_3-N loads from the Farmington Manor nursing home would be completely exhausted prior to entering the impaired segment of the river. This expectation is supported by data collected in 1992, 1996, 1997 and 1999. $CBOD_5$ and NH_3-N levels were consistently low in the St. Francis River immediately upstream of the Farmington West WWTP tributary. The impact of this small upstream source is, therefore, included in the background upstream nonpoint source loadings.

Due to the reasons listed above, it is believed that discharge from the Farmington West WWTP was the most significant cause for the impairments. A review of permit monitoring data collected prior to the upgrade, between 2001 and 1998, showed NH_3-N values as high as 9.2 mg/L in the summer and 13.9 mg/L in the winter. Likewise $CBOD_5$ values were as high as 63 mg/L in the summer and 54 mg/L in the winter. The expired permit for this facility limited NH_3-N to 2.5 mg/L in summer and 3.0 mg/L in winter and $CBOD_5$ to 10 mg/L in the summer and 25 mg/L in the winter. These limits were both the daily maximum and the monthly average.

As was stated in Section 1 under Defining the Problem, more data were collected in the summer of 2004 during two 24-hour water quality surveys (post-construction monitoring) of the St. Francis River. Water quality data are in Appendix C.2. Figure 1 below indicates that, while improvement is evident, compliance with water quality criteria, specifically the minimum of 5 mg/L for dissolved oxygen, has yet to be fully achieved.

Figure 1: Observed Early Morning DO in the St. Francis River



Plant Performance:
The upgrades at the plant have resulted in significantly improved performance. This is evident in the discharge monitoring reports (DMRs) for $CBOD_5$ and ammonia nitrogen (Figures 2 and 3). See also the data tables in Appendix D. However, this performance, as shown in Figure 1, is not a guarantee of protection of water quality. One uncertainty factor is the dissolved oxygen content upstream of the effluent tributary and thus beyond the control of the facility. See the instream monitoring data in Appendix E.

The facility is still a potential contributor to stream degradation, and the current effluent limits have been re-examined to reduce the uncertainty. For $CBOD_5$, if the plant discharges at the full design flow of 2.4 MGD, with the maximum concentration allowed in the present permit, the load will be within the limits of the WLA for both summer and winter. For NH_3-N, under the same scenario, the WLA would be exceeded by 105 percent in the summer, and 29 percent in the winter.

Figure 2. Maximum daily $CBOD_5$ at Farmington West WWTP

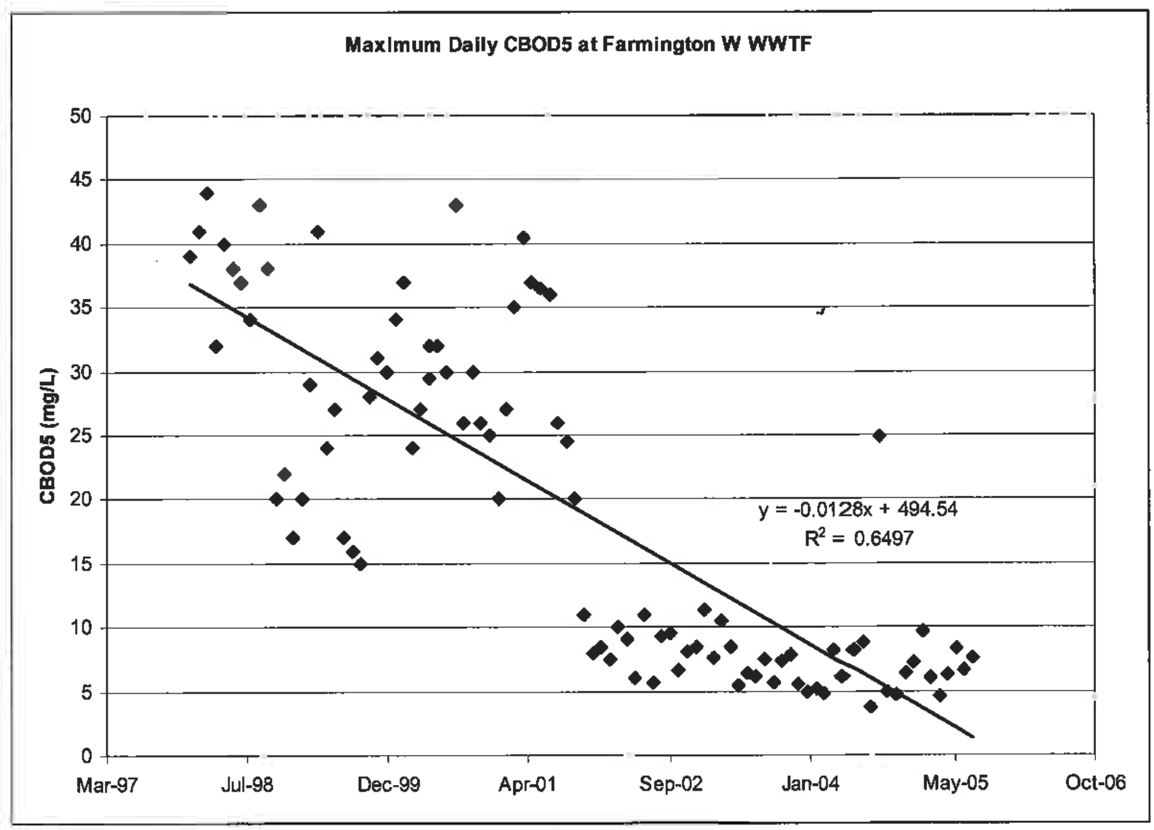
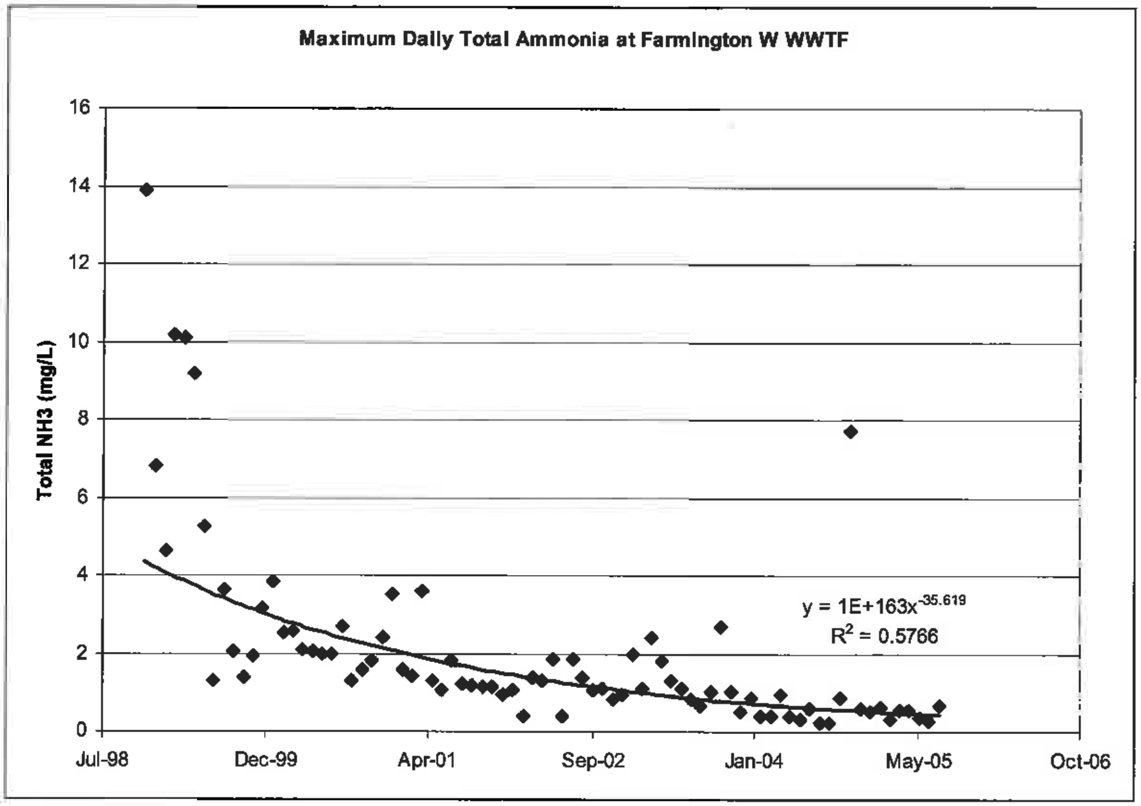


Figure 3. Maximum daily total ammonia at Farmington West WWTP



The QUAL2E model was run again (using the 2004 data), with the same settings as previously, to re-estimate what limits will protect water quality in the St Francis River. While the river is listed for BOD and ammonia, data from stream surveys indicate a significant load of total nitrogen and total phosphorus in the effluent from the WWTP. These nutrient issues are being addressed through voluntary minimization of nutrient loading to the WWTP, as discussed in the Concluding Remarks below. Using the concentrations from the QUAL2E model, the wasteload allocations were calculated as follows and are summarized in Table 2:

WLA = (design flow in cfs)(concentration in mg/L)(5.395 conversion factor)

Summer: $WLA_{NH3\text{-}N}$ = (3.72 cfs)**(2.0 mg/L)**(5.395) = **40.1 lbs/day**

Winter: $WLA_{NH3\text{-}N}$ = (3.72 cfs)**(2.5 mg/L)**(5.395) = **50.2 lbs/day**

To calculate the wasteload allocation for BOD_5, seasonality does not have to be considered:

WLA = (3.72 cfs)**(10 mg/L)**(5.395) = **200.7 lbs/day**

Table 2: TMDL Waste Load Allocations for St. Francis River near Farmington

Summer	BOD_5	NH_3-N
Pounds per day	201	40
WLA mg/L	10	2
Winter		
Pounds per day	201	50
WLA mg/L	10	2.5

Concluding Remarks:
The department has discussed the nutrient issue with Farmington West WWTP management. It appears that the most likely source of nutrients is laundry detergent in the waste streams of several local industries. These industries will be approached about a voluntary phosphorous minimization program before the city calculates "local limits" that would require onsite pretreatment. Although planned for the future, criteria for nutrients do not currently exist in Missouri's WQS and therefore there are no nutrient criteria that are applicable to the St. Francis River. When nutrient criteria are promulgated, appropriate limits for this facility will need to be calculated.

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.

The MOS is implicit in this TMDL and is included in conservative model assumptions and calculations. One example is that QUAL2E simulations were run using an effluent DO of 5 mg/L, while, in 2004, the plant consistently produced a discharge containing more than 6 m/L DO (Table 3). Effluent DO concentration over all the years was above 5.5 mg/L, except once in 2001 when it measured 4.9 mg/L in the afternoon (14:40). All early morning DO measurements were ≥5.5 mg/L. This is a conservative approach that is used as part of the margin of safety.

Table 3: Early morning effluent DO concentration

Year	Month	Day	Time	Flow	C	DO
1996	8	8	750		26	5.5
1996	8	7	650		26	5.7
1997	7	23	615		27	5.6
1997	7	24	620		27	6.1
2001	8	10	605	1.5	26	5.7
2001	8	9	605		26	6
2004	7	21	625	1.7	26	6.4
2004	7	22	612		27	6.5

Note: C = temperature in degrees Celsius

7. Seasonal Variation

Toxicity of ammonia species (NH_3 & NH_4^+) to fishes and invertebrates is well documented[7]. High pH and temperature increase the proportion of the more toxic NH_3 form and thus ammonia toxicity limits are seasonal in nature. Both summer and winter TMDL allocations for ammonia were developed.

8. Monitoring Plan for TMDLs Developed under Phased Approach

Using the reopener clause, instream-monitoring sites were added to Farmington West's permit in January 2003. Since then, ambient water quality data has been gathered monthly by the facility in the St. Francois River both upstream and downstream of the tributary. The parameters that are being collected at these points are DO, BOD, pH, temperature, NH_3-N, nitrate plus nitrite as nitrogen, total Kjeldahl nitrogen, and total phosphorus. These data may be found in Appendix E. The next monitoring scheduled by the department will be low flow studies in 2007 and 2008. 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 Plans

This TMDL will be implemented through permit action. Farmington West WWTP completed an upgrade to their facility November 22, 2001. Permit limits from modeling performed in 1999 were written into the State Operating Permit (#MO-0040312) and went into effect March 1, 2002. These were $CBOD_5$ 10/10 mg/L (daily maximum/monthly average) in the summer and 25/25 mg/L in the winter. For ammonia, the limits were 2.5/2.5 mg/L in the summer and 3.0/3.0 mg/L for the winter. The current permit for the facility expired in May 2005. Based on the WLAs detailed in this TMDL, new permit limits (Water Quality Based Effluent Limits) for the WWTP will be calculated using the methods and procedures outlined in the EPA Technical Support Document (EPA/505/2-90-001). As discussed above (see Concluding Remarks), nutrient limits will not be included in the permit at this time. Instead, they will be addressed through voluntary minimization of nutrients by the responsible industries or through pretreatment limits. If future monitoring shows that water quality standards are not being met, the permit can be reopened to incorporate new or modified effluent limitation or other conditions necessary to ensure compliance with Missouri's Water Quality Standards. If other sources are discovered, this TMDL will be revisited.

10. Reasonable Assurances

The department has the authority to write and enforce State Operating Permits. Inclusion of effluent limits (determined from the allocations established by the modeling) into a state permit, and quarterly monitoring of the effluent reported to the department, should provide reasonable assurance that instream water quality standards will be met.

---

[7] *Ambient Water Quality Criteria for Ammonia-1984*, EPA 440/5-85-001, and *1999 Update of Ambient Water Quality Criteria for Ammonia*, EPA-822-R-99-014

11. Public Participation

This water quality limited segment of the St. Francis River is included on the approved 2002 303(d) list for Missouri. 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 St. Francis River TMDL was from Nov. 18 to Dec. 18 2005. Groups that received the public notice announcement included the Missouri Clean Water Commission, Farmington West WWTP, the Water Quality Coordinating Committee, the St. Francois County Soil and Water Conservation District, Stream Team volunteers in the watershed (31), the appropriate legislators (3) and others that routinely receive the public notice of Missouri State Operating Permits (also called NPDES permits). One comment was received; however, it did not require any adjustments to the TMDL. This letter and the department's response have been placed in the St. Francis River file, as detailed below.

12. Administrative Record and Supporting Documentation

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

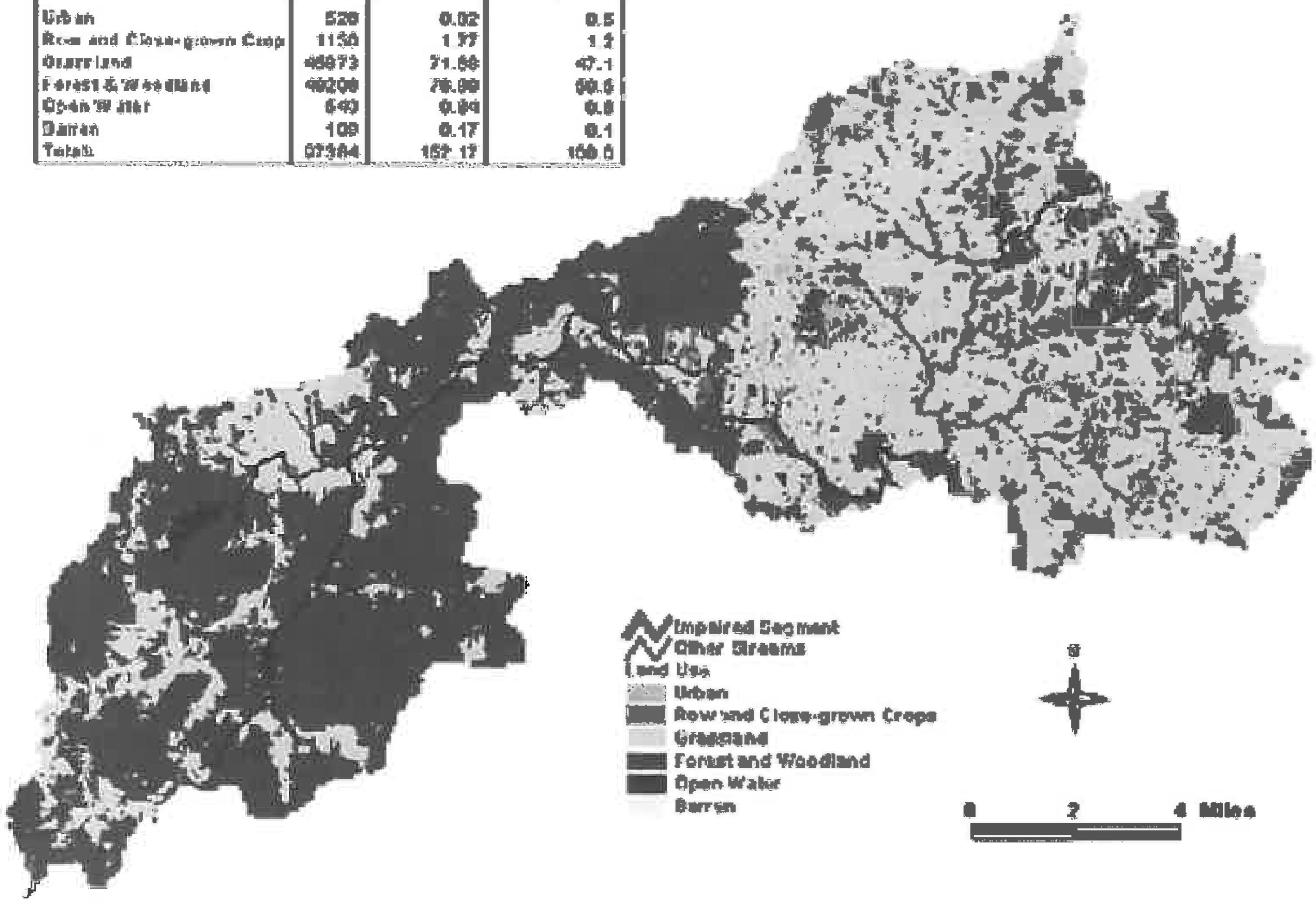
- Farmington West WWTP State Operating Permit MO-0023019
- Early morning water quality study July 8, 1992, conducted by the department's Water Pollution Control Program (now Water Protection Program)
- Environmental Services Program, 48-hour water quality studies of August 6-8, 1996, and July 22-24, 1997
- Water Pollution Control Program data from August 8-10, 2001 (now Water Protection Program)
- Water Protection Program data from July 21-22, 2004
- QUAL2E input and output files
- Information Sheet, public notice announcement, comment letter and response

13. Appendices

Appendix A – Land Use in the Upper St. Francis River Watershed – Map and Distribution List
Appendix B – Map of the Upper St. Francis River Watershed
Appendix C – Topographic Map of the Impaired Segment with Sampling Sites and Corresponding Water Quality Data
Appendix D – Discharge Monitoring (DMR) Data from the Farmington West WWTP
Appendix E – Instream Monitoring Data collected by the WWTP from the St. Francis River
Appendix F – Construction permit (2001)

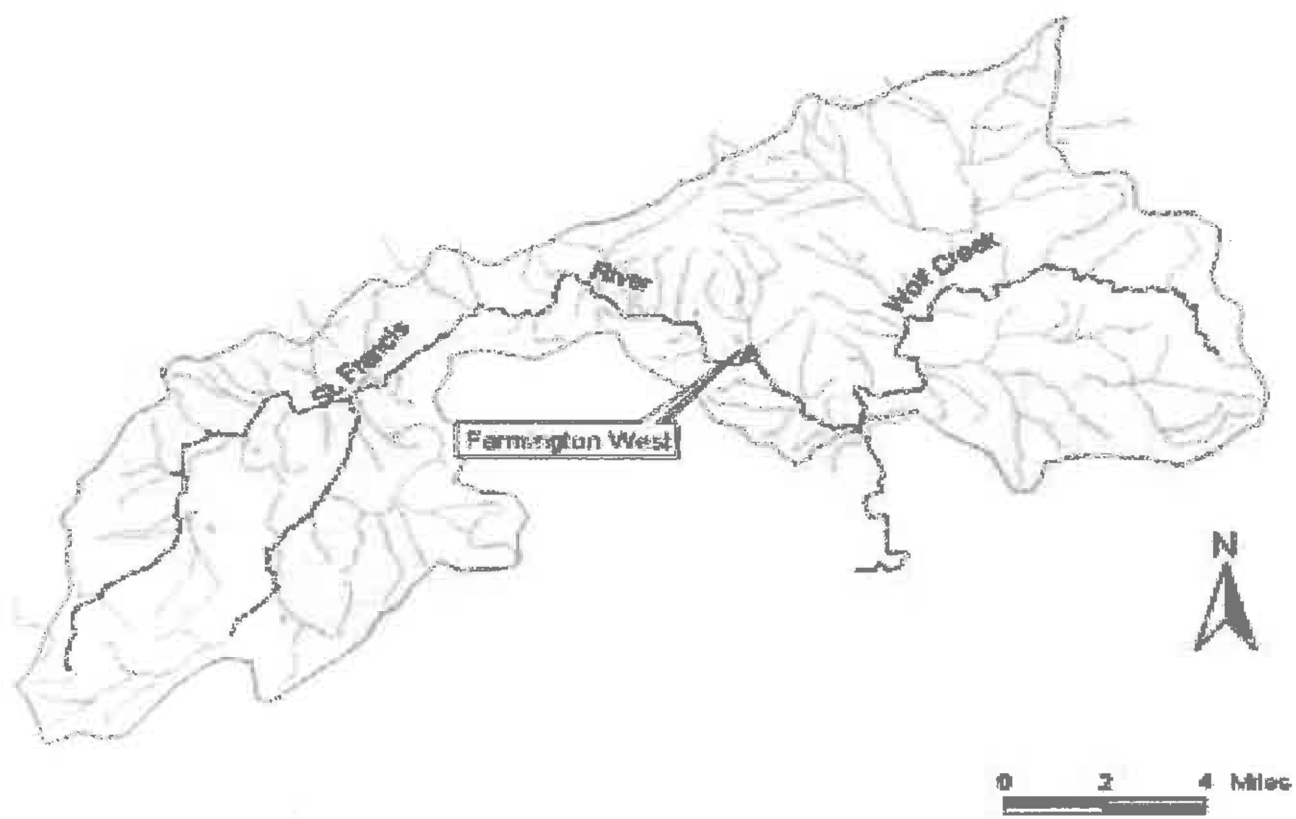
Appendix A: Land Use Map of the Upper St. Francis River upstream from Wolf Creek

Land Use Type	Acres	Sq Miles	Percentage
Urban	528	0.82	0.5
Row and Close-grown Crop	1130	1.77	1.2
Grassland	45873	71.68	47.1
Forest & Woodland	49204	76.88	50.5
Open Water	540	0.84	0.6
Barren	109	0.17	0.1
Total	97384	152.17	100.0



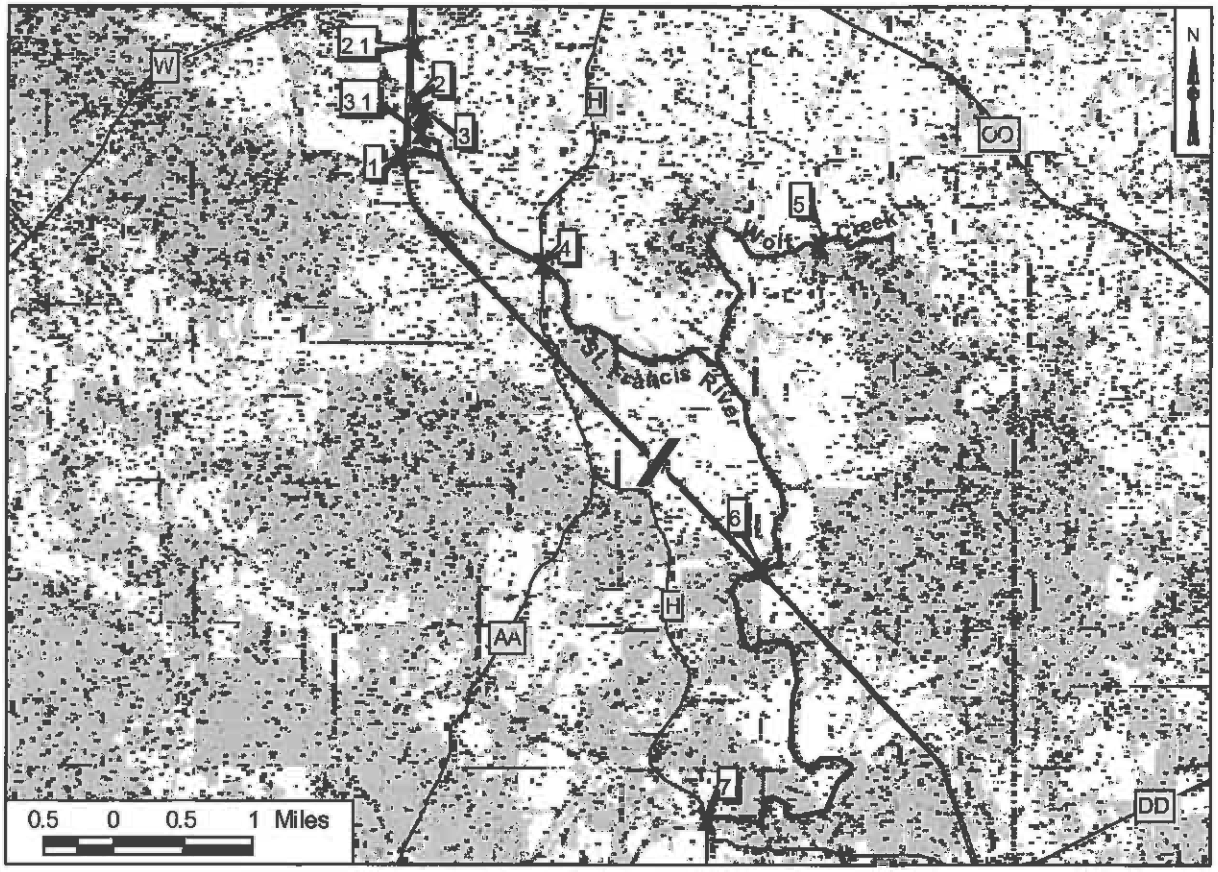
Appendix B

Appendix B: Upper St. Francis River Watershed.



Appendix C
Topographic Map and Water Quality Data

Appendix C.1 Topographic map of Impaired Section of the St. Francis River with Sampling Sites



MDNR Monitoring Sites

1 – St. Francis River 0.25 mile above effluent tributary
2 – Tributary to St. Francis River 50 yards above outfall
2.1 – Tributary to St. Francis River 0.5 miles above outfall
3 – Farmington West WWTP outfall
3.1 – Tributary to St. Francis River 50 yards below outfall
4 – St. Francis River at Gruner Ford Conservation Area
5 – Wolf Creek 4 miles below Farmington East WWTP
6 – St. Francis River 1.75 miles below Wolf Creek
7 – St. Francis River at Highway H

Appendix C.2 Data from water quality studies 1996, 1997, 2001 and 2004

Site #	1996	Time (24 hr)	Temp (°C)	DO (mg/L)	$CBOD_5$ (mg/L)	TKN (mg/L)	NH_3N (mg/L)	$NO_2 + NO_3$ (mg/L)
1	8/7/1996	630	25	2.7	non-detect		non-detect	non-detect
2.1	8/7/1996	605	23	4.2	non-detect		non-detect	0.46
3	8/7/1996	650	26	5.7				
4	8/7/1996	615	25	1.1	non-detect		0.26	2.82
6	8/7/1996	640	25	6.3	non-detect		non-detect	0.74
7	8/7/1996	706	27	8.6	non-detect		non-detect	0.07
1	8/7/1996	1240	28	4	3		non-detect	0.06
2.1	8/7/1996	1220	25	4.3	non-detect		non-detect	0.45
3	8/7/1996	1145			9		5.41	1.93
3	8/7/1996	1205	27	7.2				
4	8/7/1996	1225	27	6.3	non-detect		0.55	2.72
6	8/7/1996	1243	26	8.4	non-detect		non-detect	0.68
7	8/7/1996	1302	28	10.9	3		non-detect	non-detect
1	8/8/1996	720	25	2	non-detect		0.11	non-detect
2.1	8/8/1996	710	24	4.8	non-detect		non-detect	0.21
3	8/8/1996	750	26	5.5				
4	8/8/1996	650	25	1.2	non-detect		0.57	2.72
6	8/8/1996	630	25	5.4	non-detect		0.05	0.73
7	8/8/1996	605	26	8.2	non-detect		non-detect	0.1
1	8/8/1996	1335	28	3.7	non-detect		0.12	0.07
2.1	8/8/1996	1315	26	10.9	non-detect		non-detect	0.53
3	8/8/1996	1125			7		6.13	3.5
3	8/8/1996	1135	27	6.6				
4	8/8/1996	1255	27	7.5	1.999		0.68	2.56
6	8/8/1996	1235	27	9.2	non-detect		0.06	0.68
7	8/8/1996	1210	28	9.2	non-detect		non-detect	0.06
Site #	**1997**	**Time (24 hr)**	**Temp (°C)**	**DO (mg/L)**	**$CBOD_5$ (mg/L)**	**TKN (mg/L)**	**NH_3N (mg/L)**	**$NO_2 + NO_3$ (mg/L)**
1	7/23/1997	600	27	3.7	1.999		0.07	0.08
2.1	7/23/1997	540	24	3.3	1.999		0.02	0.52
3	7/23/1997	615	27	5.6				
4	7/23/1997	600	25	1.4	non-detect		4.23	0.66
6	7/23/1997	545	26	4.9	non-detect		0.07	0.94
1	7/23/1997	1310	29	4.4	non-detect		0.06	0.08
2.1	7/23/1997	1255	26	5.6	1.999		0.02	0.35
3	7/23/1997	1230	25	5.6	9		8.87	0.86
4	7/23/1997	1230	27	5.2	non-detect		3.17	0.94
6	7/23/1997	1215	27	7.2	non-detect		0.05	0.88
1	7/24/1997	600	26	3.4	non-detect		0.07	0.07
2.1	7/24/1997	540	23	4.6	non-detect		0.01	0.34
3	7/24/1997	620	27	6.1				
4	7/24/1997	558	25	1.3	non-detect		1.64	1.16

6	7/24/1997	540	26	4.7	non-detect		0.06	0.92
1	7/24/1997	1230	28	4.5	non-detect		0.05	0.07
2.1	7/24/1997	1245	25	7.5	non-detect		0.06	0.36
3	7/24/1997	1210	25	5.9	16		6.24	0.77
4	7/24/1997	1213	26	5.3	1.999		1.94	1.01
6	7/24/1997	1155	27	7.1	non-detect		0.07	0.93
Site #	**2001**	**Time (24 hr)**	**Temp (°C)**	**DO (mg/L)**	**$CBOD_5$ (mg/L)**	**TKN (mg/L)**	**NH_3N (mg/L)**	**$NO_2 + NO_3$ (mg/L)**
1	8/8/2001	1455	28	6.6	2	1.44	non-detect	non-detect
2	8/8/2001	1445	28	9.4	6	1.21	0.05	0.26
3	8/8/2001	1440	27	4.9	non-detect	non-detect	non-detect	16.1
3.1	8/8/2001	1430	28	4.7	2	0.52	0.44	12.1
4	8/8/2001	1505	28	5.8	non-detect	1.43	0.11	2.79
5	8/8/2001	1610	29	5.8	non-detect	1.16	0.13	6.8
6	8/8/2001	1520	28	6	non-detect	1.17	0.1	1.3
7	8/8/2001	1540	28	5.9	3	0.76	non-detect	0.67
1	8/9/2001	620	26	4.7	non-detect	0.66	non-detect	non-detect
2	8/9/2001	610	24	4.1	4	1.17	0.12	0.36
3	8/9/2001	605	26	6	non-detect	0.099	non-detect	15.8
3.1	8/9/2001	600	26	2.2	non-detect	1.13	0.54	10
4	8/9/2001	630	26	3.3	non-detect	0.99	0.12	2.89
5	8/9/2001	720	25	4.2	non-detect	0.79	0.09	7.6
6	8/9/2001	640	26	4	non-detect	0.78	0.15	1.19
7	8/9/2001	655	27	4.3	non-detect	0.79	0.09	0.73
1	8/9/2001	1430	30	6.8	non-detect	0.63	non-detect	non-detect
2	8/9/2001	1415	30	7.2	4	1.5	0.07	0.3
3	8/9/2001	1410	28	5.7	non-detect	1.05	0.25	15.9
3.1	8/9/2001	1405	29	4.9	non-detect	0.55	0.29	12.7
4	8/9/2001	1440	29	6.6	non-detect	1.35	0.07	4.12
5	8/9/2001	1530	27	6.2	non-detect	0.099	0.16	8.21
6	8/9/2001	1450	29	6.6	non-detect	0.89	0.17	1.29
7	8/9/2001	1505	29	5.4	non-detect	0.68	0.05	0.75
1	8/10/2001	620	26	5.4	non-detect	0.64	non-detect	non-detect
2	8/10/2001	610	24	4.3	4	0.71	0.1	0.29
3	8/10/2001	605	26	5.7	non-detect	1.42	non-detect	14
3.1	8/10/2001	600	26	2.7	non-detect	2.23	0.47	12.4
4	8/10/2001	630	25	2.9	non-detect	0.87	0.08	3.84
5	8/10/2001	715	25	4.5	non-detect	0.71	0.17	7.91
6	8/10/2001	640	26	4.2	non-detect	0.85	0.17	1.47
7	8/10/2001	650	27	3.8	non-detect	0.82	0.1	0.72
Site #	**2004**	**Time (24 hr)**	**Temp (°C)**	**DO (mg/L)**	**$CBOD_5$ (mg/L)**	**TKN (mg/L)**	**NH_3N (mg/L)**	**$NO_2 + NO_3$ (mg/L)**
3	7/21/04	625	26	6.4				
3	7/21/04	1350	28	7.1				
1	7/22/04	630	25.5	2	non-detect	0.63	0.07	0.03

2	7/22/04	550	25	5	non-detect	0.42	non-detect	0.19
3	7/22/04	612	27	6.5				
3.1	7/22/04	600	26.5	3.6	non-detect	0.82	0.06	11.5
4	7/22/04	555	26	4.2	non-detect	1.26	non-detect	11.4
5	7/22/04	650	25	5.2	non-detect	1.01	non-detect	6.55
6	7/22/04	620	26	6.9	non-detect	1.01	non-detect	6.84
7	7/22/04	650	27.5	7.6	non-detect	0.77	non-detect	1.78
1	7/22/04	1300	28	3.7	non-detect	0.63	0.05	0.03
2	7/22/04	1235	30	8.2	non-detect	0.41	non-detect	0.17
3	7/22/04	1100			3.05	0.94	0.11	16.3
3	7/22/04	1223	28	7.2				
3.1	7/22/04	12:45	29	8.2	non-detect	1.11	non-detect	16.9
4	7/22/04	1310	28	8.4	non-detect	1.3	non-detect	11
5	7/22/04	1325	27	6.4	2.12	1.01	non-detect	6.41
6	7/22/04	1250	28	9.5	2.34	1.17	non-detect	6.85
7	7/22/04	1230	30	9.9	2.02	0.82	non-detect	1.76

Temp=Temperature in degrees Celsius; D.O.=Dissolved Oxygen; $CBOD_5$=Chemical Biochemical Oxygen Demand; TKN=Total Kjeldahl Nitrogen; NH_3N=Ammonia as Nitrogen; NO_2+NO_3= Nitrite plus Nitrate as Nitrogen

Appendix D
Discharge Monitoring Reports (data) from Farmington West WWTP from facility update through August 2005

Table D-1. CBOD results from DMRs from Farmington West WWTF

Month/ Year	Max daily conc CBOD (mg/L)	Month/ Year	Max daily conc CBOD (mg/L)	Month/ Year	Max daily conc CBOD (mg/L)	Month/ Year	Max daily conc CBOD (mg/L)
---	---	Jan-03	11.3	Jan-04	4.9	Jan-05	7.3
---	---	Feb-03	7.6	Feb-04	5.2	Feb-05	9.7
Mar-02	10	Mar-03	10.5	Mar-04	4.8	Mar-05	6
Apr-02	9	Apr-03	8.5	Apr-04	8.2	Apr-05	4.6
May-02	6	May-03	5.4	May-04	6.1	May-05	6.3
Jun-02	11	Jun-03	6.4	Jun-04	8.2	Jun-05	8.3
Jul-02	5.7	Jul-03	6.2	Jul-04	8.8	Jul-05	6.7
Aug-02	9.3	Aug-03	7.5	Aug-04	3.7	Aug-05	7.6
Sep-02	9.6	Sep-03	5.7	Sep-04	24.9	---	---
Oct-02	6.7	Oct-03	7.4	Oct-04	5	---	---
Nov-02	8.1	Nov-03	7.8	Nov-04	4.7	---	---
Dec-02	8.4	Dec-03	5.6	Dec-04	6.4	---	---

Table D-2. NH_3-N results from DMRs from Farmington West WWTF

Month/ Year	Max daily conc NH3-N (mg/L)	Month/ Year	Max daily conc NH3-N (mg/L)	Month/ Year	Max daily conc NH3-N (mg/L)	Month/ Year	Max daily conc NH3-N (mg/L)
---	---	Jan-03	1.97	Jan-04	0.88	Jan-05	0.51
---	---	Feb-03	1.1	Feb-04	0.41	Feb-05	0.64
Mar-02	1.37	Mar-03	2.4	Mar-04	0.41	Mar-05	0.33
Apr-02	1.31	Apr-03	1.83	Apr-04	0.97	Apr-05	0.54
May-02	1.88	May-03	1.31	May-04	0.4	May-05	0.55
Jun-02	0.39	Jun-03	1.11	Jun-04	0.31	Jun-05	0.37
Jul-02	1.86	Jul-03	0.84	Jul-04	0.59	Jul-05	0.27
Aug-02	1.37	Aug-03	0.66	Aug-04	0.23	Aug-05	0.69
Sep-02	1.07	Sep-03	1.03	Sep-04	0.25	---	---
Oct-02	1.11	Oct-03	2.7	Oct-04	0.86	---	---
Nov-02	0.83	Nov-03	1.04	Nov-04	7.71	---	---
Dec-02	0.94	Dec-03	0.51	Dec-04	0.61	---	---

Appendix E
Instream Monitoring Data

Farmington West WWTP personnel collected these data at the following sites, as identified in their state operating permit:

Site S1-5 is in the St Francis River, 300 feet upstream its confluence with the receiving tributary.
Site S1-6 is in the St. Francis River, 300 feet downstream of the tributary.

Instream DMR Data for Farmington West Wastewater Treatment Plant

Date	Analyte	S1 - 5	S1 - 6
5/25/2005	NH3-N	0.13	0.1
	DO	1.9	2.1
	Temp-C	21	21
	pH	7.31	7.37
	BOD	3.4	3.6
	TKN	1.39	1.51
	NO3+NO2-N	<0.02	9.04
	TP	0.023	1.95
4/19/2005	NH3-N	0.1	0.07
	DO	3.1	3.3
	Temp-C	20	20
	pH	7.22	7.39
	BOD	3.8	4
	TKN	1.39	1.61
	NO3+NO2-N	0.13	0.174
	TP	0.39	0.239
3/10/2005	NH3-N	0.06	0.05
	DO	4.1	4.4
	Temp-C	13	13
	pH	7.29	7.43
	BOD	4.3	4.4
	TKN	0.915	0.937
	NO3+NO2-N	0.065	0.475
	TP	<0.010	0.364
2/3/2005	NH3-N	0.08	0.05
	DO	4.7	4.8
	Temp-C	14	14
	pH	7.32	7.41
	BOD	3.1	3.3
	TKN	0.952	0.851
	NO3+NO2-N	0.172	0.439
	TP	<0.010	0.25
1/26/2005	NH3-N	0.1	0.08
	DO	5.2	5
	Temp-C	16	16
	pH	7.41	7.49
	BOD	2.8	3.3
	TKN	0.891	0.983
	NO3+NO2-N	0.365	0.439

Date	Analyte	S1 - 5	S1 - 6
	TP	0.023	0.236
12/9/2004	NH3-N	0.07	0.05
	DO	4.9	4.2
	Temp-C	18	18
	pH	7.37	7.46
	BOD	3.6	4.4
	TKN	1.33	1.46
	NO3+NO2-N	0.02	0.092
	TP	0.459	0.435
9/15/2004	NH3-N	0.14	0.11
	DO	5.9	5.5
	Temp-C	26	26
	pH	7.13	7.21
	BOD	4.8	5.1
	TKN	2.88	3.79
	NO3+NO2-N	0.026	2.92
	TP	0.214	14.3
8/26/2004	NH3-N	0.16	0.1
	DO	6	5.7
	Temp-C	27	27
	pH	7.18	7.21
	BOD	4.8	5.6
	TKN	1.41	1.37
	NO3+NO2-N	0.049	1.81
	TP	0.341	5.01
7/7/2004	NH3-N	0.13	0.07
	DO	6.9	6.3
	Temp-C	26	26
	pH	7.31	7.47
	BOD	3.6	4.3
	TKN	2.96	3.08
	NO3+NO2-N	0.059	0.801
	TP	0.02	3.04
6/24/2004	NH3-N	0.16	0.1
	DO	6.6	6.5
	Temp-C	24	24
	pH	7.48	7.59
	BOD	2.8	2.8
	TKN	1.65	2.21

Date	Analyte	S1 – 5	S1 - 6
	NO3+NO2-N	0.01	1.28
	TP	0.366	4.87
5/25/2004	NH3-N	0.1	0.07
	DO	6	6.4
	Temp-C	21	21
	pH	7.37	7.51
	BOD	1.6	1.6
	TKN	1.49	1.63
	NO3+NO2-N	0.049	0.322
	TP	0.085	1.1
4/23/2004	NH3-N	0.12	0.09
	DO	5.9	6.6
	Temp-C	19	19
	pH	7.5	7.43
	BOD	2.8	3.2
	TKN	2.99	2.56
	NO3+NO2-N	<0.010	0.921
	TP	0.063	1.49
3/19/2004	NH3-N	0.17	0.11
	DO	5.7	6.1
	Temp-C	17	17
	pH	7.44	7.37
	BOD	3.2	3.3
	TKN	2.38	2.59
	NO3+NO2-N	0.133	0.33
	TP	0.033	0.426
2/19/2004	NH3-N	0.15	0.13
	DO	5	6
	Temp-C	16	16
	pH	7.31	7.4
	BOD	3.1	3
	TKN	2.75	2.35
	NO3+NO2-N	0.013	0.204
	TP	0.133	0.257
1/14/2004	NH3-N	0.14	0.14
	DO	4.9	6.2
	Temp-C	10	10
	pH	7.27	7.39
	BOD	2.8	2.8
	TKN	2.68	1.8
	NO3+NO2-N	1.08	1.1
	TP	2.31	1.71
12/11/2003	NH3-N	0.15	0.16
	DO	4.6	6
	Temp-C	8	8
	pH	7.31	7.44
	BOD	3.2	4.6
	TKN	0.758	0.634
	NO3+NO2-N	0.03	0.112
	TP	0.11	0.183

Date	Analyte	S1 – 5	S1 – 6
11/19/2003	NH3-N	0.16	0.21
	DO	4.3	6.1
	Temp-C	10	12
	pH	7.23	7.36
	BOD	3.1	4.7
	TKN	1.91	1.17
	NO3+NO2-N	0.105	0.25
	TP	0.046	0.032
10/29/2003	NH3-N	0.23	0.34
	DO	3.6	0.57
	Temp-C	12	17
	pH	7.1	7.33
	BOD	3.1	3.9
	TKN	1.09	3.28
	NO3+NO2-N	0.053	6.34
	TP	0.177	11.6
9/1/2003	NH3-N	0.2	0.29
	DO	3.4	3.5
	Temp-C	17	17
	pH	7.13	7.41
	BOD	2.9	3.7
	TKN	0.833	1.08
	NO3+NO2-N	0.16	6.93
	TP	0.02	16.5
8/27/2005	NH3-N	0.025	0.32
	DO	2.8	3.5
	Temp-C	26	26
	pH	7.09	7.37
	BOD	2.8	4.2
	TKN	0.536	0.871
	NO3+NO2-N	0.19	7.68
	TP	0.043	20.6
7/23/2003	NH3-N	0.1	0.16
	DO	3.5	3.7
	Temp-C	23	23
	pH	7.04	7.31
	BOD	1.4	3.3
	TKN	1.02	1.38
	NO3+NO2-N	0.04	4.09
	TP	0.08	11.6
6/18/2003	NH3-N	0.19	0.53
	DO	1.3	1.6
	Temp-C	67	67
	pH	7.11	7.06
	BOD	3.3	3.8
	TKN	1.32	1.57
	NO3+NO2-N	0.03	0.736
	TP	0.098	0.457
5/14/2003	NH3-N	0.15	0.64
	DO	1.2	1.9

Date	Analyte	S1 - 5	S1 – 6
	Temp-C	64	64
	pH	7.04	7.01
	BOD	2.88	2.76
	TKN	0.121	0.808
	NO3+NO2-N	0.046	0.919
	TP	0.709	1.09
4/16/2003	NH3-N	0.14	0.15
	DO	1.3	1.6
	Temp-C	68	68
	pH	7.24	7.12
	BOD	2.64	2.64
	TKN	1.15	1.08
	NO3+NO2-N	0.154	0.801
	TP	0.207	0.214
3/12/2003	NH3-N	0.19	0.17
	DO	1.1	1.3
	Temp-C	62	62
	pH	7.04	7.51
	BOD	3.15	3.45
	TKN	1.33	2.56
	NO3+NO2-N	0.023	0.539
	TP	7.24	1.01

Temp-C=Temperature in degrees Celsius; D.O.=Dissolved Oxygen; BOD=Biochemical Oxygen Demand; TKN=Total Kjeldahl Nitrogen; NH_3N=Ammonia as Nitrogen; NO_2+NO_3= Nitrite plus Nitrate as Nitrogen; TP=Total Phosphorus

Note: All units are in milligrams per liter (mg/L) except temperature (Celsius) and pH (Standard Units)

Appendix F
Excerpt from the Farmington West Construction Permit

C295386-01 Farmington, Missouri Permit No. 2977

CONSTRUCTION PERMIT

Expansion of the wastewater treatment facilities at the Farmington West Plant will increase treatment capacity from 1.2 million gallons per day to 2.4 million gallons per day. The project will include the replacement of headworks components, adding primary clarification, modifying existing aeration basins, adding two additional aeration basins and one final clarifier and adding a new secondary sludge pumping station. A tertiary filter system will be added to decrease solids in the effluent. The ultraviolet disinfection system will be replaced with a higher capacity system. Equipment that will be added to the sludge handling facilities will lime-stabilize biosolids produced at the plant as needed. Sludge storage will be increased by building an enclosure for sludge drying beds that are currently not in use.

Headworks improvements are to include replacement of existing screw pumps, adding a mechanical bar screen, and modifications to the grit chamber area to provide flow to the new primary clarifiers. Two 50-foot diameter primary clarifiers are to be constructed.

All four existing aeration basins will be upgraded with additional aeration equipment and modifications to flow control structures.

Two new 280,586-gallon aeration basins will be constructed to increase the secondary treatment capacity. One new 50-foot diameter final clarifier will be constructed and improvements will be made to existing final clarifiers.

Four 250 square foot travelling bridge tertiary filters will be constructed.

A new ultraviolet disinfection system including a new 31-foot long ultraviolet effluent disinfection channel, ultraviolet light system, and parshall flume effluent measuring device will be constructed.

A lime stabilization system will be added to treat biosolids.

An 8,600 square foot covered storage area will be constructed to store the treated biosolids prior to land application.

Construction at the treatment facility will include modification of existing structures and the addition of pumps, piping, and appurtenances appropriate to the scope and purpose of the project.

All construction at or modifications to the Farmington West Plant during this project shall be in accordance with the approved plans and specifications.

Missouri Department of Natural Resources
Water Pollution Control Program

Total Maximum Daily Loads (TMDLs)

for

Saline Creek
Jefferson County, Missouri

Completed December 14, 2000
Approved January 12, 2001

Two Total Maximum Daily Loads (TMDLs)
For Saline Creek
Pollutants: Biochemical Oxygen Demand (BOD) and Ammonia (NH_3N)

Name: Saline Creek

Location: Near Arnold in Jefferson County, Missouri

Hydrologic Unit Code (HUC): 07140102-080004

Water Body Identification (WBID): 2190

Missouri Stream Class: Saline Creek is a Class C stream[1] from the Ron Rog Sewage Treatment Plant (STP) outfall to 0.5 miles below the Highway 141 Sewage Treatment Plant (STP) outfall. The remaining mile of Saline Creek is a Class P stream[2].

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

Size of Impaired Segment: 2 miles

Location of Impaired Segment: This segment, which starts at the Ron Rog outfall and ends 1.2 miles downstream of the Hwy 141 outfall, is totally contained within Survey 3011, 43N, 5E

Pollutants: BOD and NH_3N

Pollutant Source: Ron Rog STP and Highway 141 STP

Permit Numbers:	Ron Rog STP	NPDES Permit No. MO-0054151
	Highway 141 STP	NPDES Permit No. MO-0094552

TMDL Priority Ranking: Medium

1. Background and Water Quality Problems

There are actually two separate portions of Saline Creek that show impairment; one each below the Ron Rog plant and the Hwy 141 plant. These portions are right next to each other and their combined length is two miles. The Ron Rog Sewer Treatment Plant (STP) consists of two contact stabilization plants with a combined design flow of 2.7 cubic feet per second (cfs). This facility discharges wastewater to Saline Creek, which flows easterly through northeastern Jefferson County into the Meramec River eight miles above its mouth. In the upper reaches, Saline Creek is a losing

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

[2] Class P streams maintain flow even during drought conditions. See 10 CSR 20-7.031(1)(F)

stream. Dye studies have shown both Saline and its major tributary, Sugar Creek, send groundwaters to the south that emerge in Romaine Creek. Above the Ron Rog outfall, Saline Creek rarely has surface flow. A few pools are present and can contain minnows, suggesting that there is some subsurface flow in the abundant creek gravels. For the first mile below the Ron Rog outfall about 80-85% of the effluent flow is subsurface, but apparently nearly all of this flow reappears in the creek upstream of the Highway 141 STP. The portion of Saline Creek below the Ron Rog STP is not considered a losing stream and is not listed as such in Missouri's Water Quality Standards (WQS). The Highway 141 STP is smaller than Ron Rog, consisting of two contact stabilization plants with a combined design flow of 1.94 cfs. Below the Hwy 141 outfall, the stream gradient flattens greatly and the stream becomes a series of long pools.

Missouri Department of Natural Resources (MDNR) conducted a water quality study on the receiving stream in August and September 1992 (see Saline Creek Data in Appendix C). It showed low levels of dissolved oxygen below both treatment plants, with the largest sag below the Ron Rog plant. Ammonia levels throughout the study area were as high as 6 milligrams per liter (mg/L). In the September portion of the study, the effluent from both plants was found to be improved, as was instream water quality, but the steam was still considered as not attaining beneficial uses.

The Northeast Public Sewer District (NEPSD) of Jefferson County operates both sewage treatment plants. On April 1, 1996, NESPD agreed to submit a plan within nine months for pretreatment at the Ron Rog facility. A Settlement Agreement was signed between MDNR and NEPSD on June 25, 1997, requiring that NESPD immediately comply with interim limits contained in the permit. This could be accomplished in any way the district chose, including constructing a pipe to the Meramec, which was already included in the district's short-term construction plans. NEPSD also agreed to comply with final effluent limits by Dec. 31, 2000. Due to the absence of an acceptable pretreatment plan and continued effluent violations, NEPSD was issued an Abatement Order, signed by MDNR on Oct. 10, 1999. On April 10, 2000, a pretreatment plan was submitted. On May 17, 2000, the interim effluent limits were achieved.

Due to the long-standing nature of these problems, this TMDL will recommend that NEPSD move the discharge from these two facilities out of the Saline Creek watershed. This should allow Saline Creek to meet water quality standards.

2. Description of the Applicable Water Quality Standards and Endpoint for this TMDL

Designated Uses:
The designated uses of Saline Creek, WBID 2190, are Livestock and Wildlife Watering, and Protection of Warm Water Aquatic Life and Human Health-Fish Consumption. The Class C portion of Saline Creek below Ron Rog STP is an effluent dominated stream and is considered to be a Limited Warm Water Fishery[3]. The Class P portion is under the General Warm Water Fisheries classification. The stream classifications and designated uses may be found at 10 CSR 20-7.031(1)(C) and Table H.

[3] Missouri's Water Quality Standards allow Ozark type Class C streams to be classified as "limited" warm water fisheries in the absence of recreationally important fish species. This two-mile section of Saline Creek is a very small and heavily effluent dominated stream most of the time. It has a very limited fish fauna and does not contain recreationally important species.

Anti-degradation Policy:
Missouri's Water Quality Standards include the 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 -- it requires that existing beneficial uses are protected. TMDLs would normally be based on this tier, assuring that numeric criteria (such as dissolved oxygen, ammonia) are met to protect uses.

Tier II requires no degradation of high-quality waters, 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 no degradation under any conditions. Management may require no discharge or prohibition of certain polluting activities. TMDLs would need to assure no measurable increase in pollutant loading.

Removal of the discharges from the Saline Creek watershed will result in the protection of existing beneficial uses, which conforms to Missouri's Tier I anti-degradation policy.

Specific Criteria:

Ammonia : The specific criteria, found in Missouri's WQS at 10 CSR 20-7.031(4), apply to all classified waters. The specific criteria for the ammonia TMDL are found in 10CSR20-7.031 Table B. These limits are pH and water temperature dependent. Seasonal ammonia limits at the typical seasonal pH and water temperature values are given in Tables 1 and 2. These tables have divided the stream into the Class C and P portions.

Biochemical Oxygen Demand (BOD): Dissolved oxygen (DO) is the water quality standard that is exceeded in Saline Creek. DO is critical for the health of aquatic life and is not a pollutant. It also cannot be allocated in a TMDL. BOD is generally the pollutant used to determine the impact that sewer treatment plant (STP) discharges will have on DO levels in a receiving stream. There is no numeric criterion in the WQS for BOD. Since DO cannot be allocated, oxygen levels must be linked to BOD when the source of the problem is a sewage treatment plant. State WQS for all Missouri streams except cold water fisheries call for maintenance of 5 mg/L dissolved oxygen[4] or the normal background level of dissolved oxygen, whichever is lower.[5] Since the normal background level for dissolved oxygen cannot be calculated due to insufficient data, 5.0 mg/L DO has been chosen.

For Saline Creek to meet WQS, the BOD load coming from the STPs must be addressed. This normally would be achieved by determining the load capacity for BOD in the receiving stream. Due to natural conditions existing on Saline Creek, little or no upstream dilution and no mixing zone allowances, it would be technologically difficult for the STPs to meet the loading needed to resolve the impairment of Saline Creek. As plans were already being developed to move the

[4] 10 CSR 20-7.031(4)(J)
[5] 10 CSR 20-7.031(4)(A)(3)

discharge out the watershed, it seemed most appropriate that this TMDL help expedite the existing plan.

Mixing zone: Since there will be no discharge from Ron Rog and Hwy 141 STPs, there is no mixing zone.

Summary of Numeric Instream Criteria: Tables 1and 2 summarize the instream numeric criteria from the Missouri Water Quality Standards.

Table 1: Instream Criteria for Ron Rog and Hwy 141 STP (C portion)

Diss. Oxygen (mg/l) May-Oct. *Diss. Oxygen(mg/l) Nov.-April*	*5.0* *5.0*
Ammonia (mg/l), May-Oct. *(pH 7.8, Temperature 26° C)*	*2.0*
Ammonia (mg/l), Nov.-April *(pH 7.8, Temperature 6° C)*	*3.3*

Table 2: Instream Criteria for Hwy 141 STP (P portion)

Diss. Oxygen (mg/L) May-Oct. *Diss. Oxygen (mg/L) Nov.-April*	*5.0* *5.0*
Ammonia (mg/L), May-Oct. *(pH 7.8, Temperature 26° C)*	*1.2*
Ammonia (mg/L), Nov.-April *(pH 7.8, Temperature 6° C)*	*2.1*

Endpoint for this TMDL:
For several years DNR has urged NEPSD to come into compliance with water quality standards. The method for attaining compliance was their choice. Now, DNR will require all effluent from Ron Rog and Hwy 141 STPs being discharged into Saline Creek to be removed from the watershed. This can be accomplished by constructing a pipe to the Meramec River or farther, or by connecting to regional sewers.

3. Calculation of Load Capacity

Since the discharges from these two STPs are to be removed from the Saline Creek watershed, there is no Load Capacity at the critical low flow 7Q10 flow of zero. If this TMDL needs to be reopened after evaluation of future monitoring results, load capacity would be recalculated at that time.

4. Load Allocation (Nonpoint Source Load)

There is no upstream flow in Saline Creek at the 7Q10[6] low flow, and only very rarely at other times due to the losing nature of upper Saline and its tributaries. Therefore, no nonpoint source (NPS) impacts from upstream are believed to exist during low flow conditions. About half the floodplain of the Saline Creek study area is in row crops and there is no agriculture outside the floodplain. There is little or no livestock production in the basin. Agriculture is not believed to have an NPS impact during low flow conditions. Throughout the study reach the stream parallels Highway 141, a major four-lane divided highway with considerable adjoining residential and commercial development. These nonpoint sources are not likely to contribute to the impairments of BOD and ammonia. Post implementation monitoring will assess whether there are any unidentified NPS contributions. If there are, MDNR will reopen this TMDL and revise it appropriately in response to the new data. Nothing is being allocated for NPS at this time.

5. Waste Load Allocation (Point Source Loads)

There are six small permitted wastewater discharges from extended aeration plants in the upper parts of the Saline or Sugar Creek watershed. Because of the "losing nature" of the upper Saline, none of the flows from these plants is believed to reach the study area except during exceptionally heavy rains. Sugar Creek joins Saline below Hwy 141 and the data shows no increased contamination from this tributary. The impaired segment's upstream end begins at the Ron Rog STP and ends below Highway 141 STP before Saline Creek joins the Meramec River. The Ron Rog and Highway 141 STPs are the only point source loads discharging to the impaired segment of Saline Creek. Since this discharge is being removed from the watershed, the Wasteload Allocation will be zero pounds per day.

6. Margin of Safety

The margin of safety for this TMDL is implicit in the decision to remove the discharge from the Saline Creek watershed.

7. Seasonal Variation

Seasonal variation for ammonia is addressed in the standards. Maintenance of 5 mg/L dissolved oxygen applies to all seasons, including critical low flow conditions.

8. Monitoring Plans

The Missouri Department of Natural Resources' (MDNR) St. Louis Regional Office will check the plant sites at six-month intervals to determine when NEPSD completes redirecting discharge from Ron Rog and Hwy 141 STPs out of the Saline Creek watershed. MDNR's Water Pollution Control Program will do a stream survey of Saline Creek in the vicinity of these two STPs within two years of removing the discharge, and will determine at that time whether applicable water quality standards are met, or if nonpoint sources are having an impact.

---

[6] The 7-day average minimum flow with a recurrence interval of 10 years. Indicates drought conditions.

9. Implementation Plans

For several years MDNR has urged the NEPSD to come into compliance with Missouri's water quality standards (WQS). The method for attaining compliance was their choice. Now, MDNR will require all effluent from Ron Rog and Hwy 141 STPs being discharged into Saline Creek to be removed from the watershed. This will be written into the permits for the two STPs and can be accomplished by constructing a pipe to the Meramec River or farther, or by connecting to regional sewers. Once completed, this requirement should assure that WQS will be met in Saline Creek. After the stream survey conducted by MDNR (mentioned under the Monitoring Plans section above) is completed, MDNR will assess whether applicable water quality standards are met. If standards are met, then MDNR will delist Saline Creek for dissolved oxygen and ammonia. If standards are not met, MDNR will reopen this TMDL and revise it appropriately to meet all applicable statutes and regulations. This TMDL will be incorporated into Missouri's Water Quality Management Plan.

10. Reasonable Assurances

The MDNR has the authority to write and enforce NPDES permits. Inclusion of the requirement to remove all discharge from Ron Rog and Hwy 141 STPs from the Saline Creek watershed, established in this TMDL, into a state NPDES permit should provide reasonable assurance that instream water quality standards will be met.

11. Public Participation

This water quality limited segment is included on the approved 1998 303(d) list for Missouri. The Missouri Department of Natural Resources developed this TMDL. A public notice period was held from Oct. 27 to Nov. 26, 2000. Groups receiving the public notice announcement included the Missouri Clean Water Commission, the affected facility, the Water Quality Coordinating Committee, the TMDL Advisory Committee, Stream Team volunteers in the watershed, and others that routinely receive the public notice of NPDES permits. Comments were received from Northeast Public Sewer District, the Meramec River Recreation Association, Sierra Club and the Missouri Chapter of American Fisheries Society. Some adjustments were made to the TMDL document in response to comments received, but the overall approach and the numeric targets remain unchanged. Copies of the notice, the comments and MDNR's response to the comments are on file with MDNR.

12. Appendices and documents on file with MDNR

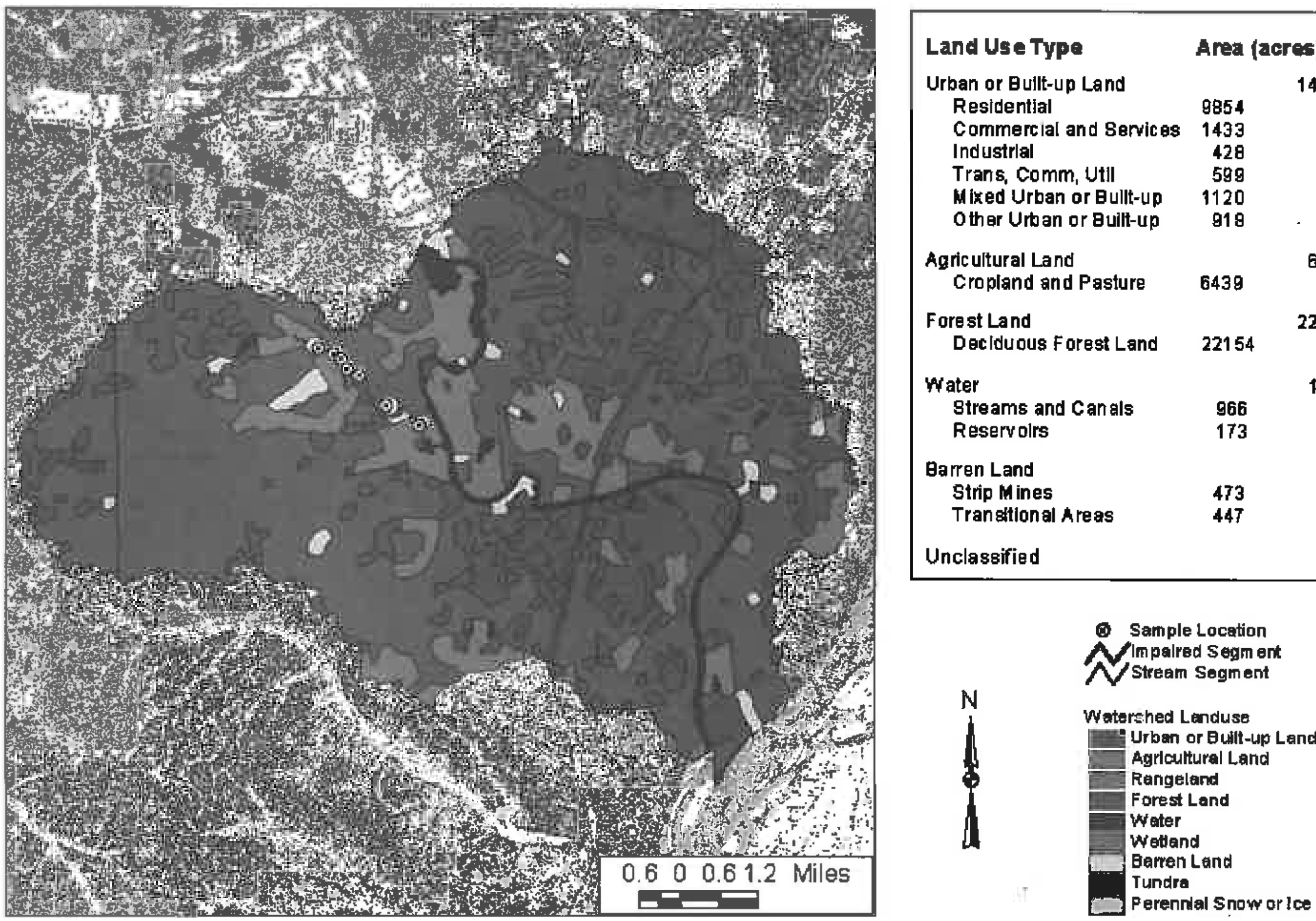
Appendix A – Land Use Types for Saline Creek Watershed
Appendix B – Map of Sample Locations and Impaired Stream Segment
Appendix C – Saline Creek Data

Documents on file with MDNR:

Ron Rog STP - NPDES Permit No. MO-0054151
Highway 141 STP - NPDES Permit No. MO-0094552

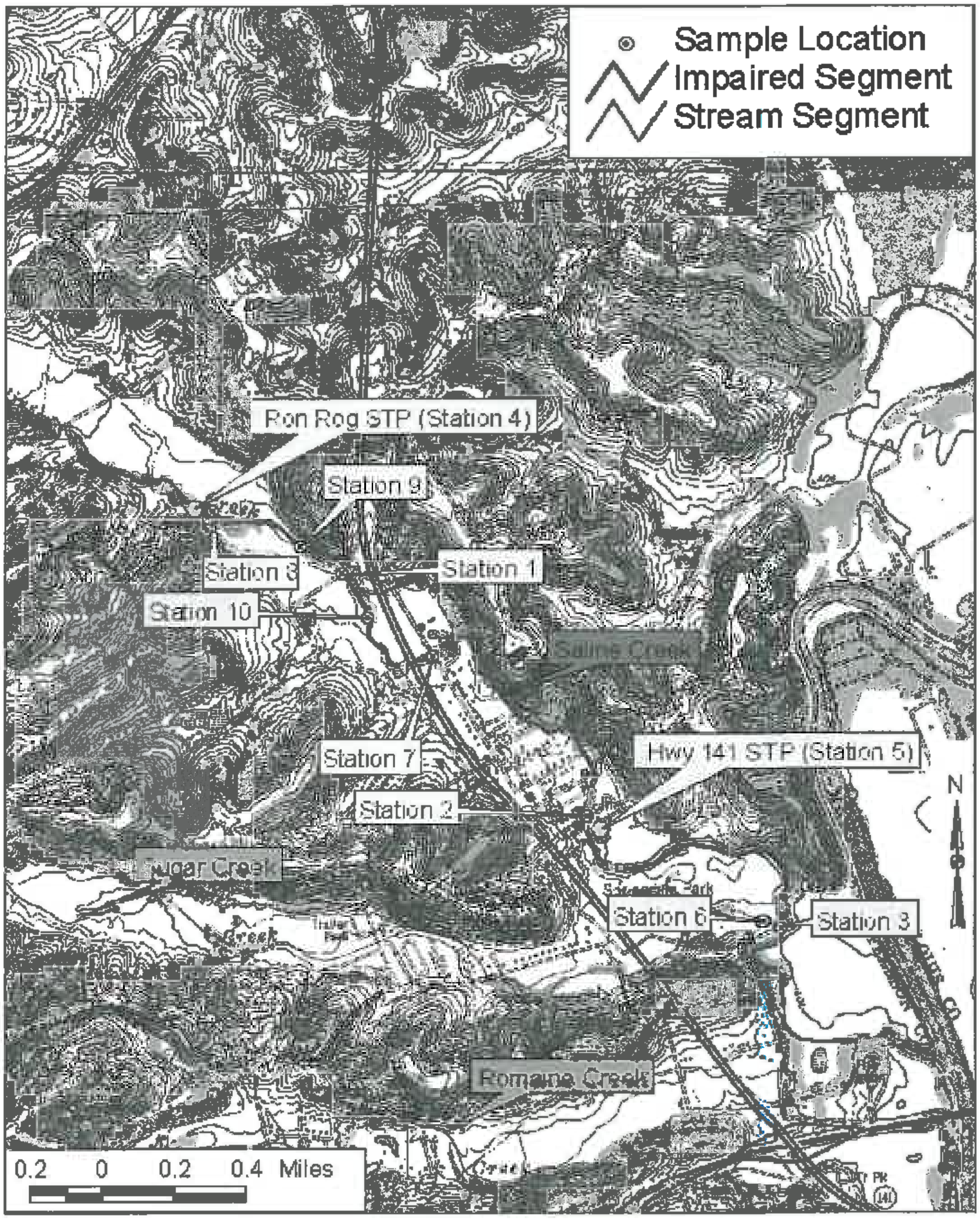
Analysis of Treatment Requirements for Northeast Sewer District Ron Rog and Highway 141
Sewer Treatment Plants (August and September, 1992)
Addendum to Saline Creek Water Quality Model, August 18, 1995
1997 Settlement Agreement and cover letter
1999 Abatement Order
Public Notice announcement
Public comments
MDNR's response to public comments

Appendix A. Land Use Types for Saline Creek Watershed (07140102-080004)



Land Use Type	Area (acres)	
Urban or Built-up Land		14352
Residential	9854	
Commercial and Services	1433	
Industrial	428	
Trans, Comm, Util	599	
Mixed Urban or Built-up	1120	
Other Urban or Built-up	918	
Agricultural Land		6439
Cropland and Pasture	6439	
Forest Land		22154
Deciduous Forest Land	22154	
Water		1139
Streams and Canals	966	
Reservoirs	173	
Barren Land		920
Strip Mines	473	
Transitional Areas	447	
Unclassified		1

Appendix B. Map of Sample Locations and Impaired Stream Segment Saline Creek, Jefferson County, Missouri



APPENDIX C

SALINE CREEK DATA

SITE	SITE DESCRIPTION	DATE	TIME	FLOW CFS	TEMP 0C	DO mg/L	CONDUCT uS	pH	NH4 mg/L	NO3 mg/L	CBOD mg/L
1	SALINE CREEK 0.6 MILE BELOW RON ROG TREATMENT PLANT	8/18/1992	1308	1.50	23	3.2	765	7.50	4.0	3.0	<4
1	SALINE CREEK 0.6 MILE BELOW RON ROG TREATMENT PLANT	8/19/1992	0649		22	2.1	900	7.10	3.0	5.0	<4
1	SALINE CREEK 0.6 MILE BELOW RON ROG TREATMENT PLANT	8/19/1992	1255		24	2.9	800	7.45	6.4	6.9	<4
1	SALINE CREEK 0.6 MILE BELOW RON ROG TREATMENT PLANT	8/20/1992	0647		20	2.5	885	7.30	6.5	8.7	<4
1	SALINE CREEK 0.6 MILE BELOW RON ROG TREATMENT PLANT	9/15/1992	1244	0.30	25	5.7	780	7.60	0.13	8.0	<4
1	SALINE CREEK 0.6 MILE BELOW RON ROG TREATMENT PLANT	9/16/1992	0735		22	4.8	920	7.40	0.06	9.0	<4
1	SALINE CREEK 0.6 MILE BELOW RON ROG TREATMENT PLANT	9/16/1992	1253		25	6.6	860	7.60	0.05	10.0	<4
1	SALINE CREEK 0.6 MILE BELOW RON ROG TREATMENT PLANT	9/17/1992	0715		21	4.7	940	7.30			
2	SALINE CREEK 1.6 MILE BELOW RON ROG TREATMENT PLANT	8/18/1992	1255		22	13.5	640	7.80	<.05	2.0	5
2	SALINE CREEK 1.6 MILE BELOW RON ROG TREATMENT PLANT	8/19/1992	0640		21	4.5	780	7.00	<.05	2.0	<4
2	SALINE CREEK 1.6 MILE BELOW RON ROG TREATMENT PLANT	8/19/1992	1247		23	11.2	700	7.50	5.8	2.9	
2	SALINE CREEK 1.6 MILE BELOW RON ROG TREATMENT PLANT	8/20/1992	0639		19	5.9	800	7.10	6.0	4.6	<4
2	SALINE CREEK 1.6 MILE BELOW RON ROG TREATMENT PLANT	9/15/1992	1228	1.80	23	9.8	620	7.70	<.05	4.0	<4
2	SALINE CREEK 1.6 MILE BELOW RON ROG TREATMENT PLANT	9/16/1992	0745		21	6.3	830	7.20	<.05	4.0	<4
2	SALINE CREEK 1.6 MILE BELOW RON ROG TREATMENT PLANT	9/16/1992	1236		23	10.3	700	7.50	<.05	5.0	<4
2	SALINE CREEK 1.6 MILE BELOW RON ROG TREATMENT PLANT	9/17/1992	0657		20	6.0	790	7.20	<.05	4.0	<4
2	SALINE CREEK 1.6 MILE BELOW RON ROG TREATMENT PLANT	7/19/1995	0530	2.70	24	4.4	727		0.07	6.0	<1
2	SALINE CREEK 1.6 MILE BELOW RON ROG TREATMENT PLANT	7/20/1995	0530		24	3.6	747		0.08	6.4	<1
3	SALINE CREEK 0.6 MILE BELOW HIGHWAY 141 TREATMENT	8/18/1992	1240	2.00	20	5.3	660	7.40	1.0	3.0	<4
3	SALINE CREEK 0.6 MILE BELOW HIGHWAY 141 TREATMENT	8/19/1992	0627		22	3.5	760	6.80	1.0	3.0	<4
3	SALINE CREEK 0.6 MILE BELOW HIGHWAY 141 TREATMENT	8/19/1992	1234		22	5.0	720	7.15	6.4	3.1	<4

SITE	SITE DESCRIPTION	DATE	TIME	FLOW CFS	TEMP 0C	DO mg/L	CONDUCT uS	pH	NH4 mg/L	NO3 mg/L	CBOD mg/L
3	SALINE CREEK 0.6 MILE BELOW HIGHWAY 141 TREATMENT	8/20/1992	0624		20	4.3	780	7.00	6.4	3.7	<4
3	SALINE CREEK 0.6 MILE BELOW HIGHWAY 141 TREATMENT	9/15/1992	1216		22	5.6	600	7.40	0.13	4.0	<2
3	SALINE CREEK 0.6 MILE BELOW HIGHWAY 141 TREATMENT	9/16/1992	0652		21	4.8	820	7.40	0.16	4.0	<4
3	SALINE CREEK 0.6 MILE BELOW HIGHWAY 141 TREATMENT	9/16/1992	1225		22	5.5	700	7.20	0.16	4.0	<4
3	SALINE CREEK 0.6 MILE BELOW HIGHWAY 141 TREATMENT	9/17/1992	0639		21	4.6	770	7.10			
4	RON ROG TREATMENT PLANT EFFLUENT	8/18/1992	1340	1.50	24	7.3	780		4.0	4.0	<4
4	RON ROG TREATMENT PLANT EFFLUENT	8/19/1992	0707		22	5.2	940	7.30	7.7	8.5	<4
4	RON ROG TREATMENT PLANT EFFLUENT	8/19/1992	0710		24	6.6	940	7.00	4.0	6.0	<4
4	RON ROG TREATMENT PLANT EFFLUENT	8/19/1992	1320		25	7.3	820	7.05	6.4	7.6	<4
4	RON ROG TREATMENT PLANT EFFLUENT	9/15/1992	1307	0.30	25	7.0	780	7.60	0.40	8.0	<4
4	RON ROG TREATMENT PLANT EFFLUENT	9/16/1992	0758			6.4	930	7.30	0.19	8.0	<4
4	RON ROG TREATMENT PLANT EFFLUENT	9/16/1992	1313		25	7.4	820	7.60	0.17	11.0	<4
4	RON ROG TREATMENT PLANT EFFLUENT	9/17/1992	0738		24	7.0	920	7.40	0.32	8.0	<4
5	HIGHWAY 141 TREATMENT PLANT EFFLUENT	8/18/1992							10.0	1.0	5
5	HIGHWAY 141 TREATMENT PLANT EFFLUENT	8/19/1992							25.0	2.8	5
5	HIGHWAY 141 TREATMENT PLANT EFFLUENT	8/19/1992	0739	0.50	24	7.5	600	6.90	2.0	5.0	9
5	HIGHWAY 141 TREATMENT PLANT EFFLUENT	8/20/1992	0732		24		680	7.30	6.2	9.4	9
5	HIGHWAY 141 TREATMENT PLANT EFFLUENT	9/15/1992							4.0	2.0	4
5	HIGHWAY 141 TREATMENT PLANT EFFLUENT	9/16/1992	0712	0.37	24	7.4	620	7.30	0.25	4.0	5
5	HIGHWAY 141 TREATMENT PLANT EFFLUENT	9/16/1992	1400						0.49	11.0	<4
5	HIGHWAY 141 TREATMENT PLANT EFFLUENT	9/17/1992	0653		24	7.2	660	7.20	0.15	7.0	<4
6	SUGAR CREEK AT MOUTH	9/16/1992	0700	0.10		4.8	620	7.40	0.05	1.0	<2
7	BRIDGE AT NURSEY	9/15/1992	1237	0.35	24	9.0	740	7.80			
7	BRIDGE AT NURSEY	9/16/1992	0726		20	6.1	860	7.40			

SITE	SITE DESCRIPTION	DATE	TIME	FLOW CFS	TEMP 0C	DO mg/L	CONDUCT uS	pH	NH4 mg/L	NO3 mg/L	CBOD mg/L
7	BRIDGE AT NURSEY	9/16/1992	1244		23	9.6	800	7.70			
7	BRIDGE AT NURSEY	9/17/1992	0707		19	6.2	870	7.30			
8	SALINE CREEK 20 YARDS BELOW RON ROG TREATMENT PLANT	7/18/1995	1715						0.70	17.7	7
8	SALINE CREEK 20 YARDS BELOW RON ROG TREATMENT PLANT	7/19/1995	0800						2.04	13.6	34
8	SALINE CREEK 20 YARDS BELOW RON ROG TREATMENT PLANT	7/19/1995	1710						1.7	15.2	9
9	SALINE CREEK 0.4 MILE BELOW RON ROG TREATMENT PLANT	7/19/1995	1030	2.60					0.13	16.8	<1
10	SALINE CREEK 0.8 MILE BELOW RON ROG TREATMENT PLANT	7/19/1995	0540	1.80	22	3.6	769				
10	SALINE CREEK 0.8 MILE BELOW RON ROG TREATMENT PLANT	7/20/1995	0545		23	2.9	810				

Missouri Department of Natural Resources
Water Pollution Control Program

Total Maximum Daily Loads (TMDLs)

for

Rock Creek
Jefferson County, Missouri

Completed July 21, 1999
Approved December 1, 1999

Rock Creek (Missouri) Final TMDLs (Total Maximum Daily Loads) for CBOD and Ammonia (two TMDLs total)

Name: Rock Creek

WBID No.: 1714 Class: P[1]

Beneficial uses: Livestock and wildlife watering; Warm water aquatic life and human health – fish consumption.

Size of Impaired Segment: 2 miles

Location of Impaired Segment: Portion from Seckman Valley WWTP outfalls which are about 0.20 miles before the confluence with Black Creek to the confluence with the Mississippi River

Pollutants: BOD and Ammonia

Pollutant Sources: West Elm Place WWTP (MO 0087165) and the IUC, Seckman Valley WWTP (MO 0087629)

TMDL Priority Ranking: High

1. Description of Waterbody, Pollutant of Concern, Pollutant Sources and Priority Ranking

Rock Creek is listed on the 1998 303(d) list due to high BOD (which causes low dissolved oxygen) and high ammonia resulting from discharges from the two wastewater treatment plants, West Elm Place and Imperial Utility Corp (IUC), Seckman Valley. The TMDL priority ranking for Rock Creek is high. Frequent violations of Water Quality Standards for dissolved oxygen and ammonia have occurred in Rock Creek. Effluent violations occur during dry weather conditions when the stream flow is effluent dominated. For this reason TMDLs are calculated at critical low flow conditions (7Q10) when effluent violations are prevalent.

Rock Creek originates 3 miles upstream of where Highway 21 crosses the stream. It flows southeasterly for 11 miles and drains into the Mississippi River. The uppermost section of Rock Creek is unclassified. The upper classified section of Rock Creek is defined as Class C[2] and extends 3 miles from where Rock Creek crosses Highway 21 down to where it becomes a Class P stream in Seckman. The Class P stream is 5 miles long. The 2-mile section that is impaired is within the Class P stretch of Rock Creek and starts at the Seckman Valley WWTP

[1] Class P – streams that maintain permanent flow even during drought periods.
[2] Class C – streams that may cease to flow in dry periods but maintain permanent pools which support aquatic life.

outfall, which is about 0.20 miles upstream of the confluence with Black Creek and extends to the Mississippi River.

Black Creek, 4.4 miles long, is a tributary of Rock Creek, and is unclassified through its entire length.

The 7Q10 of Rock Creek has not been determined but is estimated at 0.1 cfs (cubic feet per second) just upstream of the Seckman Valley Lagoons. Missouri Standards (10 CSR 20-7.031 at 5.B.I) provides maximum size of mixing zones for flows between zero and 0.1 cfs. During dry weather conditions there is no flow in Black Creek above the West Elm Place WWTP and the 7Q10 is considered zero. Flow below the facility is effluent-dominated but Black Creek is also considered a gaining stream.

The physiographic setting of Rock Creek is characterized by Mississippian-aged limestone in the upper portion of the subwatershed and Ordovician rocks, predominantly shales and limestone underlie the lower part of the basin. Portions of the upper reach of Rock Creek between Highway 21 and the community of Seckman are considered to be a losing stream. Rock Creek downstream of Seckman is considered to be a gaining stream. Missouri Standards (10 CSR 20-7.031 at 11) specifically addresses facilities located on losing streams. Downstream of Seckman, Rock Creek intercepts portions of the Decorah Shale formation and at these locations receives surcharging ground waters.

The shale and limestone in the lower reaches of Rock Creek, particularly between Seckman Lagoons and the town of Kimmswick, is highly weathered giving rise to Karst topography.

Black Creek is developed over Mississippian limestone in the upper subwatershed and in the lower reaches it is developed over limestone, shale and sandstone. Black Creek is wholly contained in Karst topography but is considered to be a gaining stream.

There are three point sources that discharge directly into Rock Creek and one point source that discharges into Black Creek. Facilities that discharge into Rock Creek include IUC, Country Club Manor WWTP (MO-0093611); IUC, Seckman School WWTP (MO-0099864); and IUC, Seckman Valley WWTP (MO-0087629). West Elm Place, Black Creek WWTP discharges into Black Creek. Due to population increase, these facilities discharge effluent near or above design capacity. Water Quality Standards are violated during low flow conditions when there is little or no dilution of effluent with stream water.

The 1992 studies by DNR determined that Seckman Valley WWTP was discharging treated wastewater with CBOD-5 and Ammonia averaging 32 mg/l and 20 mg/l, respectively. Self-monitoring data reported by the facility for January 1995 to February 1996 showed a CBOD-5 average of 19mg/l. DNR's assessment is that according to design parameters, this facility is organically overloaded and needs to be upgraded before the plant can accept more sewer connections. As discussed in the implementation plan, below, DNR's solution to effluent overload is to close the wastewater treatment plants and route the discharge to a regional wastewater treatment plant.

The following is a description of each point source.

Imperial Utilities Corporation (I.U.C.) – Country Club Manor WWTP. This is the uppermost facility along Rock Creek. It consists of a lift station and aerated lagoons and has a design population equivalent of 477 and a design flow of 0.038 MGD (0.06 cfs). Flow measurements made in July and October 1992 were approximately 0.22 cfs and 0.20 cfs, respectively. These discharges were well in excess of the facility design flow. This facility is very small and does not contribute a significant load to Rock Creek. There is no effluent data for this facility.

I.U.C. – Seckman School WWTP. This facility consists of a three-cell lagoon and lift station. It serves a nearby public school and has a design population of 223 and a design flow of 0.022 MGD (0.03 cfs). The facility did not discharge at either the July or October 1992 sampling events. This facility is very small and does not contribute a significant load to Rock Creek. There is no effluent data for this facility.

I.U.C. – Seckman Valley WWTP (I-55 Sewage Treatment Plant). This facility discharges into Rock Creek and is 0.20 miles upstream of the confluence with Black Creek. It is a two-cell aerated lagoon with a design flow of 0.048 MGD (0.07 cfs). The actual flow at the time of sampling was 0.086 MGD (0.133 cfs). This was twice the allowed discharge level. During the 1992 studies by DNR this lagoon was discharging treated wastewater with both BOD5 averaging 32 mg/l and ammonia 20 mg/l. Self monitoring data reported by the facility from January 1995 to February 1996 shows BOD5 averages 19 mg/l and TSS averages 12 mg/l. Abundant sewage fungi were observed below the discharge pipe up to 20 yards downstream. During both the July and October sampling events, greenish yellow effluent was being emitted and there was a strong hydrogen sulfide odor present.

West Elm Place – Black Creek WWTP. This consists of a lift station, two contact stabilization plants, each with its own outfall discharging into Black Creek, a sludge holding tank and a sludge filter press. The combined design Population Equivalent (P.E.) is 15,000 people with a design flow of 1.5 MGD (2.33 cfs). The actual dry weather flow is approximately 1.10 MGD (1.71 cfs). The July and October flows were 0.859 MGD (1.33 cfs) and 0.801 MGD (1.24 cfs), respectively. Studies conducted by DNR in 1992 and 1995 established that the effluent CBOD-5 was less than 10 mg/l and ammonia nitrogen ranged between 5 and 9 mg/l. Self-monitoring data by the facility for January 1995 through February 1996 showed CBOD-5 average of 17 mg/l and TSS 12 mg/l.

Only the last two facilities contribute BOD and Ammonia to the impaired portion of Rock Creek. A complete description of facilities and instream monitoring sites including data collected during the July 1992 sampling events is given in Appendix I.

These waterbody segments were modeled using the Qual2E model. The first step was to calibrate the hydraulic portion of the model. The lack of USGS gauging stations in the vicinity of Rock Creek or its tributaries necessitated several flow, stream width and stream depth measurements to be made in April 1992. Measurements were made every 200 feet along Rock Creek and Black Creek to allow for the construction of a hydraulic model. Furthermore, water quality surveys and effluent discharge studies were done in July and October 1992. These studies permitted the calibration of the water quality portion of the model. An additional water quality study was conducted in July 1995 to verify the model.

The original 1992 model simulated DO, CBOD5 and ammonia very well and also performed fairly well with 1995 data. Qual2e output files and accompanying graphs are attached.

The calibrated model was used to predict water quality conditions within the mixing zone and just beyond the mixing zone along Rock Creek. The rationale was to determine maximum effluent strengths which would result in the achievement of instream water quality standards for DO and ammonia. The prognosis based on simulated results is that instream dissolved oxygen standards during 7Q10 low flow conditions can barely be achieved with stringent CBOD5 limits. It is questionable if the two facilities can meet the water quality standards even with a high degree of treatment.

A phased TMDL approach will be used. Advanced waste-water treatment may be sufficient for the instream water to meet applicable water quality standards. The facilities have the option to upgrade; however, if after any upgrade instream monitoring shows that standards are not met, the permits will require implementation of even more stringent effluent limits capable of meeting Water Quality Standards or the elimination of these discharges. Based on conversations with the utility companies involved, Missouri believes all the discharges will be eliminated, and then all applicable state Water Quality Standards will be met.

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

Designated Uses: Rock Creek has beneficial uses that include livestock and wildlife watering, fish consumption and protection of aquatic life.

Ammonia:
Missouri's Water Quality Standards, 10CSR20-7.031 Table B, lists the chronic ammonia limits for general warm water fisheries such as Rock Creek. These limits are pH and water temperature dependent. Seasonal ammonia limits and the typical seasonal pH and water temperature values are given in Table 1.

Table 1: Instream Criteria

	Within Mixing Zone	*Beyond Mixing Zone*
Dissolved Oxygen (mg/l)	*3.0*	*5.0*
Ammonia (mg/l), June-September (pH 7.8, Temperature 26° C)	*14.0*	*1.2*

Ammonia (mg/l), October-May (pH 7.8, Temperature 8° C)	*16.0*	*2.0*

CBOD:
There is no numeric criterion in the water quality standards for CBOD. Since the effect of CBOD is to exert oxygen demand on the receiving waterbody, dissolved oxygen is the surrogate indicator for BOD or CBOD. Missouri considers BOD and CBOD to be sufficiently equivalent to be used interchangeably in these TMDLs, since CBOD is the more dominant process and is what is measured in BOD5. There is only about 5 mg/l more or less difference between CBOD and BOD. However, in QUAL2E model simulation of DO, both carbonaceous and nitrogenous BOD is factored into the model. State water quality standards call for maintenance of 5 mg/l or the normal background level of dissolved oxygen, whichever is lower. The DO limits are provided in Table 1.

Anti-degradation policy

Missouri's water quality standards include the EPA "three-tiered" approach to anti-degradation.

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

Tier II requires no degradation of high-quality waters, 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 no degradation under any conditions. Management may require no discharge or prohibition of certain polluting activities. TMDLs would need to assure no measurable increase in pollutant loading.

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

3. Loading Capacity – Linking Water Quality and Pollutant Sources

The loading Capacity is the greatest amount of pollutant loading that a stream can take without becoming impaired.

Load Capacities for streams with wastewater dischargers depends on the flow of the stream. Since the load from the wastewater discharger is more or less constant, water quality standards exceedances are most likely to occur at low flow conditions. These critical conditions are called the design stream flow. The Load Capacity for the impaired portion of Rock Creek were calculated using the low flow condition as follows:

Ammonia

(Design stream flow in cfs)(Ammonia concentration from WQ standards)(5.4)= Pollutant capacity of the stream in pounds per day. *(1)*

The design flow for the impaired section of Rock Creek is the sum of the 7Q10 low flow of Rock Creek just upstream of the Seckman Valley WWTP (0.1 cfs), plus the design flow of the two WWTPs (1.16 cfs for Seckman Valley and 2.32 cfs for the WEP Black Creek plant). This design flow is 3.58 cfs. The instream chronic ammonia standard for Rock Creek at typical water temperature and pH is 1.2 mg/l summer and fall, 2.0 mg/l winter and spring. Using Formula 1, the Load Capacity at the end of the mixing zone for ammonia is 23.20 #/day summer/fall and 38.66 #/day winter/spring.

CBOD

(Design stream flow in cfs)(CBOD concentration at which DO conc. from WQ standards is achieved)(5.4)= CBOD capacity of the stream in pounds per day. *(2)*

The design flow of 3.58 cfs was used to calculate the load capacity for CBOD. The LC value is based on the highest instream concentration of CBOD predicted by the model at which in stream water quality standards for DO concentration are met, the point at the end of the mixing zone. The CBOD value (0.9 mg/l) was derived from Qual2E model estimation at end of the mixing zone (mile 8.2) and the end-of-pipe load capacity of CBOD was calculated at 17.4 #/day in summer and 48.3 #/day in winter.

4. Load Allocations

Missouri is establishing the load allocations under the critical flow conditions as the actual nonpoint loading to the segment. The Load Allocation is the term used for the nonpoint source pollutant load and is calculated using Formula 3.

(7Q10 stream low flow in cfs)(background instream pollutant concentration at the 7Q10 low flow in mg/l)(5.4)= pollutant load in #/day.
(3)

There is no flow in Black Creek other than the wastewater discharge at the 7Q10 low flow and thus there is no ammonia or CBOD load allocation for Black Creek. 7Q10 low flow for Rock Creek is 0.1 cfs, and during field studies ammonia concentrations upstream of the Seckman Valley WWTP were consistently measured as less than the detection limit (0.05 mg/l). Taking the concentration as one-half the detection limit, the ammonia load allocation is:

(0.1cfs)(0.025 mg/l)(5.4)= 0.01 #/day

Likewise, the Load Allocation for BOD is established as the actual background loading, and is calculated using Formula 3. The background concentration of BOD is zero, so the Load Allocation for BOD is zero pounds per day.

5. Wasteload Allocation

The CBOD wasteload allocation is based on the results of the qual2e modeling. The ammonia wasteload allocation is based on the observed decay rate of ammonia in the mixing zone.

CBOD wasteload allocations:

The total CBOD wasteload allocation is established as the loading capacity as determined using the qual2e model at the WWTP discharge minus the margin of safety minus the load allocation (which is zero). This total wasteload allocation is then divided between the two facilities based on flow. The total wasteload allocations are:

(loading capacity) - (MOS) - (load allocation) = wasteload allocation

Summer: (17.4 #/day) - (3.48 #/day) - (0) = 13.9 #/day CBOD end-of-pipe
Winter: (48.3 #/day) - 3.48 #/day) - (0) = 44.8 #/day CBOD end-of-pipe

Dividing this total wasteload to the individual facilities based on flow gives:

Summer: Seckman Valley WWTP (13.9 #/day) * (.33) = 4.6 #/day CBOD end-of-pipe
WEP Black Cr. WWTP (13.9 #/day) * (.67) = 9.3 #/day CBOD end-of-pipe
Winter: Seckman Valley WWTP (44.8 #/day) * (.33) = 14.8 #/day CBOD end-of-pipe
WEP Black Cr. WWTP (44.8 #/day) * (.67) = 30 #/day CBOD end-of-pipe

Ammonia wasteload allocations:

The actual loading from the point source pollutant load is calculated using Formula 4. The very small facility discharges are ignored. Since there is no effluent data for Seckman Valley WWTP, that effluent concentration is assumed to be the same as West Elm Place WWTP. The data shows that ammonia nitrogen ranged between 5 and 9 mg/l, so 7 mg/l was selected:

(Design flow of WWTP in cfs)(average effluent pollutant concentration in mg/l)(5.4)= pollutant #/day)

(4)

Using this formula, the actual ammonia loadings are:

WEP Black Cr. WWTP all seasons:	(2.32 cfs)(7 mg/l)(5.4)=	87.7 #/day
Seckman Valley WWTP all seasons:	(1.16 cfs)(7 mg/l)(5.4)=	43.8 #/day

For a total existing end-of-pipe ammonia loading of 131.5 #/day. This number will be used later when calculating the percent reduction required to meet water quality standards.

<u>Instream Ammonia Losses Between WWTP outfalls and the point on Rock Creek where Chronic Ammonia Standards are Required</u>

The point on Rock Creek where chronic ammonia criteria become required is 0.2 miles downstream of the Seckman Valley WWTP and 1.75 miles downstream of the Black Creek WWTP. Formula 4 shows the calculation of these losses:

(Ammonia decay rate mg/l per mile)(Distance in miles between outfall and stream point where chronic criteria must be met)(stream flow at 7Q10 low flow in cfs)(5.4)= ammonia losses #/day

(5)

During field studies, ammonia decay rates in Black Creek were estimated based on instream measurements to be approximately 4 mg/l per mile in summer and 2 mg/l per mile in winter. Accounting for the uncertainty in these estimated decay rates, calculation of instream ammonia losses in this TMDL uses the conservative decay rates of 2.0 and 1.2 mg/l per mile for summer and winter respectively in Black Creek and thus contributes to an inherent margin of safety. Rock Creek ammonia decay rates were similar to most other effluent dominated Missouri streams and were estimated at approximately 1 mg/l per mile in summer. Winter ammonia decay studies were not made on Rock Creek but winter ammonia decay in Rock Creek is estimated at 0.8 mg/l per mile. These decay rates would normally be modeled by an exponential decay function, and the model provides a calculated decay at the end of the mixing zone given the distance or time from the discharge to the end of the mixing zone. In this TMDL, the exponential model was not needed because the decay for this segment was obtained by actual measurements at the ends of the mixing zone. Thus the actual instream ammonia losses are calculated as:

Summer:

Black Cr.	(7 mg/l) - (1.0 mg/l/mi)(1.75 mi) =	5.25 mg/l NH_3 at end of mixing zone
Rock Cr.	(7 mg/l) - (1.0 mg/l/mi)(0.25 mi) =	6.75 mg/l NH_3 at end of mixing zone

Winter:
Black Cr. (7 mg/l) - (0.8 mg/l/mi)(1.75 mi) = 5.6 mg/l NH3 at end of mixing zone
Rock Cr. (7 mg/l) - (0.8 ml/l/mi)(0.25 mi) = 6.8 mg/l NH3 at end of mixing zone

The instream criteria for ammonia beyond the mixing zone is 1.2 mg/l in summer and 2.0 mg/l in winter. The existing end-of-mixing-zone winter ammonia concentrations of 5.6 and 6.8 mg/l respectively will have to be reduced to 1.2 and 2.0 mg/l respectively.

The actual ammonia end-of-mixing-zone load after instream decay is then:

Summer:
WEP (2.32 cfs)(5.25 mg/l)(5.4) = 65.8 #/day
Seckman Valley (1.16 cfs)(6.75 mg/l)(5.4) = 42.3 #/day
Total 108.1 #/day
Winter:
WEP: (2.32 cfs)(5.6 mg/l)(5.4) = 70.1 #/day
Seckman Valley: (1.16 cfs)(6.8 mg/l)(5.4) = 42.6 #/day
Total 112.7 #/day

In order to attain water quality standards at the end of the mixing zone, the summer load of 108.1 pounds per day and the actual winter load of 112.7 pounds per day must be reduced to a loading that will meet water quality standards. That target is the loading capacity minus the margin of safety minus the load allocation. This is summarized as follows:

Summer: (23.2 #/day) - 4.64 #/day) - (.01 #/day) = 18.56 #/day NH3 after mixing zone
Winter: (38.66 #/day) - (7.73 #/day) - (.01#/day) = 31.43 #/day NH3 after mixing zone

The percentage of the actual load that meets water quality standards is the wasteload allocation. This percentage beyond the mixing zone is:

Summer: (18.5 #/day) / (108.1 #/day) * 100% = 17%
Winter: (31.43 #/day) / (112.7 #/day) * 100% = 28%

The required percentage of the actual load beyond the mixing zone equals the required percentage at the end of the pipe. The total wasteload allocation at the end of the pipe is:

Summer: (131.5 #/day) * (.17) = 22.4 #/day NH3 as N total end-of-pipe
Winter: (131.5 #/day) * (.28) = 36.8 #/day NH3 as N total end-of-pipe

This total wasteload allocation figured at the end of the pipe is divided between the facilities based on flow, giving the wasteload allocations for each individual facility:

Summer: WEP Black Cr. WWTP (.67) * (22.4 #/day) = 15 #/day NH3 as N end-of-pipe

Seckman Valley WWTP (.33) * (22.4 #/day) = 7.4 #/day NH3 as N end-of-pipe
Winter: WEP Black Cr. WWTP (.67) * (36.8 #/day) = 24.6 #/day NH3 as N end-of-pipe
Seckman Valley WWTP (.33) * (36.8 #/day) = 12.1 #/day NH# as N end-of-pipe

6. Margin of Safety

The margin of safety accounts for the uncertainty of our understanding about how the waterbody responds to the parameter being measured..

There is insufficient data to determine the uncertainty of the loading capacity of Rock Creek for both ammonia and BOD. Therefore, the margin of safety for both ammonia and CBOD5 were estimated at 20% . The margins of safety are:

Ammonia (summer/fall): (23.2 #/day)(0.2) = 4.64 #/day
Ammonia (winter/spring): (38.66 #/day)(0.2) = 7.73 #/day
CBOD: (17.4 #/day)(0.2) = 3.48 #/day

7. Seasonal variation

Seasonal variation for instream chronic ammonia standard is calculated at typical seasonal water temperature and pH. For Rock Creek, an ammonia concentration of 1.2 mg/l was used for summer and fall conditions (pH 7.8, temp. 26° C) and a value of 2.0 was applied to winter and spring conditions (pH 7.8, temp. 8° C).

Qual2E was the model used to provide steady state simulation of flow, dissolved oxygen, CBOD-5 and ammonia, and the results used to establish the seasonal CBOD loading capacities.

8. Monitoring Plan for TMDLs Developed Under the Phased Approach

Two 24-hour water quality studies of Rock Creek during summer low flow conditions will be conducted the first year after both these facilities have completed any upgrades.As discussed below, it is expected that the discharging facilities will be closed. As a result of the elimination of all discharges, the applicable water quality standards will be met.

9. Implementation Plans

These two TMDLs will be incorporated into Missouri's Water Quality Management Plan. These are phased TMDLs. As pointed out above there is little likelihood that the Seckman Valley WWTP and Black Creek WWTP can meet the stringent effluent limits required by the waste load allocations established in these TMDLs. The facilities have the option to upgrade in order to meet applicable water quality standards; however, as a matter of course, plans are now underway to have all the facilities along Rock Creek and Black Creek eliminated and their sewer lines connected to the Rock Creek Regional WWTP at Kimmswick within the next three years. The regional facility has been upgraded to treat more influent and it is still being considered for further upgrades to accommodate additions to the sewer plant. The Rock Creek regional facility discharges directly into the Mississippi River. Therefore, allocations to future growth within this segment are zero, since it will be accomodated in practice by relocated discharge to the Mississippi River. As the implementation of these TMDLs will improve the water quality of Rock Creek, they satisfy the Anti-degradation requirements of the Missouri Water Quality Standards.

The following table shows seasonal effluent limits required to meet Water Quality Standards.

Table 4: Effluent Limits

	Season	*Seckman Valley WWTP*	*Black Creek WWTP*
CBOD-5 (mg/l)	*June-September*	*2.0*	*2.5*
CBOD-5 (mg/l)	*October-May*	*10.0*	*10.0*
Ammonia (mg/l)	*June-September*	*2.0*	*2.5*
Ammonia (mg/l)	*October-May*	*10.0*	*10.0*

10. Reasonable Assurances

All the facilities have NPDES permits, which provides the authority to assure that water quality standards will be met and maintained. Once all the wastewater treatment facilities along Rock and Black Creek are eliminated and their sewer lines connected to the Rock Creek regional WWTP at Kimmswick, it is guaranteed that water quality standards will be attained.

11. Public Participation

This water quality limited segment is included on the approved 1998 303(d) list for Missouri. The Missouri Department of Natural Resources developed the TMDL, Division of Environmental Quality, Water Pollution Control Program. The TMDL was placed on public notice from April 16, 1999 to May 21, 1999 and in addition, six public meetings to allow input from the public on impaired waters were held between August 18 and September 22, 1999. No comments pertaining to Rock Creek were received during the public notice or the public meetings.

12. Administrative Record

An Administrative Record for these TMDLs is being maintained by the Missouri DNR.

13. Data and Information Sources

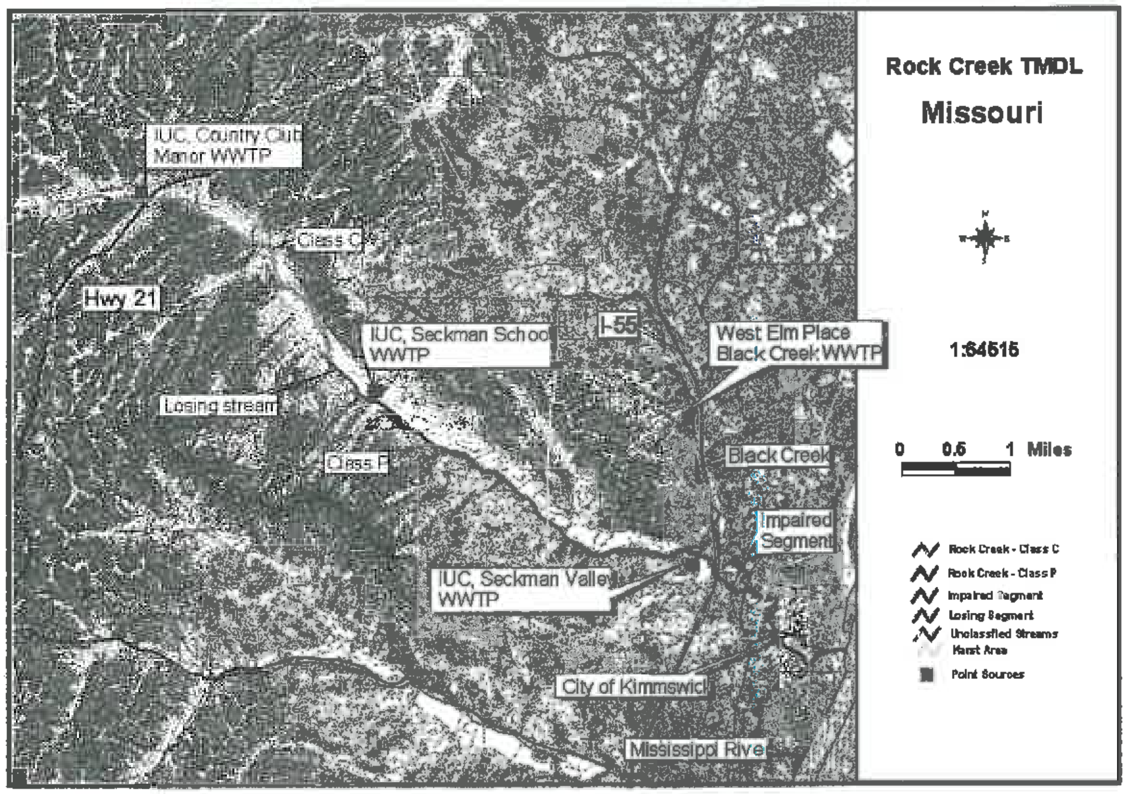
Field Data:

- April 1992, stream morphometry, streamflow and qualitative evaluation of fish and benthos, MDNR-WPCP
- July 1992, 48-hour water quality survey
- October 1992, 48-hour water quality survey, MDNR-ESP
- July 1995, 36-hour water quality survey, MDNR-WPCP
- February 1996, 36-hour ammonia decay survey

References:

- Missouri Water Quality Standards
- Standards Implementation Policy
- EPA Ambient criteria document for dissolved oxygen
- EPA Regulation 131.12
- Review of Rock Creek TMDL, Missouri

Attachments: 1. Qual2E output for West Elm Place study
2. Mixing zone provisions of Missouri's Water Quality Standards (10 CSR 20-7.031(4)(A)(5))


Rock Creek TMDL
Missouri
1:64515
0 0.5 1 Miles
Rock Creek - Class C
Rock Creek - Class P
Impaired Segment
Losing Segment
Unclassified Streams
Karst Area
Point Sources
IUC, Country Club
Manor WWTP
Class C
Hwy 21
IUC, Seckman School
WWTP
I-55
West Elm Place
Black Creek WWTP
Losing stream
Class P
Black Creek
Impaired
Segment
IUC, Seckman Valley
WWTP
City of Kimmswick
Mississippi River

Missouri Department of Natural Resources
Water Pollution Control Program

Total Maximum Daily Loads (TMDLs)

for

North Moreau Creek
Moniteau County, Missouri

Completed July 22, 1999
Approved December 1, 1999

North Moreau Creek [Missouri] TMDLs (Total Maximum Daily Load) For Suspended Algae (NFR), Carbonaceous Biological Oxygen Demand (CBOD), and Ammonia (NH3 as N) (three TMDLs total)

Name: North Moreau Creek

Missouri WBID: 0942

Class: P

Beneficial Uses: Livestock and Wildlife watering, Warm Water Aquatic life, Fish Consumption, Swimming, and Recreation

Size of Impaired Segment: 10 miles

Location of Impaired Segment: from SE1/4 S-4, T-44N, R-5W to SW1/4 S-20, T-44N, R-14W

Pollutants: Suspended Algae (NFR) documented
Carbonaceous biological oxygen demand (CBOD)
Ammonia (NH_3) not documented but possible

Pollutant Source: California South Wastewater Lagoons (CSWL)

TMDL Priority: High

1. Description of Waterbody, Pollutant of Concern, Pollutant Sources and Priority Ranking

North Moreau Creek, WBID 0942, is a class P stream. Class P streams maintain permanent flow even in drought periods. The impaired segment of this stream is 10 miles long and extends from SE1/4 S-4, T-44N, R-15W to SW1/4 S-20, T-44N, R-14W in Moniteau County. This segment appears on the Section 303(d) list with NFR as the pollutant. The pollutant of concern in the impaired segment is Suspended Algae discharged by the lagoons, CBOD and ammonia are possible pollutants. The sole pollutant sources are the three California South Lagoons – a wastewater treatment system.

This submittal contains three TMDLs, the one listed for NFR is required; the other two for CBOD and ammonia are being submitted by Missouri as Section 303(d)(3) TMDLs, which do not require EPA review and approval. The TMDL priority for this segment is high.

The California South lagoon system consists of three lagoons with individual discharges into North Moreau Creek. The west lagoon is a three-cell lagoon with a surface area of 25 acres and a design flow of about 0.9 MGD. The middle lagoon is a three-cell lagoon with a surface area of 68 acres and a design flow of 1.4 MGD. The east lagoon has two aerated cells operated in series followed by a polishing cell. It has a surface area of 18 acres and a design flow of 1.2 MGD. The total system has a nominal dry weather capacity of 3.5 MGD.

The present NPDES permit prohibits discharge during the summer. This condition was included to reduce the impacts of discharge on the stream during a time when in-stream dilution and in-stream dissolved oxygen levels were lowest. In spite of these provisions, there were chronic problems with high levels of algae in the receiving stream and numerous complaints from the public about the green appearance of the stream.

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

The designated beneficial uses of North Moreau creek are general warm-water fishery (human fish consumption), livestock and wildlife watering, whole body contact recreation and boating. The impaired use is protection of aquatic life.

Non Filterable Residues (NFR): Narrative standards for NFR are covered under the general criteria in the state Water Quality Standards under 10 CSR 20-7.031. Section (3)(A) states that " Waters shall be free from substances in sufficient amounts to cause the formation of putrescent, unsightly or harmful bottom deposits or prevent maintenance of full beneficial use." Section (3)(C) states that "Waters shall be free from substances in sufficient amounts to cause unsightly color or turbidity, offensive odor or prevent full beneficial use." Since the standard is narrative, an interpretation is needed to link it to a numeric criterion that is used to determine when water quality standards are met. This TMDL establishes this numeric criterion based on experience at other relatively large wastewater discharges. This experience has shown that a limit of 35 mg/l of suspended solids in winter and spring, and 25 mg/l in summer and fall, are protective of aquatic life uses. This numeric criterion and the flow may be used to determine the loading capacity, which then may be allocated to the sources of the pollutant.

Ammonia: Missouri's Water Quality Standards, 10CSR20-7.031 Table B, lists the chronic ammonia limits for general warm-water fisheries. These limits are pH and water temperature dependent. Seasonal ammonia limits and the typical seasonal pH and water temperature values are:

Period	Temperature	pH	Ammonia (mg/l)
July 1 – Oct. 31	26C	7.8	1.2
Nov 1 – Mar 31	4C	7.8	2.1
April 1 – June 30	14C	7.8	2.0

CBOD: There is no numeric criterion in Missouri's water quality standards for CBOD. Since the effect of CBOD is to exert oxygen demand on the receiving waterbody, dissolved oxygen is the surrogate of concern. State water quality standards call for the maintenance of 5 mg/l or the normal background level of dissolved oxygen, whichever is lower.

Antidegradation Policy

Missouri's water quality standards include the EPA "three-tiered" approach to antidegradation.

Tier 1 defines baseline conditions for all waters. It requires that existing beneficial uses be protected. TMDLs would normally be based on this tier, assuring that numeric criteria such as dissolved oxygen and ammonia concentrations are met to protect uses.

Tier 2 requires no degradation of high-quality waters, 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 1 criteria.

Tier 3, the most stringent tier, applies to waters designated in the water quality standards as outstanding state and national resource waters. Tier 3 requires no degradation under any conditions. Management may require no discharge or prohibit certain polluting activities. TMDLs would need to assure no measurable increase in pollutant loading.

These TMDLs satisfy Tier 1, because after implementations the beneficial uses will be protected.

3. Loading Capacity – Linking Water Quality and Pollutant Sources

The loading capacity (LC) is the greatest amount of loading that a water can receive without violating water quality standards (40 CFR 130.2(f)). When the water body has little or no nonpoint source loads and the point source facilities have relatively constant discharge flows, then the loading capacity depends on the flow of the water body. The flow condition most likely to accompany an exceedence of applicable water quality standards occurs under low flow conditions. Under these conditions, there is less water available to dilute the pollutant so that water quality standards are met at the end of the mixing zone. These TMDLs are established at the critical low flow conditions.

Missouri's Water Quality Standards, 10CSR20-7.031 in section (4)(A)1 notes that a special case occurs when stream flows are less than the 7Q10 low flow value (the lowest average flow for seven consecutive days with a recurrence interval of ten years). Missouri DNR has used this section of the standards to define critical (worst case flow conditions, or design flow conditions) flow for point source discharge of pollutants to be the 7Q10 low flow.

The loading capacities of pollutants are based on the applicable water quality standards and the flow of the stream at the critical flow condition. When statutes allow a mixing zone to a facility discharge, the loading capacities are calculated at the end of the facility discharge pipe, such that the water quality standards are met at the end of the mixing zone.

For CBOD and Ammonia, load capacities and point source load allocations are usually accomplished using the Qual2e model. Estimates of NFR load capacities and point source load allocations are based on empirically derived numbers. This empirical approach, where these limits were developed interactively over many years for common types of waste water treatment facilities, is based on the relationship of the observed instream conditions downstream of specific wastewater discharges and the permit limits for those facilities.

Empirically derived limits for NFR are based on a review made during the past year by DNR. This review looked at the presence or absence of deposited solids in streams below 256 wastewater treatment facilities, 179 sewage lagoons and 77 mechanical plants. NFR permit limits in lagoons are typically 60-80 mg/l while those for mechanical plants are almost always 30 mg/l with a few plants having 45 mg/l. Deposited solids judged to be in excess of state water quality standards were present below 49 lagoons (27%) but only two of the mechanical plants (3%). These findings support our belief that 30 mg/l NFR should be protective of state water quality standards.

Missouri believes that these empirical limits are sufficiently robust to assure that when applied to a particular type of facility, the applicable water quality standards will be met. Since this TMDL is "phased" or iterative in nature, any errors caused by this empirical process would be corrected in later phases.

In the case of North Moreau Creek, the Qual2e model was not employed because the California South facility was not allowed to discharge wastewater during design low flow conditions. Thus, no field data was available to calibrate or verify a model at this critical period. Review of other stream models of wastewater discharge to other small Missouri stream and appropriate effluent limits predictions by those models were used to empirically set CBOD and Ammonia limits for the California South lagoons and estimate load capacities of North Moreau Creek. The summary of the point source load allocation recommendation from those models is attached as Appendix One.

The limits for ammonia and BOD were based on typical advanced waste treatment limits needed at other facilities discharging relatively large volumes of effluent to streams with little or no dry weather dilution capacity.

	CBOD5 (mg/l)	NFR (mg/l)	NH_3N (mg/l)
July 1- Oct. 31	10	20	1.4
Nov.1 – March 31	25	30	3.0
April 1- June 30	25	30	3.0

The loading capacity in pounds per day at end-of-pipe is calculated by

(advanced treatment limit concentration, mg/l) (discharge flow, cfs) (5.4) = loading capacity

The effluent flow is 5.42 cfs year round, and the resulting loading capacity at end-of-pipe is summarized in the table below

END-OF-PIPE LOADING CAPACITIES

	CBOD5 (lb/da)	NFR (lb/da)	NH_3N (lb/da)
July 1- Oct. 31	293	585	41
Nov.1 – March 31	732	878	88
April 1- June 30	732	878	88

For comparison, the load capacity for ammonia at the end of the mixing zone may be calculated from the following formula, with the results provided in the table below:

(NH_3N WQS criterion in mg/l)(Flow in cfs)(5.4) = Load Capacity in lb/day[2]

END-OF-MIXING ZONE LOADING CAPACITIES

	Effluent Flow (cfs)	Stream 7Q10 Low Flow (cfs)	NH_3N WQS Value (mg/l)	NH_3N Load Capacity (#/day)
July 1 - Oct.31	5.42	0.00	1.2	35.1
Nov. 1 - April 1	5.42	2.00	2.1	84.1
April 1 - June 30	5.42	2.00	2.0	80.1

As can be seen in the above two tables, comparing the loading capacity at the end of the pipe with the loading capacity at the end of the allowed mixing zone, the empirically derived numbers are reasonable considering that some ammonia is not conserved when traveling from the end of the pipe to the end of the mixing zone.

4. Load Allocations (LA)

Missouri is establishing that the load allocations for the three pollutants are the actual background loadings under the critical flow conditions.

The upstream nonpoint source load comes from pasture and crop fields, farmsteads, roads, road ditches and woodlots. The nonpoint source load is estimated by using observed dry weather ammonia, CBOD and NFR concentrations in North Moreau Creek upstream of the California South lagoons and the 7Q10 stream low flow values for each season. The calculation uses the same formula as Formula 3 except the concentration and flow values are those of the stream rather that the effluent from the WWTP. The table below summarizes these calculations.

[2] The constant 5.4 is a conversion factor that gives the results in pounds per day

	In-stream Concentration (mg/l)			In-stream Flow (cfs)	Nonpoint Source Load Allocation (#/day)		
	CBOD	NFR	NH_3N		CBOD	NFR	NH_3N
July 1 - Oct. 31	2	3	0.02	0.0	0.0	0.0	0.0
Nov.1 – Mar.31	2	3	0.02	2.0	21.6	32.4	0.2
April 1 - June 30	2	3	0.02	2.0	21.6	32.4	0.2

5. Wasteload Allocation

The wasteload allocation is determined by:

(loading capacity) - (margin of safety) - (load allocation) - (held in reserve) = wasteload allocation

These TMDLs establish that zero loading is held in reserve for future growth for the three pollutants.

The wasteload allocations for the three pollutants are summarized in the tables below:

WASTELOAD ALLOCATIONS AT END-OF-PIPE FOR CBOD

	Loading capacity (lb/da)	Margin of safety (lb/da)	Load allocation (lb/da)	Wasteload allocation (lb/da)
July 1 - Oct.31	293	29.3	0	263.7
Nov. 1 – April 1	732	73.2	21.6	637.2
April 1 – June 30	732	73.2	21.6	637.2

WASTELOAD ALLOCATIONS AT END-OF-PIPE FOR NFR

	Loading capacity (lb/da)	Margin of safety (lb/da)	Load allocation (lb/da)	Wasteload allocation (lb/da)
July 1 - Oct.31	585	58.5	0	526.5
Nov. 1 - April 1	878	87.8	32.4	757.8
April 1 - June 30	878	87.8	32.4	757.8

WASTELOAD ALLOCATIONS AT END-OF-PIPE FOR NH3 as N

	Loading capacity (lb/da)	Margin of safety (lb/da)	Load allocation (lb/da)	Wasteload allocation (lb/da)
July 1 - Oct.31	41	4.1	0	36.8
Nov. 1 - April 1	88	8.8	0.2	79
April 1 - June 30	88	8.8	0.2	79

6. Margin of Safety (MOS)

The margin of safety accounts for any lack of knowledge concerning the relationship between load and wasteload allocations and water quality (CWA § 303(d)(1)(C). 40 C.F.R. §130.7(c)(1).

There is not enough data to determine the uncertainty of the link between the loading capacities and the applicable water quality standards for this segment. Therefore, a 10% margin of safety was selected for all pollutants. If these TMDLs are reopened, the margin of safety will be reevaluated. The margins of safety for the loading capacity as determined at the end of the pipe are summarized in the table below:

END-OF-PIPE LOADING CAPACITY MARGIN OF SAFETY

	CBOD5 (lb/da)	NFR (lb/da)	NH_3N (lb/da)
July 1- Oct. 31	29.3	58.5	4.1
Nov.1 – March 31	73.2	87.8	8.8
April 1- June 30	73.2	87.8	8.8

7. Seasonal Variation

Seasonal variation has been addressed by establishing seasonal wasteload allocations at the California South Lagoon.

Seasonal limits for BOD and Ammonia are necessary because decay of these substances is biologically mediated and varies with water temperature and because dissolved oxygen gas saturation varies with water temperature. The impact of suspended solids on the receiving stream is primarily physical (smothering of natural stream substrate) and is not related to water temperature or other seasonal effects

8. Monitoring Plan for TMDLs Developed under the Phased Approach

The North Moreau Creek TMDLs are phased TMDLs. DNR plans two water quality surveys of the stream during summer low flow conditions in 2002. If those surveys show the stream is in compliance with water quality standards, the TMDL will be considered complete. If the surveys show exceedences of water quality standards, the results of these studies will be used to reevaluate these TMDLs and use the revised allocations to reissue new limits that will assure that the applicable water quality standards will be met.

9. Implementation Plans

These TMDLs will be incorporated into Missouri's Water Quality Management Plan.

On February 26, 1999, Missouri DNR re-issued NPDES MO 0023272 for the California South lagoons. This permit required that water quality based limits for BOD, NFR and ammonia be consistent with the Analysis of Effluent Needs done in February 1998. The permit requires these water quality based limits to be met by February 1, 2000. If future monitoring shows that water quality standards are not being met, then this TMDL will be reopened and reevaluated, and the permit will be reissued with new limits that assure that applicable water quality standards will be met.

10. Reasonable Assurances

Because the source of the instream impairment is a point source discharge regulated by an NPDES permit, Missouri DNR has adequate authority to require the necessary level of treatment at this facility.

11. Public Participation

Missouri DNR published a Public Notice on May 28, 1999, announcing the availability of the draft total maximum daily load (TMDL) analysis for the North Moreau Creek. The department invited the general public and any interested parties to review the report and send their comments through July 2, 1999. No comments were received. Six public meetings to allow input from the public on impaired waters were held between August 18 and September 22, 1999. There were no comments received on North Moreau Creek.

12. Administrative Record

An Administrative Record for these TMDLs is being maintained by the Missouri DNR.

13. Data and Information Sources

The Environmental Services Program (ESP), in cooperation with Water Pollution Control Program collected all chemical and flow data pertaining to the impaired stream segment.

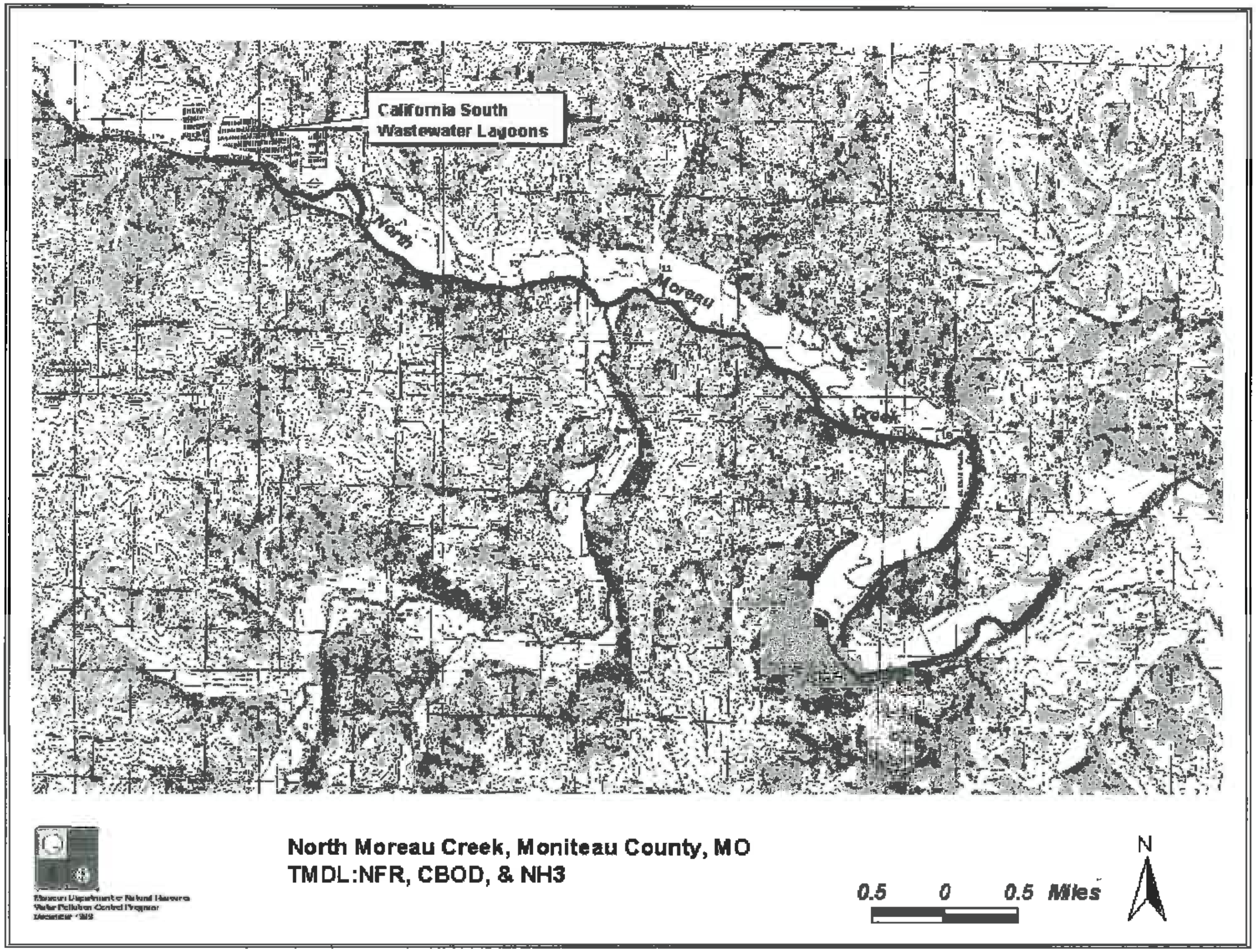
Appendix One: CBOD and Ammonia Limits derived from the Qual2e Model for Nineteen Streams.

The streams below were all modeled by Missouri DNR using Qual2e at low flow summer and winter conditions. Recommended effluent limits based upon model predictions are shown.

Stream	Facility	7Q10 Low flow (cfs)	Summer		Winter	
			CBOD	NH3N	CBOD	NH3N
Turkey Cr.	Joplin Turkey Cr.	0.1	10	2.5	10	3.0
Bear Cr.	Hannibal	0.0	16	4.0	25	4.0
Wolf Cr.	Farmington E.	0.0	20	5.0	20	5.0
St. Francis R.	Farmington W.	0.1	10	1.3	25	2.6
Walnut Cr.	El Dorado Springs	0.0	10	1.8	25	3.5
East Cr.	Belton	0.0	12	3.0	20	4.0
Perche Cr.	Columbia	0.5	10	1.5	10	2.0
Trib. Coon Cr.	Moberly	0.0	15	3.0	25	3.5
S. Fk. Salt R.	Mexico	0.0	10	2.0	20	2.0
Salt Fork	Marshall	0.1	10	2.0	10	3.0
W. Fk. Niangua R.	Marshfield	0.0	25	1.4	25	2.2
Hubble Cr.	Jackson	0.0	10	2.0	10	3.0
Todd Cr.	Kansas City Todd Cr.	0.0	10	2.5	15	3.5
Plattin Cr.	Festus	0.5	15	2.5	25	3.4
Brushy Cr.	Sedalia W.	0.0	10	2.5	20	3.5
L. Dry Fk.	Rolla SE	0.0	5	2.0	5	3.0
Elkhorn Cr.	Montgomery City	0.0	20	2.4	25	3.6
Williams Cr.	Mt. Vernon	0.9	5	2.0	10	3.0
Clear Cr.	Monett	0.0	5	2.8	10	3.8

References Maintained as Administrative Record

1) NPDES permit # MO 0023272
2) Analysis of Effluent Needs, February 1998


California South
Wastewater Lagoons
North
Moreau
Creek
North Moreau Creek, Moniteau County, MO
TMDL:NFR, CBOD, & NH3
0.5
0
0.5 Miles
N

Missouri Department of Natural Resources
Water Pollution Control Program

Total Maximum Daily Load (TMDL)

for

Davis Creek
Lafayette County, Missouri

Completed December 26, 2000
Approved January 31, 2001

Revised June 17, 2003
(with additional changes July 15 and July 21, 2003)

Approved August 13, 2003

Phased Total Maximum Daily Load (TMDL)
For Davis Creek Low Dissolved Oxygen Impairment
Pollutants: Biochemical Oxygen Demand (BOD), Ammonia Nitrogen(NH_3-N)
And Nutrients

Name: Davis Creek

Location: Near the city of Odessa in Lafayette County, Missouri

Hydrologic Unit Code (HUC): 10300104-060001

Water Body Identification (WBID): 0912

Missouri Stream Class: The impaired segment of Davis Creek is a Class C stream[1]

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

Size of Impaired Segment: 2 miles

Location of Impaired Segment: N 1/2 Section 9, Township 48 N, Range 27 W to SE 1/4 Section 10, Township 48 N, Range 27 W

Pollutants: BOD (Biochemical Oxygen Demand), Ammonia Nitrogen (NH_3-N) and Nutrients

Pollutant Source: Odessa Municipal Wastewater Treatment Facility—Southeast Lagoon and non-point sources exacerbated by lack of riparian canopy.

Permit Number: NPDES Permit No. MO-0026387

TMDL Priority Ranking: High

1. Background and Water Quality Problems

Davis Creek is on the 1998 303(d) list due to high BOD (which causes low dissolved oxygen) and high ammonia resulting from discharges from the Odessa Southeast Lagoon System. Missouri has proposed listing the waterbody on the 2002 303(d) list for nutrients. This TMDL is a revision of the TMDL approved by EPA on January 31, 2001. Since the approval of the 2001 Davis Creek TMDL additional data have been collected. Analyses of these data demonstrated that a significant water quality issue affecting the

[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)

overall health of the stream system has not been addressed. Although not identified on Missouri's EPA approved 1998 303(d) list, nutrient contributions are now known to play a significant role in the stream ecology than recognized in the original TMDL. The TMDL priority ranking for Davis Creek is high. During dry weather the stream flow in Davis Creek is effluent dominated. For this reason this TMDL was calculated at critical low flow conditions (7Q10).

The Odessa Southeast Lagoon System (OSLS) consists of a three cell lagoon with a facility design flow of 0.58 cubic feet per second (cfs). This translates to 375,000 gallons/day with a design population equivalent of 3,575. The facility discharges wastewater to a tributary to Davis Creek, and the outfall is located approximately 50 yards up the tributary from Davis Creek. Davis Creek then flows easterly through southern Lafayette County into the Blackwater River. The OSLS has been in noncompliance in the past. No monitoring records were sent in to Missouri Department of Natural Resources (MDNR) from December 1992 to May 1994. In 1997 the OSLS was cited for noncompliance due to exceedences in Total Suspended Solids (TSS) and BOD. As of the writing of this TMDL, however, the OSLS is in compliance.

At the request of the Water Pollution Control Program (WPCP), the Environmental Services Program (ESP) conducted two stream surveys of Davis Creek near Odessa, Missouri, in Lafayette County during July 15-17, 1997, and again July 8-9, 1998, as part of a wasteload allocation study. The purpose of the surveys was to quantify pollutant loading from the Odessa Southeast Lagoon System during minimal summer flows. Davis Creek at the point of discharge is a class C stream. There are no other point source discharges to Davis Creek above the impaired segment.

Land use within this area according to the Lafayette County Natural Resources Conservation Service (NRCS) is mostly row crop with some pasture and forested areas. In the six areas sampled during the 1997/1998 survey, the stream was moderately to mostly channelized, with partial to little tree canopy present. In two sample locations, erosion from livestock access and vehicle use was noted. Historically, the Davis Creek area was subject to infrequent flooding and riparian vegetation consisted of a mixture of native hardwood trees such as cottonwood, black walnut and white oak and native grasses. Currently, trees are found in scattered plots along the creek, and cultivated cropland accounts for much of the Davis Creek floodplain.[2]

Additionally, MDNR Planning Section staff collected data on August 14, 2002 and September 11, 2002 in connection with the Total Maximum Daily Load approved by the Environmental Protection Agency in 2001. During the course of the monitoring effort, the condition of the riparian corridor of Davis Creek was observed. It was noted that upstream from the OSLS outfall the dissolved oxygen measurement was less than 5.0 mg/L. Algae were present from the discharge pipe to the first downstream monitoring site. Algae past that point did not seem to be a problem. Water in the creek past the mixing zone was turbid but not green. Cattle impacts to the stream were observed at the

[2] Lafayette County Soil Survey, Soil Conservation Service, 1975, http://soils.missouri.edu/surveys/lafayette/gmapunit.htm#Blackoar

second sampling site, but were not evident upstream from the discharge pipe. Tree canopy was not improved since the previous studies in 1997 and 1998.

According to observations made by DNR staff during the August and September 2002 data collection trips, Davis Creek has an unusual flow regime. Davis Creek has stream segments that have decreasing, rather than increasing flow due to stream water flowing under the sand and gravel streambed, but not attributed to karst characteristics. Above the OSLS outfall, flow is intermittent with no flow during dry weather. Riparian (tree) canopy was lacking and high stream temperature and lowered dissolved oxygen could result from this degraded riparian condition. In the 1997/1998 as well as the August and September 2002 studies morning dissolved oxygen readings, whether above or below the OSLS outfall were less than 5.0 mg/L. According to data collected by MDNR, it is not unusual for Osage Plains region streams, of which Davis Creek is one, to naturally have dissolved oxygen levels of less than 5.0 mg/L.

Livestock access in Davis Creek was noted at station #4 in the 1997 and 1998 studies. Nonpoint source impacts were estimated and were not considered to be significant at the time the TMDL was written. Now, however, nonpoint source impacts are suspected to be more of a factor in the impairment to Davis Creek. A discussion of how the estimates were arrived at is located in Section #3, Load Allocation (Nonpoint Source Load).

Possible vehicle use in the stream was noted at station #5 in the 1997 study. The purpose for this traffic was unknown, but could be linked to moving cattle across the stream to other pastures, moving farming equipment between farm fields or recreational use.

As previously mentioned, water quality investigation of Davis Creek was conducted in both 1997 and 1998. Originally, this investigation concluded that the discharge from the OSLS was solely responsible for depressed levels of dissolved oxygen in Davis Creek and exceedence of State Water Quality Standards for ammonia. The OSLS did not have water quality based effluent limits for NH_3-N at that time. In the 1998 study, DO analysis results taken in the field included: 5.3 mg/L taken at 5:40 am; 5.2 mg/L taken at 6:07 am; 9.0 mg/L taken at 1:10 pm and 4.8 pm at 12:45 pm. The selection of pH 7.8 and the corresponding temperatures for the ammonia criteria were chosen to reflect typical seasonal conditions present (summer conditions). Subsequent to this study additional data has been collected that show that the role of non-point source and the ecological functions of the stream itself are contributing to the depression of DO. Elevated phosphorus and nitrogen in the system coupled with lack of riparian cover are leading to greater biological impacts in the stream (nuisance algae growth.)

The data in Appendix C show instances when dissolved oxygen levels in Davis Creek have fallen below the state standard of 5.0 mg/L. The low DO levels have been measured at the 7/8 and 9/98, 8/14/02, 9/11/02 studies, usually in the early mornings when dissolved oxygen levels in streams are lowest due to utilization during the night by living organisms. Readings of 2.0 and 4.0 mg/L DO were recorded on South Davis Creek (a nearby stream without point sources used for comparison) and in upper Davis Creek above the Odessa outfall.

During dry weather conditions there is no flow in Davis Creek above the Odessa Southeast Lagoons and the 7Q10 is considered zero. The July 15-17, 1997, survey reports that "The OSLS effluent discharge was the only noted source of flow into Davis Creek."[3]

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

Designated Uses

The designated uses of Davis Creek, WBID 0912, are Livestock and Wildlife Watering and "Limited" Warm Water Fishery. The stream classifications and designated uses may be found at 10 CSR 20-7.031(1) C and table H.

Anti-degradation Policy

Missouri's Water Quality Standards include the 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—it requires that existing beneficial uses are protected. TMDLs would normally be based on this tier, assuring that numeric criteria (such as dissolved oxygen, ammonia) are met to protect uses.

Tier II requires no degradation of high-quality waters, 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 no degradation under any conditions. Management may require no discharge or prohibition of 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 conform to Missouri's Tier I anti-degradation policy.

---

[3] Stream Survey Sampling Report, Odessa SE Lagoon System and Davis Creek Survey, Missouri Department of Natural Resources, July 15-17, 1997, Page 5

Specific Criteria

Ammonia

The specific criteria, found in Missouri's Water Quality Standards at 10 CSR 20-7.031(4), apply to all classified waters. The specific criteria for the ammonia TMDL are found in 10 CSR 20-7.031 Table B. These limits are pH and water temperature dependent. Seasonal ammonia limits at the typical seasonal pH and water temperature values are given in the table found in **4. Waste Load Allocation (Point Source Loads); Summary of Loads.**

BOD_5

Dissolved oxygen (DO), is the water quality standard that is exceeded in Davis Creek. DO is not a pollutant and cannot be allocated in a TMDL. The determination of in-stream DO is a function of the physical, chemical, and biological processes. Demands for oxygen arise from the decomposition of organic matter either introduced to or generated within the stream and from chemical loads introduced to the stream. Oxygen can be restored to the system through photosynthesis by plants and reaeration of the stream. Photosynthesis and reaeration rates depend on sunlight and temperature and these parameters must be also considered when evaluating the aquatic community. Evaluation of in-stream DO is therefore a complex problem when all the processes are in play. The issue is further complicated because of the interrelationships between non-point sources, point sources, and stream characteristics.

Because wastewater contribution is a major source, a first step in rectifying the in-stream impairment is to establish limits on the discharge. BOD_5 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 water quality standards for BOD_5. Since DO cannot be allocated to the discharger, DO is linked to BOD_5. BOD_5 is a pollutant that is measurable and may be allocated in a TMDL. BOD_5 is composed of CBOD (carbonaceous oxygen demand) and NBOD (nitrogenous oxygen demand). NBOD can be estimated directly from ammonia nitrogen (NH3-N). The numeric link between dissolved oxygen and BOD is generated by the water quality model QUAL2E, and is supported by EPA. The QUAL2E model calculates BOD_5 by using CBOD and ammonia data from actual sample analyses. The OSLS upgrade includes converting to a mechanical treatment plant. Calibration for the QUAL2E model for the existing conditions, however, is based on the current lagoon system. Waste characteristics of a mechanical plant are dramatically different than a lagoon system. The use of the in-stream data collection can therefore help guide the decision about a wasteload for the upgraded facility. A verified model, however, will have to wait until the upgrade is completed and other measures must be considered to ensure that the State Water Quality Standards for dissolved oxygen[4] is achieved.[5] Limiting discharges from the facility in and of itself may not be sufficient to ensure that the DO standard is met because of the

---

[4] 10 CSR 20-7.031(4)(J)
[5] 10 CSR 20-7.031(4)(A)(3)

effects of in-stream photosynthesis, which depends on nutrient loads, and physical characteristics controlling reaeration. Other targets must therefore be considered.

This TMDL also provides for assessment endpoints to be more than simply numeric measures of in-stream DO and NH3-N. It will also include an assessment of the biological integrity of the system as measured by a macroinvertebrate Biological Index (BI) score, calculated in accordance with Missouri's standard procedures (10 CSR 20-7.031 (4)(Q)), which demonstrates fully supporting aquatic life uses of the stream.

This TMDL will be implemented in multiple phases. Phase one will include WLAs for ammonia and BOD_5 for the OSLS as described as an alternative in the original TMDL under *Implementation*, page 9. That WLA represents limits achievable by a modern mechanical plant using activated sludge processes and is a reduction from the current level of 45 mg/L of BOD_5 to 10 mg/L.

The stream response as measured by DO, nutrients, and the BI score will guide the phase two target nutrient loads and stream restoration practices which will achieve the state water quality standards if phase one monitoring and assessment indicate impairment after the OSLS upgrade. If the facility upgrade totally corrects the DO and aquatic life impairment, then phase two would consist of monitoring and evaluation. However, it after the upgrade, the stream remains impaired, additional watershed and stream restoration measures will be implemented. A watershed assessment would be performed to determine phase two implementation of non-point source control actions necessary to ultimately achieve the WQS. The watershed assessment would inventory potential nutrient sources, identify upland measures which would improve the water quality, identify stream riparian measures, and provide the basis for seeking funding to implement best management practices.

Summary of Numeric Instream Targets:

Table 1 summarizes the instream BI target and the numeric criteria from the Missouri Water Quality Standards for the two TMDLs on Davis Creek. A pH of 7.8 su and temperatures of either 26°C for summer or 6°C for winter were chosen to reflect typical conditions for this watershed.

Table 1: Instream Targets for Odessa Southeast Lagoon System

Dissolved Oxygen(mg/l) Criteria	*5.0*
*Biological Index established in accordance with Missouri's standard procedure** *Fall* *Spring*	 ≤ 7.33 (0-10 scale) ≤ 7.16 (0-10 scale)
Ammonia (mg/L), May-October (pH 7.8, Temperature 26° C, Limited Warm Water Fishery Chronic Criteria)	*2.0*
Ammonia (mg/L), November-April (pH 7.8, Temperature 6° C, Limited Warm Water Fishery Chronic Criteria)	*3.3*
Ammonia (mg/L), May-October (pH 7.8, Temperature 26° C, Limited Warm Water Fishery Acute Criteria)	*22.4*
Ammonia (mg/L), November-April (pH 7.8, Temperature 6° C, Limited Warm Water Fishery Acute Criteria)	*26.4*

*The target is the 25th percentile of reference condition from proposed biological criteria for glide/pool warm water streams within the Plains/Missouri tributaries between the Blue and Lamine Rivers Ecological Drainage Unit. Sampling occurs in Fall and Spring, and that is why this TMDL has targets during those seasons.

2. Calculation of Load Capacity

Load capacity is defined as the maximum pollutant load that will still attain water quality standards. For this stream, modeling results show that in addition to restricting loads from the plant, reduction in nutrient load and physical improvements are needed to achieve the in-stream DO standards. For the DO capacity, the target capacity was set based on an aggressive BOD_5 limit for an upgraded facility anticipating reopener clauses in the permit and improvements to the stream ecology. These improvements could be achieved by such actions as riparian improvement, land application of sludge in an environmentally sound manner subject to state and federal regulation during summer months, or upland reductions in nutrients. The extent of these measures can only be defined after a major upgrade to the facility has occurred and the model recalibrated to more accurately reflect the attained in-stream water quality. Ammonia limits achieve both chronic and acute in-stream water quality standards. For nutrients, the target is set to achieve an in-stream biological index score of: Fall -- ≤ 7.33 and Spring -- ≤ 7.16. Because the nutrients are also a function of the results of the upgrade to the WWTP, targets for reductions in either nitrogen or phosphorus will be set in Phase Two of the TMDL. For Phase One of this TMDL the Load Capacity was calculated by this formula:

Permit limit average daily load =(Design stream flow in cfs) times (in-stream pollutant concentration in mg/L) times (the constant 5.395 to convert to pounds/day.)

Average Monthly BOD_5 Phase One

1.55 cfs*10 mg/L*5.395= 84 lb/day

Average Monthly Ammonia Phase One

Summer:
2 mg/L*1.55 cfs*5.395=17 lb/day

Winter:
3.3 mg/L*1.55 cfs*5.395=28 lb/day

3. Load Allocation (Non-point Source Load)

The LA for ammonia is set at zero. For Phase One of the TMDL the LA for BOD_5 (DO) is set at improving the contribution to low DO levels from non-point source and riparian effects particularly during the critical summer low flow period. The LA is anticipated to be adjusted after the WWTP is upgraded based on future analysis and modeling.

Non-point source loads are those other than point source loads. Phase two of this TMDL will address stream response as measured by DO, nutrients, and the BI score, and will include target nutrient loads and stream restoration practices which will achieve the state water quality standards if phase one monitoring and assessment indicate impairment after the OSLS upgrade.

Evidence of livestock impacts in the creek was noted at Station #4. While there is only observational data, non-point source loads due to livestock impacts were estimated using information from the Missouri Agricultural Statistics Service Web Site. From the Web Site the total amount of cattle for the county was found. The drainage area for Davis Creek was delineated from United States Geological Survey topographical maps. The Davis Creek watershed above the impaired segment was estimated to be 2% of the county. Two percent of the total number of cattle found in the county is approximately 1000 cattle; this figure was confirmed by the Lafayette County Natural Resources Conservation Service personnel as being realistic. Since this is a phased TMDL, further study will determine what non-point source impacts from livestock exist.

4. Waste Load Allocation (Point Source Loads)

The Odessa Southeast Lagoon is the only point source load discharging to or impacting the impaired segment of Davis Creek. For ammonia, the permit will require meeting in-stream criteria concentrations at the discharge point; no allowance is given for mixing.

Summary of Loads

The load allocations for these TMDLs are summarized in the table below:

Loads to Davis Creek near Odessa, Mo. (pounds/day -- based on 30 day averages)

		Point Load (WLA)	Non-point Load (LA)	Margin of Safety (MOS)	Load Capacity
BOD_5		84	TBD*	Implicit	TBD*
Ammonia	Summer	17	0	Implicit	17
	Winter	28	0	Implicit	28

* TBD in Phase 2 of the TMDL based on a calibrated model for the upgraded plant, additional sampling of the stream, and an assessment of the cause of the depressed DO if it still is a problem after the plant upgrade.

5. Margin of Safety

An implicit margin of safety for this TMDL is based on the conservative assumption that multiple endpoints and subsequent monitoring is planned to confirm not only that the numeric standards for the stream are met, but the ecological system is fully supported as demonstrated by the macroinvertebrate population.

6. Seasonal Variation

Seasonal variation was simulated in the QUAL2E model via the use of lower water temperatures, lower ammonia and CBOD decay coefficients and adjustments to seasonal low flow values. Seasonal limits for ammonia are necessary because decay of these substances is biologically mediated and varies with water temperature and because dissolved oxygen gas saturation varies with water temperature.

7. Monitoring Plan For TMDLs Developed Under the Phased Approach

Permit requirements will include sampling the effluent weekly for BOD_5, pH, temperature and NH3-N. Phase One Ambient monitoring upstream and downstream of the outfall will collect nitrogen, phosphorus, and dissolved oxygen samples and other information necessary to calibrate the QUAL2E model and to assess nutrient loads from the watershed. Biological monitoring in accordance with Missouri's Standard Operating

Procedure (SOP) will be conducted after the plant upgrade to determine compliance with the targeted BI scores in this TMDL.

8. Implementation Plans

An implementation plan to revise the OSLS NPDES permit, if necessary, will include a permit re-opener clause. The OSLS will have three years to comply with the new operating permit revisions. Monitoring will be done on a regular basis to assure compliance with Missouri Water Quality Standards. These three TMDLs will be incorporated into Missouri's Water Quality Management Plan.

Since this is a phased TMDL, more water quality data will be gathered and a suitable model developed that more accurately account for both point and non-point source pollution.

Another option for the permit could be a no-discharge system during critical summer months. Land application of sludge conforming to state and federal regulations is another alternative to consider.

Riparian improvements may be viable opportunities to improve DO and aquatic community. Surveyors in the past have mentioned the deterioration of the riparian corridor. In some reaches, the surveyors noted that the stream was channelized and tree canopy was reduced or lacking. This channelization and reduced tree canopy can produce lowered velocity and unshaded pools. Warmer temperatures and higher algal production are created which result in lower dissolved oxygen and stress on fish and macroinvertebrates. Once Odessa's new wastewater treatment plant is online (Phase 1), improvements in Davis Creek can be measured to determine what role nonpoint contributions make to the lowered DO problem and a nonpoint allocation made (Phase 2). Problem areas will be identified and local input will be sought regarding implementation.

Local involvement is vital to the success of any TMDL implementation plan. The Lafayette County citizens have written two watershed management plans in the past: the Higginsville Lake Watershed Management Plan and the Concordia-Edwin A. Pape Lake Watershed Management Plan. Both plans were concerned with pesticides and to a lesser degree sediment and nutrients affecting their water supply lakes. The implementation of these plans resulted in the successful reduction of the herbicide atrazine found in these two water supply lakes. Expertise gained through these efforts will be helpful in writing an implementation plan to address nonpoint sources nutrients.

9. Reasonable Assurances

In developing waste load allocations for the permitted facilities, assumptions were made which depend on reductions in the load allocation from non-point sources. To ensure water quality standards are met, there must be reasonable assurance that non-point sources contributing to the water quality problems in Davis Creek will be addressed. If after the plant upgrade, the stream's water quality is not meeting the standards, the permitee will take additional measures, such as land application of sludge or riparian improvement to insure water quality standards are met. In case the point source improvements do not fully address the impairment, additional assurance will be provided by a water quality project. State or local entities will seek funding for this project through EPA Section 319 non-point source grant funds or other funding mechanisms. Once the watershed assessment has identified actions that would reduce the non-point source loading, additional funding will be sought from a variety of funding sources to implement those practices. For example, EQIP, 319 funds, Special Area Land Treatment (SALT) funding, any city funding could be sought. Due to the uncertainty of the availability of grants, a variety of funding options need to be explored. The NPDES permit could be reopened following the assessment and subsequent implementation of non-point source control measures. Monitoring and assessment of water quality in response to the implementation of both point and non-point measures will lead decisions on additional actions necessary to ensure attainment of water quality standards. Local watershed groups would be expected to play a major part in this adaptive management of the watershed.

The Department of Natural Resources has the delegated authority to write and enforce NPDES permits. Inclusion of effluent limits, determined from the allocations and established in this TMDL, into an NPDES permit should provide reasonable assurance that instream water quality standards will be met. An agreement between MDNR and the City, separate from the NPDES permitting process, will define the actions the City should pursue if water quality standards are not achieved solely by the treatment plant upgrade. These activities include land acquisition for a retention basin or land application of effluent under certain adverse conditions. The City will also actively pursue education of the public regarding watershed issues and Best Management Practices (BMPs). The permittee, however, will only be accountable for improvements on City owned property should alternate disposal, riparian corridor improvements or other water quality management practices are deemed necessary.

10. Public Participation

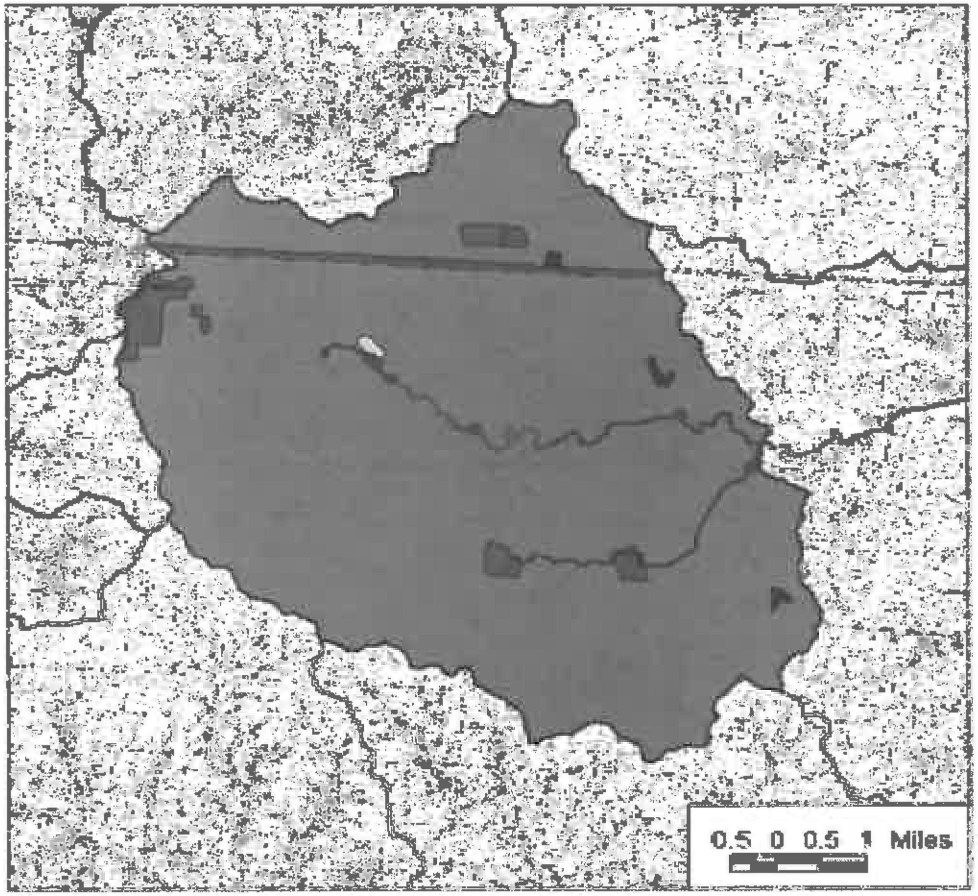
This water quality limited segment is included on the approved 1998 303(d) list for Missouri and a Total Maximum Daily Load document was approved by the EPA January 31, 2001. New monitoring data received after that date showed that nonpoint source pollution from agricultural sources were a problem contributing to the impairment that had not been taken into account in the original document. Consequently, Davis Creek was put on the proposed 2002 303(d) impaired waters list for nutrients. MDNR decided to revise the Davis Creek TMDL to include nonpoint nutrient impacts to Davis Creek. A meeting with EPA staff included a discussion of the Davis Creek TMDL and possible directions to take in the revised document occurred February 13, 2003. The Davis Creek TMDL was placed on public notice from April 28 to May 28, 2003. Three comments were received and responses returned. Copies of the public notice, comments and MDNR's response to comments are on file with MDNR.

Prior to the original TMDL approved in 2001, six public meetings to allow input from the public on impaired waters were held between August 18 and September 22, 1999. No comments pertaining to Davis Creek were received during the public meetings. This first TMDL document was sent to EPA for examination and then the edited draft placed on public notice. A public notice period was held from December 8, 2000 to January 7, 2001. Groups receiving the public notice announcement included the Missouri Clean Water Commission, the affected facility, the Water Quality Coordinating Committee, the TMDL Advisory Committee, Stream Team volunteers in the watershed, and others that routinely receive the public notice of NPDES permits. Copies of the notice, the comments and MDNR's response to the comments are on file with MDNR.

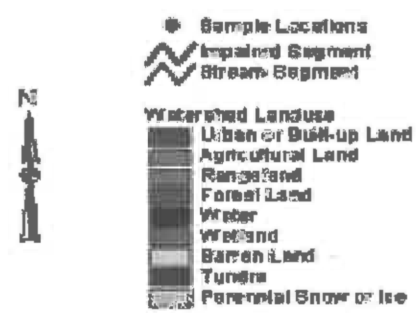
11. Administrative Record and Supporting Documentation:

An administrative record on the Davis Creek TMDL has been assembled and is being kept on file with the Missouri Department of Natural Resources, including the following:
Topographical map of impaired segment with Sampling Station Number
Land use map
Input and output documents
Permit for OSLS
Public Notice document
Davis Creek Information sheet
Copies of comment letters and MDNR response letters
Data

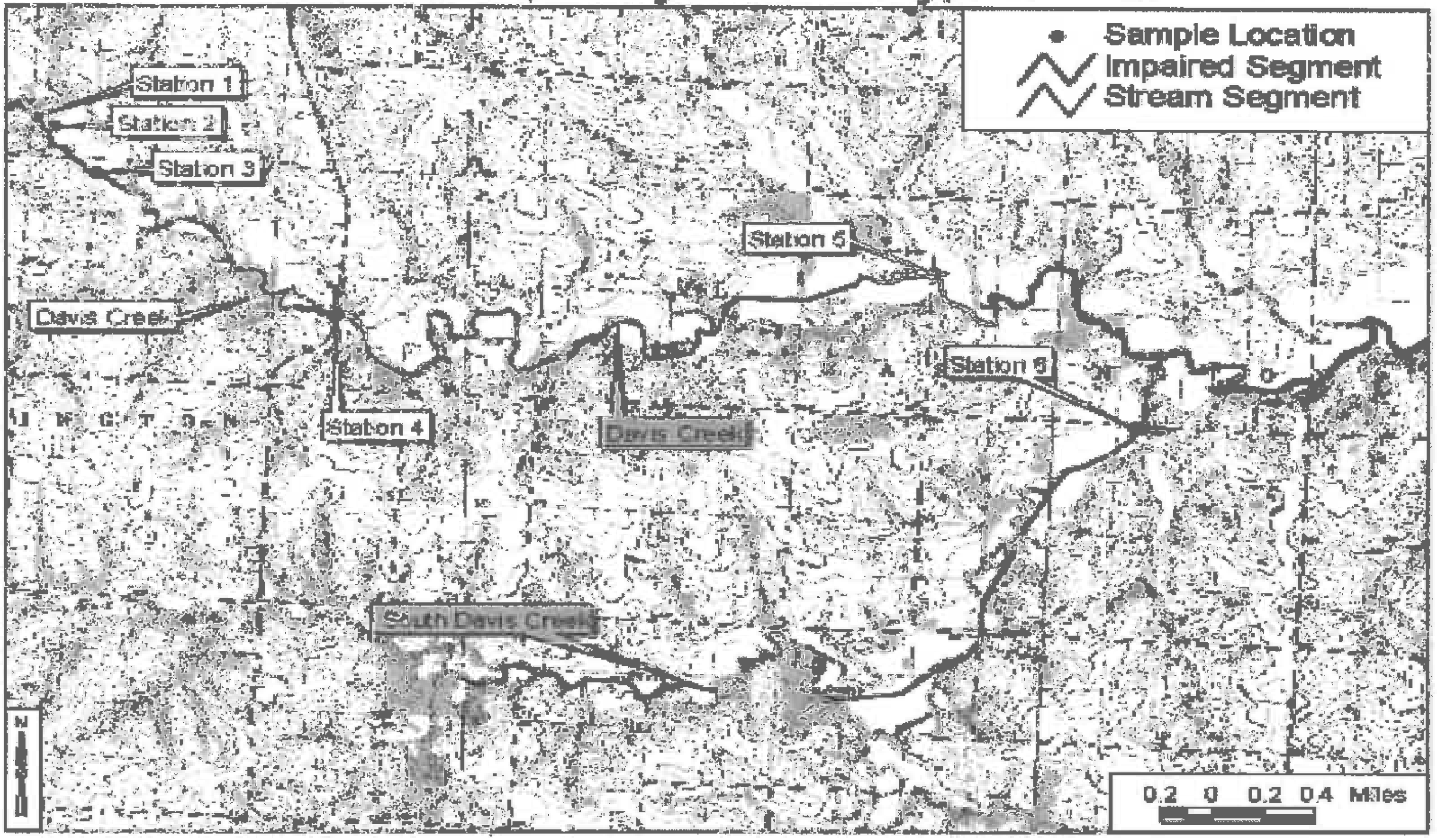
Land Use Types for Davis Creek Watershed (10300104-060001)



Land Use Type	Area (acres)	
Urban or Built-up Land		746
Residential	301	
Commercial and Services	50	
Trans, Comm, Util	395	
Agricultural Land		25701
Cropland and Pasture	25701	
Forest Land		237
Deciduous Forest Land	237	
Water		72
Reservoirs	72	
Barren Land		38
Transitional Areas	38	



Map of Sample Locations and Impaired Stream Segment Davis Creek, Lafayette County, Missouri



DAVIS CREEK DATA

DATE	STATION	TIME	FLOW	WATER TEMP	DO	pH	NO3	NH4	CBOD
7/16/1997	1.00	546		24	4.00	8.00	0.06	0.07	<4
7/16/1997	1.00	1232		26	5.00	8.00	<0.04	0.06	<2
7/16/1997	2.00	530		28	5.00	9.00			
7/16/1997	2.00	1210		29	6.00	6.00	<0.04	0.04	17
7/16/1997	3.00	614		23	0.00	8.00	0.16	0.54	16
7/16/1997	3.00	1306		29	5.00	8.00	0.29	0.49	9
7/16/1997	4.00	645		23	2.00	7.00	0.31	1.22	<4
7/16/1997	4.00	1320		29	6.00	8.00	0.32	1.11	<4
7/16/1997	5.00	555		25	5.00	8.00	0.05	0.04	<2
7/16/1997	5.00	1240		30	9.00	8.00	0.04	0.02	<4
7/16/1997	6.00	525		24	5.00	8.00	<0.04	0.02	<2
7/16/1997	6.00	1215		26	6.00	8.00	<0.04	0.01	<2
7/17/1997	1.00	544		25	4.00	8.00	0.05	0.08	<4
7/17/1997	1.00	1223		27	5.00	8.00	<0.04	0.08	<2
7/17/1997	2.00	530		28	5.00	9.00			
7/17/1997	2.00	1205		30	8.00	10.00	<0.04	0.03	17
7/17/1997	3.00	607		24	0.00	8.00	0.19	0.86	12
7/17/1997	3.00	1246		29	4.00	8.00	0.24	0.66	9
7/17/1997	4.00	625		24	0.00	7.00	0.40	1.02	<4
7/17/1997	4.00	1320		31	7.00	8.00	0.39	0.86	<4
7/17/1997	5.00	550		25	5.00	8.00	<0.04	0.05	<4
7/17/1997	5.00	1250		32	9.00	8.00	<0.04	0.04	<2
7/17/1997	6.00	520		25	5.00	7.00	<0.04	0.03	<2
7/17/1997	6.00	1225		28	6.00	9.00	<0.04	<0.01	<2
7/8/1998	1.00	547	0.02	25	4.00	8.00	0.46	0.81	4
7/8/1998	1.00	555	0.02	26	4.00	8.00	0.20	0.07	4
7/8/1998	1.00	1330	0.02	31	10.00	9.00	0.27	0.01	4
7/8/1998	2.00	540	0.40						
7/8/1998	2.00	1310	0.40	33	9.00	9.00	0.12	0.39	21
7/8/1998	3.00	610	0.84	26	0.00	8.00	0.13	1.42	21
7/8/1998	3.00	1255	0.84	30	4.00	8.00	0.19	1.86	14
7/8/1998	4.00	625	1.48	26	2.00	7.00	0.38	1.63	4

7/8/1998	4.00	1335	1.48	30	5.00	8.00	0.34	1.7	5
7/8/1998	5.00	555	0.91	26	5.00	8.00	1.08	0.05	4
7/8/1998	5.00	1310	0.91	31	11.00	8.00	0.96	0.02	4
7/8/1998	6.00	525	0.63	27	8.00	7.00	0.58	0.01	2
7/8/1998	6.00	1245	0.63	28	10.00	8.00	0.46	0.01	2
7/9/1998	1.00	1310	0.02	28	8.00	8.00	0.16	0.01	4
7/9/1998	2.00	607	0.40	32	7.00	9.00	0.10	0.595	21.5
7/9/1998	2.00	1245	0.40	30	5.00	8.00	0.07	0.8	22
7/9/1998	3.00	530	0.84	27	0.00	8.00	0.11	1.9	23
7/9/1998	3.00	1325	0.84	30	3.00	8.00	0.17	2.15	14
7/9/1998	4.00	620	1.48	26	2.00	8.00	0.27	1.92	4
7/9/1998	4.00	1340	1.48	28	4.00	8.00	0.24	2.02	6
7/9/1998	5.00	555	0.91	26	5.00	8.00	0.86	0.04	4
7/9/1998	5.00	1315	0.91	29	12.00	8.00	0.80	0.03	2
7/9/1998	6.00	530	0.63	26	9.00	8.00	0.35	0.01	2
7/9/1998	6.00	1250	0.63	28	11.00	7.00	0.27	0.01	3
3/3/2000	1.00	847	0.40	6	10.00	8.00	<0.05	<0.05	<2
3/3/2000	1.00	1145	0.40	6	12.00	8.00	<0.05	<0.05	<2
3/3/2000	2.00	840	0.02	6	8.00	7.00	0.28	<0.05	<2
3/3/2000	2.00	1150		6	11.00	7.00	0.23	0.38	2
3/3/2000	3.00	810	0.45	6	10.00	8.00	0.10	<0.05	<2
3/3/2000	3.00	1205		6	13.00	8.00	0.07	<0.05	<2
3/3/2000	4.00	750		7	9.00	8.00	0.07	<0.05	<2
3/3/2000	4.00	1215		7	11.00	8.00	0.07	<0.05	<2
3/3/2000	5.00	730	0.30	6	10.00	8.00	0.09	<0.05	<2
3/3/2000	5.00	1230		7	14.00	9.00	0.08	<0.05	<2
3/3/2000	6.00	710		7	10.00	7.00	0.56	<0.05	2
3/3/2000	6.00	1235		7	12.00	8.00	0.49	<0.05	2

Site Name	Yr	Mo	Dy	Time	Flow	°C	DO	pH	SC	K-Bl	NH3N	NO2N	TP	CBOD	TSS
Davis Cr. 0.3 mi.bl. Odessa SE Lgn	1998	7	8			26	0.5	7.59	525		1.42	0.13		21	
Davis Cr. 0.3 mi.bl. Odessa SE Lgn	1998	7	8			30	4.3	7.91	527		1.86	0.19		14	
Davis Cr. 1.7 mi.bl. Odessa SE Lgn	1998	7	8			30	4.6	7.73	526		1.7	0.34		5	
Davis Cr. 1.7 mi.bl. Odessa SE Lgn	1998	7	8			26	1.8	7.34	525		1.63	0.38		1.99	
Davis Cr. 5.2 mi.bl. Odessa SE Lgn.	1998	7	8			31	10.9	7.95	374		0.02	0.96		1.99	
Davis Cr. 5.2 mi.bl. Odessa SE Lgn.	1998	7	8			26	5.4	7.47	369		0.05	1.08		1.99	
Davis Cr. 50 yds.ab. Odessa SE Lgn.	1998	7	8		0	25	4	7.75	427		0.81	0.46		1.99	
Davis Cr. 50 yds.ab. Odessa SE Lgn.	1998	7	8		0	31	9.9	8.6	407		0.00499	0.27		1.99	
Odessa SE Lgn. Effluent Trib.	1998	7	8			30	5.3	8.1	520						
Odessa SE Lgn. Effluent Trib.	1998	7	8			33	9	9.2	507		0.39	0.12		21	
South Davis Cr. Nr mouth	1998	7	8		0.08	28	10.2	7.75	355		0.00499	0.46		0.99	
South Davis Cr. Nr mouth	1998	7	8		0.08	27	8.2	7.31	361		0.00499	0.58		0.99	
Davis Cr. 0.3 mi.bl. Odessa SE Lgn	1998	7	9			30	3.1	7.9	544		2.15	0.17		14	
Davis Cr. 0.3 mi.bl. Odessa SE Lgn	1998	7	9			27	0.2	7.58	537		1.9	0.11		23	
Davis Cr. 1.7 mi.bl. Odessa SE Lgn	1998	7	9			26	1.5	7.75	536		1.92	0.27		1.99	
Davis Cr. 1.7 mi.bl. Odessa SE Lgn	1998	7	9			28	4.4	7.48	543		2.02	0.24		6	
Davis Cr. 5.2 mi.bl. Odessa SE Lgn.	1998	7	9			29	11.8	7.7	403		0.03	0.8		0.99	
Davis Cr. 5.2 mi.bl. Odessa SE Lgn.	1998	7	9			26	5.4	7.92	398		0.04	0.86		1.99	
Davis Cr. 50 yds.ab. Odessa SE Lgn.	1998	7	9			28	7.7	8.13	447		0.00499	0.16		1.99	
Davis Cr. 50 yds.ab. Odessa SE Lgn.	1998	7	9			26	4	7.77	437		0.07	0.2		1.99	
Odessa SE Lgn. Effluent Trib.	1998	7	9			30	5.2	8.31	525						
Odessa SE Lgn. Effluent Trib.	1998	7	9			30	4.8	8.18	529		0.8	0.07		22	
South Davis Cr. Nr mouth	1998	7	9			28	11.1	7.4	347		0.01	0.27		3	
South Davis Cr. Nr mouth	1998	7	9			26	9.3	7.95	355		0.00499	0.35		0.99	
Davis Cr. 0.3 mi.bl. Odessa SE Lgn	2000	3	3	1205		6.3	12.6	8	732	1	0.02499	0.07	0.07	0.99	
Davis Cr. 0.3 mi.bl. Odessa SE Lgn	2000	3	3	810	0.45	6	9.8	7.7	728	1	0.02499	0.1	0.08	0.99	

Site Name	Yr	Mo	Dy	Time	Flow	C	DO	pH	SC	KJN	NH3N	NO3N	TP	CBOD	TSS
Davis Cr. 1.7 mi.bl. Odessa SE Lgn	2000	3	3	1215		7	11.4	8.1	651	0.499	0.02499	0.07	0.09	0.99	
Davis Cr. 1.7 mi.bl. Odessa SE Lgn	2000	3	3	750		7	9.4	7.9	656	1	0.02499	0.07	0.11	0.99	
Davis Cr. 5.2 mi.bl. Odessa SE Lgn.	2000	3	3	1230		7	14	8.7	529	0.499	0.02499	0.08	0.1	0.99	
Davis Cr. 5.2 mi.bl. Odessa SE Lgn.	2000	3	3	730	0.3	6.4	9.7	8	539	0.499	0.02499	0.09	0.13	0.99	
Davis Cr. 50 yds.ab. Odessa SE Lgn.	2000	3	3	1145	0.4	6.4	11.6	8	722	1	0.02499	0.02499	0.06	0.99	
Davis Cr. 50 yds.ab. Odessa SE Lgn.	2000	3	3	847	0.4	6	10.4	7.8	726	0.499	0.02499	0.02499	0.04	0.99	
Odessa SE Lgn. Effluent Trib.	2000	3	3			6	8.5	7	1230	1	0.02499	0.28	0.35	0.99	
Odessa SE Lgn. Effluent Trib.	2000	3	3	1150	0.05	6.5	10.8	7.3	805	1	0.02499	0.23	0.38	2	
South Davis Cr. Nr mouth	2000	3	3	1235		7.3	12.4	8.5	422	1	0.02499	0.49	0.08	2	
South Davis Cr. Nr mouth	2000	3	3	710		7.2	9.9	8.2	412	2	0.02499	0.56	0.12	2	
Davis Cr. 0.3 mi.bl. Odessa SE Lgn	2002	8	14	1445	0.67	25	4.4	7.8	619	5.83	2.42	0.26	1.77	10.2	14
Davis Cr. 0.3 mi.bl. Odessa SE Lgn	2002	8	14	632		20	4.6	7.8	671	6.79	2.75	0.02499	2.07	12.5	161
Davis Cr. 1.7 mi.bl. Odessa SE Lgn	2002	8	14	652		21	4.9	7.7	647	2.78	0.35	0.3	0.55	2.8	36
Davis Cr. 1.7 mi.bl. Odessa SE Lgn	2002	8	14	1416	3.2	25.5	6.1	8	654	2.47	0.27	0.31	0.52	4.7	24
Davis Cr. 3.3 mi.bl. Odessa SE Lgn.	2002	8	14	710	2.98	21	4.35	7.6	556	2.01	0.22	0.35	0.25	0.99	55
Davis Cr. 3.3 mi.bl. Odessa SE Lgn.	2002	8	14	1358		23	5	7.7	561	2	0.11	0.37	0.23	2.5	28
Davis Cr. 5.2 mi.bl. Odessa SE Lgn.	2002	8	14	727	1.05	19	6.2	7.9	484	1.11	0.02499	0.02499	0.1	0.99	2.499
Davis Cr. 5.2 mi.bl. Odessa SE Lgn.	2002	8	14	1337		30	8.4	8.9	474	1.15	0.02499	0.02499	0.11	0.99	2.499
Davis Cr. 50 yds.ab. Odessa SE Lgn.	2002	8	14	603		21	5.4	7.7	425	0.91	0.02499	0.07	0.12	0.99	16
Davis Cr. 50 yds.ab. Odessa SE Lgn.	2002	8	14	1508	1.54	25	5.4	7.8	436	0.66	0.02499	0.07	0.1	0.99	11
Odessa SE Lgn. Effluent Trib.	2002	8	14	616	0.44	24	6.9	8.4	659	7.57	1.31	0.02499	2.16	18.9	33
Odessa SE Lgn. Effluent Trib.	2002	8	14	1501		27	7	8.5	658	7.65	1.14	0.06	2.2	13.7	32
South Davis Cr. Nr mouth	2002	8	14	745	1.14	18.5	5.8	8.1	319	0.66	0.02499	0.02499	0.08	2.3	28
South Davis Cr. Nr mouth	2002	8	14	1324		22.5	7.2	8.7	313	0.84	0.02499	0.02499	0.08	0.99	13
Davis Cr. 0.3 mi.bl. Odessa SE Lgn	2002	9	11	700	0.2	21	0.499	8.2	729	6.27	1.49	0.02499	2.48	8.9	30
Davis Cr. 0.3 mi.bl. Odessa SE Lgn	2002	9	11	1339		23	4	8.1	702	6.59	1.23	0.1	2.51	18.6	88

Site Name	Yr	Mo	Dy	Time	Flow	C	DO	pH	EC	TKN	NH3N	NO3N	TP	FCol	TSS
Davis Cr. 1.7 mi.bl. Odessa SE Lgn	2002	9	11	716		22	1.6	8	727	2.62	0.36	0.22	0.91	3	90
Davis Cr. 1.7 mi.bl. Odessa SE Lgn	2002	9	11	1312	0.16	24	4.2	7.8	718	2.73	0.28	0.23	0.91	3	14
Davis Cr. 3.3 mi.bl. Odessa SE Lgn.	2002	9	11	1247		22	2.9	7.7	691	2.19	0.18	0.31	0.24	0.99	11
Davis Cr. 3.3 mi.bl. Odessa SE Lgn.	2002	9	11	728	0.01	21	1.3	7.9	706	2.31	0.2	0.3	0.26	0.99	18
Davis Cr. 5.2 mi.bl. Odessa SE Lgn.	2002	9	11	1231	0.02	25	5.9	8.4	336	0.78	0.02499	0.02499	0.13	0.99	54
Davis Cr. 5.2 mi.bl. Odessa SE Lgn.	2002	9	11	746		20	5.4	8.9	349	0.62	0.02499	0.02499	0.11	0.99	22
Davis Cr. 50 yds.ab. Odessa SE Lgn.	2002	9	11	1359		24	5.8	8	391	0.68	0.02499	0.02499	0.11	3	14
Davis Cr. 50 yds.ab. Odessa SE Lgn.	2002	9	11	627	0.17	20	3.1	7.9	393	0.98	0.02499	0.02499	0.13	2	50
Odessa SE Lgn. Effluent Trib.	2002	9	11	636	0.17	25	4.6	8.8	744	7.81	0.09	0.05	2.86	15.5	71
Odessa SE Lgn. Effluent Trib.	2002	9	11	1351		27	5.4	8.9	672	7.18	0.05	0.02499	2.78	19.6	57
South Davis Cr. Nr mouth	2002	9	11	759		19	2	8.1	395	0.86	0.02499	0.02499	0.13	5	39
South Davis Cr. Nr mouth	2002	9	11	1214		23	4.2	8.3	424	1.11	0.02499	0.02499	0.14	8	25

Davis Creek Macroinvertebrate Data

Sample No.	Water-body	Sea-son	Year	TRw Chiro	EPT TAXA	Biw Chiro	Siw Chiro	Biw Chiro	SlwChiro	TR_Q	TR_B	Score_TRwCh
984847	Davis Ck	S	1998	70	12	7.427963	2.530365	7.427963	2.530365	71	36	3
984848	Davis Ck	S	1998	48	5	8.105818	2.916503	8.105818	2.916503	50	25	3
988957	Davis Ck	F	1998	69	10	7.116121	2.486257	7.116121	2.486257	68	34	5
988958	Davis Ck	F	1998	55	4	7.834953	3.087497	7.834953	3.087497	58	29	3

EPT_Q	EPT_B	Score_EPTTaxa	BI_Q	Score_BIwCh	SI_Q	SI_B	Score_SIwCh	Total_Score	NVAL	CriteriaCat
13	6	3	6.448843	3	2.800808	1.400404	3	12	13	RP_S_W_PMOBL
8	4	3	7.156479	3	2.29318	1.14659	5	14	9	GP_S_W_PMOBL
13	6	3	7.053335	3	3.077887	1.538944	3	14	11	RP_F_W_PMOBL
6	3	3	7.332527	3	2.88778	1.44389	5	14	8	GP_F_W_PMOBL

Missouri Department of Natural Resources
Water Pollution Control Program

Total Maximum Daily Loads (TMDLs)

for

Clear Creek
Barry County, Missouri

Completed July 22, 1999
Approved December 1, 1999

Clear Creek (Monett, Missouri)
Final TMDLs (Total Maximum Daily Load)
For BOD, Ammonia, and Suspended Solids
(three TMDLs total)

Waterbody: Clear Creek

Missouri WBID No.: 3239

Missouri Class: C (Class C streams may cease flow in dry periods but maintain permanent pools which support aquatic life)

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

Pollutants: Biological Oxygen Demand (BOD)
Suspended Solids (NFR)
Ammonia (NH_3)

TMDL Priority: High

1. Description of Waterbody, Pollutant(s) of Concern, Pollutant Source(s) and Priority Ranking

Clear Creek, Missouri WBID No.: 3239, is a Class 'C' Ozark stream. Class C streams may cease flow in dry periods but maintain permanent pools that support aquatic life. A three-mile segment of this stream is impaired for aquatic life, livestock and wildlife watering, and fish consumption. The impaired segment stretches from Sec. 36 to Sec. 28 of T26N & R28W in Barry County and has a high TMDL priority ranking. The three pollutants of concern are Ammonia, BOD, and Suspended Solids (NFR - nonfilterable residue).

Monett Wastewater Treatment Plant (WWTP) is the sole source of pollution in Clear Creek. The WWTP serves the entire city of Monett, including sizeable discharges of organic wastewaters from food processing industries located within the city. Recurring mechanical problems at the WWTP and intermittent flows of high BOD influent from food processing industries within the city led to frequent exceedences of the NPDES permits (BOD and NFR monthly averages of 30 mg/l).

The Missouri Attorney General's Office initiated legal action in December 1988, against the city due to chronic noncompliance with permit limits.

Clear Creek had exceedences of state Water Quality Standards for dissolved oxygen (DO) and ammonia for 2-3 miles downstream of the discharge point during periods when the WWTP was operating normally and caused occasional severe water quality problems for many more miles when the WWTP was not operating properly. State Water Quality Standards require a minimum of 5.0 mg/l-dissolved oxygen or maintenance of at least the normal "background" dissolved oxygen minimum. Standards also require a maximum of 2-mg/l ammonia-N in summer, 3.1 mg/l spring and fall and 3.2 mg/l in winter in Clear Creek. A water quality study[1] in September 1978, found dissolved oxygen levels of 2-3 mg/l two miles downstream of the outfall, ammonia levels of 7.5-11 mg/l just below the discharge and 2-3 mg/l two miles downstream. In water quality studies done in July and September 1985, dissolved oxygen levels were at or slightly below 2 mg/l one mile downstream and 2-2.5 mg/l two miles downstream. Ammonia levels were 2-3 mg/l just downstream of the discharge and about 1.5-2 mg/l one mile downstream. At various times during these surveys and other times when the stream was observed by DNR personnel, deposits of solids discharged by the WWTP were also noted to be a problem. Missouri DNR, Water Pollution Control Program, used the data from the water quality surveys conducted in 1978 and 1985 to configure and verify the Qual2e water quality model of approximately 3.5 miles of Clear Creek below the wastewater discharge. This model was then used to predict reductions in effluent strength of CBOD and ammonia necessary to meet instream water quality standards. This model was completed in March 1990, and was subsequently forwarded to USEPA Region VII for review.

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

Missouri's Water Quality Standards are in 10CSR20-7.031. There are no state water quality standards for BOD. BOD is of concern because it can cause low levels of dissolved oxygen in receiving waters. The Missouri dissolved oxygen standards are used in this TMDL as the surrogate for BOD. The DO standard is linked to the BOD loading, and this TMDL sets the load allocations of BOD in order to meet the water quality standards for DO. This linking is accomplished by using the Qual2e model.

Applicable numeric (acute) criteria for ammonia and dissolved oxygen within mixing zones:

Pollutant	Summer	Spring & Fall	Winter
Ammonia	22.4 mg/l	24.6 mg/l	25.8 mg/l
Dissolved Oxygen	3.0 mg/l		

Applicable numeric criteria for ammonia and dissolved oxygen beyond mixing zones:

Pollutant	Summer	Spring & Fall	Winter
Ammonia	2.0 mg/l	3.1 mg/l	3.2 mg/l
Dissolved Oxygen	5.0 mg/l or normal "background" DO minimum		

If the 5-mg/l concentration of DO beyond the mixing zone cannot be maintained under natural conditions, the Missouri standards allow the natural DO profile of the stream to be used. For this segment, the applicable DO standard is a warm weather 7-day mean minimum of 4 mg/l.

[1] Stream Surveys of Clear Creek were completed by the Missouri DNR, Environmental Services Program, in Sept. 1978 and July and Sept. 1985. Reports were not published but are on file at the MDNR, Water Pollution Control Program, Jefferson City, Mo.

The applicable criterion for suspended solids is the narrative criterion in 10 CSR 20-7.031 section (3)(C) that states:

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

Instream deposition of suspended solids is also addressed by another portion of the narrative criteria, section (3)(A) that 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."

Missouri links this suspended solids narrative standard to a numeric criterion based on experience at other relatively large wastewater discharges into small receiving streams. This experience has shown that a suspended solids concentration of 30 mg/l is protective year round. As a result, the narrative suspended solids standard is interpreted as a numeric target concentration of 30 mg/l, which can be converted using the flow into a numeric target loading for suspended solids.

Missouri's Water Quality Standards include the EPA "three-tiered" approach to anti-degradation.

Tier 1 defines baseline conditions for all waters. It requires that existing beneficial uses be protected. TMDLs would normally be based on this tier, assuring that numeric criteria such as dissolved oxygen and ammonia concentrations are met to protect uses.

Tier 2 requires no degradation of high-quality waters, 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 1 criteria.

Tier 3, the most stringent tier, applies to waters designated in the Water Quality Standards as outstanding state and national resource waters. Tier 3 requires no degradation under any conditions. Management may require no discharge or prohibit certain polluting activities. TMDLs would need to assure no measurable increase in pollutant loading.

These TMDLs satisfy Tier 1 of Missouri's anti-degradation policy, since after these TMDLs have been implemented, water quality in the impaired segment will be improved and meet the applicable standards, and the beneficial uses will be protected.

3. Loading Capacity – Linking Water Quality and Pollutant Sources

The loading capacity of a pollutant is calculated from the flow and the instream numeric criterion. The flow is variable, and the worst-case value used to calculate the loading capacity. The worst-case condition for WWTP discharges is the low flow condition. Missouri uses the 7Q10 for the low flow value.

The loading capacity can be calculated at any point within a stream. In this TMDL, the pollutant source is a WWTP discharge. Missouri statutes allow WWTP discharges to have a mixing zone, and requires only acute criteria to be met within this mixing zone. The chronic criteria must be met beyond the allowed mixing zone. In these TMDLs, the loading capacity is calculated at the WWTP discharge pipe, before the mixing zone. Therefore, the instream water quality standard that must be met at the end of the mixing zone must be linked to the pollutant concentration or load in the discharge. This link is provided by the Qual2e model.

Requiring the instream concentration of each pollutant meet the instream water quality standard at the end of the mixing zone, the Qual2e model predicted the end-of-pipe maximum concentration allowable. The allowable CBOD concentration is 5.5 for summer and 10mg/l for winter. The allowable ammonia N concentration is 2.8 for summer, 4 for spring/fall, and 3.8 mg/l for winter. Missouri believes that BOD and CBOD are equivalent for the purposes of managing dissolved oxygen, and use the two interchangeably in this TMDL (see footnote 2).

Since the 7Q10 low flow is zero, the design flow for Clear Creek is the design flow of the Monett WWTP, 3.7 MGD or 5.7 cfs. Using Formula 1 below, the CBOD[2] load capacity as determined in the discharge from the WWTP is 154 pounds in spring, fall and summer and 308 pounds in winter. Ammonia load capacity in the discharge is 123 pounds/day in spring and fall, 86 pounds/day in summer and 117 pounds/day in winter.

(CBOD in mg/l)(Flow in cfs)(5.4) = (Pounds per day) (1)

Based upon experience at other relatively large wastewater discharges to small streams[3], a suspended solids concentration of 30 mg/l was felt to be protective year round. Using Formula One this would result in a suspended solids load capacity of 924 pounds per day.

These loading capacities are for the WWTP discharge, and may be allocated to the wasteload. As mentioned before, the upstream flow is zero at the critical condition, and so the upstream load contribution is zero for these pollutants. These loading capacities will result in the attainment of the water quality standards beyond the allowed mixing zone for all the pollutants.

4. Load Allocation (LA)

All loads to Clear Creek during conditions when Water Quality Standards exceedences occur are point source loads. There are no non-point source loads during water quality critical periods. Therefore, the load allocations for all pollutants in these TMDLs are zero because there is no upstream flow at the 7Q10 low flow and only very rarely at other times due to the losing stream nature of upper Clear Creek and tributaries.

---

[2] CBOD would be 5 mg/l less than BOD.

[3] A review of receiving stream impacts below 179 wastewater lagoons and 77 mechanical wastewater treatment plants was conducted in 1999. Lagoons allow NFR limits of 60 to 80 mg/l. Forty-nine of the 179 lagoons queried (27%) had observed instream impairment due to suspended solids. Only 2 of 77 mechanical plants (3%) had observed instream impairment due to suspended solids. Mechanical plants have NFR limits that are typically 30 mg/l with a few plants having 45 mg/l limits. Thus, we believe that NFR limits of 30-45 are generally protective while limits above 60 may not be. We believe this provides justification for the use of 30 mg/l as the proposed point source load concentration for suspended solids.

5. Wasteload Allocation (WLA)

The wasteload allocation of the single point source is the loading capacity minus the load allocation minus the margin of safety minus the load allocation reserved for future growth. The allocation reserved for future growth is zero. The wasteload allocations for the Monett WWTP are:

(loading capacity) - (margin of safety) - (load allocation) - (held in reserve) = wasteload allocation

Suspended Solids (discharge from the pipe):

(924 lb/da) - (462 lb/da) - (0) - (0) = 462 pounds per day suspended solids year round

CBOD (discharge from the pipe):

Spring Summer Fall:

(154 lb/da) - (15.4 lb/da) - (0) - (0) = 138.6 pounds per day CBOD

Winter:

(308 lb/da) - (30.8 lb/da) - (0) - (0) = 277.2 pounds per day CBOD

Ammonia as N (discharge from the pipe):

Spring Fall:

(123 lb/da) - (12.3 lb/da) - (0) - (0) = 110.7 pounds per day NH_3 as N

Summer:

(86 lb/da) - (8.6 lb/da) - (0) - (0) = 77.4 pounds per day NH_3 as N

Winter:

(117 lb/da) - 11.7 lb/da) - (0) - (0) = 105.3 pounds per day NH_3 as N

Summarizing, 462 pounds per day of suspended solids is allocated to the Monett WWTP discharge before the mixing zone. The CBOD allocations to the discharge before the mixing zone are 138.6 pounds per day for spring, summer, and fall, and 277.2 pounds per day for winter. The ammonia N allocations to the discharge before the mixing zone are 110.7 pounds per day for spring and fall, 77.4 pounds per day for summer, and 105.3 pounds per day for winter.

If monitoring data indicates that applicable water quality standards are not being met, these TMDLs will be reopened and these allocations will be re-evaluated.

6. Margin of Safety

These TMDLs are based on technical work performed in the 1980s and early 1990s, which resulted in the issuance of an NPDES permit and a WWTP upgrade that was completed in 1996. This prior work allocated the maximum loading to the discharging facility that would meet instream applicable water quality standards.

When a model, such as Qual2e, is used to determine allowable loading, it is acceptable to use an implicit margin of safety by selecting conservative estimates of model parameters. The implicit margin of safety is not selected in these TMDLs because conservative estimates were not selected. The margins of safety in these TMDLs are being set as follows:

BOD: The Qual2e Model predictions performed in the early 1990s of in-stream dissolved oxygen showed that none of the seasonal limits will allow maintenance of 5 mg/l dissolved oxygen, and advanced water treatment limits were placed in the NPDES permit. More recent data does not exist, and therefore, it is not possible at this time to obtain quantitative estimates of the uncertainty in the predicted instream dissolved oxygen due to BOD loading. Therefore, the margin of safety for the BOD loading is set at 10% of the loading capacity. If in the future, monitoring data shows that the DO standard is not attained, then this TMDL will be re-opened and the margin of safety will be re-evaluated. The margin of safety for BOD is 15.4 pounds per day in spring, summer, and fall, and 30.8 pounds per day in winter. These numbers apply to the loading at the discharge of the WWTP.

Ammonia: The ammonia limits in the issued NPDES permit were set based on allocating 100% of the load capacity to the Monett WWTP. More recent data does not exist, and therefore, it is not possible at this time to obtain quantitative estimates of the uncertainty in the predicted instream ammonia concentration beyond the mixing zone. Therefore, the margin of safety of the ammonia loading is set at 10% of the loading capacity. In the future, if the monitoring data shows that the ammonia standard is not attained, then this TMDL will be re-opened and the margin of safety will be re-evaluated. The margin of safety for ammonia is 12.3 pounds per day in spring and fall, 8.6 pounds per day in summer, and 11.7 pounds per day in winter. These numbers apply to the loading at the discharge of the WWTP.

Suspended Solids: Based on experience with large WWTP discharges to low flow streams, Missouri selected 50% of the load capacity for suspended solids as the margin of safety, which is 462 pounds per day year round. This number applies to the discharge of the WWTP.

7. Seasonal Variation

Seasonal variation has been addressed by establishing seasonal effluent limits at the Monett WWTP based on seasonal simulations using the Qual2e model.

Seasonal limits for BOD and Ammonia are necessary because decay of these substances is biologically mediated and varies with water temperature and because dissolved oxygen gas saturation varies with water temperature. The impact of suspended solids on the receiving stream is primarily physical (smothering of natural stream substrate) and is not related to water temperature or other seasonal effects

8. Monitoring Plan for TMDLs Developed under the Phased Approach

These are phased TMDLs. The facility completed an upgrade in the WWTP in 1996. DNR conducted a water quality survey of Clear Creek below the Monett WWTP in August 1999, and will conduct an additional water quality and invertebrate study of Clear Creek and a nearby stream without a point source discharge in 2000. The August data has not yet been evaluated. If these studies show compliance with Water Quality Standards, the TMDL will be considered completed. If these studies show noncompliance with Water Quality Standards, the data from these studies will be used to further refine the Qual2e stream model and the suspended solids allocation, as appropriate. If water quality standards are not met, these TMDLs will be re-opened and Missouri will re-evaluate the loading capacity and allocations, as appropriate. Then new water quality based permit limits will be issued that are protective of state water quality standards.

9. Implementation Plans

These TMDLs will be incorporated into Missouri's Water Quality Management Plan.

In prior work, an undated letter from Timothy Amsden, Acting Director of the Water Management Division, received by DNR July 9, 1990, contained EPA's approval that the model and its predicted acceptable effluent limits constituted an acceptable advanced treatment review for an EPA grant to fund new construction at Monett WWTP. A copy of the model and recommended treatment limits is included as an appendix.

NPDES Permit MO 0021440 was subsequently reissued and included a schedule of compliance that required the Monett WWTP to meet the following effluent limits (in mg/l) by August 15, 1996:

Pollutant	Spring/Fall	Summer	Winter
BOD	10	10	10
NFR	15	15	15
Ammonia-N	4.0	2.8	3.8

An upgrade of the Monett WWTP to meet these new water quality based limits was completed on schedule.

Presently, Missouri conducted a water quality survey in August 1999 and is in the process of evaluating the data. Missouri will conduct additional water quality monitoring and an invertebrate study in 2000. If these studies indicate that the applicable water quality standards are met, then these TMDLs will be successfully implemented. If not, then these TMDLs will be reopened and re-evaluated and modified as appropriate so that the instream water quality will meet the applicable Water Quality Standards.

10. Reasonable Assurances

There are no nonpoint sources of the pollutants in this segment, and the NPDES permit is the authority that assures the sole discharging point source facility will meet the wasteload allocations in these TMDLs.

11. Public Participation

The Missouri Department of Natural Resources, Division of Environmental Quality, Water Pollution Control Program, developed this TMDL. These TMDLs were public noticed from April 2 to May 7, 1999. Six public meetings to allow input from the public on impaired waters were held between August 18 and September 22, 1999. No comments pertaining to Clear Creek were received during the public notice or the public meetings.

12. Administrative Record

An Administrative Record for these TMDLs is being maintained by the Missouri DNR.

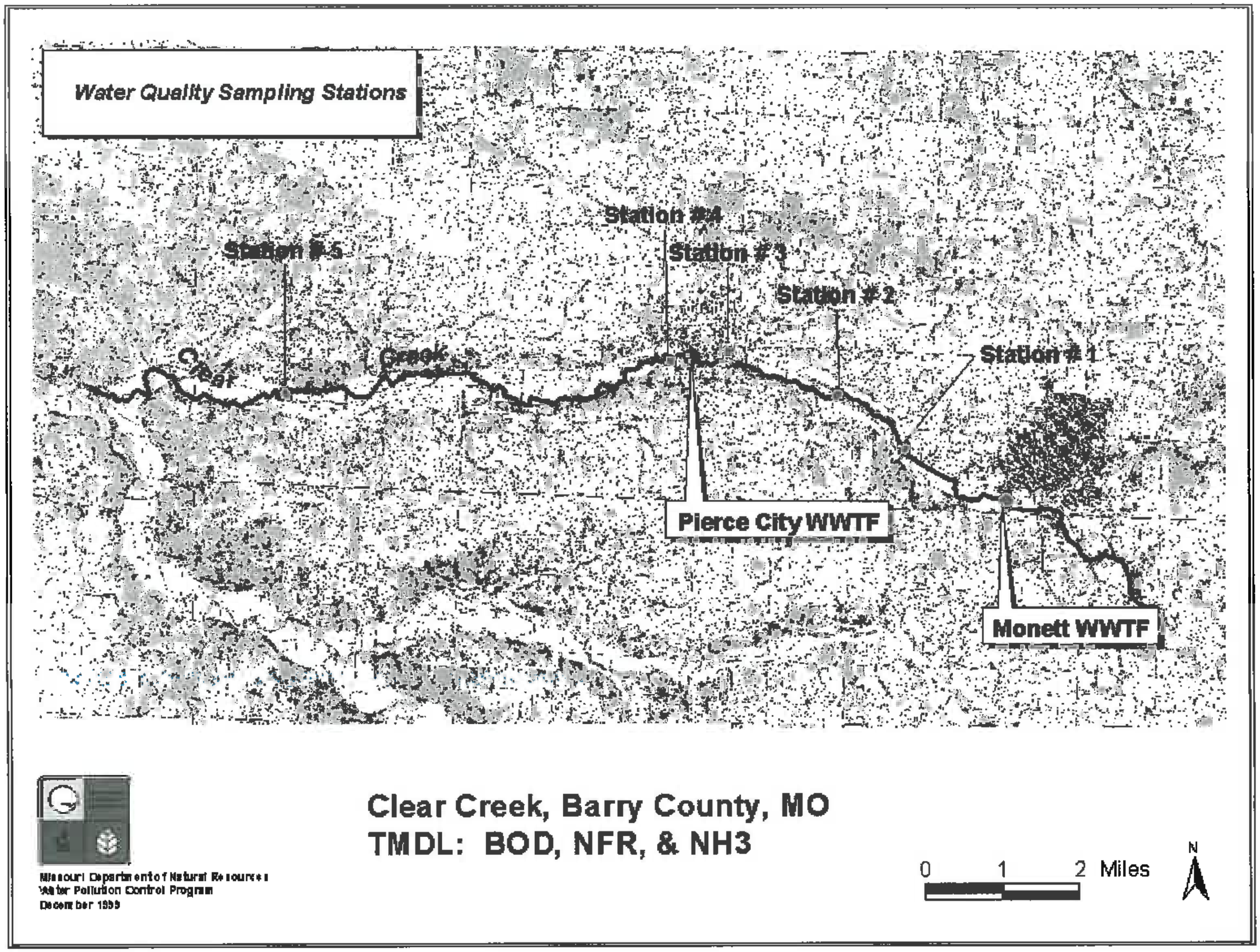
13. Data and Information Sources

The Missouri Department of Natural Resources, Environmental Services Program (ESP), in cooperation with the Water Pollution Control Program, collected all chemical and flow data pertaining to the impaired stream segment. This data and information is available upon request.

References Maintained as Administrative Record

1. Qual2e output

2. Mixing zone provisions of Missouri's Water Quality Standards (10 CSR 20-7.031(4)(A)(5))


Water Quality Sampling Stations
Station #5
Station #4
Station # 3
Station # 2
Station # 1
Clear
Creek
Pierce City WWTF
Monett WWTF
Missouri Department of Natural Resources
Water Pollution Control Program
December 1999
Clear Creek, Barry County, MO
TMDL: BOD, NFR, & NH3
0
1
2 Miles
N

Missouri Department of Natural Resources

Total Maximum Daily Load Information Sheet

Main Ditch

Water Body Segment at a Glance:

County: Butler
Nearby Cities: Poplar Bluff
Length of impaired segment: 14 miles
Length of impairment within segment: 1 mile
Pollutants 1, 2: Ammonia and pH
Source of 1, 2: Poplar Bluff Wastewater Treatment Plant, or WWTP
Pollutant 3: Temperature
Source 3: Channelization
Length of impairment within segment: 10 miles
Water Body ID: 2814

State map showing location of watershed

Scheduled for TMDL development: 2015

Description of the Problem

Designated beneficial uses of Main Ditch

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

Use that is impaired

- Protection of Warm Water Aquatic Life

Standards that apply

- Missouri's Water Quality Standards (WQS), 10 CSR20-7.031 Section (4)(E), state that water contaminants shall not cause pH to be outside of the range of 6.5-9.0 Standard Units (SU).
- The criteria for ammonia vary with water temperature and pH. At typical temperatures and a pH value of 7.8, ammonia criteria would be 1.5 mg/L in summer and 3.1 mg/L in winter (chronic). These values are taken from Table B3 in 10 CSR 20-7.031. Table B1 indicates that the acute criterion at a pH of 7.8 is 12.1 mg/L.
- The specific criteria for temperature are found in Missouri's Water Quality Standards, 10 CSR 20-7.031 (4)(D). There it states:

  Water contaminant sources or physical alteration of the stream shall not raise or lower the water temperature more than 5 °F (2.8 °C), or contribute to a stream temperature in excess of 90 °F (32 °C).

Background information and water quality data

Main Ditch begins south of Poplar Bluff, Mo., where Pike Creek drops off the Ozark Plateau and becomes a "bootheel" ditch. In 1988, three wastewater treatment lagoons serving Poplar Bluff were combined into one, which currently receives all of the city's wastewater and discharges it to Main Ditch. As a result of this wastewater discharge, ammonia, dissolved oxygen, pH and volatile suspended solids (VSS) levels violate the state's water quality standards.

History

A TMDL has already been approved for low dissolved oxygen biochemical oxygen demand (or BOD, related to low dissolved oxygen) and VSS. For more discussion on this TMDL, see the Main Ditch TMDL information sheet for dissolved oxygen., BOD and VSS[1]. The TMDL was approved by the U.S. Environmental Protection Agency, or EPA, Dec. 19, 2005[2]. The department has conducted several water quality studies in Main Ditch. In 2007, plans were made, and a contractor hired by the city of Poplar Bluff, to pursue a petition for site-specific criteria for dissolved oxygen in Main Ditch. Rationale for the site-specific criteria is the belief that the ditch has naturally low dissolved oxygen. This petition is stalled due to unresolved issues with EPA regarding its approvability and it has not been submitted. A new state operating permit that reflects the TMDL wasteload allocations was issued by the department Dec. 11, 2009, and subsequently has been appealed by the city. The deposition and hearing on the permit should occur in August or September 2010.

Ammonia

Ammonia is a common by-product of wastewater treatment and, under certain conditions, can be toxic to aquatic life. As mentioned above, the chronic water quality standard for protection of aquatic life for ammonia is temperature and pH dependent. A water is judged to be impaired if the chronic numeric criteria are exceeded on more than one occasion, with an exposure period of 30 days, during the last three years data is available. Based on consistently high pH values, high temperatures and exceedance of the ammonia criteria on all days sampled in 2002 at site 4 (see Table 1), 30-day exceedances are likely to have occurred. Additional data were collected in 2008. However, these data were considered incomplete, due to the lack of temperature data, and are insufficient to determine whether an impairment still exists. Therefore, a one-mile segment below the wastewater treatment facility is judged to be impaired by ammonia.

Table 1. 2002 Ammonia as Nitrogen Data for Main Ditch*

Site	Date	Temp	pH	NH3N (mg/L)
4	7/9/2002	35	9.9	0.22
4	7/9/2002	28	9.5	0.4
4	7/10/2002	35	9.7	0.23
4	7/10/2002	29	9.2	0.58
4	8/6/2002	33	8.8	0.62
4	8/6/2002	29	8.9	1.12
4	8/7/2002	33	9.5	0.37
4	8/7/2002	27	9.2	1.07

*Shaded cells indicate exceedances. At a temperature of 30 °C and a pH of 9.0 (the highest allowed under the standards), the ammonia criterion is 0.1 mg/L.

[1] Access the Information Sheet at: www.dnr.mo.gov/env/wpp/tmdl/info/index.html

[2] The approved TMDL can be found at: www.dnr.mo.gov/env/wpp/tmdl/wpc-tmdl-EPA-Appr.htm

pH

Acidic or alkaline waters can be toxic to aquatic life, so the criteria for pH is a range from 6.5-9.0. The evidence for the impairment is based on data gathered by the department in 2002 and 2008, and by MEC Water Resources, Inc. in 2008. Five of nine measurements (55.6 percent) failed to meet the criteria 0.5 mile downstream of the WWTP. This is greater than 10 percent, which is the guideline for judging impairment. In addition, 11 of 31 measurements (35.5 percent) violated the criteria further downstream, so a one-mile segment of Main Ditch was judged as impaired by pH (Figure 1).

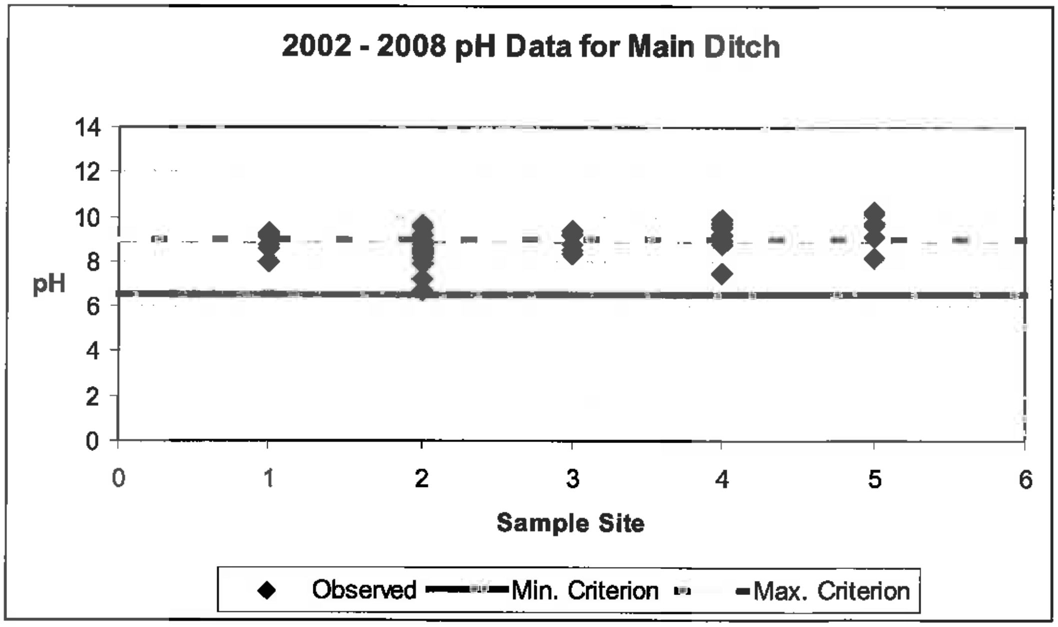


Figure 1

Temperature

The temperature impairment is caused by the creek being channelized. This means the meandering (winding) creek was straightened to facilitate draining the bottomlands and large scale farming. In the process, overhanging vegetation, that may have provided shade, was removed. One of the primary effects of channelization is an increase in the velocity of water moving downstream. This increase in velocity can contribute to a reduction in baseflow, which can be associated with higher stream water temperatures. For water temperature, a water body is judged as impaired if more than 10 percent of the measurements fail to meet the water quality standard. Eleven of 32 water temperature measurements (34.4 percent) on Main Ditch exceeded the criteria (Figure 2). Because high temperatures persist several miles below the wastewater treatment plant and are present in the upstream tributary, Pike Creek, it is believed there are additional unknown factors contributing to high temperature in Main Ditch.

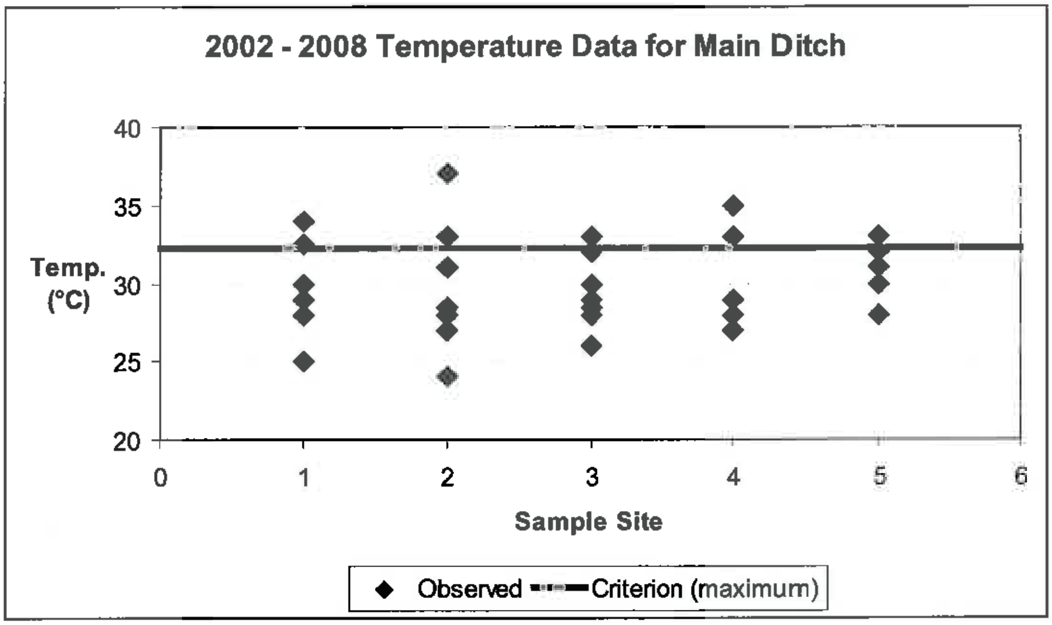
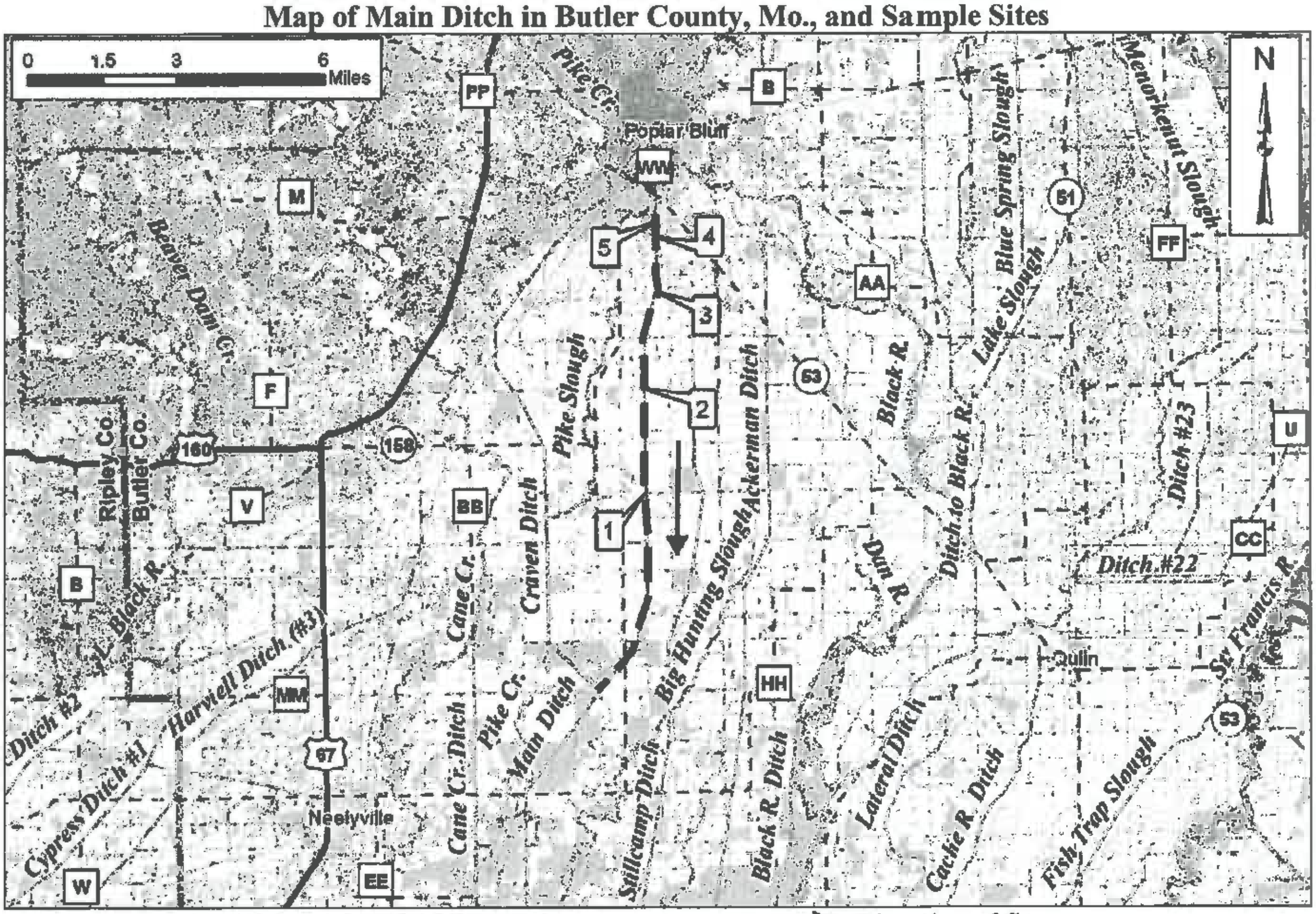


Figure 2

Map of Main Ditch in Butler County, Mo., and Sample Sites



Impaired Segment — Direction of flow

Sample site descriptions are on the next page.

Sample Sites

1 – Main Ditch 5.8 miles below Poplar Bluff lagoon outfall
2 – Main Ditch 3.8 mi. below Poplar Bluff lagoon outfall
3 – Main Ditch 1.5 miles below Poplar Bluff lagoon outfall
4 – Main Ditch 0.5 miles below Poplar Bluff lagoon outfall
5 – Poplar Bluff Lagoon Effluent

The final Main Ditch TMDL will be based on the most current available data and information. For TMDL status or additional information, please contact the Water Protection Program.

For more information call or write:

Missouri Department of Natural Resources
Water Protection Program
P.O. Box 176, Jefferson City, MO 65102-0176
1-800-361-4827 or 573-751-1300 office
573-522-9920 fax
Program Home Page: www.dnr.mo.gov/env/wpp/index.html

Missouri Department of Natural Resources
Total Maximum Daily Load Information Sheet

South Blackbird Creek

Water Body Segment at a Glance:

State Map Showing Location of Watershed

County: Putnam
Nearby Cities: Unionville and Martinstown
Length of impaired segment: 13 miles
Length of impairment within segment: 5.0 miles
Pollutant: Ammonia
Source: Unknown
Water Body ID: 0655

Scheduled for TMDL development: 2016

Description of the Problem

Beneficial uses of South Blackbird Creek

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

Use that is impaired

- Protection of Warm Water Aquatic Life

Standards that apply

- The criteria for ammonia are found in Missouri's Water Quality Standards at 10 CSR 20-7.031. These values are taken from Table B3 and vary with water temperature and pH. At typical temperatures and pH values, the chronic criterion[1] for ammonia would be 1.5 mg/L in the summer and 3.1 mg/L in the winter. The acute criterion at 7.8 pH for cool and warm-water fisheries is 12.1 mg/L.

[1] Acute criteria apply to short exposures to toxic conditions that aquatic creatures can survive without harm. Chronic criteria apply to conditions producing adverse effects of aquatic life or wildlife following long term exposure but having no readily observable effect over a short time period. Chronic criteria are much lower than the acute criteria.

Background information and water quality data

South Blackbird Creek is a northern Missouri prairie stream that flows east to join Blackbird Creek in southeastern Putnam County. Ammonia is a common by-product of wastewater treatment and, under certain conditions, can be toxic to aquatic life. However, there are no known sources of wastewater along the impaired segment, so the source of the ammonia is unknown. Evidence for this impairment is based on data gathered by the department from 2002-2006. A water body is judged to be impaired if the chronic or acute numeric criteria are exceeded on more than one occasion during the last three years for which data is available. In South Blackbird Creek, there were three exceedences of the chronic standard in last three years of data (see table below).

According to the Department's 2008 303(d) listing methodology[2], a water body must be in exceedance of the acute criterion continuously for 24 hours and the chronic criterion 30 days to be considered an exceedance of the standard. An assessment of available stream data using this methodology found that there is good evidence that the acute standard was exceeded once, on March 12, 2003. (data not shown). For the chronic criteria (table below), the sampling dates were too far apart to provide strong evidence that any of the exceedances exceeded 30 days in length. Thus, this stream is judged to be unimpaired by ammonia. However, ammonia levels in South Blackbird are typically high on some occasions and further monitoring should be scheduled to determine the source of this ammonia. South Blackbird Creek is on the current 303(d) List for ammonia and, according to the U.S. Environmental Protection Agency, the these data do not show "good cause" for delisting this stream for ammonia.

Ammonia as Nitrogen, or NH3N, Data for South Blackbird Creek

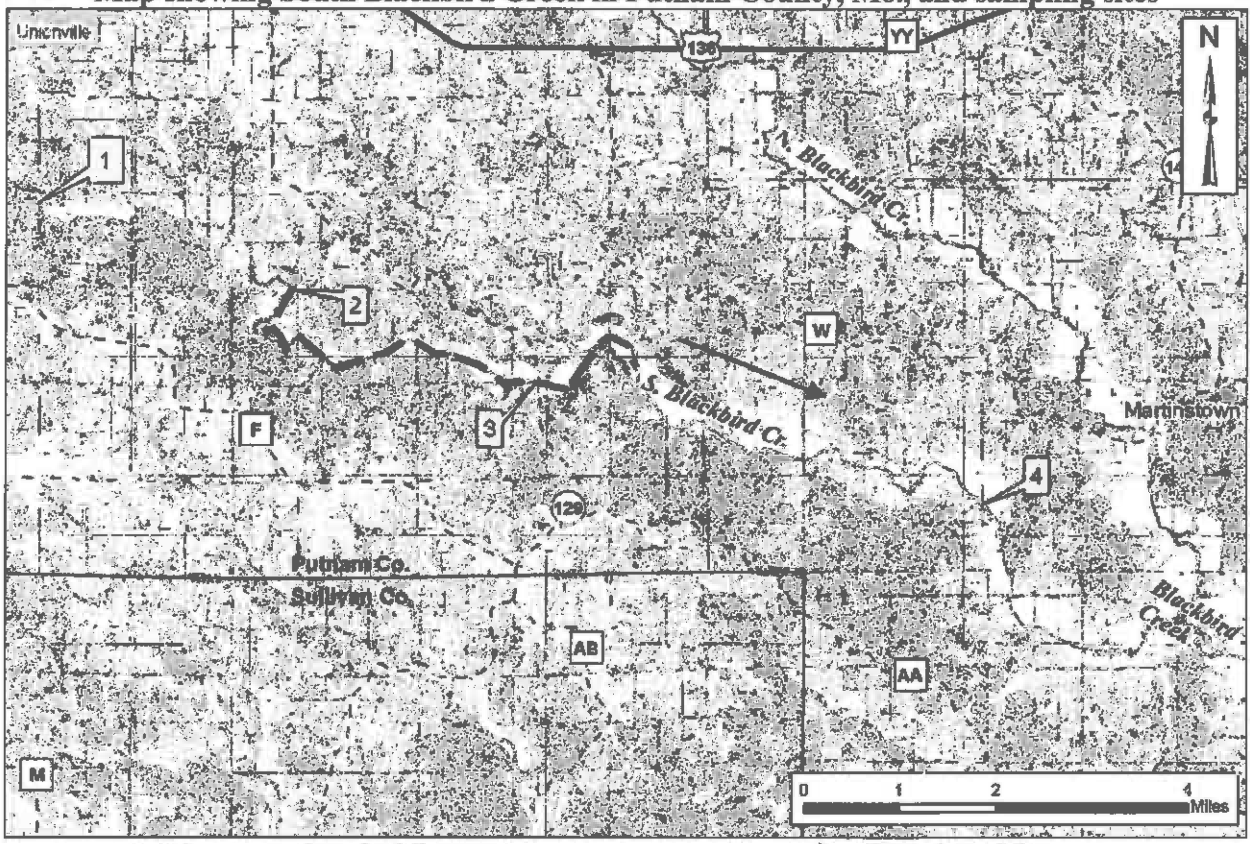
Site	Date	°C	pH	NH3N
2	12/10/02	2	7.9	1.5
2	1/14/03	0	8.2	3.89
2	3/18/03	17	8.5	0.14
2	3/12/03		7.7	2.74
1	7/14/05	20	7.7	1.26
1	11/9/05	8.7	8.1	0.67
1	5/26/06	19.8	7.6	2.61
3	7/14/05	21.9	7.7	0.5
3	11/9/05	10.3	7.7	0.03
3	2/17/06	0.7	7.9	5.08
3	5/26/06	20.3	7.9	0.12
4	7/14/05	23.4	8	0.01499
4	11/9/05	11.2	7.8	0.09
4	5/26/06	23.9	8	0.01499

Shaded cells indicate exceedance

On the next page there is a map of South Blackbird Creek showing the impaired segment and the location of the sampling sites.

[2] This methodology may be accessed at: www.dnr.mo.gov/env/wpp/waterquality/303d.htm

Map showing South Blackbird Creek in Putnam County, Mo., and sampling sites



Impaired Segment — Direction of flow

Sample Sites
1 – S. Blackbird Cr. at Premium Standard Farms Green Hills (Site 56)
2 – S. Blackbird Cr. at Fern Trail
3 – S. Blackbird Cr. at Hwy 129
4 – S. Blackbird Cr. 2.5mi. WSW of Martinstown

For more information call or write:

Missouri Department of Natural Resources
Water Protection Program
P.O. Box 176, Jefferson City, MO 65102-0176
1-800-361-4827 or 573-751-1300 office
573-522-9920 fax
Program Home Page: www.dnr.mo.gov/env/wpp/index.html

Missouri Department of Natural Resources

Total Maximum Daily Load Information Sheet

North Fork Spring River and Dry Branch (Fork[1])

Water Body Segment at a Glance:

Counties: Dade, Barton and Jasper
Nearby Cities: Lamar, Galesburg
Length of Impaired Segment - N. Fork Spring River
Water Body ID 3186: 14.5 miles
Pollutant: Bacteria
Source: Rural Nonpoint Source
Length of Impaired Segment
Water Body ID 3188: 51.5 miles
Pollutant 1: Bacteria
Source: Rural Nonpoint Source
Pollutant 2: Unknown
Source: Unknown
Pollutant 3, 4: Low Dissolved Oxygen, Ammonia
Source: Lamar Wastewater Treatment Plant
Length of Impairments
Within Segment 3188: 26.5 miles (dissolved oxygen)
51.5 miles (bacteria and unknown)
[none given] miles (ammonia)
Length of Impaired Segment – Dry Branch (Fork)
Water Body ID 3189: 9 miles
Pollutant: Bacteria
Source: Rural Nonpoint Source

Scheduled for TMDL development: 2013; 2016 (low DO)

Description of the Problem

Beneficial uses of North Fork Spring River and Dry Branch (Fork)

- Livestock and Wildlife Watering
- Protection of Warm Water Aquatic Life
- Protection of Human Health (Fish Consumption)
- Whole Body Contact Recreation – Category A (Dry Fork) and B (North Fork Spring River)
- Secondary Contact Recreation (WBID 3186 only)

Uses that are impaired

- Protection of Warm Water Aquatic Life (unknown, low DO and ammonia)
- Whole Body Contact Recreation – Categories A and B (bacteria)

[1] While this water body is named Dry Branch on the 2008 303(d) List, it is named Dry Fork on USGS topographic maps and in Missouri's water quality standards. The name will be corrected to Dry Fork and the length corrected to 10.2 miles in the 2010 303(d) List.

Standards that apply

- Missouri's water quality standards, or WQS, at 10 CSR 20-7.031(4)(C) state that the *E.coli* bacteria count shall not exceed 126 colonies per 100 milliliters of water (126 col/100 mL) for Category A and 206 col/100 mL for Category B. This count is the geometric mean during the recreational season (April 1- October 31) in waters designated for whole body contact recreation.
- In Table A of the Water Quality Standards, the criteria for dissolved oxygen, or DO, in streams is a minimum of 5 mg/L (milligrams per liter or parts per million).
- The standards for ammonia vary with water temperature and pH. At typical temperatures and pH values, a summer ammonia criterion would be 1.5 mg/L with a winter criterion of 3.1 mg/L. These values are taken from Table B3 in 10 CSR 20-7.031.
- Because North Fork Spring River is also impaired by other unknown pollutants, specific criteria cannot be cited. However, all Missouri streams are protected by the general criteria found in 10 CSR 20-7.031 (3). The general criteria that could apply to North Fork Spring River 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.

Background information and water quality data

The North Fork of the Spring River is a major tributary to the Spring River, which flows into Kansas just north of Joplin, Missouri. Around Lamar, the river it is known locally as Muddy Creek. A TMDL for sediment was written for the North Fork and approved by the U.S. EPA in Oct. 2006.

The name and length of Dry Branch were corrected in the 10/30/09 revision of the Missouri's WQS to Dry Fork, length 10.2 miles. It is a tributary to the North Fork Spring River, entering at Carytown in Jasper County (see map on last page).

Bacteria

Evidence for the bacteria impairment is based on monitoring conducted by the Jasper County Health Department and the Carthage High School Stream Team in 2007. Excessive amounts of fecal bacteria in surface water used for recreation are an indication of an increased risk of pathogen-induced illness to humans. Infections due to pathogen-contaminated waters include gastrointestinal, respiratory, eye, ear, nose, throat and skin diseases. *E. coli*, are bacteria found in the intestines of warm blooded animals and are used as indicators of the risk of waterborne disease from pathogenic (disease causing) bacteria or viruses. Most *E. coli* strains are harmless, but some can cause serious illness in humans and are occasionally responsible for product recalls. The harmless strains are part of the normal flora of the intestines, and can benefit their hosts by preventing the establishment of pathogenic bacteria within the intestine[2,3]. Missouri's bacteria criteria are based on specific levels

---

[2] Hudault S, Guignot J, Servin AL (July 2001). "*Escherichia coli* strains colonising the gastrointestinal tract protect germfree mice against *Salmonella typhimurium* infection". *Gut* **49** (1): 47–55

[3] Reid G, Howard J, Gan BS (September 2001). "Can bacterial interference prevent infection?". *Trends Microbiol.* **9** (9): 424–8.

of risk of acute gastrointestinal illness. The levels of risk correlating to these criteria are no more than eight illnesses per 1,000 swimmers in fresh water.

Dry Fork is designated as Category A for the whole body contact recreation use, which means it has swimming areas that are open to and fully accessible by the public. The geometric mean of the 2007 recreational season data was 488 col/100 mL, which exceeds the *E. coli* criterion of 126 col/100 mL for Category A waters (Figure 1).

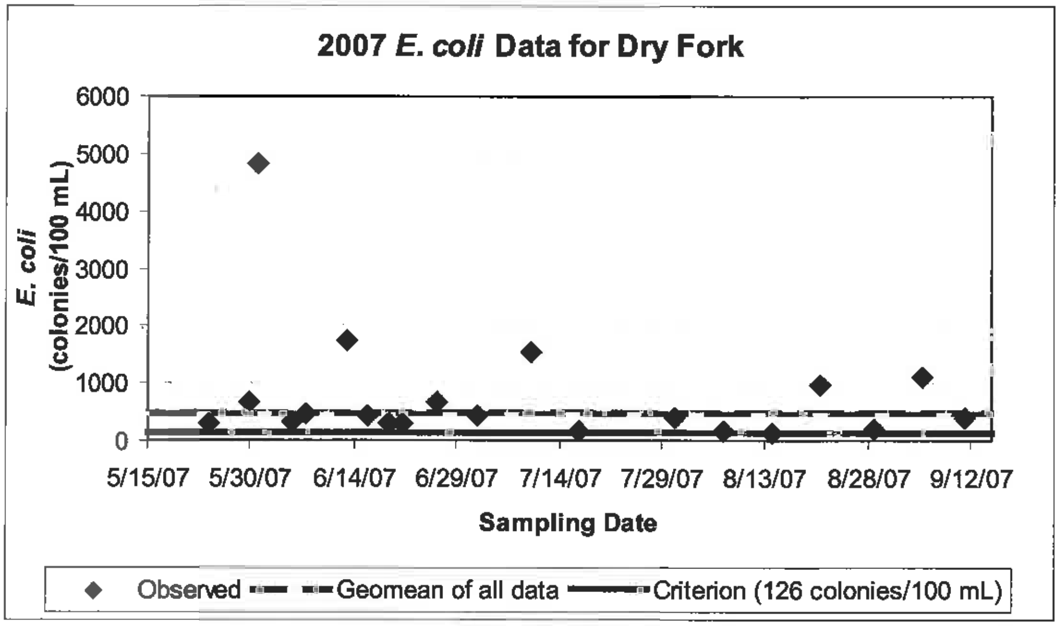


Figure 1

North Fork Spring River is designated as Category B for the whole body contact recreation use, which means it has places deep enough for total immersion (i.e., swimming), but they may be on private lands or inaccessible to the public. The geometric mean of 488 col/100 mL for the 2007 recreational season data from both segments of North Fork Spring River (WBIDs 3186 and 3188) exceeded the *E. coli* criterion of 206 col/100 mL for Category B waters (Figure 2).

People can protect themselves from waterborne illness by avoiding contact with contaminated water. However, when swimming anywhere, it is wise to take common sense precautions. These include washing hands before eating, showering after swimming and avoiding exposure to questionable water if you have open cuts or wounds.

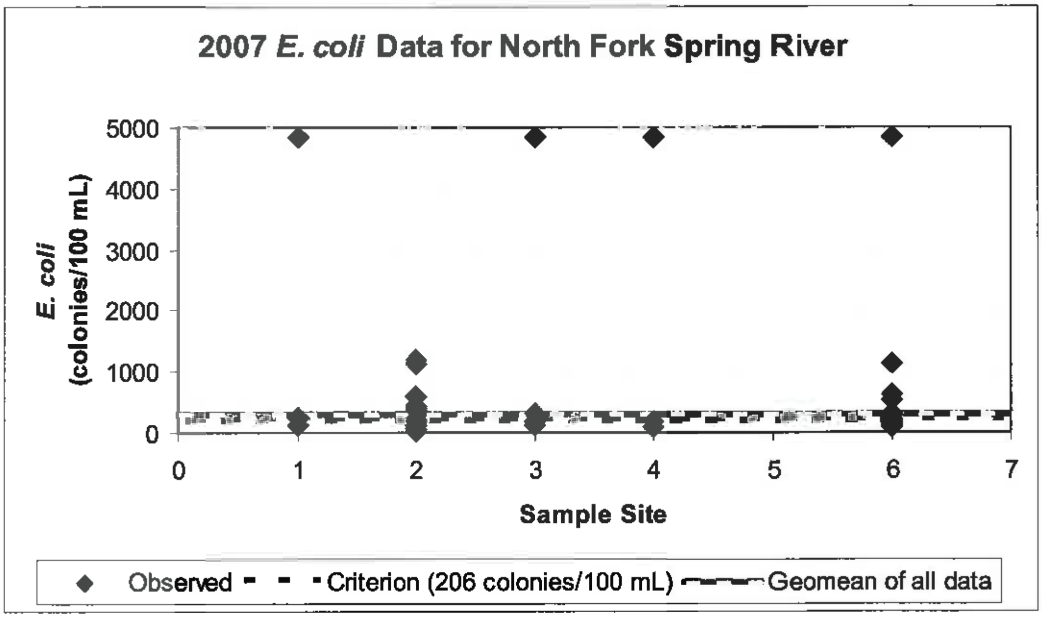


Figure 2

Dissolved Oxygen

For dissolved oxygen, or DO, if more that 10 percent of measurements in a water body fail to meet the water quality criteria, that water body is judged to be impaired. In the case of North Fork Spring River, evidence of low DO is based on monitoring by the department from 2003-07. Of these data, 1192 of 1415 samples (84.2 percent) did not meet the DO water quality criterion of 5 mg/L (Table 1). This situation is believed to be caused by the Lamar Wastewater Treatment Plant, or WWTP. Wastewater effluent that is high in biochemical oxygen demand will lower the dissolved oxygen in a stream and stress, or be lethal to, the aquatic organisms that require dissolved oxygen to survive. Like all wastewater discharges in Missouri, the Lamar WWTP must meet the requirements of a discharge permit issued by the Missouri Department of Natural Resources. The limits in this permit can be adjusted to prevent the creek from being impaired.

Table 1. Dissolved Oxygen Data for North Fork Spring River

Site	From	To	No. Samples	No. <5 mg/L	Percent <5
15 - 20	2003	2007	15	1	6.7
17	8/28/2006	8/31/2006	303	298	98.3
14	7/31/2006	8/4/2006	382	291	76.2
10 - 14	2003	2007	40	26	65
8	8/7/2006	8/10/2006	332	330	99.4
5	2003	2007	11	3	27.3
5	8/7/2006	8/10/2006	332	243	73.2
			1415	1192	84.2*

*Frequency of exceedance for all data is greater than 10 percent, thus indicating an impaired condition.

Ammonia

Ammonia is a common by-product of wastewater treatment and, under certain conditions, can be toxic to aquatic life. Again, evidence for this impairment is based on data gathered by the department from 2003-07. A water body is judged to be impaired if the chronic or acute numeric criteria are exceeded on more than one occasion during the last three years for which data is available. In the North Fork Spring River, there were two exceedences of the acute (one hour exposure) criterion on two consecutive days in 2005 (Table 2). Like all wastewater discharges in Missouri, the Lamar WWTP must meet the requirements of a discharge permit issued by the Missouri Department of Natural Resources. The limits in this permit can be adjusted to prevent the creek from being impaired.

Table 2. Ammonia as Nitrogen (NH_3N) Data for North Fork Spring River Exceedances highlighted*

Site Number	Sample Date	Temp (°C)	pH	NH_3N (mg/L)
19	9/22/2003	19	8	3.56
12	7/27/2005	23.5	8	9.34
12	7/27/2005	25.7	8	8.15
12	7/28/2005	22.9	7	8.71
12	7/28/2005	27.4	9	7.82
10	8/30/2004	24	7	4.22
8	9/27/2006	18	8	2.91

* Ammonia criteria are pH and temperature dependant

Unknown

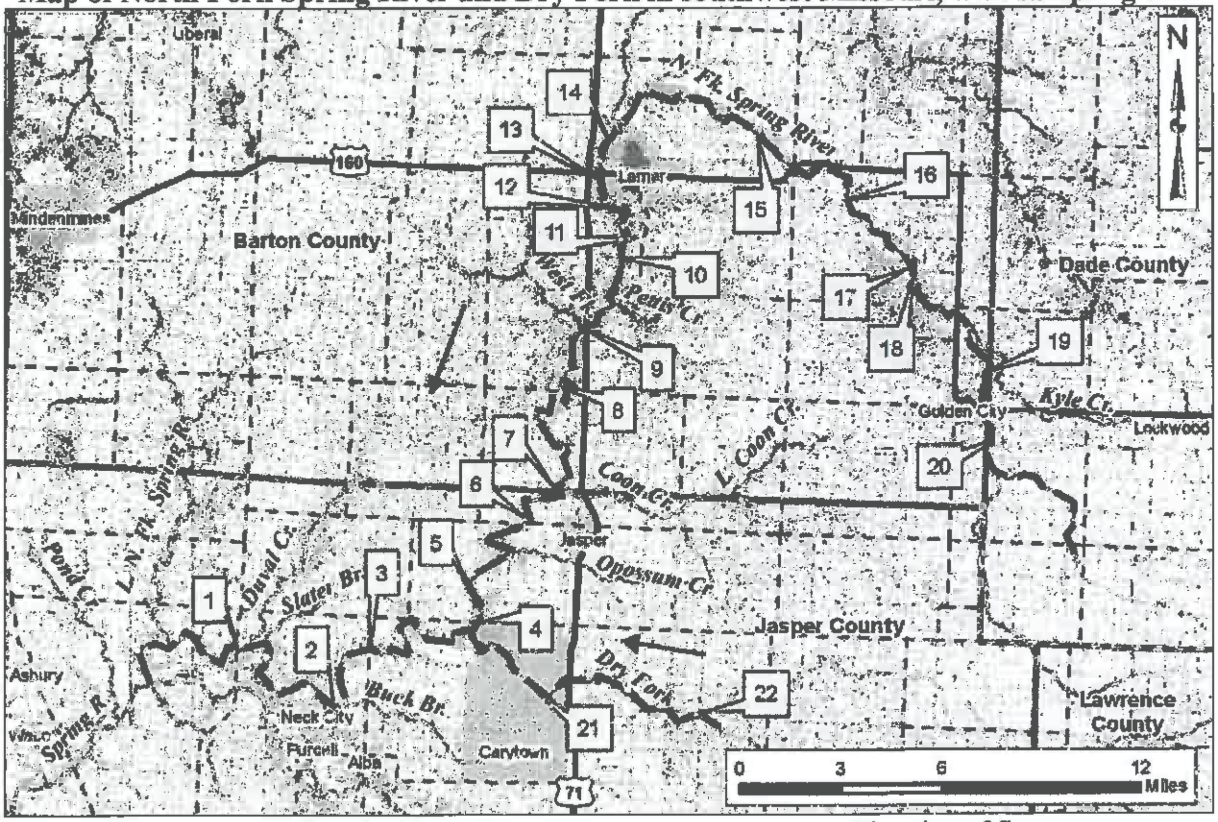
The unknown impairment is based on biological data gathered by the department when they monitored invertebrate community in 2003, 2004, 2006 and 2007. A Stream Condition Score of 16 or higher indicates no impairment (Table 3). Reference streams in this ecological drainage unit score 16 or higher on 90.9 percent of riffle/pool samples. For North Fork Spring River, only 13 of 33 samples, or 39 percent, received a score of 16 or higher so it is judged to be impaired. However, the cause of the substandard biological community is unknown.

Table 3. Aquatic Macroinvertebrate data for North Fork Spring River (2003 – 2007)

Site Number	No. of Samples	No. of Samples ≥16*	Percentage of Samples ≥16
5	2	1	50%
7	2	2	100%
8	2	2	100%
9	2	0	0%
10	2	1	50%
14	4	2	50%
15	2	1	50%
16	4	1	25%
17	2	1	50%
18	5	2	40%
19	3	0	0%
20	3	0	0%
		Total No. of Samples =	33
		Total No. of Samples ≥16 =	13
		Percentage of Total Samples ≥16 =	39%

*Scores greater than or equal to (≥) 16 indicate no impairment

Map of North Fork Spring River and Dry Fork in southwest Missouri, with sampling sites



Impaired Segment   Direction of flow

Sample Sites				
Site #	Site Description		Site #	Site Description
1	N. Fk. Spring R. at Hwy 43		12	N. Fk. Spring R. 0.5 mi.bl. Lamar WWTP
2	N. Fk. Spring R at CR 210		13	N. Fk. Spring R. just ab. Lamar WWTP
3	N. Fk. Spring R. at Hwy O		14	N. Fk. Spring R. at Lamar Heights
4	N. Fk. Spring R. at Hwy M		15	N. Fk. Spring R. ds NE 50th Ln.
5	N. Fk. Spring R 22 mi bl Lamar WWTP		16	N. Fk. Spring R. 12 mi.ab. Lamar
6	N. Fk. Spring R. nr Hwy H		17	N. Fk. Spring R. us SE 30th Rd.
7	N. Fk. Spring R 16 mi bl Lamar WWTP		18	N. Fk. Spring R. 15 mi.ab. Lamar
8	N. Fk. Spring R 10.5 mi bl Lamar WWTP		19	N. Fk. Spring R. 20 mi.ab. Lamar
9	N. Fk. Spring R. nr. Hwy. 71		20	N. Fk. Spring R. nr. SE 79th Road
10	N. Fk. Spring R 3.5 mi bl Lamar WWTP		21	Dry Fork at County Road 150
11	N. Fk. Spring R 2.7 mi bl Lamar WWTP		22	Dry Fork at County Road 100

The final North Fork Spring River TMDL will be based on the most current available data and information. For TMDL status or additional information, please contact the Water Protection Program at:

Missouri Department of Natural Resources, Water Protection Program
P.O. Box 176
Jefferson City, MO 65102-0176
1-800-361-4827 or 573-751-1300 office or 573-522-9920 fax
Program Home Page: dnr.mo.gov/env/wpp/index.html

Missouri Department of Natural Resources

Total Maximum Daily Load Information Sheet

Big Creek

Water Body Segment at a Glance:

County: Harrison
Nearby Cities: Bethany
Length of impaired segment: 22 miles
Length of impairment within segment (Pollutant): 1.0 mile (Ammonia)
6.0 miles (Low Dissolved Oxygen)
Source: Bethany Wastewater Treatment Plant
Water Body ID: 0444


State Map Showing Location of Watershed

Scheduled for TMDL development: 2016

Description of the Problem

Designated beneficial uses of Big Creek

- Livestock and Wildlife Watering
- Protection of Warm Water Aquatic Life
- Protection of Human Health (Fish Consumption)
- Public Drinking Water Supply

Use that is impaired

- Protection of Warm Water Aquatic Life

Standards that apply

- In the Missouri Water Quality Standards, found in 10 CSR 20-7.031 Table A, the criterion for dissolved oxygen, or DO, in streams is a minimum of 5.0 mg/L (milligrams per liter or parts per million).
- The criteria for ammonia vary with water temperature and pH. At typical temperatures and a pH value of 7.8, ammonia criteria would be 1.5 mg/L in summer and 3.1 mg/L in winter (chronic). These values are taken from Table B3 in 10 CSR 20-7.031. From Table B1, the acute criterion at this pH is 12.1 mg/L.

Background information and water quality data

The Bethany Wastewater Treatment Plant, or WWTP, discharges to Big Creek, a tributary of the Grand River, in northern Missouri. Water quality conditions in Big Creek are not protective of aquatic life. In water quality studies conducted by the department in July and Sept. 2003, the creek was found to be high in ammonia. Ammonia is a common by-product of wastewater treatment and, under certain conditions, can be toxic to aquatic life. The acute[1] ammonia standard was exceeded on three days (data in table). The chronic ammonia standard is based on a 30-day exposure, which could not be established by these shorter term studies. Even so, the ammonia criterion was consistently violated during low flow conditions, conditions which can persist in this portion of Big Creek for more than 30 days.

Ammonia as Nitrogen in Big Creek*

Site	Sample Date	NH3-N (mg/L)
3	23-Jul-03	13.4
3	24-Jul-03	11.2
3	3-Sep-03	17.9
3	4-Sep-03	15.6
2	23-Jul-03	1.96
2	24-Jul-03	1.83
2	3-Sep-03	9.45
2	4-Sep-03	8.71
1	24-Jul-03	0.01499
1	3-Sep-03	0.01499
1	4-Sep-03	0.01499

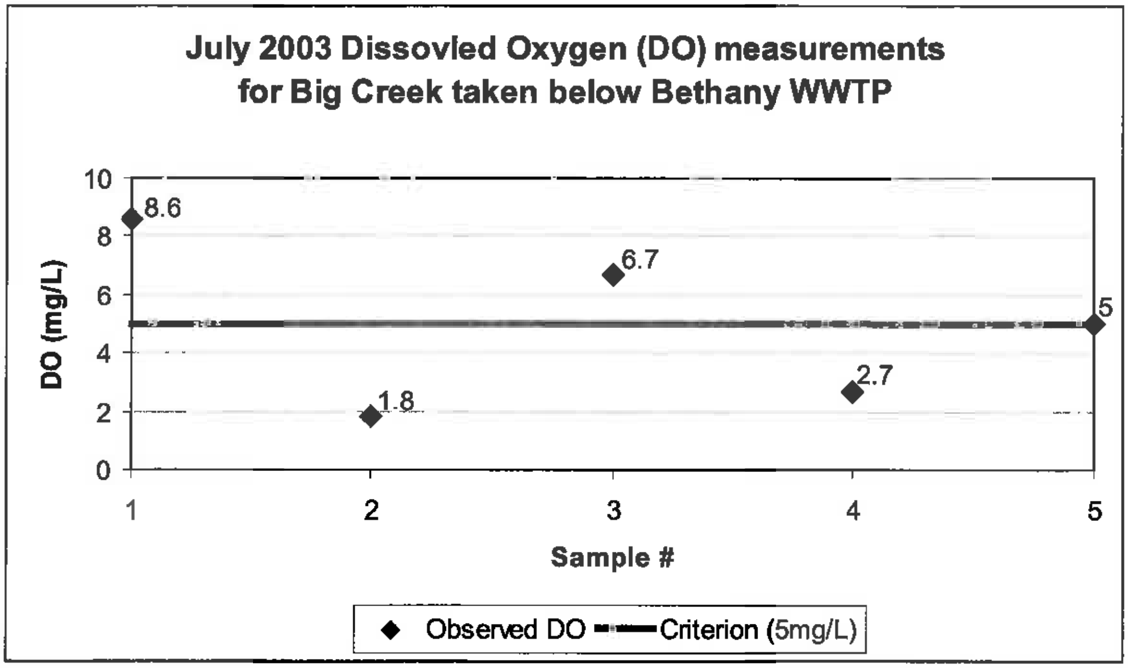
*shaded cells indicate exceedance of water quality criteria

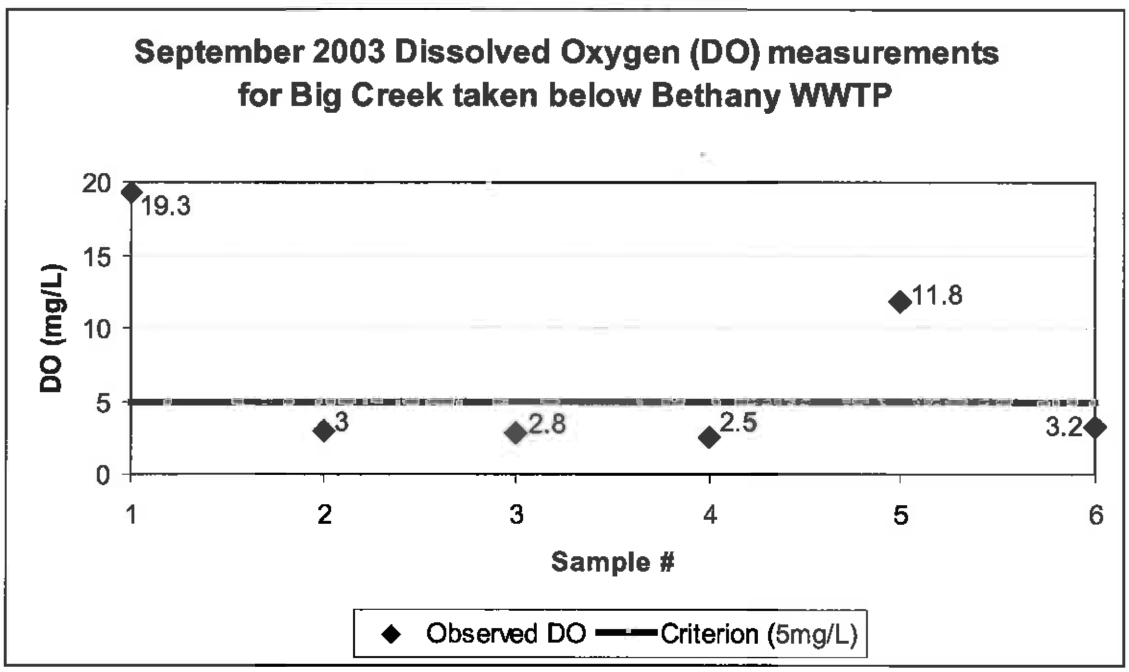
For dissolved oxygen, if more that 10 percent of measurements in a water body fail to meet the water quality criteria, that water body is judged to be impaired. During the 2003 studies, low levels of dissolved oxygen were documented in Big Creek in six of 11 samples (54 percent) taken from sites below the Bethany WWTP. The data from these samples are summarized in two charts on the next page.

Wastewater effluent that is high in biochemical oxygen demand, or BOD, will lower the dissolved oxygen in a stream and stress or be lethal to the aquatic organisms that require dissolved oxygen to survive. Like all wastewater discharges in Missouri, the Bethany WWTP must meet the requirements of a discharge permit issued by the Missouri Department of Natural Resources. The limits in this permit can be adjusted to prevent the creek from being impaired.

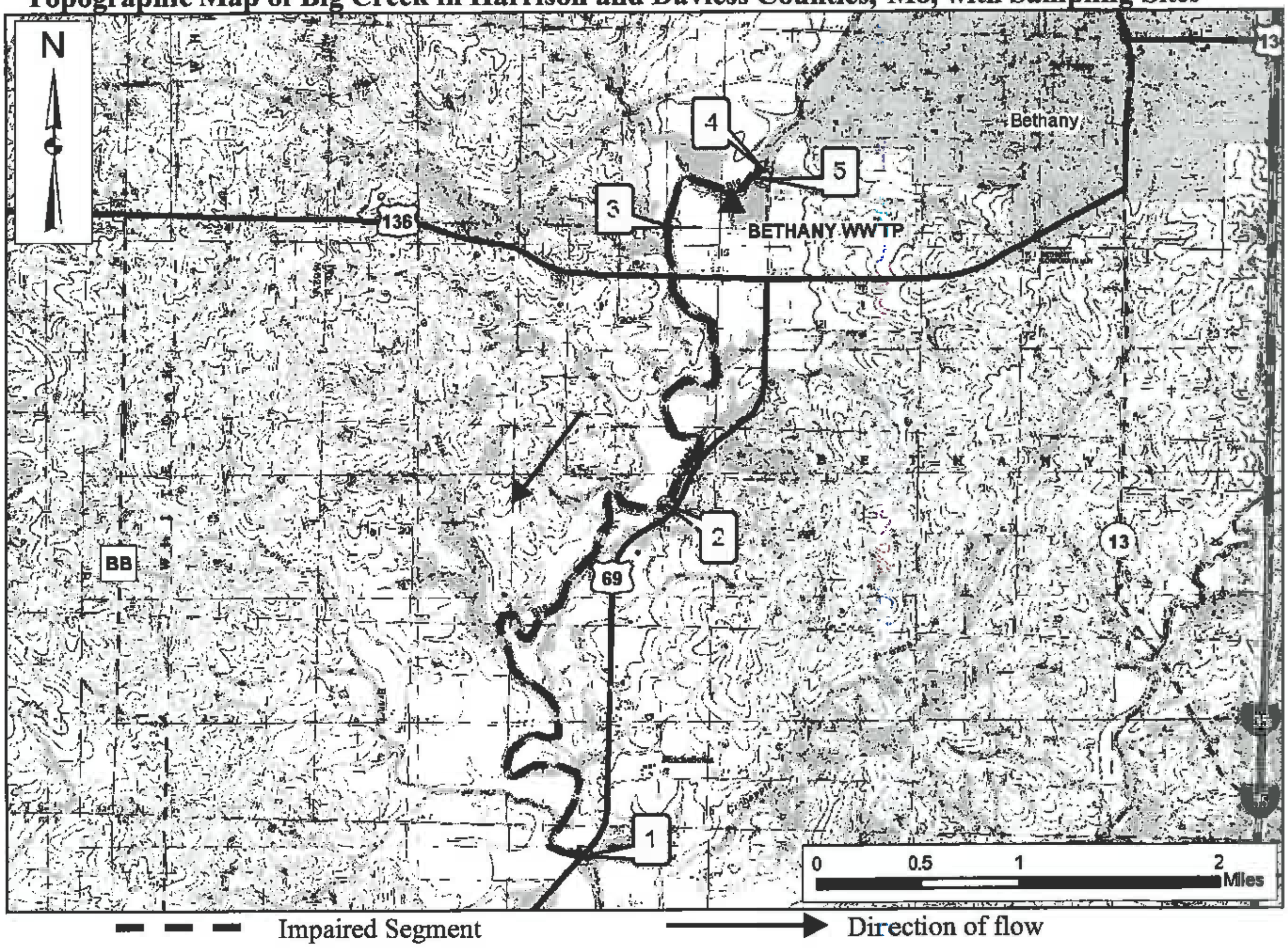
A map, showing the impaired segment of Big Creek and department sampling sites, can be found on the last page of this information sheet.

[1] Acute criteria apply to short exposures to toxic conditions that aquatic creatures can survive without harm. Chronic criteria apply to conditions producing adverse effects on aquatic life or wildlife following long-term exposure but having no readily observable effect over a short time period. Chronic criteria are much lower than the acute criteria.


July 2003 Dissovled Oxygen (DO) measurements
for Big Creek taken below Bethany WWTP
DO (mg/L)
10
8
6
4
2
0
8.6
6.7
5
2.7
1.8
1
2
3
4
5
Sample #
Observed DO
Criterion (5mg/L)


September 2003 Dissolved Oxygen (DO) measurements
for Big Creek taken below Bethany WWTP
DO (mg/L)
20
15
10
5
0
19.3
11.8
3
2.8
2.5
3.2
1
2
3
4
5
6
Sample #
Observed DO
Criterion (5mg/L)

Topographic Map of Big Creek in Harrison and Daviess Counties, Mo, with Sampling Sites



Sample Sites
1 – Big Creek 6.0 miles below Bethany WWTP
2 – Big Creek 2.6 miles below Bethany WWTP
3 – Big Creek 0.9 miles.below Bethany WWTP
4 – Bethany WWTP Outfall
5 – Big Creek 0.1 miles above of Bethany WWTP

The final Big Creek TMDL will be based on the most current available data and information. For TMDL status or additional information, please contact the Water Protection Program.

For more information call or write:

Missouri Department of Natural Resources
Water Protection Program
P.O. Box 176, Jefferson City, MO 65102-0176
1-800-361-4827 or 573-751-1300 office or 573-522-9920 fax
Program Home Page: www.dnr.mo.gov/env/wpp/index.html

Water Quality Improvement Plan for

Silver Creek

Clayton County, Iowa

Total Maximum Daily Load
for Sediment and Ammonia

clean water
starts with you.
IOWA DNR WATERSHED IMPROVEMENT

Prepared By:
Jennifer Kurth and Mindy Buyck

Iowa Department of Natural Resources
Watershed Improvement Section
2010

Table of Contents

List of Figures

List of Tables

General Report Summary

What is the purpose of this report?

This Water Quality Improvement Plan serves multiple purposes. First, it is a resource for guiding locally-driven water quality improvements in Silver Creek. Second, it satisfies the Federal Clean Water Act requirement to develop a Total Maximum Daily Load (TMDL) report for all federally impaired waterbodies. As an impaired waterbody, Silver Creek is eligible for financial assistance to improve water quality. This document is meant to help guide watershed improvement efforts to remove Silver Creek from the federal 303(d) list of impaired waters.

What is wrong with Silver Creek?

Silver Creek is not supporting its Class B (WW-2) aquatic life designated use. Class B (WW-2) is defined as small warmwater streams which support fish populations primarily composed of minnows and other nongame species. Silver Creek was first added to the Section 303(d) Impaired Waters List in 2002 following biological sampling in 2000. It was determined that the Silver Creek biological community was impaired based on assessment of the fish and benthic macroinvertebrate communities. Benthic macroinvertebrates are animals that are larger than 0.5 mm and lack backbones.

Because the cause (stressor) of the poor condition of the biological community was unknown, a method called Stressor Identification (SI) was used to determine the primary stressors in Silver Creek. The SI procedure relates impairments described by biological assessments to one or more specific causal agents (stressors) and separates water quality (pollutant) impacts from habitat alteration impacts. The SI determined that the primary pollutant related causal factors in the Silver Creek water quality impairment are sediment and ammonia. The Stressor Identification document can be found at http://www.iowadnr.gov/water/watershed/tmdl/files/final.si_silver10tmdl.pdf.

What is causing the problem?

Excess sediment negatively impacts a stream's biological community in two ways. First, deposits of fine sediment on the bottom of the channel bury vital habitat used by fish and benthic macroinvertebrates. Second, suspended sediments can impair respiration by clogging gills and can reduce visibility, making it harder for predators to find their prey. Ammonia can affect stream life at both acute and chronic levels. Acute levels of ammonia kill fish and benthic macroinvertebrates in the stream. Chronic levels of ammonia are lower but, with repeated exposure, they can reduce growth and hatching rates, cause damage to gill, liver, or kidney tissue, and increase susceptibility to disease.

Sediment and ammonia can originate from point or nonpoint sources, or a combination of both. Point sources of pollution are easily identified sources that enter a waterbody at a distinct location, such as a wastewater treatment plant outfall. Nonpoint sources of pollution are discharged in a more indirect and diffuse manner, and are often more difficult to locate and quantify. Nonpoint source pollution is usually carried by rainfall or snowmelt over the land surface and into a nearby lake or stream.

The area of land that drains to a lake or stream is called a watershed. Watershed runoff often carries pollutants with it that can degrade water quality. In Silver Creek, the primary nonpoint pollution sources are soil erosion from agricultural land uses, and direct deposition of ammonia via defecation or urination by livestock with access to streams. Both of these nonpoint sources can be reduced by implementing land management practices that control soil loss and livestock stream access. Modeling has demonstrated that the two point sources in the watershed—the City of Monona Wastewater Treatment Plant and the Swiss Valley Farms Creamery—are not contributing to the sediment and ammonia impairments in the lower (impaired) section of Silver Creek.

What can be done to improve Silver Creek?

To improve water quality and the overall health of Silver Creek, the amount of sediment and ammonia entering the stream must be reduced. A combination of land and animal management practices must be implemented in the watershed to obtain necessary reductions. Potential watershed improvement measures include:

- increased use of conservation tillage,
- adoption of manure and fertilizer application strategies to reduce ammonia loss,
- construction of grass waterways, buffer strips, terraces, and sediment control basins,
- restricting access of livestock to stream and providing permanent watering structures away from the stream, and
- rotational grazing.

Who is responsible for a cleaner Silver Creek?

Everyone who lives or works in the Silver Creek watershed has a role in water quality improvement. Because the pollutants are from non-point sources, voluntary management of land and animals will be required to see positive results. Much of the land in the watershed is in agricultural production, and financial assistance is often available from government agencies to individual landowners willing to adopt changes in tillage practices and manure management. Financial assistance may also be available for the restoration of wetlands that naturally filter sediment and nutrients from water before it enters the stream. Improving water quality in Silver Creek will require a collaborative effort of citizens and agencies with a genuine interest in protecting the stream now and in the future.

Technical Elements of the TMDL

Name and geographic location of the impaired or threatened waterbody for which the TMDL is being established:	Silver Creek, located in Clayton County Hydrologic Unit Code: HUC8 07060004 IDNR Waterbody ID: IA 01-TRK-0381_0 Section 16 T94N R5W (Mouth) Section 32 T95N R5W (confluence with unnamed tributary)
Surface water classification and designated uses:	A1 Primary Contact Recreation B(WW-2) Aquatic Life
Impaired beneficial uses:	B(WW-2) Aquatic Life
Identification of the pollutants and applicable water quality standards:	Biological targets are based on the Fish Index of Biotic Integrity (FIBI) and Benthic Macroinvertebrate Index of Biotic Integrity (BMIBI). Stream segments having FIBI or BMIBI scores below the 25th percentile of reference sites are considered impaired. In order to meet the biological targets, secondary targets are set for delivered sediment and ammonia. Measurements from the monitored Silver Creek stream segments are compared to stream reference sites within the same ecological region. These biotic index targets are set for scores equaling or exceeding the 25th percentile of regional reference sites.
Quantification of the pollutant loads that may be present in the waterbody and still allow attainment and maintenance of water quality standards:	Sediment target is set at 2,745 tons per year (maximum daily load = 34.1 tons/day) Ammonia target: 12.33 lbs per day
Quantification of the amount or degree by which the current pollutant loads in the waterbody, including the pollutants from upstream sources that are being accounted for as background loading, deviate from the pollutant loads needed to attain and maintain water quality standards:	The long term average for sediment indicates an annual load of 14,930.4 tons per year.. Ammonia loads are episodic and exceed toxicity given stream temperature and pH conditions.
Identification of pollution source categories:	Nonpoint source pollutants have been identified as sources of impairments to Silver Creek. They include runoff from agricultural land uses and livestock with direct access to the stream.

Wasteload allocations (WLA) for pollutants from point sources:	There are two point sources contributing sediment into Silver Creek. Swiss Valley Creamery 50.2 tons/year and Monona Waste Water Treatment Plants: 14.2 tons/year During low flow the point sources are hydrologically disconnected from the watershed via sinkhole drainage. Therefore there is no WLA given for ammonia
Load allocations (LA) for pollutants from nonpoint sources:	The sediment LA is set to 2,406.1 tons per year or 30.35 tons per day based on an 82 percent reduction from the current load. Ammonia LA is set at 11.10 lbs/day based on meeting Iowa Water Quality Standards (WQS).
A margin of safety:	An explicit margin of safety (MOS) of 10 percent was used for the sediment TMDL. An explicit of 10 percent MOS was used for the ammonia TMDL.
Consideration of seasonal variation:	Seasonal variation is accounted for in the calculation of the TMDL via statistical analysis including a coefficient of variation.
Reasonable assurance that load allocations will be met:	Load allocations can be achieved voluntarily by participation in a watershed management plan with implementation of best management practices.
Allowance for reasonably foreseeable increases in pollutant loads:	Nearly all available land for intensive agriculture is currently under such use and livestock populations appear stable. The Monona WWTP has treatment capacity for a 29 percent population growth (based on 2000 census data), although the population appears to be declining. Therefore no allowance for an increase in pollutant loads was given.
Implementation plan:	Although not required by the Clean Water Act, a general Implementation Plan is included in this report to assist managers in removing this stream from the 303(d) Impaired Waters List.

1. Introduction

The Federal Clean Water Act requires all states to develop lists of impaired waterbodies that are not meeting water quality standards (WQS) and designated uses. This list of impaired waterbodies is referred to as the state's 303(d) list. In addition to developing the 303(d) list, a Water Quality Improvement Plan, or Total Maximum Daily Load (TMDL) report, must also be developed for each impaired waterbody included on the list. Silver Creek was first added to the Section 303(d) Impaired Waters List in 2002 following biological sampling in 2000 as part of the Iowa Department of Natural Resources (IDNR) stream biocriteria project. It was determined that the Silver Creek biological community was impaired based on assessment of the fish and benthic macroinvertebrate communities. Benthic macroinvertebrates are animals that are larger than 0.5 mm and lack backbones. These animals live on rocks, logs, sediment, debris and aquatic plants during some period in their life. They include crayfish, mussels, snails, aquatic worms, and the immature forms of aquatic insects such as stonefly and mayfly nymphs.

Because the cause (stressor) of the poor condition of the biological community was unknown, a method called Stressor Identification (SI) was used to determine the existing stressors in Silver Creek. The process involves "critically reviewing available information, forming possible stressor scenarios that might explain the impairment, analyzing those scenarios, and producing conclusions about which stressor or stressors are causing the impairment" (U.S. EPA 2000). The SI determined that excess sediment and ammonia were causing the impairment in Silver Creek. The document can be found at http://www.iowadnr.gov/water/watershed/tmdl/files/final.si_silver10tmdl.pdf.

A TMDL is a calculation of the maximum amount of a pollutant a waterbody can receive without exceeding the water quality standards. The TMDL is allocated to permitted point sources (wasteload allocations), nonpoint sources (load allocations), and an allowance for a margin of safety to account for uncertainty in the TMDL calculation. The TMDL calculation is represented by the following general equation:

$$TMDL = LC = \Sigma\, WLA + \Sigma\, LA + MOS$$

Where:

TMDL	=	total maximum daily load
LC	=	loading capacity
Σ WLA	=	sum of wasteload allocations (point sources)
Σ LA	=	sum of load allocations (nonpoint sources)
MOS	=	margin of safety (to account for uncertainty)

One purpose of this Water Quality Improvement Plan for Silver Creek, located in Clayton County in northeast Iowa, is to serve as the TMDL for sediment and ammonia. The second purpose of the plan is to provide local stakeholders and watershed managers with a tool to promote awareness of water quality issues, guide watershed improvement efforts, and assist the development of a Watershed Management Plan and subsequent funding applications for water quality improvement projects.

The water quality parameters addressed by this plan are sediment and ammonia, which are adversely affecting the biological community in Silver Creek. The plan outlines a phased approach to TMDL development and implementation. A phased approach is helpful when the origin, interaction, and quantification of pollutants contributing to water quality problems are complex and difficult to fully understand and predict.

The TMDL includes an assessment of existing pollutant loads to the stream and a determination of how much of a specific pollutant the stream can tolerate and still meet water quality standards and support its designated uses. The allowable amount of pollutant the stream can receive is the loading capacity, also called the target load. The TMDL also includes a description of potential solutions to the water quality problem. This group of solutions is generally defined as a system of best management practices (BMPs) that will improve water quality in Silver Creek with the ultimate goal of supporting all designated uses. These BMPs are outlined in the implementation plan in Chapter 6. A water quality monitoring plan designed to help assess water quality improvement and BMP effectiveness is provided in Chapter 7.

This Water Quality Improvement Plan will be of little value to real water quality improvement unless a Watershed Management Plan is developed and watershed improvement activities and BMPs are implemented. This will require the active engagement of local stakeholders and the collaboration of several state and local agencies. Completion of the TMDL should also be followed by several other actions, including:

- collection of biological and water quality data as part of an ongoing monitoring plan,
- evaluation of collected data, and
- modification of the targets and/or implementation plan (if necessary).

Monitoring is a crucial element in assessing attainment of water quality standards and designated uses, determining if water quality is improving, degrading, or remaining unchanged, and assessing the effectiveness of implementation activities and the possible need for additional BMPs.

2. Description and History of Silver Creek

The Silver Creek watershed includes a total of 17,909 acres (28.1 square miles) in the northwest portion of Clayton County, extending east from Luana to the outskirts of Monona, to a point where Silver Creek empties into Roberts Creek about three miles north of St. Olaf. The main stem flows in a south-southeasterly direction. The impaired segment is the lower 4.9 miles of the main stem, from the confluence with an unnamed tributary to the confluence with Roberts Creek (Fig. 2-1).

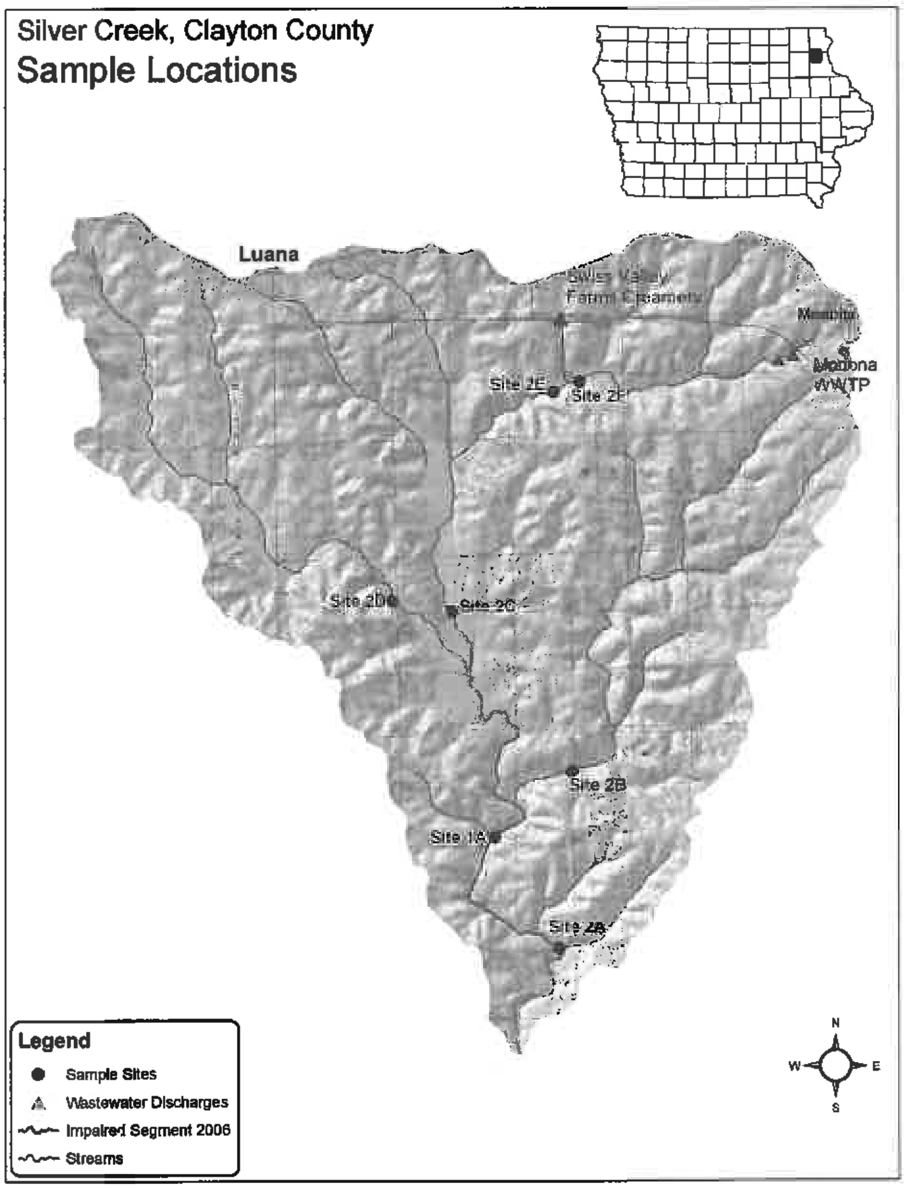


Figure 2-1. The Silver Creek watershed with the impaired stream segment, TMDL sampling sites (Site 1A—2000, Sites 2A-F—2006), and point sources.

2.1. Silver Creek

Hydrology. Silver Creek flows near the towns of Luana and Monona through a largely agricultural landscape to its junction with Roberts Creek. Approximately 17 miles downstream, Roberts Creek joins the Turkey River just south of the town of Elkader. The Silver Creek basin consists of a single HUC 12 sub-watershed with several small, unnamed tributaries. The Silver Creek watershed contains numerous sinkholes (common in the karst geology of the region), many of which are located in or around the channel. Surface flow from this and many surrounding watersheds contributes to groundwater flow, which eventually resurfaces outside the Silver Creek watershed at Big Spring (Halberg et al. 1983). These geological features directly impact stream flow in Silver Creek. It was noted during the 2006 Rapid Assessment of Stream Conditions Along Length (RASCAL) assessment that a large percentage of stream flow enters the groundwater system at several sinkholes located along the channel (Fig. 2-2) and that springs contribute to the stream flow of Silver Creek in several locations (Fig. 2-3), possibly influencing water quality (Palas 2007).

Figure 2-2. In-stream sinkhole in Silver Creek.

Morphometry & Substrate. The main channel of Silver Creek has a slope (measurement of a change in elevation in feet per mile of channel) of 16.72 feet/mile and a sinuosity ratio of 774.24, indicating that the stream has not been excessively channelized. An average basin slope of 8.53 percent and a stream density (ratio of stream miles to square miles of the basin) of 1.46 indicate that surface flows reach the stream very quickly. Less than 11 percent of Silver Creek has a vegetated riparian buffer zone width of more than 60 feet and there are several areas with notable bank erosion. Silver Creek substrates are dominated by silt and sand, with only a few stretches with cobble substrate in the lower portion of the watershed.

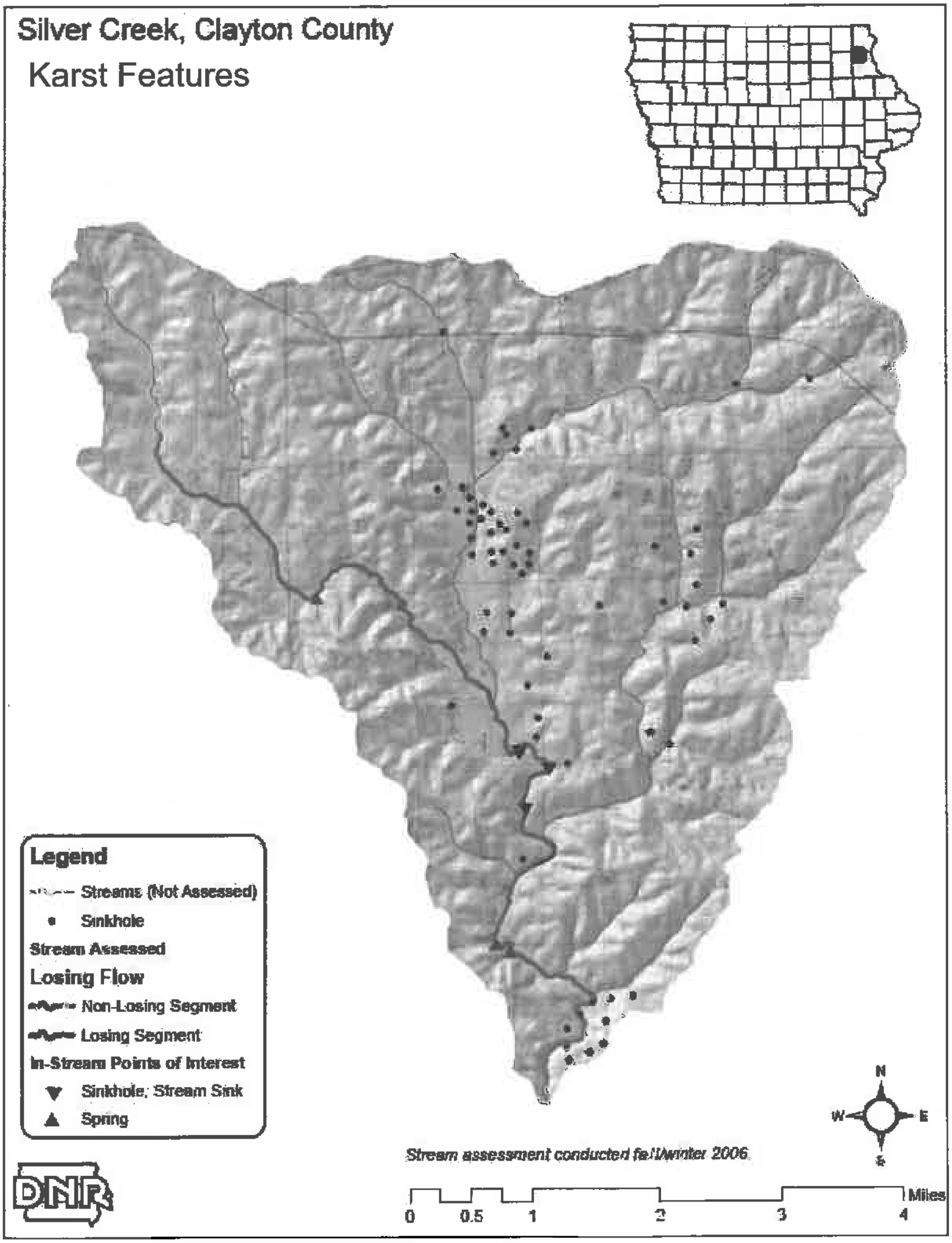


Figure 2-3. Locations of springs, sinkholes, and in-stream sinks in the Silver Creek watershed.

2.2. The Silver Creek Watershed

Land Use. Current land use in the watershed is dominated by agriculture (Table 2-1). According to the 2006 RASCAL analysis and tablet PC land cover/land use assessment, approximately 87 percent of the 17,909 acres in the watershed are devoted to row crop agriculture (Palas 2007). Livestock is also prevalent in the area. Based on the assessment, cattle graze more than 41 percent of the stream channel, with higher percentages in the lower portion of the watershed. This coincides with an analysis of 2002-2006 aerial imagery that shows most hay and small grains production concentrated in the south and western portions of the watershed.

Table 2-1. 2002 land uses in the Silver Creek watershed.

Land cover	Area, acres	Percent of total
Corn	7,300.7	40.8
Ungrazed and CRP grassland	76.8	0.4
Soybeans	4,404.7	24.6
Alfalfa	891.8	5.0
Roads, barren, unknown	2,182.5	12.2
Forest	436.0	2.4
Grazed grassland	1,077.6	6.0
Commercial industrial	604.5	3.4
Other row crop	245.3	1.4
Residential	579.7	3.2
Water and wetlands	109.0	0.6
Total	**17,908.6**	**100.0**

There are an estimated 2,946 cattle, 6,566 hogs, and 102 sheep held in pastures and feedlots in the watershed. These estimates are based on the 2002 Census of Agriculture for Clayton County. Although livestock inventories vary throughout the year depending on sale and slaughter rates, it is assumed that the census number is representative of the average population for the year. The county level data was reduced by calculating the percentage of the county that is part of the watershed, assuming an even distribution of livestock. Runoff from livestock can deliver substantial quantities of nutrients, oxygen demanding pollutants, and ammonia to streams depending on factors such as proximity to surface water, number and type of livestock, and manure controls.

Soils, climate, and topography. The watershed is within the bedrock-dominated terrain of the Driftless Area of the Paleozoic Plateau ecoregion (52b), which is strikingly different from the rest of Iowa (Fig. 2-4). Steep slopes and bluffs, higher relief, sedimentary rock outcrops, dense forests, and unique boreal forest microhabitats differentiate this ecoregion from the Western Corn Belt Plains (47) to the west (Prior 1991; Griffith et al., 1994). The Silurian Escarpment, a prominent physiographic feature that helps define the southern and western boundary of this ecoregion, separates the mostly cropland area of the west from the mixed land use of the driftless area. Dissolution of limestone and dolomite rocks results in karst features such as sinkholes, caves, and springs, and makes groundwater vulnerable to contamination. The streams of this region are located in entrenched valleys, and have cool waters with high gradients flowing over rocky substrates. The fish communities found here reflect a preference for cool, clear water with relative consistency of flow.

The geological composition of Silver Creek's watershed (fractured limestone bedrock covered by a thin layer of soil) increases the threat of agricultural pollutants to the groundwater. The soil survey report for Clayton County documents over 60 sinkholes in the Silver Creek watershed, including locations in or adjacent to the stream channel (Fig. 2-3). At these points, nearly all of the surface water flow enters the groundwater system, eventually resurfacing outside the Silver Creek watershed at Big Spring (Halberg et al. 1983).

The climate is typical of the Midwest, with most of the annual rainfall occurring from late spring through early fall. Spring and summer rainfall can be intense, with large amounts of rain occurring in short time spans. High intensity rainfall increases the potential for localized flooding and soil erosion. From January 1990 to December 2008, average annual precipitation at the National Weather Service (NWS) COOP station located in Waukon (15 miles north of watershed) was 41.3 inches (IEM 2008).

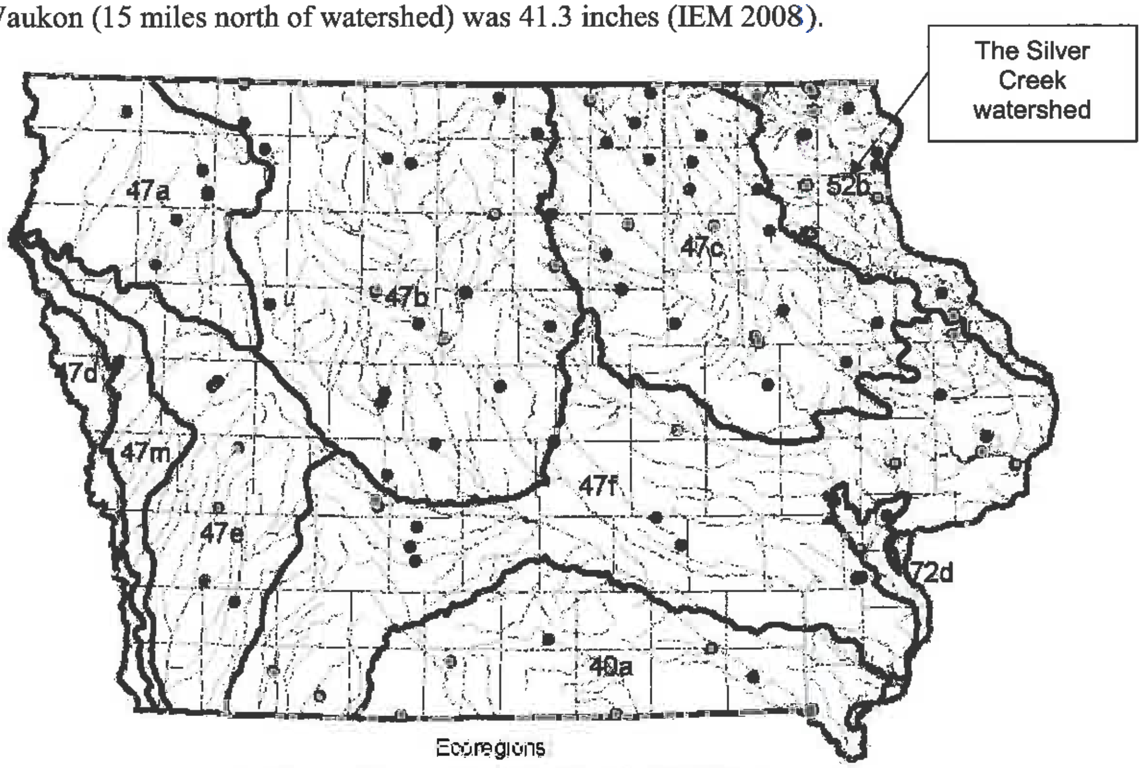


Figure 2-4. Iowa ecoregions and wadeable stream reference sites (red dots). The Silver Creek watershed is under the two in ecoregion 52b.

3. Problem Identification

3.1. Applicable water quality standards.

The Iowa stream classification document designates the protected aquatic life use for Silver Creek, Clayton County as B (WW-2). Class B (WW-2) streams are small warmwater streams which support fish primarily composed of minnows and other nongame species. In 1998, the aquatic life use was assessed as "partially supporting" based on a 1991 stream use assessment. Biological assessments conducted in 2000 at one site in the stream confirmed that the biological community in Silver Creek did not meet expectations, so the stream was added to the 2002 303(d) Impaired Waters List as "not supporting" its aquatic life use.

The methods used to determine support of aquatic life use include calculating a series of biological metrics that reflect stream water quality and habitat integrity from the biological sampling data collected. The metrics are based on the numbers and types of benthic macroinvertebrate and fish species that were collected. The biological metrics were combined to make a fish index of biotic integrity (FIBI) and a benthic macroinvertebrate index (BMIBI). The biotic indexes rank the biological integrity of a stream sampling reach on a scale from 0 (minimum) to 100 (maximum). Table 3-1 shows general qualitative scoring guidelines for the two indexes.

Table 3-1. Qualitative scoring guidelines for the BMIBI and FIBI.

Biological Condition Rating	BMIBI	FIBI
Poor	0 - 30	0 -25
Fair	31 - 55	26 - 50
Good	56 - 75	51 - 70
Excellent	76 - 100	71 - 100

Biological sampling from reference streams in Iowa's ecoregions has been used to derive target BMIBI and FIBI scores for each ecoregion (See Section 2, Fig. 2-4). The reference stream BMIBI and FIBI scores shown are the minimum scores for biological integrity that support aquatic life use in ecoregion 52b (Table 3-2). Below these values a stream is considered either partially or not supporting designated uses. The stream is then listed for a biological impairment of undetermined cause based on low FIBI and/or BMIBI scores. The Silver Creek BMIBI and FIBI scores are well below the ecoregion 52b biological impairment conditions (Table 3-3).

Table 3-2. Reference criteria for assessing biological integrity.

Ecoregion	BMIBI	FIBI
52B Ref. (Paleozoic Plateau)	61	52

IDNR staff followed the SI protocols to determine the cause of the Silver Creek biological impairment. The SI procedure relates impairments described by biological assessments to one or more specific causal agents (stressors) and also separates water quality (pollutant) impacts from habitat alteration impacts. The SI determined that the primary pollutant related causal factors in the Silver Creek water quality impairment are sediment and ammonia.

The State of Iowa Water Quality Standards (WQS) are published in the Iowa Administrative Code (IAC), Environmental Protection Rule 567, Chapter 61. Although the State of Iowa does not have numeric criteria for sediment, narrative water quality criteria do apply. Chapter 61.3(2) of the WQS contains the general water quality criteria, which are applicable to all surface waters. These narrative criteria require that waters be free of "aesthetically objectionable conditions" and "substances…in quantities which would produce undesirable or nuisance aquatic life". The State of Iowa does have numeric criteria for ammonia in Chapter 61.3(3). The ammonia standards vary depending on the pH and temperature of the water; therefore, there is no single numeric criterion for ammonia. The WQS can be accessed on the web at http://www.iowadnr.com/water/standards/files/chapter61.pdf.

3.2. Problem statement.

In 2002, the stream was assessed as "not supporting" because the 2000 monitoring assessment revealed poor biological integrity. The FIBI and BMIBI scores for Silver Creek from the 2000 sampling and additional biological sampling in 2005 are shown in Table 3-3. BMIBI and FIBI scores from sampling locations (See Section 2, Fig. 2-1) in the Silver Creek watershed generally indicate poor to fair biological condition based on the ratings in Table 3-1. The shaded columns list the Biological Impairment Criteria (BIC) that are determined from the range of IBI scores sampled from ecoregion 52b reference stream sites. The Silver Creek BMIBI and FIBI scores are below the ecoregion biological impairment conditions, which is strong evidence that the biological impairment is consistent across space and time.

Table 3-3. Index of Biotic Integrity scores for benthic macroinvertebrates (BMIBI) and fish (FIBI) from the Silver Creek Watershed.

Site	Year	BMIBI	BMIBI Biological Impairment Criterion (BIC)	FIBI	FIBI Biological Impairment Criterion (BIC)
Site 1A	2000	46	61	41	52
Site 2A	2005	26	61	19	52
Site 2E	2005	41	61	30	52

Data sources. Full biological sampling was performed at one location in 2000 (Site 1A) and two locations in 2005 (Sites 2A and 2E), with rapid bioassessment protocol (RBP) sampling at two additional sites in 2005 (Sites 2D and 2F) (See Section 2, Fig. 2-1). Water quality samples were collected from three Silver Creek sites (2A, 2D, and 2E) biweekly from July through October 2006, monthly from November 2006 to March of 2007, and biweekly from April through June 2007. Although planned, water quality sampling was not possible at two sites (Sites 2B and 2C) because there was no flowing water at those sites in the summer of 2006. Additionally, diurnal temperature and dissolved oxygen fluctuations were monitored in 2007 at site 2A in May (for 14 days) and September (for 18 days). These data were used to determine the stressors that were causing the biological impairment in Silver Creek.

After the initial water quality data was collected, the first modeling attempts indicated a need for better resolution data for longitudinal modeling. Based on the aspects of the model that would not calibrate, it was determined that more water quality data directly downstream of the point sources were needed to better understand their influence in the watershed. Additional sampling sites were chosen and bi-weekly water samples were collected from June through September 2008 at two new sites (3A and 3B) and three sites from the original sampling plan from 2005 (2A, 2C, and 2E) (Fig. 3-1).

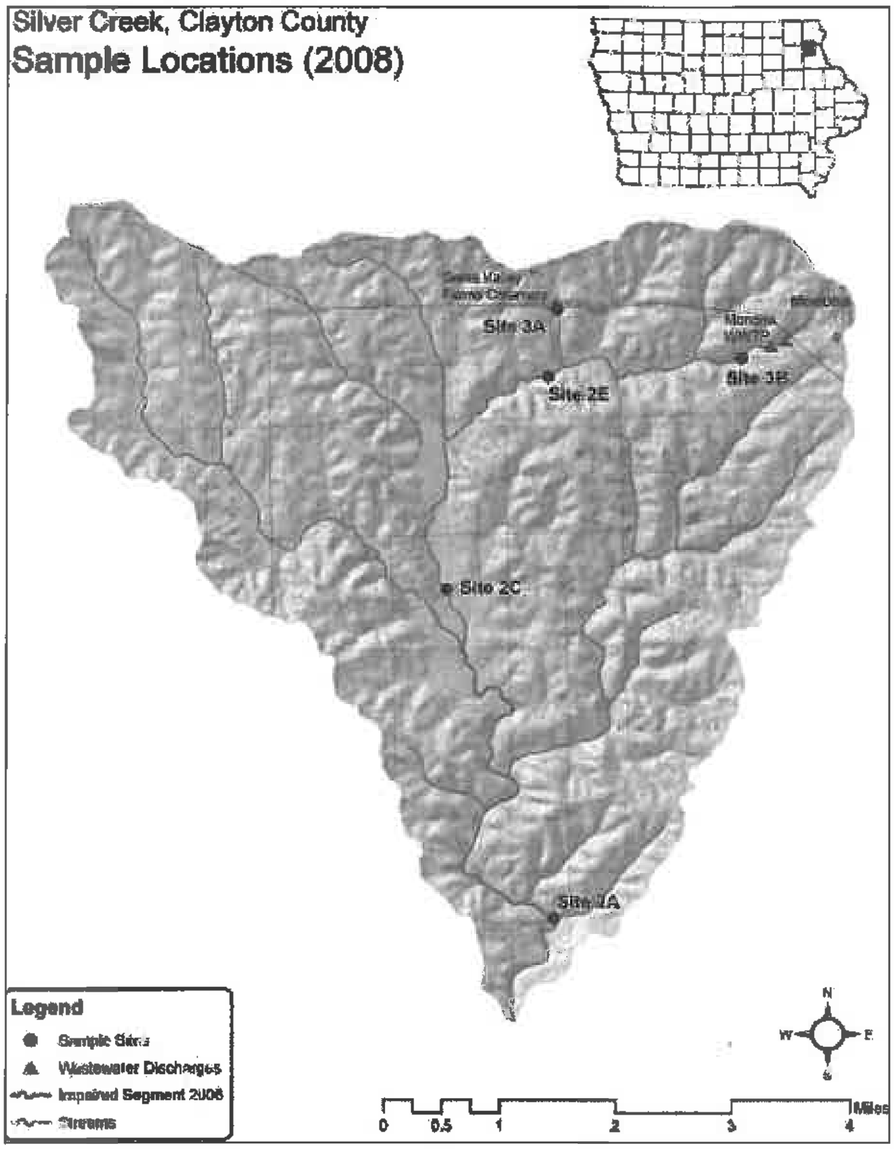


Figure 3-1. Additional sampling sites for June-September 2008 data collection.

Point Sources: There are two National Pollution Discharge Elimination System (NPDES) permitted point sources in the Silver Creek watershed; a wastewater treatment plant (WWTP) for the City of Monona and an industrial site, the Swiss Valley Farms Creamery (Table 3-4). The City of Monona had a population of 1,550 (2000 U.S. Census data), but the population appears to be declining according to real estate estimates.

Table 3-4. Point Sources in the Silver Creek Watershed.

Facility	Monona (WWTP)	Swiss Valley Farms (Industrial)
IA NPDES #	2264001	2200100
EPA #	IA0036927	IA0003808
Treatment type	Activated sludge	Activated sludge
5-day Carbonaceous Biochemical Oxygen Demand (CBOD5) (mg/L)[1]	25 (30 day avg.)	35[2]/19[3]/13[4] (30 day avg.)
Total Suspended Solids (TSS) (mg/L)[1]	30	66 (30 day avg.)
pH[1]	6.0-9.0	6.0-9.0
Population equiv.	2,179	11,976
Design flow (MGD)[5]	0.312/0.1341/0.971	0.0/0.0/0.18

1. These are the NPDES permit limits for these facilities for CBOD5, TSS, and pH.
2. CBOD5 permit values for January and February for creamery
3. CBOD5 permit values for Mar. - June and Sept. – Dec. for creamery
4. CBOD5 permit values for July and August for creamery.
5. Average wet flow/Average dry flow/Maximum wet flow

The point sources do not significantly contribute to the delivered sediment load. However, because the two point sources do have permit limits for total suspended solids (TSS), continuous discharge loads of TSS from the Monona WWTP and the creamery are included in the TMDL analysis and TSS wasteload allocations for the facilities are included.

Modeling indicated that ammonia discharged from the point sources does not reach the impaired section during low flow because the water drains into a large sink hole in the upper portion of the impaired segment. Even so, continuous discharge loads of ammonia from the Monona WWTP and the creamery are included in the TMDL analysis and ammonia wasteload allocations for the facilities are included. These were included because Iowa does have a water quality standard for ammonia and, during high flow, a portion of this water bypasses the sinkhole.

3.3. Interpreting Silver Creek Data.

According to the Methodology for Developing Iowa's 2004 Section 303(d) List of Impaired Waters, reference stream FIBI and BMIBI scores shown in Table 3-2 for the watershed ecoregion are considered 'supporting' the aquatic life use. Silver Creek will be considered no longer impaired when the ecoregion 52b BICs are met.

Sediment. Although there are not specific numerical water quality standards for sediment, excessive sediment can adversely impact aquatic life as demonstrated in the Silver Creek SI process. Silver Creek has been shown to have quantities and coverage of stream bottom silt much higher than found in the reference streams for the ecoregion. This excess sediment adversely affects aquatic life. As shown in Table 3-5, the percentage of the substrate measured as silt was well outside the ecoregion inter-quartile range at sites 1A in 2000 and 2A and 2E in 2005. Typical levels of silt substrate in healthy streams in this ecoregion are much lower, with a mean of 18 percent and a median of 15 percent for Paleozoic Plateau reference sites.

The embeddedness of the streambed in riffle areas also impacts aquatic life. Riffles are shallow stretches of a stream where the current is above the average stream velocity and water forms small rippled waves as a result. Riffles often consist of a rocky bed of gravel or other small stones and are important habitat for benthic macroinvertebrates and juvenile fish. The riffle embeddedness rating indicates the percent of the coarse substrate area that has the interstitial spaces (area between rocks) filled by fine sediment and is scored on a scale of 1-5 (Table 3-6). In conjunction with copious bottom algae, the excess silt alters the physical habitat by crowding out benthic macroinvertebrates, changing the available food sources, and causing a negative shift in community composition (BMIBI score). The loss of interstitial spaces impacts fish reproductive activity and alters the organisms that are available as food (FIBI score).

Table 3-5. Comparison of altered substrate indicators at sites 1A, 2A, and 2E to the ecoregion reference sites.

Parameter	Site 1A (2000)	Site 2A (2005)	Site 2E (2005)	Ecoregion 52b Reference Range[2]
Substrate silt fraction[1]	60	90	70	8.5 to 29.67
Embedded riffle rating (Table 3-6)	5	4	3	1.93 to 2.43

1. Percent of bottom covered by silt. One measurement taken at each site.
2. Reference conditions are measured as the inter-quartile range (25th percent value to 75th percent value).

Table 3-6. Embedded riffle rating and related percent embeddedness of coarse substrate.

Embedded riffle rating	Percent of Coarse Substrate Embedded
1	0-20 %
2	20-40 %
3	40-60 %
4	60-80 %
5	80-100 %

Ammonia. Un-ionized ammonia is directly toxic to aquatic invertebrates and fish. Iowa has water quality standards designed to protect aquatic life against acute and chronic toxicity from un-ionized ammonia. The criteria are expressed as total ammonium ion concentration from which un-ionized ammonia concentration can be determined as a function of pH and temperature. For a given concentration of total ammonium ion, an increase in pH and/or temperature will result in an increase in un-ionized ammonia concentration. The water quality standards for acute and chronic ammonia toxicity for a range of pH conditions are shown in Table 3-7.

Table 3-7. Acute and Chronic WQS for Total Ammonia at 20℃, pH 8-9.

pH	Acute Criterion, mg/L - N	Chronic Criterion, mg/L - N
8.0	8.40	1.71
8.1	6.95	1.47
8.2	5.72	1.26
8.3	4.71	1.07
8.4	3.88	0.906
8.5	3.20	0.765
8.6	2.65	0.646
8.7	2.20	0.547
8.8	1.84	0.464
8.9	1.56	0.397
9.0	1.32	0.342

There were violations of Iowa's chronic ammonia WQS on two consecutive sampling occasions in the summer of 2006 at site 2A. On July 26th the ammonia level measured was 0.75 mg/L and the chronic criterion was 0.74 mg/L. On August 7th the ammonia level measured was 3.6 mg/L with a chronic criterion of 2.4 mg/L. These ammonia violations are not known to be associated with a runoff event or spill of animal waste or fertilizer. While ammonia violations occurred in the unnamed tributary to which the point sources discharge, they did not correspond with ammonia violations in the impaired section of Silver Creek. Modeling has shown that the sinkhole removes most of the water during low flow conditions. Additionally, as evidenced by the lack of water at site 2C in 2005, the water from the point sources never reached the impaired segment of Silver Creek in 2005.

High ammonia concentrations in Silver Creek are likely caused by runoff from manure and direct deposition by livestock with stream access and can cause serious water quality problems in three major ways:

1. Acute levels of ammonia kill fish and benthic macroinvertebrates in the stream.
2. Chronic levels of ammonia are lower but, with repeated exposure, they can reduce growth and hatching rates, cause damage to gills, liver, or kidneys, and increase susceptibility to disease.
3. Ammonia exerts an oxygen demand (OD) in streams through nitrification, depleting dissolved oxygen (DO). In addition, there is often an additional OD from heterotrophic bacteria growth and metabolism of organic components in manure.

4. TMDL for Sediment

A Total Maximum Daily Load (TMDL) for sediment is required for Silver Creek by the Federal Clean Water Act. This chapter quantifies the maximum amount of sediment that Silver Creek can tolerate without violating the state's water quality standards.

4.1. TMDL Target

General description of the pollutant. Excess fine sediments reduce the availability of favorable spawning habitat for fish and buries desirable habitat for benthic macroinvertebrates, thus reducing BMIBI and FIBI scores. Reducing sediment delivery in Silver Creek will improve BMIBI and FIBI scores by reducing streambed silt, embeddedness in riffle coarse substrates, suspended solids and turbidity, and increasing the size and quality of riffle and pool habitat.

Silt and sediment are naturally transported by streams and rivers. However, excessive sediment loads delivered from upland watershed sources via sheet, rill, and gully erosion can result in sediment deposition (siltation) of streams, causing a loss of aquatic habitat and reduced channel transport capacity. Excessive turbidity and siltation can be detrimental for sight-feeding fish, benthic-dwelling organisms, and basic aquatic life functions. Alterations to a stream's natural hydrologic regime, such as channelization and/or artificial drainage, can cause an imbalance in the natural discharge-sediment load equilibrium of the stream and lead to bed and bank degradation, contributing to excessive siltation/sedimentation (Lane, 1955).

Selection of environmental conditions. The SI performed on Silver Creek found that one of the specific causes of impairment to the benthic macroinvertebrate and fish communities is excessive siltation/sedimentation of the streambed. Critical or seasonal environmental conditions do not apply. Siltation/sedimentation poses long-term, chronic threats for aquatic life, and therefore does not warrant consideration for acute seasonal impacts.

Sources of water body pollutant loading. The major sources of sediment to Silver Creek include sheet and rill erosion and stream bank erosion. Point source inputs from the Monona Water Treatment Plant and the Swiss Valley Creamery are minor and account for less than one half of one percent of the total input. The estimated annual load from each source is as follows:

Sheet and rill erosion as estimated by RUSLE (see appendix D):	12,202 tons/year
Stream bank erosion (see appendix D):	2,664 tons/year
Swiss Valley Creamery:	50.2 tons/year
Monona Waste Water Treatment Plants:	14.2 tons/year
Total:	**14,930.4 tons/year**

Water body pollutant loading capacity (TMDL). The goal for Silver Creek is to reduce the average siltation/sedimentation rate of the streambed from its current level (average of 80 percent silt substrates between two sites) to that of the mean percentile of data for reference streams in the Paleozoic Plateau Ecoregion (18 percent silt). To achieve this, in-stream siltation/sedimentation of the channel would need to be reduced by 82 percent from current levels. Assuming that the relationship between external sediment delivery to the stream and the siltation/sedimentation rate of the streambed will remain proportional and constant over time, the external sediment loading reduction needed to achieve the TMDL target is also 82 percent. Based on the long term annual average sediment loading of 14,930.4 tons/year, the load capacity for sediment is 2,745 tons/year (avg. 7.6 tons/day).

In November of 2006, The U.S. Environmental Protection Agency (EPA) issued a memorandum entitled *Establishing TMDL "Daily" Loads in Light of the Decision by the U.S. Court of Appeals for the D.C. circuit in Friends of the Earth, Inc. v. EPA, et al., No. 05-5015, (April 25, 2006) and Implications for NPDES Permits.* In the context of the memorandum, EPA

> *"...recommends that all TMDLs and associated load allocations and wasteload allocations include a daily time increment. In addition, TMDL submissions may include alternative, non-daily pollutant load expressions in order to facilitate implementation of the applicable water quality standards..."*

As recommended by EPA, the loading capacity of Silver Creek for sediment is expressed as a daily maximum load, in addition to the allowable average annual load of 2,745 tons/year described above. The annual average load is more applicable to the assessment of in-stream water quality and water quality improvement actions, while the daily maximum load expression satisfies the legal uncertainty addressed in the EPA memorandum.

The maximum daily load was estimated from the annual average load using a statistical approach that is outlined in more detail in Appendix D. This approach uses a lognormal distribution to calculate the daily maximum from the long-term (e.g., annual) average load. The methodology for this approach is taken directly from a follow-up guidance document entitled *Options for Expressing Daily Loads in TMDLs* (EPA, 2007), and was issued shortly after the November 2006 memorandum cited previously. This methodology can also be found in EPA's 1991 *Technical Support Document for Water Quality Based Toxics Control.* Using this approach, the allowable maximum daily load (loading capacity) for sediment in Silver Creek is calculated to be 34.1 tons/day.

Decision criteria for water quality standards attainment. The decision criteria for water quality standards attainment in Silver Creek are based on meeting biological conditions typical of healthy reference streams for this ecoregion. This would require achieving and maintaining a BMIBI score of at least 61 and a FIBI score of at least 52.

4.2. Pollution Source Assessment

Existing load. Existing sediment loads delivered to Silver Creek are not regularly monitored, therefore long-term approximations of the annual sediment loads were estimated based on the Revised Universal Soil Loss Equation (RUSLE) and a cursory assessment of gullies and eroding stream banks present in the watershed. The annual existing load of sediment delivered to the stream is estimated to be 14,930.4 tons/year.

Departure from load capacity. The target for sediment loading to Silver Creek is 2,745 tons per year. Existing daily loads of sediment in the stream are 14,930.4 tons/year on average (Fig. 4-1). A 82 percent reduction in current annual sediment delivery to the stream is needed to achieve the TMDL target.

Identification of pollutant sources. Sediment is delivered to the stream during rain events from nonpoint sources throughout the watershed. Sheet and rill erosion occurring in agricultural fields represents the dominant source of sediment in the Silver Creek watershed (Fig. 4-2). The second largest source is stream bank erosion. Point sources account for less than one half of one percent.

Allowance for increases in pollutant loads. Most of the land area in the Silver Creek watershed available for row crop farming is currently under such land use practice. Stream channels in the watershed appear to be mostly stable at this time and are not expected to degrade or widen excessively in the coming years. Additionally, the population of Monona appears to be declining from a high of 1,550 in 2000 according to real estate estimates. Therefore, no allowance for increased sediment loads was given in the TMDL.

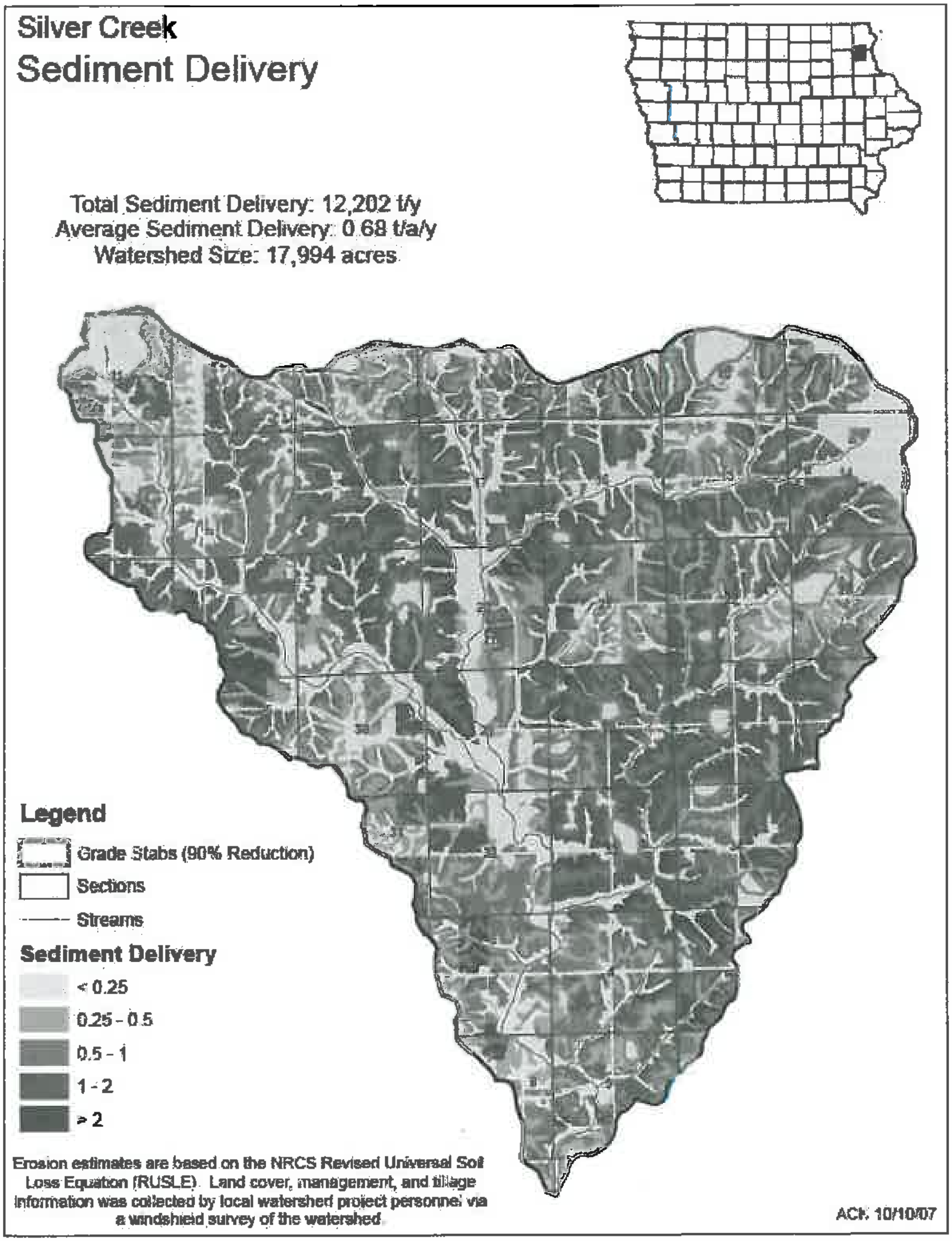


Figure 4-1. RUSLE estimate of sediment delivery in the Silver Creek watershed based on 2002 photography.

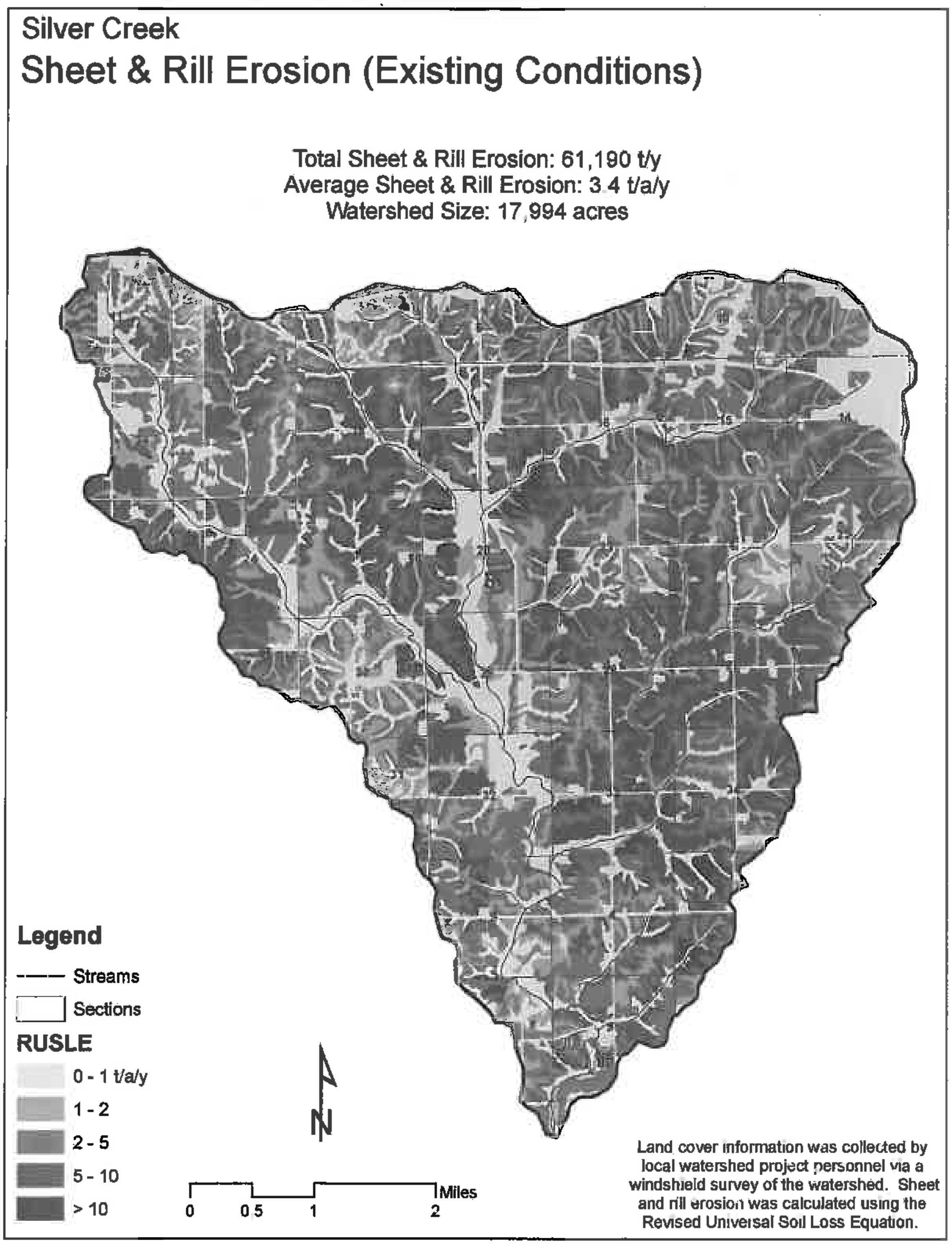


Figure 4-2. RUSLE estimate of sheet and rill erosion in the Silver Creek watershed based on 2002 photography.

4.3. Pollutant Allocation

Wasteload allocation. A wasteload allocation represents the portion of the TMDL attributed to point sources in the watershed. The only point source dischargers in the Silver Creek watershed are the City of Monona Wastewater Treatment Plant and the Swiss Valley Farms Creamery. Neither of these permitted facilities contribute a significant amount of sediment to the watershed. Even under the conservative assumption of both facilities discharging maximum daily loads at maximum flow capacity the sum of the contribution from both facilities would be less than one half of one percent of the total sediment load. Therefore no reductions were made to current permitted levels for these facilities resulting in the following WLAs:

Swiss Valley Creamery:	50.2 tons/year
Monona Waste Water Treatment Plants:	14.2 tons/year

Load allocation. The load allocation (LA) represents the portion of the TMDL attributed to nonpoint sources in the watershed. In Silver Creek, 99.6 percent of the existing sediment loads originate from nonpoint sources; therefore, the load allocation is 2,406.1 tons/year.

Margin of safety. To account for uncertainties in data or modeling, a margin of safety is a requirement of all TMDLs. For this TMDL, an explicit margin of safety of ten percent was used to account for uncertainties in nonpoint source sediment delivery. Furthermore, estimates of long term sediment loading were based on the absence of existing conservation practices which provides an additional implicit margin of safety.

4.4. Reasonable Assurance

Reasonable assurance for the reduction of nonpoint source loading is given by the availability of technical and financial assistance for conservation practices and watershed improvement grants. Funding made available to local stakeholder groups on an annual basis provides an opportunity for local citizens and landowners to seek their own solutions with technical guidance from state and local government agencies.

4.4. TMDL Summary

The following equation represents the Total Maximum Daily Load (TMDL) and its components for Silver Creek:

$$TMDL = LC = \Sigma\ WLA + \Sigma\ LA + MOS$$

Where:	TMDL	=	total maximum daily load
	LC	=	loading capacity
	Σ WLA	=	sum of wasteload allocations (point sources)
	Σ LA	=	sum of load allocations (nonpoint sources)
	MOS	=	margin of safety (to account for uncertainty)

Once the loading capacity, wasteload allocations, load allocations, and margin of safety have all been determined for the Silver Creek watershed, the general equation above can be expressed for the Silver Creek TMDL for sediment.

Expressed as the maximum annual average, which is helpful for water quality assessment and watershed management:

TMDL = LC = **Σ** WLA (64.4 tons/yr) + Σ LA (2,406.1 tons/yr)
+ MOS (274.5 tons/yr) = **2,745 tons/year sediment**

Expressed as the maximum daily load:

TMDL = LC = **Σ** WLA (0.45 tons/day) + Σ LA (30.35 tons/day)
+ MOS (3.4 tons/day) = **34.1 tons/day sediment**

5. Total Maximum Daily Load (TMDL) for Ammonia

A Total Maximum Daily Load (TMDL) for ammonia is required for Silver Creek by the Federal Clean Water Act. This chapter will quantify the maximum amount of ammonia that Silver Creek can tolerate without violating the state's water quality standards.

5.1. TMDL Target

General description of the pollutant. The stressor identification process identified episodic high levels of ammonia that lead to depleted dissolved oxygen conditions and toxicity issues for fish and benthic macroinvertebrates within the impaired segment of Silver Creek. Targets for ammonia toxicity are given in Table 3-7 (Section 3). Ammonia enters the stream as episodic events corresponding with run-off events or from defecation and elimination from livestock with direct access to the stream (Figure 5-1).

Figure 5-1. Silver Creek flowing through a cattle pasture.

Selection of environmental conditions. Ammonia toxicity is dependent on pH and temperature. Higher levels of ammonia will deplete oxygen levels within streams through the process of nitrification. In addition to ammonia toxicity, depleted oxygen levels are stressful to aquatic life. Because of the temperature and oxygen demand concerns, the critical period will be in the summer during times of higher temperatures and low-flow conditions when any inputs of ammonia to the stream will have greater impacts.

Water body pollutant loading capacity (TMDL). The TMDL was based on violating numeric water quality standards of either ammonia toxicity at an average pH and temperature for the stream in a summer month or the dissolved oxygen criteria by inputting ammonia. To simulate this, a model was built in QUAL2K. Appendix D outlines in detail the modeling approach used to achieve these results.

Decision criteria for water quality standards attainment. The decision criteria for water quality standards attainment in Silver Creek are based on meeting water quality standards for chronic ammonia toxicity and/or minimum dissolved oxygen criteria.

5.2. Pollution Source Assessment

Existing load. Ammonia toxicity is dependent on temperature and pH. Controlling the chronic ammonia toxicity in Silver Creek requires controlling episodic releases as opposed to reducing an existing load. Therefore, an existing load would consist of episodic events at given temperature and pH conditions. Ammonia also depletes dissolved oxygen. Therefore any source assessment must also consider the effects of episodic ammonia releases on the dissolved oxygen levels of the stream.

Identification of pollutant sources. The main pollutant sources to the impaired segment are nonpoint sources consisting of run-off from open feedlots and from defecation and elimination from livestock with direct access to the stream.

Allowance for increases in pollutant loads. No changes in land use are expected. Additionally, the population of Monona appears to be declining from a high of 1,550 in 2000 according to real estate estimates and the design capacity of the facility is for a population of 2,179. Therefore, there are no allowances for pollutant load increases.

5.3. Pollutant Allocation

Wasteload allocation. The Wasteload Allocation (WLA) is the sum of the wasteload allocations of the Monona WWTP and the Swiss Valley Farms Creamery. However these are not hydrologically connected to the impaired segment of Silver Creek as they are drained by a large in-stream sink hole during low-flow conditions before reaching the impaired segment. Therefore, a WLA is not applicable to this TMDL.

Load allocation. Nonpoint sources responsible for the ammonia impairment in the impaired section include runoff from animal feeding operations and livestock with direct access to, and defecating or urinating in, the stream. The daily load allocation was determined based on modeling (Appendix D) and is set at 11.10 lbs/day.

Margin of safety. The statutes and regulations require that a TMDL include a margin of safety to account for any lack of knowledge concerning the relationship between load and wasteload allocations and water quality. EPA guidance explains that the margin of safety (MOS) may be implicit (i.e., incorporated into the TMDL through conservative assumptions in the analysis) or explicit (i.e., expressed in the TMDL as loadings set aside for the MOS). An explicit margin of safety of ten percent was incorporated into the Silver Creek Ammonia TMDL.

5.4. Reasonable Assurance

Reasonable assurance for the reduction of nonpoint source loading is given by the availability of technical and financial assistance for conservation practices and watershed improvement grants. Funding made available to local stakeholder groups on an annual basis provides an opportunity for local citizens and landowners to implement their own solutions with technical guidance from state and local government agencies.

5.5. TMDL Summary

The following equation represents the TMDL and its components for Silver Creek:

$$TMDL = LC = \Sigma\, WLA + \Sigma\, LA + MOS$$

Where:			
	TMDL	=	total maximum daily load
	LC	=	loading capacity
	Σ WLA	=	sum of wasteload allocations (point sources)
	Σ LA	=	sum of load allocations (nonpoint sources)
	MOS	=	margin of safety (to account for uncertainty)

Once the loading capacity, wasteload allocations, load allocations, and margin of safety have all been determined for the Silver Creek watershed, the general equation above can be expressed for the Silver Creek TMDL for ammonia.

Expressed as a daily average:

TMDL = LC = Σ WLA (n/a) + Σ LA (11.10 lbs/day)
+ MOS (1.23) = **12.33 lbs/day**

6. Implementation Plan

This implementation plan is not a requirement of the Federal Clean Water Act. However, the Iowa Department of Natural Resources recognizes that technical guidance and support are critical to achieving the goals outlined in this TMDL. Therefore, this plan is included to be used by local professionals, watershed managers, and citizens to support decision-making and planning. The best management practices (BMPs) listed below represent a comprehensive list of tools that may help achieve water quality goals if applied in an appropriate manner; however, it is up to land managers, citizens, and local conservation technicians to determine exactly how best to implement them.

6.1. General Approach and Reasonable Timeline

Initiative and action by local landowners and citizens are crucial to improving the overall health of any watershed. This is especially true of the Silver Creek watershed because most of the land is privately owned. Watershed work and improvements to the creek should proceed in conjunction with a comprehensive monitoring system that will adequately characterize daily, seasonal, and annual pollutant loadings in the creek as well as the health of the biological community as improvements to the watershed are made.

General approach. The existing loads, loading targets, a general listing of BMPs needed to improve water quality and the health of the biological community, and a monitoring plan to assess progress are established in this TMDL. Ideally, the TMDL would be followed by the development of a watershed management plan. The watershed management plan should include more comprehensive and detailed strategies to better guide the implementation of specific BMPs. Other ongoing tasks required to obtain real and significant water quality improvements include continued monitoring, assessment of the biological community, assessment of water quality trends, assessment of WQS attainment, and adjustment of proposed BMP types, locations, and implementation schedule based on measured results.

Timeline. Development of a comprehensive watershed management plan takes time—perhaps as long as one to three years. Implementation of watershed BMPs could take upwards of five to ten years, depending on funding, willingness of landowner participation, and time needed for design and construction of any structural BMPs. Realization and documentation of water quality benefits and improvement in the biological community may take 10 years or longer. depending on weather patterns, amount of data collected, and the successful location, design, construction, and maintenance of BMPs. Utilization of the monitoring plan as outlined in Chapter 7 should begin immediately to establish baseline conditions, and should continue throughout implementation of BMPs and beyond.

6.2. Best Management Practices

The two major pollutants contributing to the impairment of Silver Creek are excess sediment and episodic ammonia toxicity. While both of these are the by-product of land management, they require different approaches to remediate them.

Sediment erosion and delivery to a waterbody are best controlled with land management and conservation practices that reduce bare ground and slow soil erosion, thereby slowing and reducing sediment loads delivered to streams. These practices include such things as vegetated buffer strips, terraces, contour farming, no-till practices, water and sediment control structures, sediment basins, and grassed waterways. Additionally, targeted bank and stream stabilization practices and restricting cattle access to the stream would help reduce in-stream sediment delivery. Currently, less than 11 percent of the main stem has a riparian zone of more than 60 feet and more than 81 percent of Silver Creek is flanked by pasture and row crops and has a riparian zone of less than 10 feet (Figure 6-1) (Palas 2007). Fifteen acres of filter strips in the headwater area of Silver Creek represent the largest continuous block of land enrolled in the Conservation Reserve Program (CRP) in the watershed and only 74 acres total of the 17,991 acre watershed are enrolled in CRP.

Figure 6-1. Current land use adjacent to Silver Creek in much of the watershed.

Targeted bank and stream stabilization practices would help reduce in-stream sediment delivery. Riprap is one of the more commonly used stream bank stabilization techniques. It is a permanent cover of rock used to stabilize stream banks, provide in-stream channel stability, and provide a stabilized outlet below concentrated flows. It is generally used on stream banks at the toe (bottom) of the slope, with other structures placed up-slope to prevent soil movement.

Soil bioengineering is a method of using vegetation to stabilize a site with or without structural controls. Some refer to bioengineering as softening the traditional rock-the-bank approach because non-invasive vegetation is used to blend the site into its surrounding landscape. Chapter 18 of the USDA Soil Conservation Service (now Natural Resource Conservation Service (NRCS)) Engineering Field Handbook is one of the most comprehensive sources of information on soil bioengineering. Chapter 18 describes soil bioengineering as a combination of biological and ecological concepts to arrest and prevent shallow slope failures and erosion.

Using RUSLE, it is possible to estimate soil loss reduction with certain land management and conservation practices. This is done by changing the existing conditions to create a landscape with the ideal practices in place. For Silver Creek, three scenarios were created: 1) placing terraces in areas with C slopes or greater, 2) using no-till practices on all crop land in the watershed, and 3) a combination of these practices (Figures 6-2 through 6-4). Table 6-1 gives the estimated percent reduction in sheet and rill erosion and ultimate sediment delivery with these practices as indicated by RUSLE.

Table 6-1. RUSLE estimated soil loss reduction with land management practices.

	Existing Conditions (2006)	Terraces on C slopes or greater	Percent Reduction	No-till for all cropland	Percent Reduction	Combination of terraces and no-till	Percent Reduction
Sheet & Rill Erosion (tons/yr)	61,190	50,832	17	27,514	55	22,899	63
Average Erosion (tons/acre/yr)	3.40	2.82		1.53		1.27	
Sediment Delivery (tons/yr)	12,202	10,126	17	5,496	55	4,567	63
Average Delivery (tons/acre/yr)	0.68	0.56		0.31		0.25	

This is just an example of the effect certain BMPs can have on reducing sediment delivery to Silver Creek. Even with 100 percent implementation of these two BMPs, the sediment reduction does not meet the target reduction of 82 percent, demonstrating that it is unlikely that only one or two BMPs will suffice. Rather, a comprehensive package of BMPs will be required to address the issues that have led to the excessive sedimentation in Silver Creek (Table 6-2).

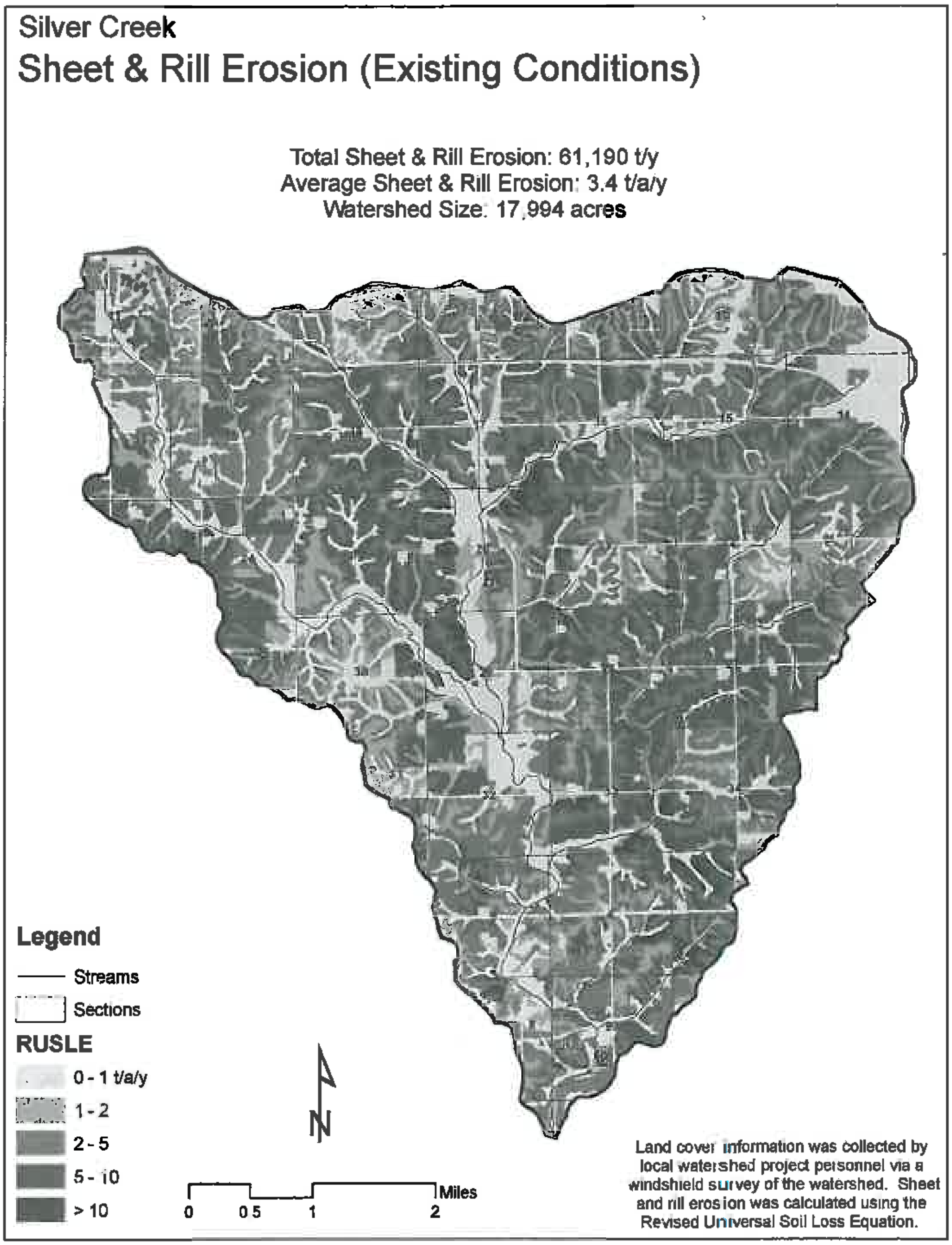


Figure 6-2. Current RUSLE sediment loss estimates with existing land uses.

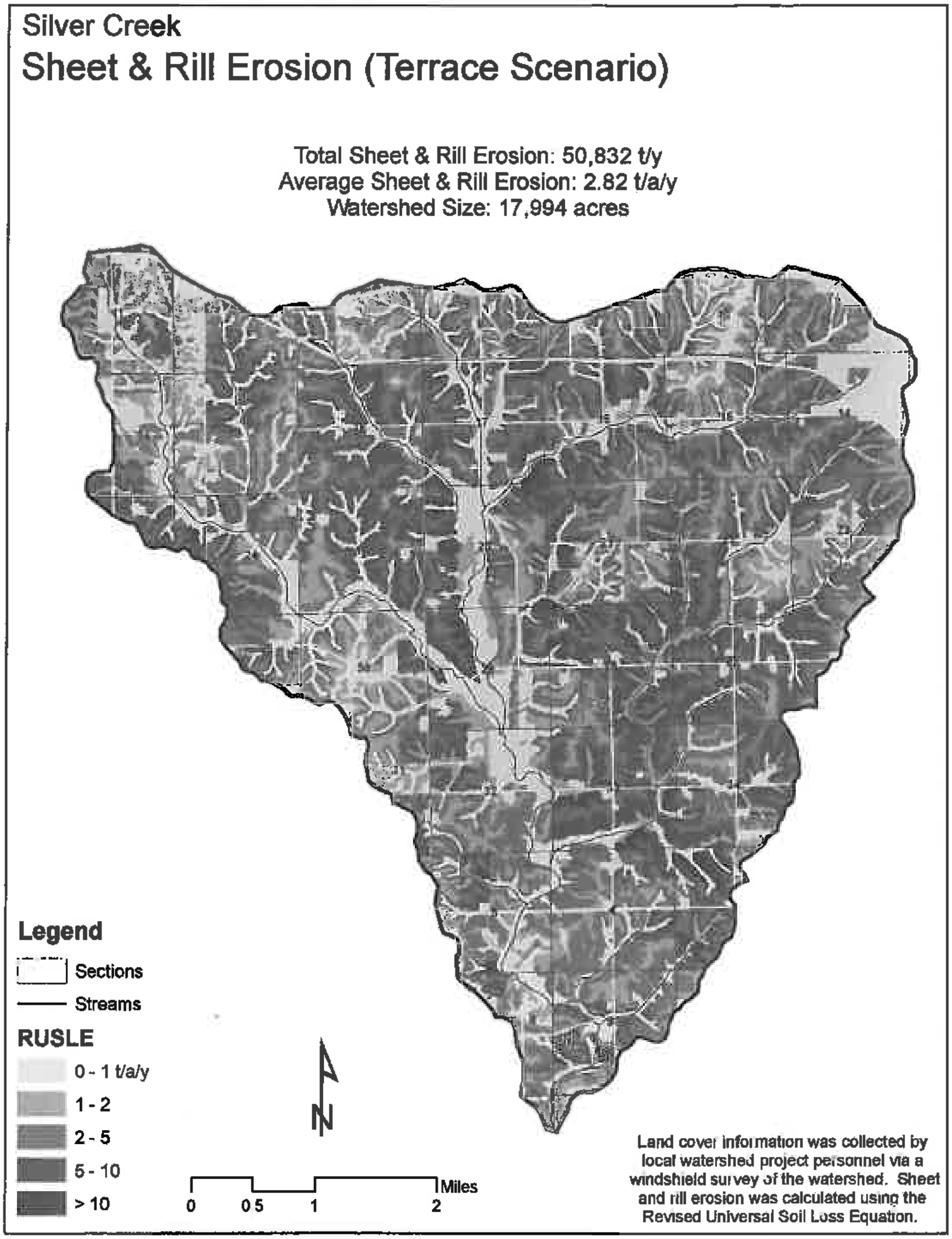


Figure 6-3. Reductions in soil loss with implementation of terracing on appropriate sites on the landscape. This results in a 17 percent reduction in erosion.

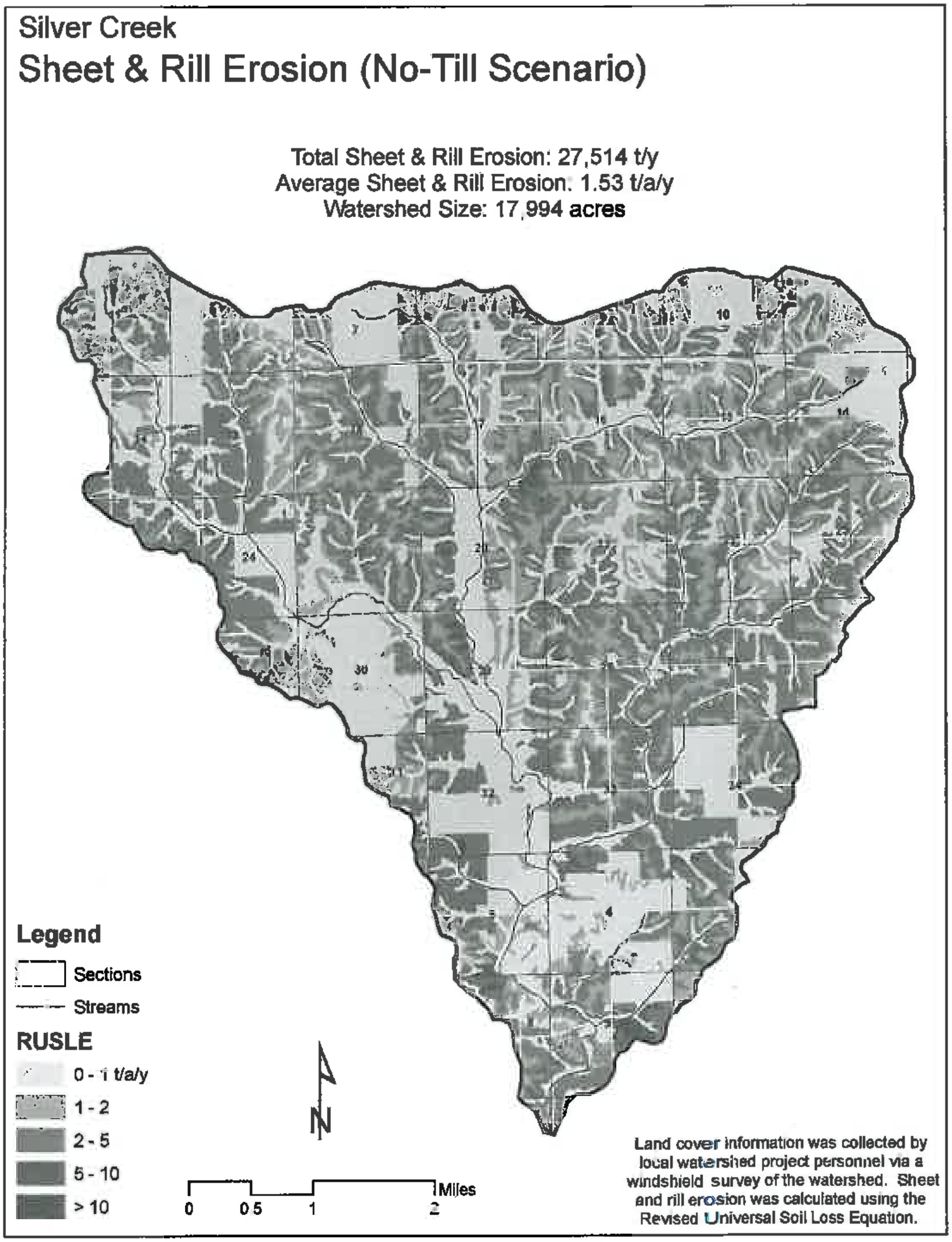


Figure 6-4. Reductions in soil loss with implementation of no-till farming on appropriate sites on the landscape. This results in a 55 percent reduction in erosion.

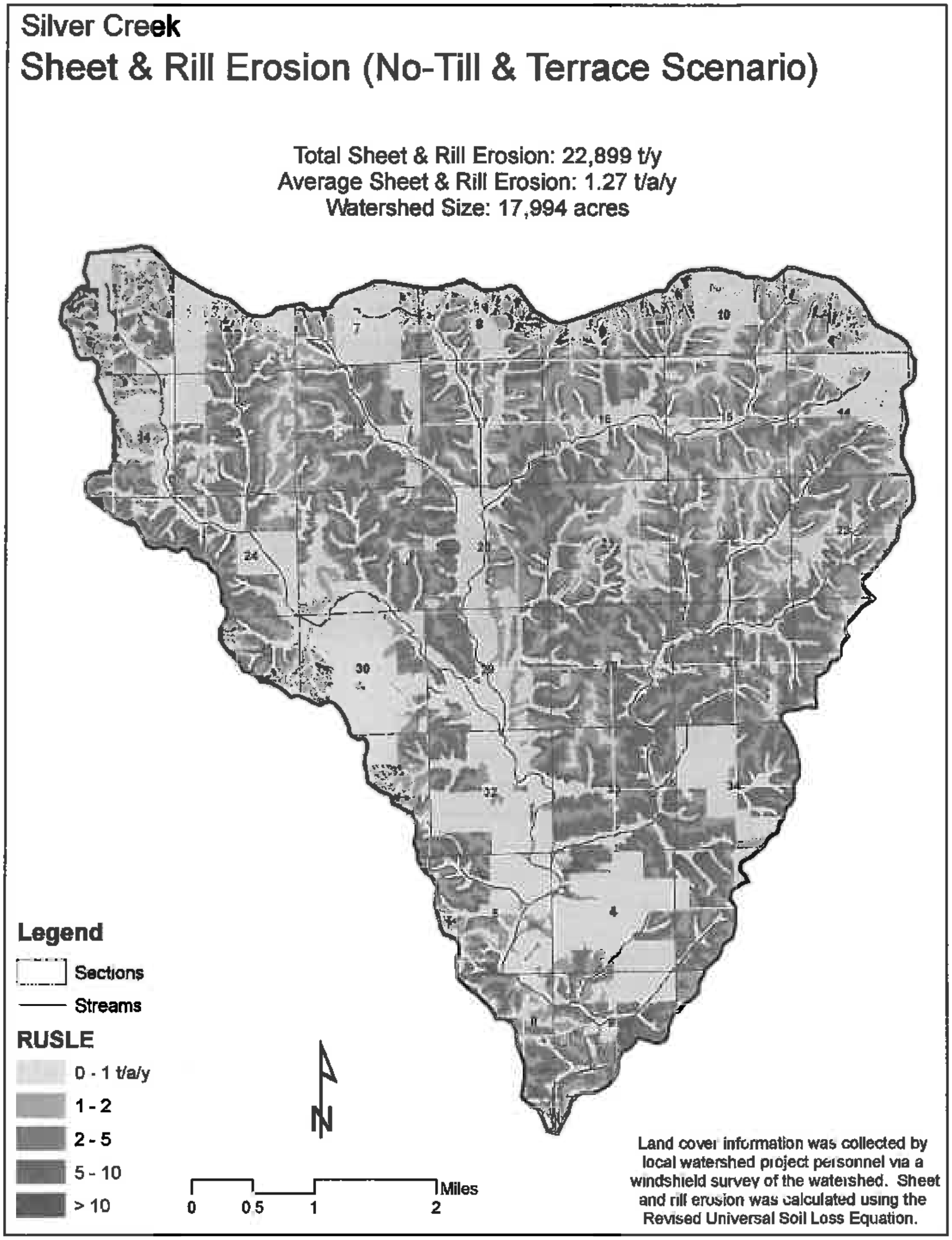


Figure 6-5. Reductions in soil loss with implementation of no-till farming and terracing on appropriate sites on the landscape. This results in a 63 percent reduction in erosion.

Controlling episodic ammonia toxicity is more complicated, since toxicity is dictated by water temperature and pH. However, controlling how much ammonia reaches the stream via runoff from animal feeding operations and limiting livestock access to streams would greatly limit ammonia inputs. Animal feeding operations can best control manure releases by constructing and maintaining proper retaining structures. Restricting livestock access to the stream by fencing them out and providing alternate watering structures and shading away from the stream would limit the time spent in or near the stream and help prevent episodic ammonia inputs.

In summary, no single BMP will be able to sufficiently reduce pollutant loads to Silver Creek. Rather, a comprehensive package of BMPs will be required to address the issues that have led to the poor condition of the biological community in Silver Creek. Table 6-2 identifies some potential BMPs that could reduce the inputs of sediment and ammonia. This list is not all-inclusive, and further investigation may reveal some alternatives to be more or less feasible and applicable to site-specific conditions than others. Development of a more detailed watershed management plan would be helpful in selecting, locating, and implementing the most effective and comprehensive package of BMPs practicable, and would maximize opportunities for future technical and funding assistance.

Table 6-2. Potential BMPs for water quality improvement.

BMP or Activity	Sedimentation Reduction Potential	Ammonia Reduction Potential
Conservation Tillage:		
Moderate vs. Intensive Tillage	Moderate	NA
No-Till vs. Intensive Tillage	High	NA
No-Till vs. Moderate Tillage	High	NA
Cover Crops	High	NA
Diversified Cropping Systems	Moderate	NA
In-Field Vegetative Buffers	High	NA
Terraces	High	NA
Streambank stabilization		
Riprap installation	Moderate	NA
Soil bioengineering	Moderate	NA
Pasture/Grassland Management:		
Livestock Exclusion from Streams	Moderate	High
Rotational vs. Constant Intensive Grazing	Moderate	Moderate
Seasonal vs. Constant Intensive Grazing	Moderate	Moderate
Riparian Buffers	Moderate	Moderate
Wetlands	High	High

7. Future Monitoring

Water quality monitoring is a critical element in assessing the current status of water resources and historical trends. Furthermore, monitoring is necessary to track the effectiveness of water quality improvements made in the watershed and document the status of the waterbody in terms of achieving total maximum daily loads. Also, because the impaired use is for aquatic life, biological sampling is critical to document any improvement in the biological community that may result from implementation efforts within the watershed and to demonstrate improvements in FIBI and BMIBI scores to a level that exceeds ecoregion biological impairment criteria.

Future water quality monitoring in the Silver Creek watershed can be agency-led, volunteer-based, or a combination of both. The Iowa Department of Natural Resources (IDNR) Watershed Monitoring and Assessment Section administers a water quality monitoring program that provides training to interested volunteers. This program is called IOWATER. More information can be found at the program web site: http://www.iowater.net/Default.htm.

Biological monitoring should be conducted by a professional organization such as the University of Iowa Hygienic Lab (UHL) to ensure accuracy and consistency of methods.

7.1. Monitoring Plan to Track TMDL Effectiveness

Currently, due to resource limitations, there are no plans for water quality monitoring or biological sampling in the Silver Creek watershed.

7.2. Idealized Plan for Future Watershed Projects

The ideal monitoring plan for Silver Creek would involve water chemistry sampling, biological sampling, habitat sampling, and continuous sampling for dissolved oxygen and temperature (Table 7-1) at select sites in the watershed (Figure 7-1).

Table 7-1. Idealized monitoring plan for Silver Creek.

Component	Sample Frequency	Parameters/Details
Water chemistry sampling	Bi-weekly- March to October Monthly- November to February	All common parameters listed in Appendix A of the Iowa Water Monitoring Plan 2000 (http://wqm.igsb.uiowa.edu/publications/plan2000.htm)
Benthic Macroinvertebrate and Fish sampling	Annually	Should be done to track improvement in benthic macroinvertebrates and fish and evaluate changes in species susceptible to ammonia toxicity and low DO.
Habitat sampling	Annually	Concurrently with the biological sampling, habitat assessment should take place according to IDNR protocols. Will track improvement in habitat conditions that may be contributing to the impairment such as sedimentation and substrate embeddedness.
Continuous DO and temperature	Continuously from June to October	Dissolved oxygen autosampler deployment according to UHL protocols (6 minute intervals)

While resources may not currently be available to implement this type of monitoring plan, this strategy should be incorporated into the Silver Creek Watershed Management Plan discussed in Section 6. Then, as funding becomes available to support watershed improvement efforts, this monitoring plan can be implemented by the local watershed group(s).

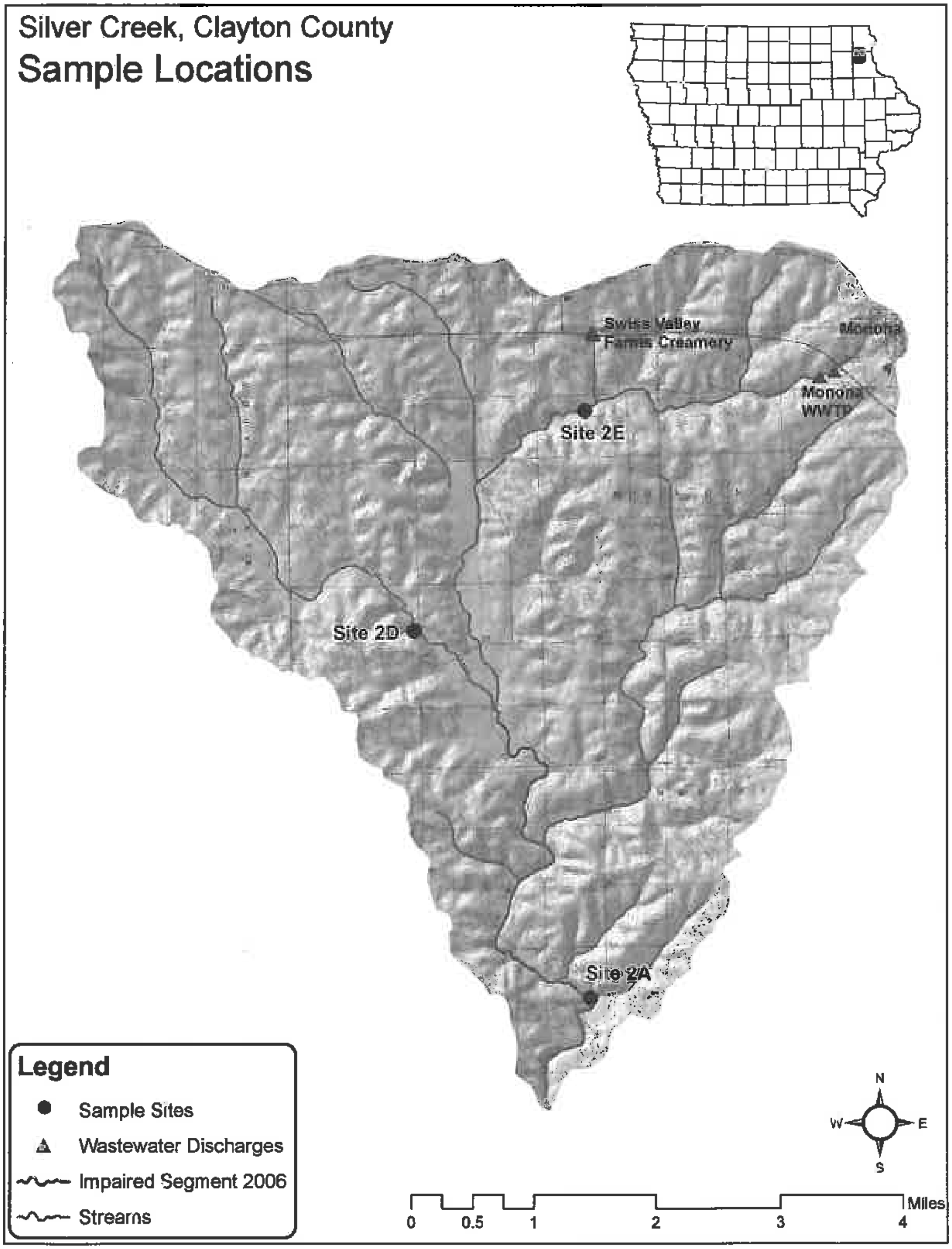


Figure 7-1. Recommended sample sites for idealized monitoring plan.

8. Public Participation

Public involvement is important in the TMDL process because it is the land owners, tenants, and citizens who directly manage land and live in the watershed that determine the water quality in Silver Creek. During the development of this TMDL, considerable effort was made to ensure that the local watershed project coordinator was involved in the process to agree on feasible and achievable goals for the water quality in Silver Creek.

8.1. Public Meetings

An informal meeting to discuss Silver Creek was held in Elkader, Iowa on October 9, 2007. This meeting included representatives from the Silver Creek Watershed Project, IDNR, and commissioners for the Clayton County Soil and Water Conservation District.

A formal public meeting was held at the Luana Savings Bank in Luana, Iowa, from 6:00 to 8:00 pm on January 14, 2010. Nearly 20 people attended, indicating that there is local support of water quality improvement efforts. The primary purposes of the meeting were to present the draft of the Silver Creek TMDL to the public, and to provide stakeholders with an opportunity to ask questions and offer input.

Key agency attendees included:

- IDNR – Watershed Improvement Section (TMDL)
- IDNR – Section 319 Program
- IDNR – Field Office 1
- IDALS – Division of Soil Conservation (Regional Coordinator)

Key stakeholder groups represented included:

- Rural residents, land owners, and agricultural producers
- Swiss Valley Farms Creamery, Monona
- Silver Creek Watershed Project

8.2. Written Comments

The draft TMDL was posted on the Iowa Department of Natural Resources website on December 31, 2009 and comments were accepted from December 31, 2009 to February 1, 2010.

No public comments were received for the Silver Creek TMDLs.

9. References

Griffith, G.E., J.M. Omernik, T.F. Wilton, and S. M. Pierson. 1994. Ecoregions and sub-ecoregions of Iowa: a framework for water quality assessment and management. Jour. Iowa Acad. Sci. 10(1): 5-13.

Halberg, G.R., B.E. Hoyer, E.A. Bettis, III, and R.D. Libra. 1983. Hydrogeology, water quality, and land management in the Big Spring Basin, Clayton County, Iowa. Iowa Geological Survey, Open File Report 83-3.

Iowa Environmental Mesonet (IEM), 2008. Iowa State University Department of Agronomy. Precipitation and other climate information available at http://mesonet.agron.iastate.edu/climodat/index.phtml?station=IA8755&report=17. Accessed in March 2009.

Lane, E.W. 1955. The importance of fluvial morphology in hydraulic engineering, Proceedings of the American Society of Civil Engineers 81(745): 1-17.

Palas, E. 2007. Silver Creek Summary of Rapid Assessment of Stream Condition Along Length (RASCAL) data. Report to Iowa Department of Natural Resources. 13 p.

Prior, J.C. 1991. Landforms of Iowa. University of Iowa Press. Iowa City, Iowa. 153 p.

U.S. Environmental Protection Agency (EPA), 1991. Technical Support Document for Water Quality-based Toxics Control. EPA/505/2-90-001. EPA Office of Water, Washington, DC.

U.S. EPA. 2000. Stressor Identification Guidance Document. U.S. Environmental Protection Agency. December 2000.

U.S. Environmental Protection Agency (EPA), 2006. Establishing TMDL "Daily" Loads in Light of the Decision by the U.S. Court of Appeals for the D.C. circuit in Friends of the Earth, Inc. v. EPA, et al., No. 05-5015, (April 25, 2006) and Implications for NPDES Permits. Memorandum from Benjamin Grumbles, Assistant Administrator, EPA Office of Water, Washington, DC.

U.S. Environmental Protection Agency (EPA), 2007. Options for Expressing Daily Loads in TMDLs (Draft). EPA Office of Wetlands, Oceans & Watersheds, Washington, DC.

Appendix A --- Glossary of Terms and Acronyms

303(d) list: Refers to section 303(d) of the Federal Clean Water Act, which requires a listing of all public surface waterbodies (creeks, rivers, wetlands, and lakes) that do not support their general and/or designated uses. Also called the state's "Impaired Waters List."

305(b) assessment: Refers to section 305(b) of the Federal Clean Water Act, it is a comprehensive assessment of the state's public waterbodies' ability to support their general and designated uses. Those bodies of water which are found to be not supporting or just partially supporting their uses are placed on the 303(d) list.

319: Refers to Section 319 of the Federal Clean Water Act, the Nonpoint Source Management Program. Under this amendment, States receive grant money from EPA to provide technical & financial assistance, education, & monitoring to implement local nonpoint source water quality projects.

AFO: Animal Feeding Operation. A lot, yard, corral, building, or other area in which animals are confined and fed and maintained for 45 days or more in any 12-month period, and all structures used for the storage of manure from animals in the operation. Open feedlots and confinement feeding operations are considered to be separate animal feeding operations.

Base flow: Sustained flow of a stream in the absence of direct runoff. It can include natural and human-induced stream flows. Natural base flow is sustained largely by groundwater discharges.

Benthic Macroinvertebrates Animals without backbones, that are larger than 0.5 mm (the size of a pencil dot). These animals live on rocks, logs, sediment, debris and aquatic plants during some period in their life. They include crayfish, mussels, snails, aquatic worms, and the immature forms of aquatic insects such as stonefly and mayfly nymphs.

BMIBI: Benthic Macroinvertebrate Index of Biotic Integrity. An index-based scoring method for assessing the biological health of streams and rivers (scale of 0-100) based on characteristics of bottom-dwelling invertebrates.

BMP: Best Management Practice. Any structural or upland soil or water conservation practice, such as terraces, grass waterways, sediment retention ponds, reduced tillage systems, etc.

CBOD5	5-day Carbonaceous Biochemical Oxygen Demand. Measures the rate of oxygen use by micro-organisms to oxidize hydrocarbons in a sample of water at a temperature of 20°C and over an elapsed period of five days in the dark.
Confinement feeding operation	An animal feeding operation (AFO) in which animals are confined to areas which are totally roofed.
Credible data law:	Refers to 455B.193 of the Iowa Administrative Code, which ensures that water quality data used for all purposes of the Federal Clean Water Act are sufficiently up-to-date and accurate.
Cyanobacteria (blue-green algae):	Members of the phytoplankton community that are not true algae but can photosynthesize. Some species can be toxic to humans and pets.
Designated use(s):	Refer to the type of economic, social, or ecologic activities that a specific waterbody is intended to support. See Appendix B for a description of all general and designated uses.
DNR (or IDNR):	Iowa Department of Natural Resources.
Ecoregion:	A system used to classify geographic areas based on similar physical characteristics such as soils and geologic material, terrain, and drainage features.
EPA (or USEPA):	United States Environmental Protection Agency.
FIBI:	Fish Index of Biotic Integrity. An index-based scoring method for assessing the biological health of streams and rivers (scale of 0-100) based on characteristics of fish species.
FSA:	Farm Service Agency (United States Department of Agriculture). Federal agency responsible for implementing farm policy, commodity, and conservation programs.
General use(s):	Refer to narrative water quality criteria that all public waterbodies must meet to satisfy public needs and expectations. See Appendix B for a description of all general and designated uses.
GIS:	Geographic Information System(s). A collection of map-based data and tools for creating, managing, and analyzing spatial information.

Gully erosion: Soil movement (loss) that occurs in defined upland channels and ravines that are typically too wide and deep to fill in with traditional tillage methods.

HEL: Highly Erodible Land. Defined by the USDA Natural Resources Conservation Service (NRCS), it is land which has the potential for long term annual soil losses to exceed the tolerable amount by eight times for a given agricultural field.

Integrated report: Refers to a comprehensive document which combines the 305(b) assessment with the 303(d) list, as well as narratives and discussion of overall water quality trends in the state's public waterbodies. The Iowa Department of Natural Resources submits an integrated report to the EPA biennially in even numbered years.

LA: Load Allocation. The portion of the loading capacity attributed to (1) the existing or future nonpoint sources of pollution and (2) natural background sources. Wherever possible, nonpoint source loads and natural loads should be distinguished. (The total pollutant load is the sum of the waste load and load allocations.)

Load: The total amount of pollutants entering a waterbody from one or multiple sources, measured as a rate, as in weight per unit time or per unit area.

MOS: Margin of Safety. A required component of the TMDL that accounts for the uncertainty in the response of the waterbody to loading reductions.

MS4: Municipal Separate Storm Sewer System. A conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains) owned and operated by a state, city, town, borough, county, parish, district, association, or other public body (created by or pursuant to state law) having jurisdiction over disposal of sewage, industrial wastes, stormwater, or other wastes, including special districts under state law such as a sewer district, flood control district or drainage district, or similar entity, or an Indian tribe or an authorized Indian tribal organization, or a designated and approved management agency under section 208 of the Clean Water Act (CWA) that discharges to waters of the United States.

Nonpoint source pollution: Pollution that is not released through pipes but rather originates from multiple sources over a relatively large area. Nonpoint sources can be divided into source activities related either to land or water use including failing septic tanks, improper animal-keeping practices, forestry practices, and urban and rural runoff.

NPDES: National Pollution Discharge Elimination System. The national program for issuing, modifying, revoking and reissuing, terminating, monitoring, and enforcing permits, and imposing and enforcing pretreatment requirements, under Section 307, 402, 318, and 405 of the Clean Water Act. Facilities subjected to NPDES permitting regulations include operations such as municipal wastewater treatment plants and industrial waste treatment facilities, as well as some MS4s.

NRCS: Natural Resources Conservation Service (United States Department of Agriculture). Federal agency which provides technical assistance for the conservation and enhancement of natural resources.

Open feedlot An unroofed or partially roofed animal feeding operation (AFO) in which no crop, vegetation, or forage growth or residue cover is maintained during the period that animals are confined in the operation.

Periphyton: Algae that are attached to substrates (rocks, sediment, wood, and other living organisms).

Phytoplankton: Collective term for all self-feeding (photosynthetic) organisms suspended in the water quality which provide the basis for the aquatic food chain. Includes many types of algae and cyanobacteria.

Point source pollution: Pollutant loads discharged at a specific location from pipes, outfalls, and conveyance channels from either municipal wastewater treatment plants or industrial waste treatment facilities. Point sources are generally regulated by an NPDES permit.

PPB: Parts per Billion. A measure of concentration which is the same as micrograms per liter (μg/l).

PPM: Parts per Million. A measure of concentration which is the same as milligrams per liter (mg/l).

Riparian: Refers to site conditions that occur near water, including specific physical, chemical, and biological characteristics that differ from upland (dry) sites.

RUSLE: Revised Universal Soil Loss Equation. An empirical model for estimating long term, average annual soil losses due to sheet and rill erosion.

Secchi disk: A device used to measure transparency in waterbodies. The greater the Secchi depth (measured in meters), the more transparent the water.

Sediment delivery ratio: A value, expressed as a percent, which is used to describe the fraction of gross soil erosion which actually reaches a waterbody of concern.

Seston: All particulate matter (organic and inorganic) in the water column.

Sheet & rill erosion Soil loss which occurs diffusely over large, generally flat areas of land.

SI: Stressor Identification. A process by which the specific cause(s) of a biological impairment to a waterbody can be determined from cause-and-effect relationships.

Storm flow (or stormwater): The fraction of discharge (flow) in a river which arrived as surface runoff directly caused by a precipitation event. *Stormwater* generally refers to runoff which is routed through some artificial channel or structure, often in urban areas.

STP: Sewage Treatment Plant. General term for a facility that processes municipal sewage into effluent released to public waters according to the conditions of an NPDES permit.

SWCD: Soil and Water Conservation District. Agency which provides local assistance for soil conservation and water quality project implementation, with support from the Iowa Department of Agriculture and Land Stewardship.

TMDL: Total Maximum Daily Load. As required by the Federal Clean Water Act, a comprehensive analysis and quantification of the maximum amount of a particular pollutant that a waterbody can tolerate while still meeting its general and designated uses.

TSI (or Carlson's TSI): Trophic State Index. A standardized scoring system (scale of 0-100) used to characterize the amount of algal biomass in a lake or wetland.

TSS: Total Suspended Solids. The quantitative measure of seston, all materials, organic and inorganic, which are held in the water column.

Turbidity: The degree of cloudiness or murkiness of water caused by suspended particles.

UAA: Use Attainability Analysis. A protocol used to determine which (if any) designated uses apply to a particular waterbody. (See Appendix B for a description of all general and designated uses.)

UHL: University Hygienic Laboratory (University of Iowa). Provides physical, biological, and chemical sampling for water quality purposes in support of beach monitoring and impaired water assessments.

USGS: United States Geologic Survey (United States Department of the Interior). Federal agency responsible for implementation and maintenance of discharge (flow) gauging stations on the nation's waterbodies.

Watershed: The land (measured in units of surface area) which drains water to a particular body of water or outlet.

WLA: Wasteload Allocation. The portion of a receiving waterbody's loading capacity that is allocated to one of its existing or future point sources of pollution (e.g., permitted waste treatment facilities). Alternatively, the allowable pollutant load that an NPDES permitted facility may discharge without exceeding water quality standards.

WQS: Water Quality Standards. Defined in Chapter 61 of Environmental Protection Commission [567] of the Iowa Administrative Code, they are the specific criteria by which water quality is gauged in Iowa.

WWTP: Wastewater Treatment Plant. General term for a facility which processes municipal, industrial, or agricultural waste into effluent released to public waters or land applied according to the conditions of the facility's NPDES permit.

Zooplankton: Collective term for all animal plankton suspended in the water column which serve as secondary producers in the aquatic food chain and the primary food source for larger aquatic organisms.

Appendix B --- General and Designated Uses of Iowa's Waters

Introduction

Iowa's water quality standards (Environmental Protection Commission [567], Chapter 61 of the Iowa Administrative Code) provide the narrative and numerical criteria by which water bodies are judged when determining the health and quality of our aquatic ecosystems. These standards vary depending on the type of water body (lakes vs. rivers) and the assigned uses (general use vs. designated uses) of the water body that is being dealt with. This appendix is intended to provide information about how Iowa's water bodies are classified and what the use designations mean, hopefully providing a better general understanding for the reader.

All public surface waters in the state are protected for certain beneficial uses, such as livestock and wildlife watering, aquatic life, non-contact recreation, crop irrigation, and other incidental uses (e.g. withdrawal for industry and agriculture). However, certain rivers and lakes warrant a greater degree of protection because they provide enhanced recreational, economical, or ecological opportunities. Thus, all public bodies of surface water in Iowa are divided into two main categories: *general* use segments and *designated* use segments. This is an important classification because it means that not all of the criteria in the state's water quality standards apply to all water ways; rather, the criteria which apply depend on the use designation & classification of the water body.

General Use Segments

A general use segment water body is one which does not maintain perennial (year-round) flow of water or pools of water in most years (i.e. ephemeral or intermittent waterways). In other words, stream channels or basins which consistently dry up year after year would be classified as general use segments. Exceptions are made for years of extreme drought or floods. For the full definition of a general use water body, consult section 61.3(1) in the state's published water quality standards, which became effective on March 22, 2006 (Environmental Protection Commission [567], Chapter 61 of the Iowa Administrative Code).

General use waters are protected for the beneficial uses listed above, which are: livestock and wildlife watering, aquatic life, non-contact recreation, crop irrigation, and industrial, agricultural, domestic and other incidental water withdrawal uses. The criteria used to ensure protection of these uses are described in section 61.3(2) in the state's published water quality standards, which became effective on March 22, 2006 (Environmental Protection Commission [567], Chapter 61 of the Iowa Administrative Code).

Designated Use Segments

Designated use segments are water bodies which maintain flow throughout the year, or at least hold pools of water which are sufficient to support a viable aquatic community (i.e. perennial waterways). In addition to being protected for the same beneficial uses as the general use segments, these perennial waters are protected for more specific activities such as primary contact recreation, drinking water sources, or cold-water fisheries. There are a total of thirteen different designated use classes (Table B-1) which may apply, and a water body may have more than one designated use. For definitions of the use classes and more detailed descriptions, consult section 61.3(1) in the state's published water quality standards, which became effective on March 22, 2006 (Environmental Protection Commission [567], Chapter 61 of the Iowa Administrative Code).

Table B-1. Designated use classes for Iowa water bodies.

Class prefix	Class	Designated use	Brief comments
A	A1	Primary contact recreation	Supports swimming, water skiing, etc.
	A2	Secondary contact recreation	Limited/incidental contact occurs, such as boating
	A3	Children's contact recreation	Urban/residential waters that are attractive to children
B	B(CW1)	Cold water aquatic life – Type 2	Able to support coldwater fish (e.g. trout) populations
	B(CW2)	Cold water aquatic life – Type 2	Typically unable to support consistent trout populations
	B(WW-1)	Warm water aquatic life – Type 1	Suitable for game and nongame fish populations
	B(WW-2)	Warm water aquatic life – Type 2	Smaller streams where game fish populations are limited by physical conditions & flow
	B(WW-3)	Warm water aquatic life – Type 3	Streams that only hold small perennial pools which extremely limit aquatic life
	B(LW)	Warm water aquatic life – Lakes and Wetlands	Artificial and natural impoundments with "lake-like" conditions
C	C	Drinking water supply	Used for raw potable water
Other	HQ	High quality water	Waters with exceptional water quality
	HQR	High quality resource	Waters with unique or outstanding features
	HH	Human health	Fish are routinely harvested for human consumption

Designated use classes are determined based on a Use Attainability Analysis, or UAA. This is a procedure in which the water body is thoroughly scrutinized, using existing knowledge, historical documents, and visual evidence of existing uses, in order to determine what its designated use(s) should be. This can be a challenging endeavor, and as such conservative judgment is applied to ensure that any potential uses of a water body are allowed for. Changes to a water body's designated uses may only occur based on a new UAA, which depending on resources and personnel, can be quite time consuming.

It is relevant to note that on March 22, 2006, a revised edition of Iowa's water quality standards became effective which significantly changed the use designations of the state's surface waters. Essentially, the changes that were made consisted of implementing a "top down" approach to use designations, meaning that all water bodies should receive the highest degree of protection applicable until a UAA could be performed to ensure that a particular water body did not warrant elevated protection. For more information about Iowa's water quality standards and UAAs, contact the Iowa DNR's Water Quality Bureau.

Appendix C --- Water Quality Data

See Stressor Identification document for water quality data prior to 2008

Table C-1. Water quality data from supplemental monitoring in 2008 (see Figure 4-1 in Section 4 for site locations).

	Site 2A							Site 2C						
	7/16/08	7/31/08	8/11/08	8/27/08	9/11/08	9/24/08	10/7/08	7/16/08	7/31/08	8/11/08	8/27/08	9/11/08	9/24/08	10/7/08
Ammonia N as N (mg/L)	0.08	0.09	<0.05	<0.05	<0.05	<0.05	<0.05	0.89	<0.05	<0.05	4.5	0.22	<0.05	<0.05
CBOD (5 day) (mg/L)	<2	<2	<2	4	3	17	10	<2	<2	<2	5	<2	<2	<2
Chloride(mg/L)	27	29	26	26	31	28	25	53	85	140	200	140	170	220
Chlorophyll a (µg/L)	1	3	6	99	74	460	290	<1	2	2	9	4	3	6
Diss. Inorg. Carbon (mg/L)	58	63	63	64	63	57	57	6.2	69	78	100	78	91	104
DOC (mg/L)	2.1	2.5	2.7	3.7	3.8	4.6	4.8	2.1	3.4	4.1	7.7	4.2	4.2	4.5
DO (mg/L)	8.3	6.3	7.3	13.4	10.6	14.0	17.3	10.1	9.2	6.7	5.0	7.9	10.8	7.2
E. coli (#/100mL)	480	3200	520	190	440	2700	440	4200	1500	1400	390	450	330	450
pH	8.2	8.2	8.2	8.7	8.5	8.6	8.5	8.2	8.2	8.1	8.0	8.2	8.4	8.0
Temp. (°C)	22.4	24.3	19.1	17.4	14.8	18.7	13.9	20.5	23.4	16.3	16.0	16.0	19.5	14.0
Flow (cfs)	9.6	ND	0.8	0.3	0.3	<1	<1	3.4	ND	<0.1	0.2	0.1	<1	<1
NO3+NO2 as N (mg/L)	14	14	12	6.7	6.3	5.4	2.6	12	9.9	9.3	7.1	6.9	5.8	10
Ortho Phos. as P (mg/L)	0.21	0.2	0.2	0.14	0.08	0.07	0.02	0.74	1.5	2.4	4.5	3.2	4	5.1
Total Dis Solids (mg/L)	400	420	420	390	390	370	320	460	560	700	900	730	810	940
TKN as N (mg/L)	0.7	0.7	0.7	1.4	1.1	3.7	2.1	1.2	0.7	0.9	6	1.1	0.8	1
Total Org. Carbon (mg/L)	4.4	3.7	4.5	5.6	6.6	15	10	3.3	4	5.3	8.4	5.1	6.1	5.7
Total Phos. as P (mg/L)	0.28	0.28	0.29	0.35	0.26	0.48	0.22	0.75	1.6	2.5	4.8	3.4	4	5
TSS (mg/L)	56	31	41	46	65	68	32	17	14	28	11	100	35	99
TVSS (mg/L)	8	7	9	14	15	28	17	3	3	5	3	11	5	9
Turbidity (NTU)	36	24	34	30	39	39	20	8.4	4.5	12	9.7	41	32	36

Table C-1 (continued).

	Site 2E							Site 3A							Site 3B						
	7/16	7/31	8/11	8/27	9/11	9/24	10/7	7/16	7/31	8/11	8/27	9/11	9/24	10/7	7/16	7/31	8/11	8/27	9/11	9/24	10/7
Ammonia N as N (mg/L)	2.5	4.8	6.1	5.7	8	5.2	3.7	5	0.97	2.3	2.5	3.9	0.23	0.56	0.12	0.46	0.1	<0.05	2.6	<0.05	<0.05
CBOD (5 day) (mg/L)	<2	3	8	3	<2	<2	5	3	6	14	<2	3	4	6	<2	15	<2	<2	3	<2	<2
Chloride(mg/L)	58	130	160	130	160	160	150	100	150	170	150	160	180	120	98	62	170	200	82	220	220
Chlorophyll a (µg/L)	<1	1	2	9	<1	<1	6	<1	<1	<1	5	2	9	<1	1	30	1	2	9	13	6
Diss. Inorg. Carbon (mg/L)	65	81	92	87	94	93	90	78	86	96	89	97	97	88	66	29	59	60	31	59	49
DOC (mg/L)	2.9	4.8	9.8	4.4	4.8	3.5	5.1	9.1	8.6	15	6.1	7.9	6.1	7.7	1.9	17	3.3	3.4	3.3	3.5	7.5
DO (mg/L)	8.3	5.7	7.0	5.5	5.1	2.8	4.5	4.8	4.3	5.4	4.7	4.8	5.3	5.0	9.2	6.6	9.8	12.2	4.2	11.8	8.8
E. coli (#/100mL)	580	420	160	420	390	390	890	60	10	50	280	50	60	70	3400	82000	5300	620	18000	1400	310
pH	8.1	8.1	8.1	8.2	8.2	8.1	8.0	7.5	7.6	7.6	7.7	7.6	7.7	7.4	8.0	7.9	8.1	8.3	7.6	8.7	7.9
Temp. (°C)	21.7	27.3	27.1	27.1	26.1	30.2	22.1	32.7	31.8	30.3	32.0	32.1	32.7	31.0	17.6	20.4	17.0	17.6	16.3	20.6	14.2
Flow (cfs)	4	ND	2.6	1.4	1.9	1.5	2	1.3	ND	0.8	0.8	1.4	2	1.5	0.9	ND	0.4	0.2	0.6	<1	<1
NO3+NO2 as N (mg/L)	10	5.6	3.6	6.1	4.9	4.2	3.7	6.1	3.5	3.3	7	3.7	4.8	4.1	5.2	2.3	6.9	3.6	3.6	2.3	11
Ortho Phos. as P (mg/L)	0.9	2.6	3.3	3.3	4.7	3.6	4.6	2.7	2.9	3.4	3.8	4.7	3.5	3.2	0.28	0.46	2.2	0.71	0.4	0.4	1.1
Total Dis Solids (mg/L)	470	660	750	720	770	770	720	630	720	820	780	800	850	700	540	330	630	660	290	670	670
TKN as N (mg/L)	4.9	9.6	13	8	8.4	7.2	6.7	18	13	15	6.6	11	1.7	6.9	0.4	3.1	0.8	1	2.9	0.4	0.6
Total Org. Carbon (mg/L)	5.4	8.1	12	6.6	6.1	6.1	5.8	11	11	22	7.4	9.7	9	9.9	2.3	28	3.9	4	4.4	4	8.6
Total Phos. as P (mg/L)	1.1	3.1	3.8	3.6	4.8	3.7	4.6	3	3.2	4.2	4.1	5	3.8	3.6	0.28	0.85	2.2	0.73	0.46	0.43	1.1
TSS (mg/L)	16	25	16	31	10	3	41	12	13	26	5	11	12	17	2	160	2	<1	4	2	92
TVSS (mg/L)	7	12	10	13	2	1	19	11	11	22	5	10	9	15	1	34	1	<1	2	<1	37
Turbidity (NTU)	4.7	2.6	8	3.2	4.1	2.1	15	3.7	2.2	13	4.6	4.1	4.8	7.9	1	62	1.1	1	7.2	1.2	3.9

Complainant's Ex. No. 38 Page 334

Appendix D --- Modeling, Equations and Methodology

Two modeling techniques were used in the development of this TMDL. The first modeling technique used was the Revised Universal Soil Loss Equation (RUSLE) which was used to calculate soil loss and sediment delivery in the watershed. The second model used was the QUAL2K surface water quality model. This model was used to model surface water conditions observed in Silver Creek, identify sources of the ammonia impairment and calculate the minimum load of nitrogen compounds that could lead to ammonia violations within the stream.

D.1. The RUSLE Equation

The Universal Soil Loss Equation (USLE) was developed by the U.S. Department of Agriculture (USDA) based on data collected beginning in the 1930's and originally published in 1965. With additional research and data, the Revised Universal Soil Loss Equation was published in 1997 by the USDA-Natural Resource Conservation Service (NRCS). The current equation is:

$$A = R * K * LS * C * P$$

Where:	A	=	Average annual soil loss in tons per acre per year
	R	=	Rainfall/runoff erosivity
	K	=	Soil erodibility
	LS	=	Hillslope length and steepness
	C	=	Cover-management
	P	=	Support practice

While factors such as rainfall and hillslope are fixed in the watershed, other factors such as cover management and support practice can be revised to reflect a change in land use. For Silver Creek, Clayton County, a RUSLE model was developed to represent current conditions. This model was made using current GIS land use coverages and information gained through communications with NRCS personnel working in the Silver Creek watershed.

Sheet and rill erosion: ArcView GIS is used to calculate soil loss for sheet and rill erosion, using RUSLE. RUSLE C and P factors are gathered by means of field level watershed assessments. RUSLE K and LS factors are derived from statewide digital soils data and Digital Elevation Models (DEMs). Precipitation information (RUSLE R factor) exists in a county based dataset. Inputs to the equation vary based on soil type, land use, and slope; which results in output at a sub-field scale. Output units are tons/acre/year.

Sediment delivery is then calculated using ArcView, based on the "Erosion and Sediment Delivery" method developed by the state geologist for Iowa NRCS (USDA-NRCS 1998). This method uses sediment delivery ratios (SDRs), which have been derived from numerous sediment surveys and vary based on the landform regions and drainage areas of the watersheds in Iowa. Multiplying the sheet and rill erosion rate with the SDR value and the acreage yields a sediment delivery value in tons/year.

D.2. Calculating Bank Erosion

An assessment of the main channel identified areas of unstable and eroding banks (See Stressor Identification document Appendix 2, Figure 2-20,). These sections were measured for length and height. NRCS provides generalized lateral erosion rates; however, a study conduced by Zaimes et al. (2004) provided revised recession rates for different Iowa regions and landuses. Since these recession rates were specific to Iowa soils, these rates were preferred over the NRCS rates. Annual erosion was calculated using the Direct Volume Method:

(Eroding area) x (Lateral Recession Rate) x (Density) / 2000 lbs/day

The calculation was performed for each stretch of bank that was identified as eroding. A density of 1.33 g/ml was applied. For banks with pasture as the adjacent landuse a recession rate of 295 mm/year was used. For banks with row crop as the adjacent landuse, a recession of 253 mm/year was used. The total loss per section was calculated and subsequently added together to calculate the total loss (Table D-1). A sediment delivery ratio of 100% was assumed.

Table D-1. Calculation of bank sediment loss

Length of Bank (mi)	Bank Height (ft)	Land Use	LRR (mm/yr)*	Density (g/ml)	Erosion in (tons/yr)
0.4	5	Pasture	295	1.33	424.3
0.1	5	Pasture	295	1.33	106.1
0.4	8	Pasture	295	1.33	678.9
0.2	8	Pasture	295	1.33	339.4
0.13	8	Pasture	295	1.33	220.6
0.2	10	Pasture	295	1.33	424.3
0.13	6	Pasture	295	1.33	165.5
0.13	8	Row Crop	253	1.33	189.2
0.1	8	Row Crop	253	1.33	145.6
0.13	5	Row Crop	253	1.33	118.3
0.14	5	Row Crop	253	1.33	127.4
				TOTAL	2939.5

* *Lateral Recession Rate*

D.3. Calculating a Daily Expression for Sediment

As a result of the D.C. Circuit Court of Appeals decision in Friends of the Earth, Inc. v. EPA et al., No 05-5015, EPA recommended all future TMDLs and associated load allocations and waste load allocations be expressed in terms of a daily time increment (EPA 2006). Generally, TMDL analytical approaches that result in longer (non-daily) averaging periods may continue to be used to demonstrate consistency with applicable water quality criteria. However, all final TMDL submissions should include an adequate expression of daily loads in addition to any longer-term loading expression that may be developed as a result of the TMDL analysis (EPA 2006). In response to this ruling, the EPA drafted the document "Options for Expressing Daily Loads in TMDLs", providing technical support and methods acceptable to EPA for calculating daily loads in given situations (EPA 2007).

Establishing a sediment TMDL for Silver Creek posed a unique challenge in that there are no direct measurements of how much sediment is entering the stream. The Options for Expressing Daily Loads in TMDLs document presents a similar case study in which a statistical approach is considered to be the best option for identifying a maximum daily load that corresponds to the allowable average load. The method calculates the daily maximum based on a long term average and considers variation. This method is represented by the equation:

$$MDL = LTA \times e^{[z\sigma - .05\sigma^2]}$$

Where:
- MDL = maximum daily limit
- LTA = long term average
- z = z statistic of the probability of occurrence
- σ^2 = $\ln(CV^2 + 1)$
- CV = coefficient of variation

The document also provides Table D-2 to aid in calculation of the MDL.

Table D-2. Multipliers used to convert an LTA to MDL.

Averaging Period (days)	Recurrence interval	Z-score	Coefficient of variation								
			0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8
30	96.8 %	1.849	1.41	1.81	2.39	2.87	3.30	3.67	3.99	4.26	4.48
60	98.4%	2.135	1.50	2.11	2.80	3.50	4.18	4.81	5.37	5.87	6.32
90	98.9%	2.291	1.54	2.24	3.05	3.91	4.76	5.57	6.32	7.00	7.62
120	99.2%	2.397	1.58	2.34	3.24	4.21	5.20	6.16	7.06	7.89	8.66
180	99.4%	2.541	1.62	2.47	3.51	4.66	5.87	7.06	8.20	9.29	10.3
210	99.5%	2.594	1.64	2.52	3.61	4.84	6.13	7.42	8.67	9.86	11.0
365	99.7%	2.778	1.70	2.71	4.00	5.51	7.15	8.83	10.5	12.13	13.7

For Silver Creek, a long term load of 2,745 tons per year is needed to reach the desired 82 percent reduction. The coefficient of variation (CV) is the ratio of the standard deviation to the mean of the data set. For sediment, the standard deviation and mean of TSS were used, which results in a value of 2.34. The z statistic for probability of occurrence used for this TMDL is based on an averaging period of 365 days resulting in a z-score of 2.778. This yields a final LTA multiplier of 4.54 and results in a MDL of 34.1 tons/day.

D.4. QUAL2K Modeling Framework for Simulating River and Stream Water Quality Version 2.04

The QUAL2K model was developed in 2006 by Steve Chapra, Greg Pelletier and Hua Tao (Chapra et al. 2006). This version is an update to the QUAL2E model (Brown and Barnwell 1987) and was designed to model river and stream water quality. The QUAL2K model is a steady state, one-dimensional model for a well-mixed branched system with or without multiple tributaries. The variables of heat budget, temperature and water quality are simulated on a 24-hour time scale. Point source loads, non-point source loads, and withdrawals are simulated. Additional assumptions for specific variables will be discussed within the model inputs section.

This model was used to model surface water conditions observed in Silver Creek, identify sources of the ammonia impairment, and calculate the minimum load of nitrogen compounds that could lead to ammonia violations within the stream. Therefore, a steady state model capable of handling low flow conditions, nitrogen transformations, and daily DO and temperature data was necessary.

Model Segmentation and Hydraulics. QUAL2K represents a river as a series of reaches that have constant hydraulic characteristics (i.e. width, slope, substrate). The system can be broken into main stem and tributaries, and the model is capable of generating individual data and plots for each of these stems. For Silver Creek, Clayton County, the first step in model development was determining which of the tributaries are contributing at low flow conditions, which was complicated by a complex karst geological system that removes a large volume of water from the main stem of the creek. The most prominent karst feature is a large sinkhole in the main channel just south of the confluence of the main channel and the un-named tributary to the north. It has been observed several times that under normal to low flow conditions this sink hole actually drains the entire main channel dry. Therefore, during the critical low flow periods for ammonia this sinkhole effectively creates a sub-water shed whose hydrology is disconnected from any inputs from the northern portion of the Silver Creek watershed (Figure D-1).

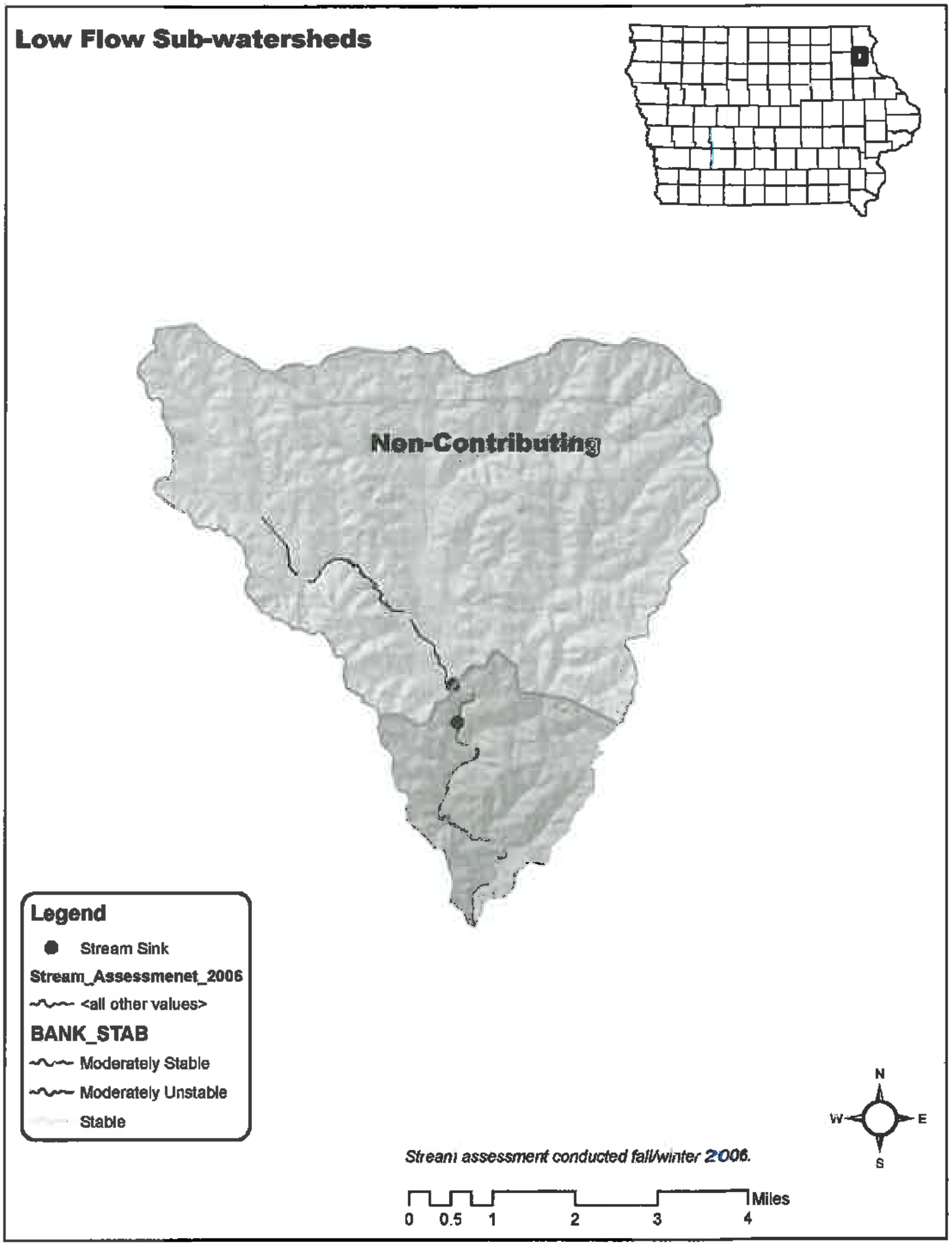


Figure D-1. Division of Silver Creek into sub-watersheds that do and do not contribute to Silver Creek main channel during low flow due to sinkhole drainage.

D.5. Modeling Scheme

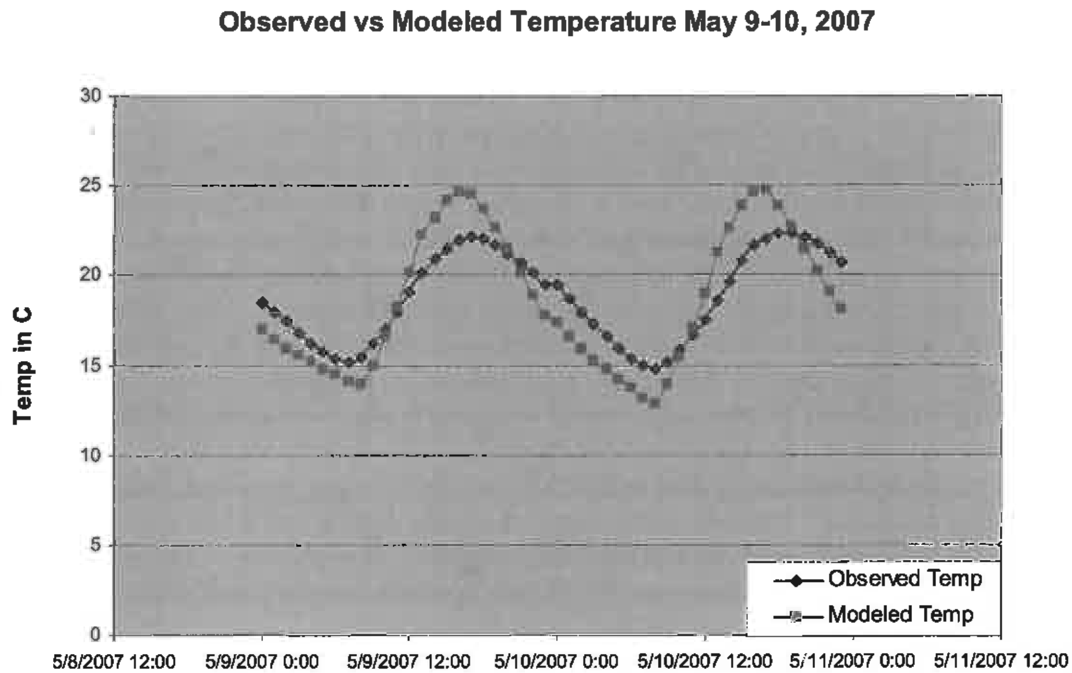
The data available for Silver Creek spans three sampling years from 2006-2008. Although there is a large amount of data, large gaps in the collected data made model calibration difficult. The two major problems were lack of continuous DO and temperature data during the water quality sampling events that yielded ammonia violations, and a lack of longitudinal data between critical sampling locations. An attempt to rectify this lack of data was made in 2008. However, during that sampling cycle no ammonia violations were observed in the impaired segment. Therefore, three separate QUAL2K models were built to accommodate these issues with available data. Each model will be discussed in depth in the results and calibration sections. Here they will be briefly reviewed for how each model was used in developing the TMDL.

The first model was built using data from 2006 and 2007 to design a steady-state base flow conditions model. This was calibrated to available continuous DO and temperature data that did not correspond with storm events or periods of high flow. This served as a base model. This model was then used to produce scenarios under which ammonia violations would occur.

D.6. Steady State Base Flow Model Calibrated for Temperature and DO

Limited continuous DO and temperature data was gathered for the Silver Creek watershed during 2007. The continuous data included breaks in the data when equipment malfunctioned. To calibrate the 24-hour DO and temperature model, a span of continuous data was chosen. This span of time was checked against precipitation records to ensure no rain events occurred. This was done to ensure steady state base flow conditions were modeled correctly. The model was calibrated to a 48-hour period of time from midnight May 9, 2007 to midnight May 11, 2007. The model was calibrated for both a curve fit for diurnal temperature and DO (Fig. D-2 and D-3) as well as a regression analysis for observed versus modeled data for temperature and DO (Fig. D-2 and D-3). The model was not considered calibrated until regression analysis yielded r-square values greater than 0.8. Stream flow was also calibrated at the mouth of the stream to ensure proper interaction between the stream and major sinkholes.

Once this initial model was calibrated, all physical parameters, light and heat inputs, and stoichiometric rates (Tables D-3 and D-4) remained the same in the subsequent models. The only variables allowed to change were weather related or water quality variables to model given conditions for different seasons and sampling events. It was assumed the rates and inputs that yielded a calibrated DO and temperature model were the governing equations for this system and would serve as base and boundary conditions.



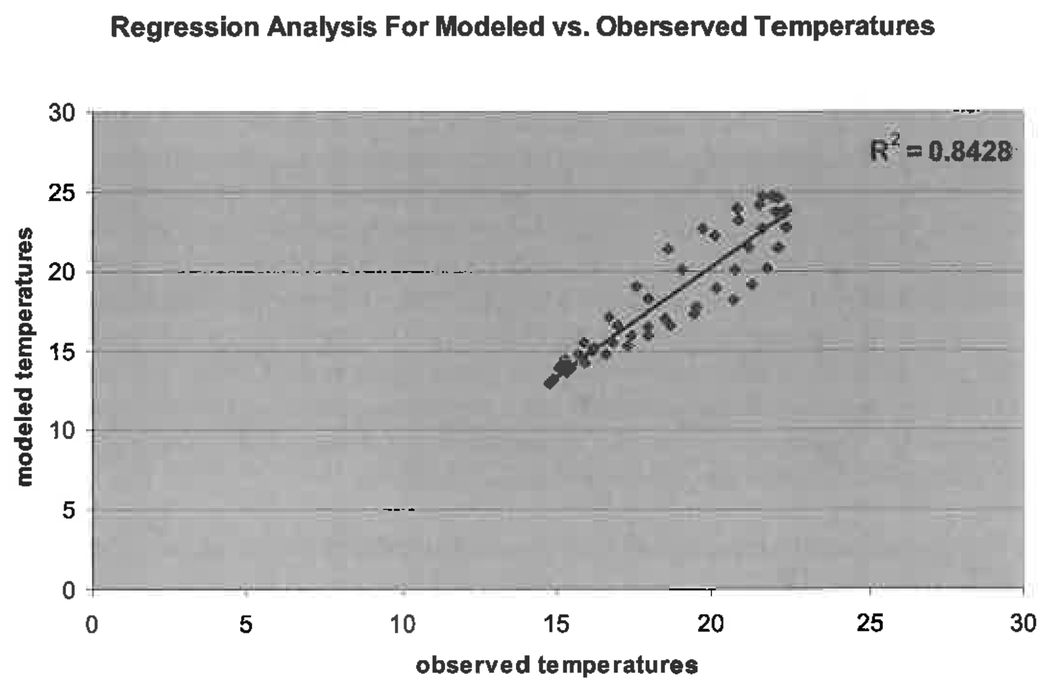
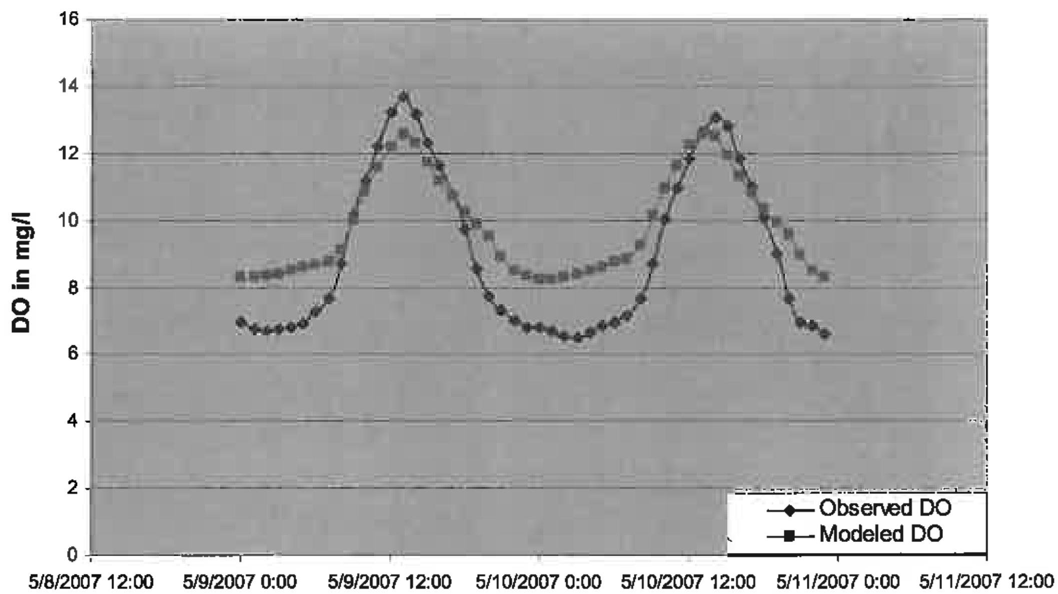


Figure D-2. Curves comparing observed and modeled temperature data in degrees Celsius and associated regression curve.

Observed vs Modeled DO May 9-10, 2007



Regression Analysis for Modeled vs. Observed DO

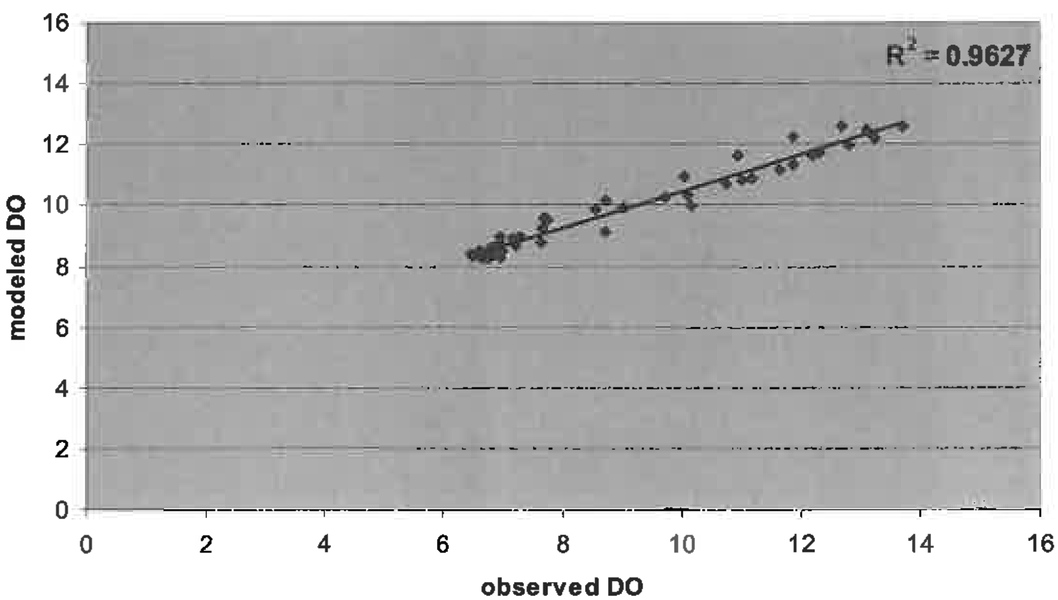


Figure D-3. Curves comparing observed and modeled DO data in mg/L and associated regression curve.

Table D-3. Physical hydrologic parameter inputs for Silver Creek mainstem and two contributing tributaries.

Reach Number	Reach Length (km)	Downstream Latitude	Downstream Longitude	Location Upstream (km)	Location Downstream (km)	Element Number >=1	Elevation Upstream (m)	Elevation Downstream (m)	Downstream Latitude Degrees	Downstream Latitude Minutes	Downstream Latitude Seconds	Downstream Longitude Degrees	Downstream Longitude Minutes	Downstream Longitude Seconds
1	1.00	42.50	72.00	10.0	9.0	2	321.8	318.2	42.00	30	0	72.00	0	0
2	1.00	42.50	72.00	9.0	8.0	2	314.6	311.0	42.00	30	0	72.00	0	0
3	1.00	42.50	72.00	8.0	7.0	2	311.0	307.4	42.00	30	0	72.00	0	0
4	1.00	42.50	72.00	7.0	6.0	2	307.4	303.8	42.00	30	0	72.00	0	0
5	1.00	42.50	72.00	6.0	5.0	2	303.8	300.2	42.00	30	0	72.00	0	0
6	1.00	42.50	72.00	5.0	4.0	2	300.2	296.6	42.00	30	0	72.00	0	0
7	1.00	42.50	72.00	4.0	3.0	2	296.6	293.0	42.00	30	0	72.00	0	0
8	1.00	42.50	72.00	3.0	2.0	2	293.0	289.4	42.00	30	0	72.00	0	0
9	1.00	42.50	72.00	2.0	1.0	2	289.4	285.8	42.00	30	0	72.00	0	0
10	1.05	42.50	72.00	1.0	0.0	2	285.800	280.000	42.00	30	0	72.00	0	0

Hydraulic Model (Weir Overrides Manning Formula; Manning Formula Override Rating Curves)

Weir Height (m)	Weir Width (m)	adam	bdam	Rating Curves Velocity Coefficient	Velocity Exponent	Depth Coefficient	Depth Exponent	Manning Formula Channel Slope	Manning n	Bot Width m	Side Slope	Prescribed Dispersion m2/s	Bottom Algae Coverage	Bottom SOD Coverage
0.0000	0.0000	1.2500	0.9000	0.0000	0.000	0.0000	0.000	0.0030	0.0600	2.00	0.0000	0.00	50.00%	5.00%
0.0000	0.0000	1.2500	0.9000	0.0000	0.000	0.0000	0.000	0.0030	0.0600	5.00	0.0000	0.00	50.00%	5.00%
0.0000	0.0000	1.2500	0.9000	0.0000	0.000	0.0000	0.000	0.0030	0.0600	5.00	0.0000	0.00	50.00%	5.00%
0.0000	0.0000	1.2500	0.9000	0.0000	0.000	0.0000	0.000	0.0030	0.0600	7.00	0.0000	0.00	50.00%	5.00%
0.0000	0.0000	1.2500	0.9000	0.0000	0.000	0.0000	0.000	0.0030	0.0600	7.00	0.0000	0.00	50.00%	5.00%
0.0000	0.0000	1.2500	0.9000	0.0000	0.000	0.0000	0.000	0.0030	0.0600	7.00	0.0000	0.00	50.00%	5.00%
0.0000	0.0000	1.2500	0.9000	0.0000	0.000	0.0000	0.000	0.0030	0.0600	7.00	0.0000	0.00	50.00%	5.00%
0.0000	0.0000	1.2500	0.9000	0.0000	0.000	0.0000	0.000	0.0030	0.0600	7.00	0.0000	0.00	50.00%	5.00%
0.0000	0.0000	1.2500	0.9000	0.0000	0.000	0.0000	0.000	0.0030	0.0600	7.00	0.0000	0.00	50.00%	5.00%
0.0000	0.0000	1.2500	0.9000	0.0000	0.000	0.0000	0.000	0.0030	0.0600	7.00	0.0000	0.00	50.00%	5.00%

Table D-4 Water column rates and governing equations.

QUAL2K

Stream Water Quality Model

Silver_creek _2 (7/26/2006)

Water Column Rates

Parameter	*Value*	*Units*	*Symbol*
Stoichiometry:			
Carbon	40	gC	gC
Nitrogen	7.2	gN	gN
Phosphorus	1	gP	gP
Dry weight	100	gD	gD
Chlorophyll	1	gA	gA
Inorganic suspended solids:			
Settling velocity	0.3	m/d	v_i
Oxygen:			
Reaeration model	Thackston-Dawson		
User reaeration coefficient α	3.93		α
User reaeration coefficient β	0.5		β
User reaeration coefficient γ	1.5		γ
Temp correction	1.024		θ_a
Reaeration wind effect	None		
O2 for carbon oxidation	2.69	gO_2/gC	r_{oc}
O2 for NH4 nitrification	4.57	gO_2/gN	r_{on}
Oxygen inhib model CBOD oxidation	Half saturation		
Oxygen inhib parameter CBOD oxidation	0.60	mgO2/L	K_{socf}
Oxygen inhib model nitrification	Exponential		
Oxygen inhib parameter nitrification	0.60	L/mgO2	K_{sona}
Oxygen enhance model denitrification	Exponential		
Oxygen enhance parameter denitrification	0.60	L/mgO2	K_{sodn}
Oxygen inhib model phyto resp	Exponential		
Oxygen inhib parameter phyto resp	0.60	L/mgO2	K_{sop}
Oxygen enhance model bot alg resp	Exponential		
Oxygen enhance parameter bot alg resp	0.60	L/mgO2	K_{sob}
Slow CBOD:			
Hydrolysis rate	0.1	/d	k_{hc}
Temp correction	1.07		θ_{hc}
Oxidation rate	0.1	/d	k_{dcs}
Temp correction	1.047		θ_{dcs}

Fast CBOD:			
Oxidation rate	0.23	/d	k_{dc}
Temp correction	1.047		θ_{dc}
Organic N:			
Hydrolysis	0.2	/d	k_{hn}
Temp correction	1.07		θ_{hn}
Settling velocity	0.1	m/d	v_{on}
Ammonium:			
Nitrification	1	/d	k_{na}
Temp correction	1.07		θ_{na}
Nitrate:			
Denitrification	0	/d	k_{dn}
Temp correction	1.07		θ_{dn}
Sed denitrification transfer coeff	0	m/d	v_{di}
Temp correction	1.07		θ_{di}
Organic P:			
Hydrolysis	0.2	/d	k_{hp}
Temp correction	1.07		θ_{hp}
Settling velocity	0.1	m/d	v_{op}
Inorganic P:			
Settling velocity	1	m/d	v_{ip}
Inorganic P sorption coefficient	0	L/mgD	K_{dpi}
Sed P oxygen attenuation half sat constant	0.05	mgO_2/L	k_{spi}
Phytoplankton:			
Max Growth rate	2.5	/d	k_{gp}
Temp correction	1.07		θ_{gp}
Respiration rate	0.1	/d	k_{rp}
Temp correction	1.07		θ_{rp}
Death rate	0.2	/d	k_{dp}
Temp correction	1.07		θ_{dp}
Nitrogen half sat constant	25	ugN/L	k_{sPp}
Phosphorus half sat constant	5	ugP/L	k_{sNp}
Inorganic carbon half sat constant	1.30E-05	moles/L	k_{sCp}
Light model	Half saturation		
Light constant	60	langleys/d	K_{Lp}
Ammonia preference	25	ugN/L	k_{hnxp}
Settling velocity	0.5	m/d	v_a
Bottom Algae:			
Growth model	Zero-order		
Max Growth rate	50	$mgA/m^2/d$ or	C_{gb}

		/d	
Temp correction	1.07		θ_{gb}
First-order model carrying capacity	1000	mgA/m^2	$a_{b,max}$
Respiration rate	0.5	/d	k_{rb}
Temp correction	1.07		θ_{rb}
Excretion rate	0.09	/d	k_{eb}
Temp correction	1.07		θ_{eb}
Death rate	0.1	/d	k_{db}
Temp correction	1.07		θ_{db}
External nitrogen half sat constant	120	ugN/L	k_{sPb}
External phosphorus half sat constant	100	ugP/L	k_{sNb}
Inorganic carbon half sat constant	1.30E-05	moles/L	k_{sCb}
Light model	Half saturation		
Light constant	60	langleys/d	K_{Lb}
Ammonia preference	25	ugN/L	k_{hnxb}
Subsistence quota for nitrogen	0.72	mgN/mgA	q_{0N}
Subsistence quota for phosphorus	0.1	mgP/mgA	q_{0P}
Maximum uptake rate for nitrogen	150	mgN/mgA/d	ρ_{mN}
Maximum uptake rate for phosphorus	5	mgP/mgA/d	ρ_{mP}
Internal nitrogen half sat constant	0.9	mgN/mgA	K_{qN}
Internal phosphorus half sat constant	0.13	mgP/mgA	K_{qP}
Detritus (POM):			
Dissolution rate	0.5	/d	k_{dt}
Temp correction	1.07		θ_{dt}
Fraction of dissolution to fast CBOD	1.00		F_f
Settling velocity	0.1	m/d	v_{dt}
Pathogens:			
Decay rate	0.6	/d	k_{dx}
Temp correction	1.07		θ_{dx}
Settling velocity	1	m/d	v_x
Light efficiency factor	1.00		α_{path}
pH:			
Partial pressure of carbon dioxide	347	ppm	p_{CO2}

D.7. Validating Model to Water Quality Data

After the base flow conditions model was calibrated, the next step was to validate the model using grab sample data collected at various times of the year. The model was validated to the parameters of temperature, DO, nitrate, ammonia, total phosphorus, pH and flow for that given event (Table D-5). Of the sampling data available to validate the model, sampling events during or directly following a precipitation event were not used. This is because the sink holes would be bypassed by the higher flow, creating conditions outside of a base flow condition. Additionally, ammonia violations were only observed during periods of low flow.

Table D-5. Results of model validation run for July 26, 2006 comparing observed conditions to modeled.

Parameter	Observed	Modeled
Temperature (C)	28.2	26.4
DO (mg/L)	7.9	7.3
NO_3 (mg/L)	2.4	2.2
NH_3 (mg/L)	0.75	0.48
TP (mg/L)	0.87	0.65
pH	8.2	8.8
Flow (m^3/s)	0.01	0.01

D.8. Using calibrated and validated model to calculate TMDL for Ammonia

The final model scenario was used to locate the sources of ammonia causing the impairment and determine how much ammonia was needed to produce a violation of Iowa's water quality standards. Once this was determined, the modeled load was used to calculate the TMDL.

The first task required examining land uses within the impaired segment of the watershed to determine which non-point sources contribute ammonia to the stream. There are two open feedlots within close proximity to the impaired section of the watershed (Fig. D-5). Runoff from these two operations along with livestock with direct access to the stream act as nonpoint sources of ammonia. These two operations were entered into the model as discharge sources. The model was then run with different discharge rates to produce ammonia violations at the most critical conservative conditions. These conditions were assumed to be a temperature of 20° C or greater, a pH of 8.2 or greater and a flow of 0.01 m^3/s. Different discharge rates and concentrations were used until violation occurred. This rate multiplied by the given concentration resulted in a daily release of 12.33 lbs. This was determined to be the maximum daily load the stream could assimilate and still meet water quality standards.

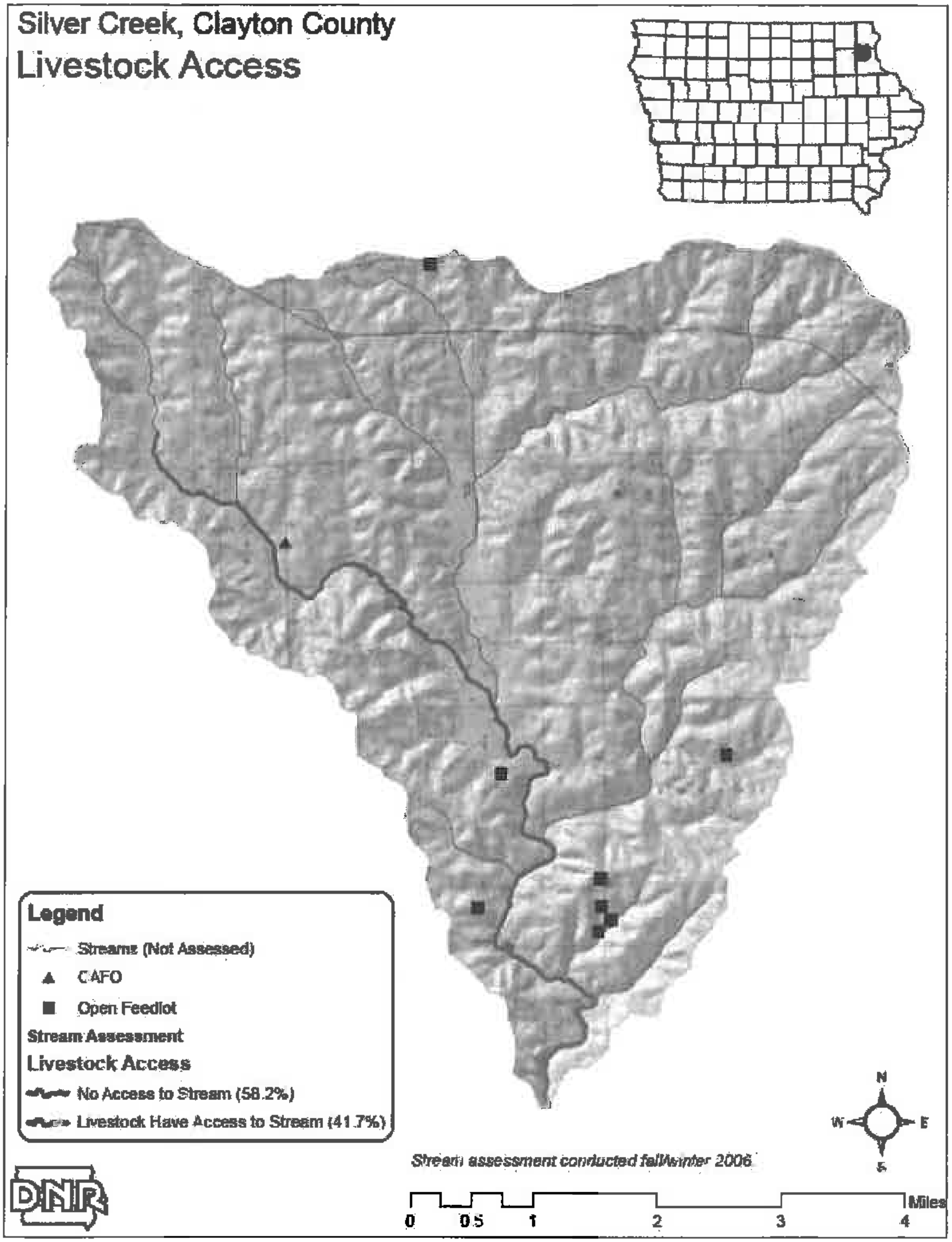


Figure D-4. Segments of Silver Creek where livestock have direct access and locations of AFO/CAFOs within watershed.

D.9. References

Brown, L.C., Barnwell, T.O., 1987. The enhanced stream water quality models QUAL2E and QUAL2E-UNCAS: documentation and user manual. EPA/600/3-87/007, United States Environmental Agency, Athens, Georgia, USA.

Chapra, S.C., G. J. Pelletier, and H. Tao. 2006. QUALIIK: A Modeling Framework for Simulating River and Stream Water Quality, Version 2.04. Documentation and Users Manual. Civil and Environmental Engineering Dept., Tufts University, Medford, MA.

U.S. Department of Agriculture , Natural Resources Conservation Service (NRCS), 1998. Field Office Technical Guide, Section 1, Erosion Prediction: IA-198 "Erosion and Sediment Delivery", Schneider, March 27, 1998

U.S. Environmental Protection Agency (EPA), 2006. Establishing TMDL "Daily" Loads in Light of the Decision by the U.S. Court of Appeals for the D.C. circuit in Friends of the Earth, Inc. v. EPA, et al., No. 05-5015, (April 25, 2006) and Implications for NPDES Permits. Memorandum from Benjamin Grumbles, Assistant Administrator, EPA Office of Water, Washington, DC.

U.S. Environmental Protection Agency (EPA), 2007. Options for Expressing Daily Loads in TMDLs (Draft). EPA Office of Wetlands, Oceans & Watersheds, Washington, DC.

Zaimes, G.N., Schultz, R.C., Isenhart, T.M. 2004. Stream bank erosion adjacent to riparian forest buffers, row-crop fields, and continuously-grazed pastures along Bear Creek in central Iowa. Journal of Soil and Water Conservation vol. 59 num. 4 p. 19-27

Appendix E --- Public Comments

The draft TMDL was posted on the Iowa Department of Natural Resources website on December 31, 2009 and comments were accepted from December 31, 2009 to February 1, 2010. On January 14, 2010, a public meeting was held in Luana, Iowa to obtain comments and input.

No public comments were received for the Silver Creek TMDLs.

Total Maximum Daily Loads For Sediment, Nutrients, and Ammonia North Fork Maquoketa River Dubuque County, Iowa

2007

Iowa Department of Natural Resources
Watershed Improvement Section

Table of Contents

1. Summary

Table 1. North Fork Maquoketa River summary.

Waterbody Name	North Fork Maquoketa River
County	Dubuque and Delaware
Use Designation Class	B(WW-2) (aquatic life)
Major River Basin	Maquoketa River Basin
Pollutants	Sediment (sheet, rill, and bank erosion) Nutrients (phosphorous limited algae) Ammonia (toxicity and oxygen demand)
Pollutant Sources	Sediment – Nonpoint sources Nutrients – Point and nonpoint sources Ammonia – Episodic nonpoint sources
Impaired Use	B(WW-2) (aquatic life)
2002 303d Priority	Low
Watershed Area	28,252 acres
Impaired Stream Length	19.5 miles
Sediment TMDL	
Target	Reduce stream bed siltation from 39% to 9% bottom coverage
Load Capacity (annual avg.)	20,200 tons per year
Existing Load (annual avg.)	87,500 tons per year
Reduction to Achieve Target (annual avg.)	67,300 tons per year
Load Allocation (annual avg.)	20,200 tons per year
Existing load (max. daily, see #7, p. 5)	51,000 tons per day (2yr. 24 hr. event)
Load Reduction (max. daily, see #7, p. 5)	39,300 tons per day (2yr. 24 hr. event)
Load Allocation (max. daily, see #7, p. 5)	11,700 tons per day (2yr. 24 hr. event)
Wasteload Allocation	No sediment point sources
Margin of Safety	Implicit - conservative assumptions
Nutrient TMDL (Phosphorous)	
Targets	Reduce diurnal DO swings to 10 mg/l or less, reduce bottom algae by 33%, maintain a minimum DO concentration of 5.0 mg/l
Load Capacity	6.64 lb/day total phosphorous (TP)
Existing Load	21.04 lb/day TP
Load Reduction to Achieve Target	14.40 lb/day TP
Load Allocation	5.40 lb/day TP
Wasteload Allocation	1.24 lb/day TP (existing daily load)
Margin of Safety	Implicit – conservative assumptions
Maximum daily load	6.64 lb/d TP
Ammonia TMDL (Episodic Toxicity)	
Target (simulated 24 hr. discharge at pH = 9.0 and temp. = 20C, flow = 10 L/sec)	Water Quality Standards Acute Criterion for Total Ammonia
Load Capacity (10 mg/l ammonia)	1.92 lb/d total ammonia
Existing Load (45 mg/l ammonia)	8.63 lb/d total ammonia
Load Reduction to Achieve Target	6.71 lb/d total ammonia
Wasteload Allocation	No episodic point sources.
Load Allocation	1.92 lb/d total ammonia
Margin of Safety	0.13 mg/l total ammonia (10 % of 1.32 mg/l WQS concentration criterion)

The Federal Clean Water Act requires the Iowa Department of Natural Resources (IDNR) to develop a total maximum daily load (TMDL) for waters that have been identified on the state's 303(d) list as impaired by a pollutant. North Fork Maquoketa River (NFMR) has been identified as impaired by sediment, nutrients, and episodic slugs of ammonia. The purpose of these TMDLs for North Fork Maquoketa River is to calculate the maximum allowable sediment, total phosphorus, and ammonia loads for the stream so that water quality standards are maintained.

Because the cause (stressor) of the biological impairment in 1998 was unknown, a method called Stressor Identification (SI) was used to determine the existing stressors on the biotic community of North Fork Maquoketa River. The process involves "critically reviewing available information, forming possible stressor scenarios that might explain the impairment, analyzing those scenarios, and producing conclusions about which stressor or stressors are causing the impairment."

Phasing TMDLs is an iterative approach to managing water quality that becomes necessary when the origin, nature, or sources of water quality impairments are not well understood. This TMDL will have two phases. Phase 1 will consist of setting specific and quantifiable targets for sediment, oxygen demand, total phosphorus, and ammonia loads to the creek. Phase 2 will consist of implementing the monitoring plan, evaluating collected data, and readjusting target values if needed and as resources are available.

In Phase 1, the waterbody load capacity, existing pollutant load in excess of this capacity, and the source load allocations are estimated based on available information. As resources become available, a monitoring plan will be used to determine if prescribed load reductions result in attainment of water quality standards and whether or not the target values are sufficient to meet designated uses.

Monitoring activities may include routine sampling and analysis, biological assessment, fisheries studies, and watershed and/or waterbody modeling. Monitoring is important for watershed TMDL plans to:

- Assess the future beneficial use status;
- Determine if the water quality is improving, degrading or remaining stable;
- Evaluate the effectiveness of implemented best management practices.

Any additional data will be used in Phase 2 to determine if the implemented TMDL and watershed management plan have been effective in addressing the water quality impairments. The data and information can also be used to determine if the TMDLs have accurately identified the required components, i.e., assimilative capacity, load and wasteload allocations, in-stream response to pollutant loads, etc., and if revisions are appropriate.

This TMDL has been prepared in compliance with the current regulations for TMDL development that were promulgated in 1992 as 40 CFR Part 130.7. These regulations and consequent TMDL development are summarized below:

1. **Name and geographic location of the impaired or threatened waterbody for which the TMDL is being established:** North Fork Maquoketa River, S31, T89N, R2W, Dubuque County at Dyersville.

2. **Identification of the pollutant and applicable water quality standards:** The pollutants causing the water quality impairments are sediment, phosphorous limited benthic algae, and episodic ammonia loads. The designated use for North Fork Maquoketa River is Aquatic Life Class B(WW-2). Excess sediment, phosphorus and ammonia have impaired the aquatic life designated use criteria as described in the Iowa Water Quality Standards.

3. **Quantification of the pollutant load that may be present in the waterbody and still allow attainment and maintenance of water quality standards:** The target of this TMDL is a reduction of sediment, benthic algae productivity and respiration, ammonia and oxygen demand loadings that allows the biological community to meet regional reference criteria. Biological targets are based on the Fish Index of Biotic Integrity (FIBI) and Benthic Macroinvertebrate Index of Biotic Integrity (BMIBI). Stream segments having FIBI or BMIBI scores below the 25^{th} percentile of reference sites are considered impaired.

   In order to meet the biological targets, secondary targets are set for delivered sediment, phosphorous, and ammonia. Measurements from the monitored NFMR stream segments are compared to stream reference sites within the same ecological region. These biotic index targets are set for scores equaling or exceeding the 25^{th} percentile of regional reference sites.

4. **Quantification of the amount or degree by which the current pollutant load in the waterbody, including the pollutant from upstream sources that is being accounted for as background loading, deviates from the pollutant load needed to attain and maintain water quality standards:** The existing FIBI and BMIBI scores based on 1999, 2001 and 2005 bioassessment sampling and the ecoregion reference scores are shown in Table 6. Based on comparisons to regional reference sites, reductions are needed for sediment, phosphorous limited benthic algae, and episodic ammonia loads to meet the ecoregion targets and protect beneficial aquatic life use.

5. **Identification of pollution source categories:** Both point and nonpoint pollutants have been identified as sources of impairments to North Fork Maquoketa River. Point sources include municipal wastewater treatment facilities. Nonpoint sources include runoff from both urban and agricultural land uses.

6. **Wasteload allocations (WLA) for pollutants from point sources:** There are no point sources in the watershed that are significant sources of sediment and therefore there are no wasteload allocations for sediment. The total phosphorous WLA for the New Vienna wastewater treatment plant is based on the existing estimated average daily load. It is 564 gram/d (1.24 lb/d) or the

monitored daily load when this data becomes available. Ammonia limits are the same as in the WLA developed during planning for the recently constructed aerated lagoon.

7. **Load allocations for pollutants from nonpoint sources:** The load allocation for sediment is set as both a long term annual average and a maximum daily load for the 2 year 24 hour storm event (3 inches). The long-term annual average load allocation is set at 20,200 tons/year delivered to the stream based on the Revised Universal Soil Loss Equation (RUSLE) model. The maximum daily load was estimated using the Modified USLE model and a 2-year return 24-hour storm event (3 inches over 24 hours). The maximum daily load allocation is set at 11,700 tons per day. The total phosphorus daily load allocation is set at 5.40 pounds per day. The total ammonia load allocation for a slug discharge to the stream over 24 hours is 1.9 pounds per day, i.e., 10 mg/l total ammonia concentration in a 1000 gal/hour discharge to the stream.

8. **A margin of safety:** The margin of safety for this TMDL is provided by the conservative assumptions made during its development. Some of these assumptions were:

   - That there are no management practices in the watershed that reduce delivered sediment to the stream when in fact there are several of these BMPs, such as riparian buffer strips and sediment control basins in place.
   - The median for the reference conditions used as a target puts the goal well above the 25th percentile of the IQR that is the threshold for determining impairment.

   Additionally, an explicit 10 % MOS was applied to the total ammonia toxicity criterion for episodic ammonia slug loads to the stream.

9. **Consideration of seasonal variation:** This TMDL was developed based on the average annual and daily maximum sediment load and the critical conditions in late summer for daily maximum dissolved oxygen fluctuations and episodic ammonia loads.

10. **Allowance for reasonably foreseeable increases in pollutant loads:** An allowance for increased sediment and phosphorus loading was not included in this TMDL. The City of New Vienna's population is stable and is expected to remain so. The watershed landuses are expected to remain predominantly agricultural. The addition or deletion of animal feeding operations within the watershed could increase or decrease nutrient and ammonia loading. An allowance for potential increases in agricultural loads is not included because such increases are not predictable.

11. **Implementation plan:** Although not required by the current regulations, an implementation plan is outlined in Section 4 of this report.

2. North Fork Maquoketa River, Description and History

2.1 The Stream

The North Fork Maquoketa River (NFMR) runs generally south and east from its headwaters near the City of Luxemburg in Dubuque County to its confluence with the Maquoketa River in Jackson County near the City of Maquoketa. The impaired NFMR segment starts near the headwaters and flows 19.5 miles to Dyersville.

Table 2. North Fork Maquoketa River features.

Waterbody Name:	North Fork Maquoketa River;
Hydrologic Unit Code:	HUC10 0706000603
IDNR Waterbody ID:	IA 01-NMQ-0020_2;
Location:	Section 31 T89N R2W; Section 21 T89N R2W
Latitude:	42° 29' N
Longitude:	91° 7' W
Water Quality Standards Designated Uses:	Aquatic Life Support, B(WW-2)
Tributaries:	Coffee Creek
Receiving Waterbody:	Maquoketa River
Stream Segment Lengths:	19.5 miles
Watershed Area:	28,252 acres

Hydrology

The NFMR impaired segment flows near the cities of Holy Cross and Luxemburg, through the City of New Vienna, and continues through the City of Dyersville. Its basin consists of a single HUC 12 sub watershed and its tributaries are Coffee Creek and several smaller unnamed streams. The segment ends in the City of Dyersville. Approximately 70 miles downstream of Dyersville, the North Fork Maquoketa River joins the Maquoketa River at the City of Maquoketa.

2.2 The Watershed

Land Use

The watershed of the impaired segment of the North Fork Maquoketa River has an area of 28,252 acres. Landuse data is based on 2002 statewide land covers derived from satellite imagery. Watershed landuses and areas are shown in Table 3. Figure A-2 in Appendix A is a map showing the distribution of land uses.

The watershed contributing to flow in the NFMR upstream from Dyersville, Iowa (Segment No. IA 01 NMQ-0020_2) is a transitional area that is divided between two ecological regions of Iowa (Figure 1). Roughly half of the lower portion of the watershed is located in the Iowan Surface of the Western Corn Belt Plains, and the upper one-half of the watershed is located in the Paleozoic Plateau (Driftless Area) ecoregion.

Table 3. 2002 landuses in the North Fork Maquoketa watershed

Land cover	**Area, acres**	**% of total**
Corn	11,817	41.8
Ungrazed and CRP grassland	6,427	22.7
Soybeans	4,629	16.4
Alfalfa	2,000	7.1
Roads, barren, unknown	864	3.1
Forest	804	2.8
Grazed grassland	769	2.7
Commercial industrial	405	1.4
Other rowcrop	372	1.3
Residential	128	0.5
Water and wetlands	38	0.1
Total	28,252	100

Estimated livestock in the watershed includes 7,200 cattle and 13,250 hogs held in pastures, feedlots, and CAFOs. These estimates are based on the 2002 Census of Agriculture. Although livestock inventory varies throughout the year depending on sale and slaughter rates, it is assumed that the Census number is representative of the average population for the year. The county level data was reduced by calculating the percentage of the county that is part of the watershed, assuming an even distribution of livestock

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. Pollutants from CAFOs are delivered to a receiving stream via runoff from land-applied manure or from leaking/failing storage structures.

Open feedlots are unroofed or partially roofed animal feeding operations in which no crop, vegetation, or forage growth or residue cover is maintained during the period that animals are confined in the operation. Runoff from open feedlots can deliver substantial quantities of nutrients, oxygen demanding pollutants, and ammonia to streams dependent upon factors such as proximity to a water surface, number and type of livestock and manure controls.

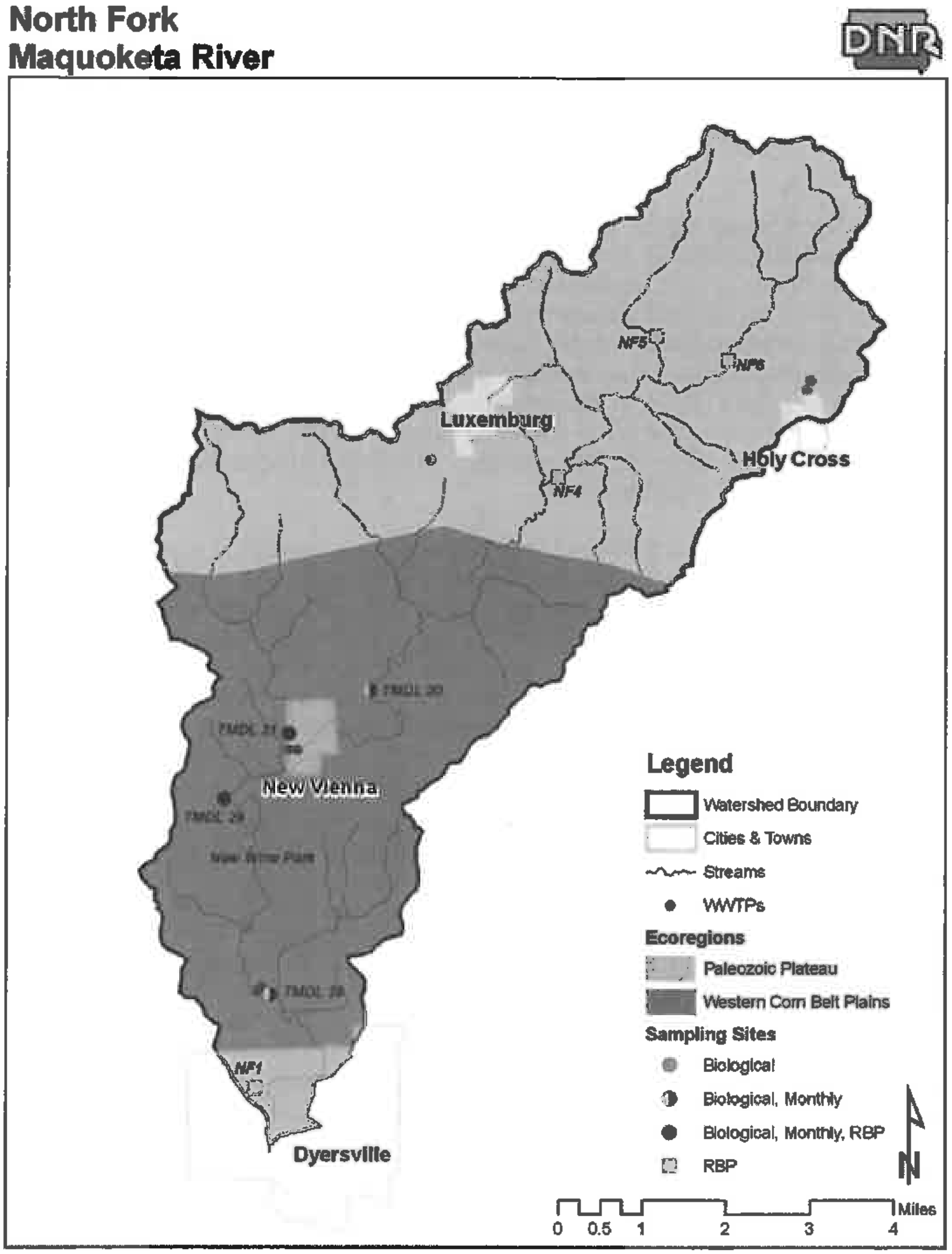


Figure 1 The North Fork Maquoketa River impaired segment and its watershed

Geology, Topography, and Soils

The watershed contributing to flow in the NFMR upstream from Dyersville, Iowa (Segment No. IA 01 NMQ-0020_2) is a transitional area that is divided between two ecological regions of Iowa (Figure 1). Roughly two-thirds of the lower portion of the watershed is located in the Iowan Surface of the Western Corn Belt Plains, and the upper one-third of the watershed is located in the Paleozoic Plateau (Driftless Area) ecoregion.

The Iowan Surface ecoregion is a geologically complex region located between the bedrock-dominated landforms of the Paleozoic Plateau region and the relatively recent glacial drift landforms of the Des Moines Lobe. The southern and southeastern border of this ecoregion is irregular and crossed by major northwest- to southeast-trending stream valleys. In the northern portion of the region, the glacial deposits are thin, and shallow limestone bedrock creates karst features such as sinkholes and sags. There are no natural lakes of glacial origin in this region, but overflow areas and backwater ponds occur on some of the larger river channels contributing to some diversity of aquatic habitat and a large number of fish species. The NFMR impaired segment is in the northeastern part of the Iowan Surface.

The bedrock-dominated terrain of the Paleozoic Plateau ecoregion is strikingly different from the rest of Iowa. Steep slopes and bluffs, higher relief, sedimentary rock outcrops, dense forests, and unique boreal microhabitats differentiate this ecoregion from the Iowan Surface Western Cornbelt Plains to the west. The Silurian Escarpment, a prominent physiographic feature that helps define the southern and western boundary this ecoregion, separates the mostly cropland area of the west from the mixed land use of the Driftless Area. Dissolution of the limestone and dolomite rocks results in karst features such as sinkholes, caves, and springs, and makes groundwater vulnerable to contamination. The streams in the Iowa portion of this region occupy entrenched valleys, and have cool waters with high gradients flowing over rocky substrates. The fish communities found here reflect this preference for cool clear water with relative consistency of flow.

The North Fork Maquoketa River watershed topography ranges from gently sloping to very steep. The upper portions of the watershed are in well-drained, silty upland soils of the Fayette-Nordness and Downs-Tama associations. These soils are formed primarily from loess.

Near Dyersville, the Chelsea-Sogn-Lamont soil association dominates. This association is characterized as sandy or loamy, excessively drained or well-drained soils on uplands or stream terraces.

3. TMDLs for Sediment, Nutrients, and Ammonia

3.1 Problem Identification

Impaired Beneficial Uses and Applicable Water Quality Standards
The Iowa stream classification document designates the protected aquatic life use for North Fork Maquoketa River as B (WW-2). In 1998, the aquatic life use was assessed as "partially supporting" based on the low diversity of fish as noted in a 1991 stream use assessment. Bioassessments conducted in 1999 and 2001 at four sites in the stream confirmed that the biological community in North Fork Maquoketa River did not meet expectations. The stream was then listed for a biological impairment of undetermined cause based on low Fish Index of Biotic Integrity (FIBI) and Benthic Macroinvertebrate Index of Biotic Integrity (BMIBI) scores. In 2004, the stream was assessed as "not supporting" due to results of biological monitoring that show poor biological integrity.

This headwater segment of the North Fork Maquoketa River is technically defined as the reach from Bear Creek upstream to the headwater. However, the impaired waterbody has been defined by the bioassessment, water quality monitoring and data evaluation as the HUC 12 sub-watershed upstream of the Hewitt Creek. Hewitt Creek is a separate HUC 12 sub-watershed that flows into the NFMR just upstream of Bear Creek at Dyersville and has not been included in this water quality evaluation. A separate TMDL will be developed for Hickory Creek, an impaired stream in the Hewitt Creek HUC 12, and Hewitt Creek will be evaluated at that time.

The FIBI and BMIBI biotic indexes rank the biological integrity of a stream sampling reach on a scale from 0 (min) to 100 (max). Table 4 shows general qualitative scoring guidelines for the two indices.

Table 4 Qualitative scoring guidelines for the BMIBI and FIBI.

Biological Condition Rating	Benthic Macroinvertebrate Index of Biotic Integrity (BMIBI)	Fish Index of Biotic Integrity (FIBI)
Poor	0 - 30	0 -25
Fair	31 - 55	26 - 50
Good	56 - 75	51 - 70
Excellent	76 - 100	71 - 100

The indices from reference streams in the various ecoregions have been used to derive target BMIBI and FIBI scores. The NFMR watershed lies in the two ecoregions shown in Table 5. The reference stream scores for the BMIBI and FIBI shown in this table are the minimum scores for biological integrity for aquatic life use support, below these values a stream is considered not or partially supporting designated uses.

Table 5 Reference criteria for assessing biological integrity

Ecoregion	BMIBI	FIBI
52B Ref. (Paleozoic Plateau)	61	59
47C Ref. (Iowan Surface)	59	71 (riffle), 43 non-riffle*

* FIBI criteria scores vary depending on the presence/absence of riffle habitat. Greater fish diversity and therefore higher FIBI scores are expected from areas with riffles. For the NFMR, only the 1999 sample was taken from a site fitting the description of riffle habitat.

The 1999, 2001 and 2005 FIBI and BMIBI scores for North Fork Maquoketa River and for reference sites are shown in Table 6. BMIBI and FIBI scores from sampling locations in the NFMR watershed generally indicate fair biological condition (Table 4). The shaded columns list the Biological Impairment Criteria (BIC) that are determined from the range of IBI scores sampled from ecoregion reference stream sites. For all sampling locations in all sampling years, the BMIBI and FIBI scores are below the reference condition biological impairment conditions. These results are strong evidence that the biological impairment is consistent across space and time.

Table 6. Index of Biotic Integrity scores for benthic macroinvertebrates (BMIBI) and fish (FIBI) from the NFMR Watershed.

Site (Stream)	Year	BMIBI	BMIBI Biological Impairment Criterion (BIC)	FIBI	FIBI Biological Impairment Criterion (BIC)
REMAP 147 (NFMR)	2005	42	59	34	UND[1]
TMDL 28 (NFMR)	2001	47	59	29	43
TMDL 28 (NFMR)	2005	26	59	37	43
New Wine Park (NFMR)	1999	N/A[2]	59	32	71[3]
TMDL 29 (NFMR)	2001	47	59	26	43
TMDL 30 (NFMR)	2001	51	59	33	43
TMDL 30 (NFMR)	2005	48	59	37	43
HI2 (Hickory Creek)	1999	53	59	37	71[3]

1. UND – Currently undetermined
2. N/A - Insufficient numbers of organisms for BMIBI calculation
3. Riffle area criterion

IDNR staff followed the Protocol for Stressor Identification (SI) to determine the cause of the North Fork Maquoketa biological impairment. The SI procedure relates impairments described by bioassessments to one or more specific causal agents (pollutants) and also separates water quality (pollutant) impacts from habitat alteration impacts. The SI determined that the primary pollutant related causal factors in the NFMR water quality impairment are sediment, nutrients (specifically phosphorous), and ammonia.

Sources and Interpretation of Monitoring Data

Bioassessment sampling was done at four locations in 1999 and 2001. Monthly water quality samples were collected from two NFMR sites from March through November of 2001 and 2005. The most important data for the development of this document were collected in 2005 at sites 28 and 30. This sampling consisted of two related measuring procedures. In the first, continuous stage data and event samples were collected using ISCO autosamplers and flow estimates were developed from the stage data. The second aspect of the data collection effort used data sondes collecting continuous dissolved oxygen and temperature measurements that were deployed from August 22 to 29.

Background. Evidence of biological impairment in the NFMR dates back to IDNR stream assessments done in 1989 and 1991. The assessment results indicated low diversity in the fish assemblage and fewer species than expected for the ecoregions. Four fish kills documented between June 1995 and July 1998 were cited as additional evidence of aquatic life use impairment leading to its inclusion on the 1998 303(d) impaired waters list. The causes of biological impairment were listed as unknown.

Follow-up sampling was conducted in 1999 to validate the aquatic life use impairment. The 1999 FIBI score from the NFMR at New Wine Park was significantly lower than the reference BIC used to determine aquatic life use support status. Because of the unusually low numbers of organisms collected from standardized sample units, it was not possible to calculate the BMIBI, which requires that at least one of three sample replicates contain 85 or more individual specimens. The three replicates had 70, 25, and 54 specimens.

In 2001, biological sampling was conducted at three locations; sites 28, 29 & 30, to further define the extent of the impairment. Based upon the combined 1999 and 2001 bioassessments, the 2002 and 2004 305(b) water quality reports evaluated the aquatic life designated use status as "not supporting" and the NFMR is currently on the 303(d) list of impaired waters. This assessment was based on low scores on the Fish Index of Biotic Integrity (FIBI) and Benthic Macroinvertebrate Index of Biotic Integrity (BMIBI) from biological monitoring conducted in 1999 and 2001.

Biological sampling was repeated at NFMR TMDL sites 28 & 30 in 2005, and a probabilistic (random) sample site was also sampled in the adjacent downstream segment for the state's Regional Environmental Monitoring and Assessment Program (REMAP) random survey of perennial rivers and streams. Resulting biotic index scores can be found in Table 6. Also during 2005, biological sampling was conducted using the IDNR Rapid Bioassessment Protocol (RBP) at 13 sites located in the NFMR and Hewitt/Hickory Creek watersheds.

For spatial co-occurrence, stressor indicator data from the NFMR were compared to the inter-quartile ranges (25th to 75th percentile) of indicators for reference sites within the Iowan Surface ecoregion (47c), or when reference data were not available, a comparison was made with a statewide data set from the probabilistic stream survey. In a few cases, the maximum or minimum ecoregion reference value, state water quality standards designed to protect aquatic life, or the mean from random statewide sites are used as benchmarks. A stressor was deemed to be present at a site when the appropriate indicator value exceeded the benchmark value.

Criteria for Assessing Water Quality Standards Attainment
Water quality standards will be considered attained when the reference stream biological targets for ecoregion 47c are met. According to the Methodology for Developing Iowa's 2004 Section 303(d) List of Impaired Waters, reference stream FIBI and BMIBI scores shown in Table 5 for the two watershed ecoregions are considered 'supporting' the aquatic life use.

The following sections on sediment, nutrients, and ammonia describe the procedures used to link the bioassessment scores to causal pollutants. Any of these stressors occurring at levels documented in the stream are capable of causing aquatic life impairment. The SI did not reveal any single stressor that is clearly the dominant cause. The stressors are manifested both as episodic and cumulative impacts.

Sediment Although there are not any specific water quality standards for sediment, excessive sediment can adversely impact aquatic life as demonstrated in the NFMR SI process. The NFMR has been shown to have quantities and coverage of stream bottom silt much higher than found in the reference streams for the relevant ecoregions. This excess sediment adversely affects aquatic life. As shown in Table 7, the measured substrate silt fraction was well outside of the ecoregion inter-quartile range at sites 28 and 30 in both 2001 and 2005.

The embeddedness of the streambed in riffle areas compared to the ecoregion reference values impacts aquatic life use support. The riffle embeddedness rating indicates the fraction of the coarse substrate area that has the interstitial spaces filled by fine sediment. In conjunction with the copious bottom algae, the excess silt alters the physical habitat crowding out benthic macroinvertebrates, changing the available food sources and causing a negative shift in community composition (BMIBI score). The loss of interstitial volume impacts fish reproductive activity and alters the organisms that are available as food (FIBI score).

Table 7. Comparison of altered substrate indicators at sites 28 and 30 to the ecoregion reference sites.

Parameter	Site 28	Site 30	Ecoregion 47c Reference
Substrate silt fraction[1], %	48 (2001), 30 (2005)	55 (2001), 57 (2005)	4 to19 IQR[3], median=9
Embedded riffles[2], %	3.2 (40 to 60%)	3.7 (40 to 70%)	1.74 to 2.53 IQR
TSS, mg/l	15 (5 to 230)	21 (5 to 120)	5 to 15 IQR at baseflow
Turbidity, ntu	7.6 (3.1 to 18)	13 (8 to 43)	4 to 9.5 IQR

1. Bottom fraction that is silt covered as a %. One measurement done in each of two years at each site.
2. Embeddedness is the fraction of coarse substrate area embedded by fine sediment as a %.
3. Reference conditions are measured as the inter-quartile range.

Nutrients Excessive nutrient loads, specifically phosphorous, have increased primary production from bottom algal growth in the NFMR. This growth changes the composition of the basal food source and leads to high nighttime DO respiration rates. When the algal blooms die off, the remaining organic matter also has an oxygen demand that reduces stream dissolved oxygen concentration.

The bottom algae blooms also cause dramatic diurnal swings in dissolved oxygen. As shown in Figure 2, dissolved oxygen concentrations range from 6.1 mg/l to 20.5 mg/l over the course of 12 hours and then drop to 5.3 mg/l in 8 hours. These large fluctuations are stressful to fish and other aquatic life. Phosphorous load reduction in NFMR will improve the BMIBI and FIBI scores by reducing algal photosynthesis and respiration and moderating the amplitude of dissolved oxygen concentration.

Dissolved oxygen measurements taken over an eight day period by the data logger show that oxygen levels fluctuate widely over each 24-hour period, with dissolved oxygen concentrations dipping below 5 mg/l on two nights at site 30. In addition, site 30 monthly grab samples have shown low levels of dissolved oxygen on several occasions. Daytime concentrations were below 5.0 mg/l on one occasion in October of 2001 and at or below 6.0 mg/l on three occasions in both 2001 and 2005.

Diurnal oxygen monitoring conducted in 2005 during base flow stream conditions showed substantial DO fluctuation between day and night caused by photosynthesis and respiration of plants and algae covering the stream bottom. Generally, minimum DO concentration occurs during the dark hours just before sunrise. Despite these large fluctuations, DO concentrations usually remain slightly over the water quality standard during base flow stream conditions. The relatively cool stream temperature mitigates respiratory oxygen demand during dark hours because DO saturation concentration increases with lower water temperature, i.e., DO concentration is higher in cool streams than in warm streams.

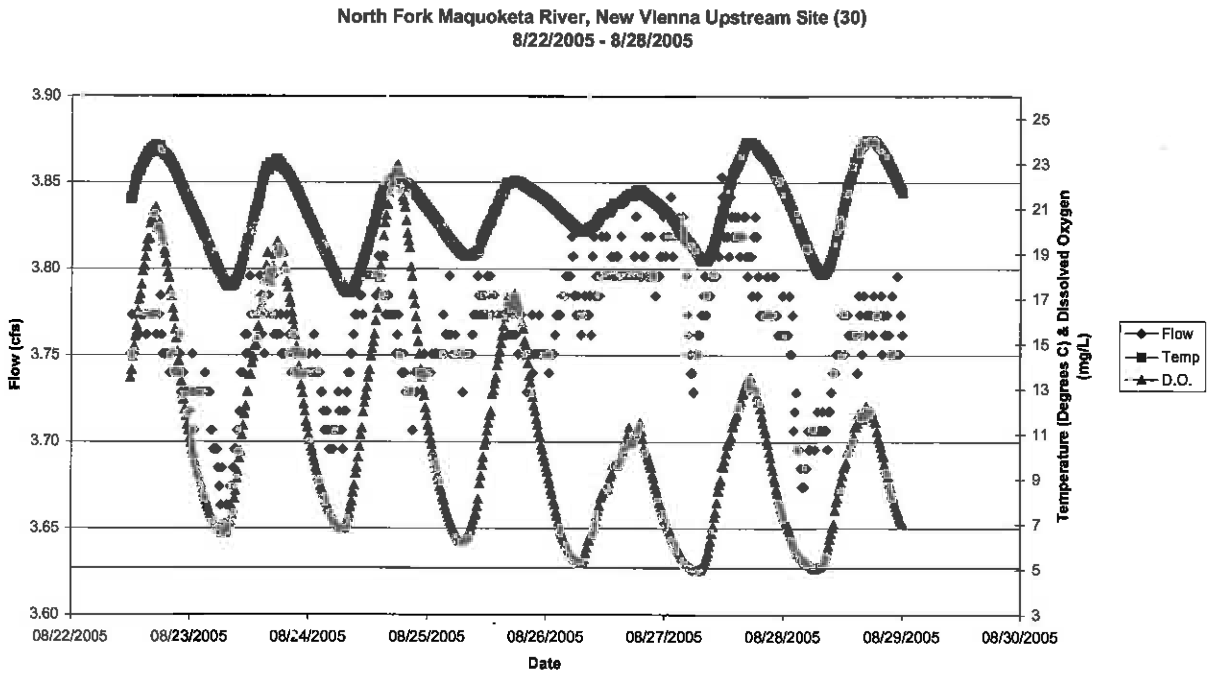


Figure 2 Site 30 continuous DO and temperature

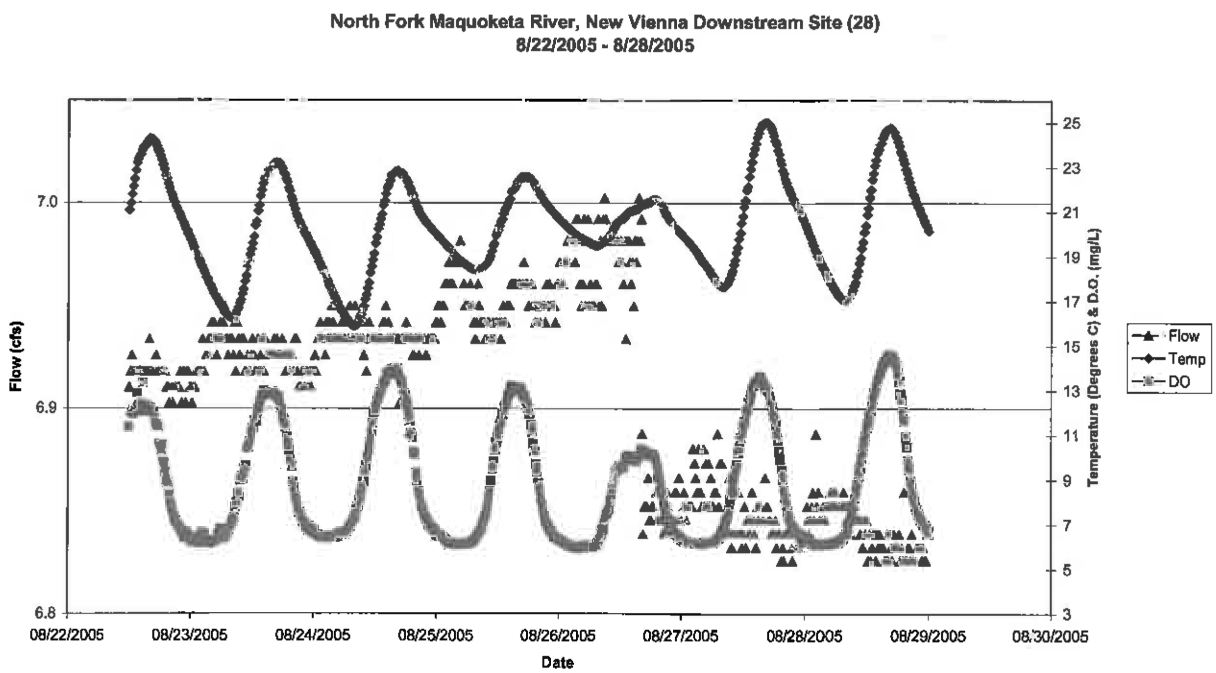


Figure 3 Site 28 continuous DO and temperature

Ammonia High ammonia concentrations in discharges to the NFMR caused by spills and runoff from manure can cause serious water quality problems in two major ways:

1. Ammonia is toxic to all fish even at relatively low concentrations.
2. Ammonia exerts an oxygen demand in streams through nitrification that significantly depletes DO. In addition to ammonia OD, spills and runoff usually have an organic component that becomes an OD from heterotrophic bacteria growth and metabolism.

Spills and runoff problems have been consistently reported for this segment of the NFMR. Figure 4 shows the timeline for monitoring activities and reported spills resulting in fish kills.

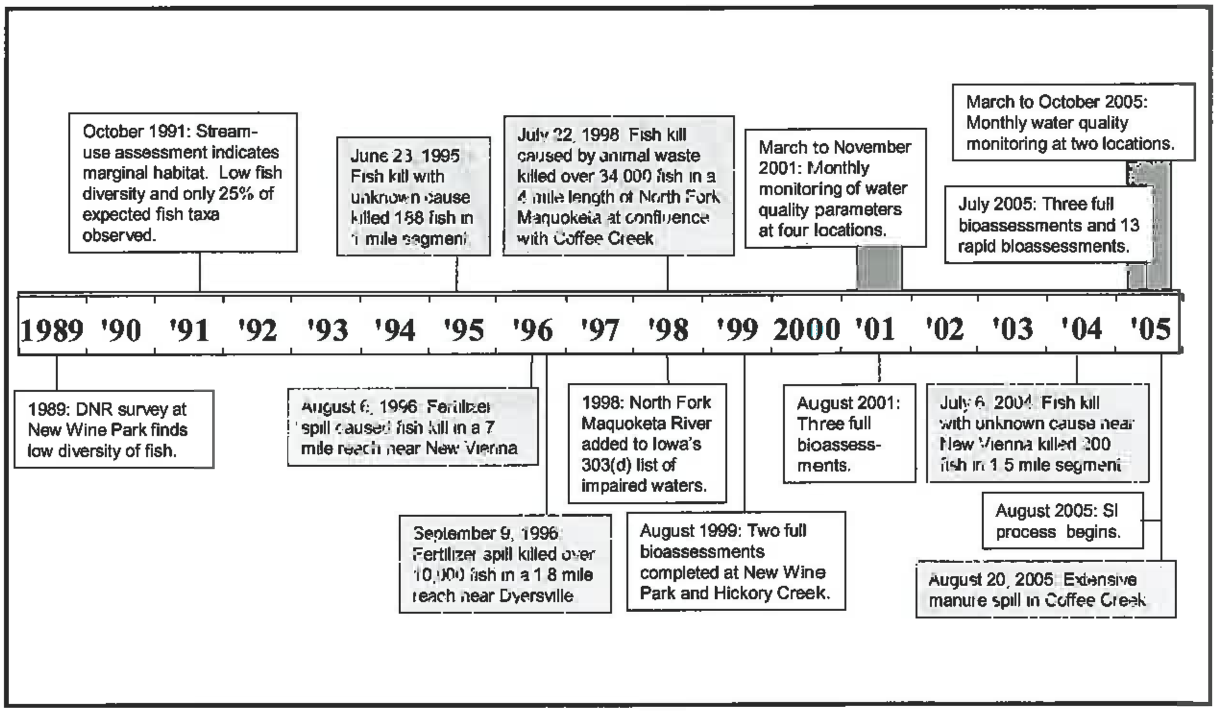


Figure 4 Timeline for NFMR monitoring and reported fish kills

Evidence consists of total ammonia levels exceeding the chronic water quality criteria on one occasion in 2001 at 3 monitoring locations on the NFMR. The ammonia violation documented in September 2005 was not known to be associated with a runoff event or spill of animal waste or fertilizer. Ammonia has also been explicitly or implicitly linked to several fish-kill events in the watershed the most recent of which occurred on July 27, 2006 near New Vienna. A fertilizer spill was responsible for one fish kill near Dyersville in September 1996. Runoff of animal waste was responsible for fish kills near New Vienna in July 1998, July 2004 and July 2006.

The segment of NFMR near New Vienna, including the Coffee Creek sub-watershed appears to be particularly susceptible to experiencing acute or chronic ammonia concentrations. It has been suggested that fish kills and other long-term water quality problems have degraded the stream reducing the populations of desirable species. The water quality standards for acute and chronic ammonia toxicity for a range of pH conditions are shown in Table 8.

Table 8 Acute and Chronic WQS Criterion for Total Ammonia at 20C, pH range 8 to 9

PH – standard units	Acute Criterion, mg/l - N	Chronic Criterion, mg/l - N
8.0	8.40	1.71
8.1	6.95	1.47
8.2	5.72	1.26
8.3	4.71	1.07
8.4	3.88	0.906
8.5	3.20	0.765
8.6	2.65	0.646
8.7	2.20	0.547
8.8	1.84	0.464
8.9	1.56	0.397
9.0	1.32	0.342

There is evidence that oxygen concentrations are sometimes below the water quality standard, especially during late summer and early fall runoff events. These episodes are likely to occur in conjunction with toxic ammonia levels resulting from runoff that contains manure and other materials. Both the ammonia and the animal waste organic matter exert an oxygen demand exceeding the stream's capacity to remain above the standard. As the ammonia is oxidized to nitrate and the organic matter decays through microbial processes, oxygen is consumed faster than it can be replenished through re-aeration and algal primary production.

The Iowa Water Quality Standards require that streams classified B(WW-2) meet the DO criteria shown in Table 9. These criteria apply to the impaired segment of the NFMR since it is classified B(WW-2).

Table 9. Criteria for Dissolved Oxygen

Stream Designated Use	**B(WW-2)**
Minimum value for at least 16 hours of every 24-hour period	5.0
Minimum value at any time during every 24-hour period	4.0

Potential Pollution Sources

Point Sources: There are three NPDES permitted point sources in the North Fork Maquoketa River watershed. These are wastewater treatment plants (wwtp) for the Cities of Luxemburg, Holy Cross, and New Vienna shown in Table 10. The New Vienna wwtp was recently (summer 2006) upgraded to a continuous discharge aerated lagoon.

Table 10. Waste Water Treatment Plants (WWTPs) in the NFMR watershed.

Muncipality	Luxemburg	Holy Cross	New Vienna
IA NPDES #	3158001	3146001	3165001
EPA #	IA0074781	IA0025992	IA0027391
Treatment type	Facultative lagoon[1]	Facultative lagoon[1]	Aerated lagoon[2]
CBOD5[3]	25 mg/l (30-day avg)	25 mg/l (30-day avg)	25 mg/l (30-day avg)
TSS [3]	80 mg/l (30-d avg)	80 mg/l (30-d avg)	80 mg/l (30-d avg)
pH[3]	6.0 to 9.0	6.0 to 9.0	6.0 to 9.0
ADW / AWW[4]	0.075	0.054	0.0278 / 0.0416
Population	331	587	428

1. Facultative lagoons are controlled discharge treatment facilities that provide 180 days of wastewater storage.
2. Aerated lagoons are continuous discharge treatment facilities.
3. These are the NPDES permit limits for these facilities for CBOD5, TSS, and pH.
4. These are the average permit flow limits for the facilities. AWW is 180-day average wet weather flow for the two controlled discharge lagoons. For the New Vienna wwtp where the discharge is continuous, the AWW flow is the 30-day average wet weather flow and ADW is the 30-day average dry weather flow ADW flow is not a consideration for controlled discharge facilities.

The two controlled discharge facilities discharge only in the spring and fall when stream flows are high and not during the design period when base flow conditions prevail, mid to late summer. Therefore, the loads from these two sources are not included in the TMDL. The continuous discharge loads from the New Vienna plant are included in the TMDL analysis and a wasteload allocation for the existing phosphorous load developed. These wastewater treatment plants do not significantly contribute to the delivered sediment load.

Non Point Sources

The potential non-point sources for nutrients, sediment, and ammonia are failed on-site septic tank treatment systems, agricultural activities that add to erosion and nutrient loading, wildlife, and runoff from built-up areas.

Some nonpoint sources in the watershed that add sediment and nutrients to the North Fork Maquoketa River are:

- Cattle in streams may deposit nutrient-rich fecal material directly to the stream and can cause bank erosion releasing sediment attached phosphorus.
- Land in agricultural production can contribute phosphorous through the use of fertilizer and land-applied manure that is delivered to streams in runoff or groundwater.
- Soil erosion from precipitation events.
- Habitat alterations like channelization and removal of riparian vegetation can increase in-stream erosion and sediment delivery from the watershed.
- Runoff from open feedlots that do not have adequate manure management or containment.

Natural Background Conditions

Background conditions are not separated from existing monitored conditions. Potential phosphorus contributions from groundwater influx have not been separated from the total nonpoint source load.

3.2 Sediment TMDL

3.2.1 Sediment TMDL Target

To meet the biological target, a sediment target has been established. Excessive fine sediments reduce the availability of favorable spawning sites for fish and buries desirable habitat for benthic macroinvertebrates, thus reducing BMIBI and FIBI scores. Reducing sediment delivery in the NFMR will improve BMIBI and FIBI scores by reducing streambed silt, reducing the embeddedness in riffle coarse substrates, increasing the size and quality of riffle and pool habitat, and reducing suspended solids and turbidity.

Modeling and Conceptual Approach

The approach used to determine existing and target sediment loads to the NFMR uses the percentage difference between the reference and measured NFMR BMIBI and FIBI scores as the percent reduction needed to attain the target. The existing delivered sediment load was estimated using two different IDNR erosion models to estimate the sediment loads from the watershed. The first model, based on the Revised Universal Soil Loss Equation (RUSLE) and incorporating IDNR ArcView coverages for data, provides long-term average annual sediment loads.

The second model is the Modified Universal Soil Loss Equation (MUSLE) that also uses IDNR ArcView coverages for data but provides erosion output estimates for a single storm event of a selected intensity and duration. The selected storm for the MUSLE modeling was a 2-year return and 24 hour duration event that in this region is a 3-inch rainfall over 24 hours. In sediment erosion estimations, the 2-year return 24-hour event is considered to be the maximum daily load.

The RUSLE model estimates soil erosion rates based on long-term annual averages. The estimated sheet and rill erosion rate in the watershed is 13.21 tons per acre per year, or 373,335 tons per year. The NRCS Erosion and Sediment Delivery procedure estimates the sheet and rill erosion sediment delivery ratio is 18.7%. The estimated sediment delivered to the stream is 69,963 tons per year, as being delivered to the stream. Gully and bed and bank erosion contribute additional sediment to the stream that is estimated to be 25% of the delivered sheet and rill erosion (reference 8). With this additional sediment load the total delivered sediment load is estimated to be 69,963 + 0.25(69,963) = 87,454 tons per year.

The MUSLE model estimates the delivered erosion from the single 2-year return 3-inch event to be 51,000 tons using the following assumptions:

- 2002 IDNR land cover
- No conservation practices (USLE P factor = 1)
- Antecedent moisture conditions set to "average"
- Iowan Surface ecoregion (model only allows one choice)

Waterbody Pollutant Loading Capacity

The target is based upon the biologic indicators. Reducing sediment will improve benthic conditions allowing aquatic species to survive and reproduce. Stream segments having FIBI or BMIBI scores below the 25^{th} percentile of regional reference sites are considered impaired.

The critical metric for sedimentation for the North Fork Maquoketa River is the percent siltation of the streambed. The median percent siltation observed during the stream assessments from 2001 and 2005 for Site 28 was 39% and for Site 30 was 56%. The 75th percentile (upper 25th) bottom siltation for ecoregion 47c reference streams is 19% and the median is 9%. The Site 28 values have been selected as the targets since it is the downstream monitoring site and represents more of the watershed than do the Site 30 values.

The percent siltation in the streambed would need to be reduced from 39% to 9% coverage, a 77% reduction. Assuming a 1:1 relationship between percent silt in the stream and sedimentation, a delivered sediment reduction of 67,300 tons per year is required.

The loading capacity is the amount of silt that can be delivered to the river and still meet the BMIBI and FIBI scores of "fully supporting". The allowable silt delivery to the North Fork Maquoketa River at the most downstream monitoring site in the impaired segment (Site 28) is 20,200 tons per year. Siltation reduced to this level will improve benthic habitat and allowing aquatic species to survive and reproduce similarly to those in ecoregion reference conditions. The load capacity is 20,200 tons of sediment per year.

3.2.3 Pollution Source Assessment

Existing Load

The existing sediment load was estimated using the RUSLE and NRCS Erosion and Sediment Delivery procedure and estimates for gully and streambank erosion. Existing delivery is approximately 69,963 tons per year or a delivered 365-day average of 192 tons per day. There is an additional load from gully and bed and bank erosion of 17,500 tons per year. The RUSLE sheet and rill erosion map developed using data collected in 2002 is shown in Figure A-3 of Appendix A.

The existing maximum day sediment load as estimated using the MUSLE model is 51,000 tons per day based on the erosion from a 2-year return 24-hour storm.

Departure from Load Capacity

The departure for the maximum daily load has been estimated based on the needed siltation reduction, i.e., 77%. The existing load of 51,000 tons per day would need to be reduced by 39,300 tons per day for the design storm. The load capacity is 11,700 tons per day.

Identification of Pollutant Sources

The sediment originates from sheet and rill erosion from agricultural land, stream banks, and gullies.

Linkage of Sources to Target

Including background sources of sediment, the sources of sediment are entirely from nonpoint sources. The estimated sheet and rill erosion from agricultural land using the RUSLE model and the NRCS Erosion and Sediment Delivery Procedure is 70,000 tons per year plus and an additional 17,500 tons per year for sediment from gully and bed and bank erosion. The delivered sediment load is linked to the biometric scores by the fraction of the NFMR stream bottom that is silted in compared to the siltation fraction for the reference conditions.

3.2.4 Pollutant Allocations

Wasteload Allocation

There are no point sources in the watershed that are significant sources of sediment and therefore there are no wasteload allocations for sediment.

Load Allocation

The sediment load allocation for the watershed of the impaired NFMR segment, has been set as both a long term annual average (from RUSLE modeling) and as a maximum daily load (MUSLE modeling of the two year return 24 hour duration). The load allocations are:

- Maximum daily load allocation = 11,730 tons per day
- Long term annual average load allocation= 20,200 tons per year

Margin of Safety

The margin of safety is provided by two conservative assumptions:

- Even though there are best management practices in the watershed that reduce delivered sediment to the stream, such as riparian buffer strips and sediment control basins, the RUSLE and MUSLE erosion modeling was done with the assumption that there are no installed BMPs.
- The median for the reference siltation conditions used as a target puts the goal well below the 75th percentile (upper 25th) of the percent siltation IQR.

3.3 Nutrient TMDL

3.3.1 TMDL Targets: Algae, Nutrient and Oxygen Demand

The stressor identification process for the impaired segment of the North Fork Maquoketa River found that excessive benthic algae and low dissolved oxygen were two of the primary stressors in the river. The excessive algae covering the bottom of the river has several negative effects on water quality that depress FIBI and BMIBI scores:

There are large diurnal fluctuations in dissolved oxygen concentration caused by the photosynthesis and respiration of the large quantities of benthic algae. In several recorded instances, DO has gone from 7 to 23 mg/l in less than 12 hours (August 24, 2005) at monitoring site 30. Dissolved oxygen saturation at 20C is 9.1 mg/l. A dissolved oxygen measurement of 23 mg/l is 2.5 times saturation, i.e., a very super-saturated condition. Data shows that there is an impact on FIBI and BMIBI scores when the daily amplitude of the minimum to the maximum DO exceeds 10 to 11 mg/l and when the nighttime DO minima is less than 5.5 mg/l. Very high DO concentrations can also be harmful to aquatic life. Abrupt changes in dissolved oxygen induce stress and subsequently make fish more susceptible to disease.

The filamentous algae growth crowds out other organisms causing a change in the benthic macroinvertebrate assemblage. This change in physical habitat causes a negative shift in community species by loss of interstitial space and alteration of available food resources. This propagates up the food chain to fish resulting in lower FIBI and BMIBI scores.

The targets for algae and associated dissolved oxygen concentrations are:

Target 1 is 200% of saturation concentration. Since the average concentration for the design day is 8.72 mg/l, the daily maximum DO for this TMDL is 17.4 mg/l.

Target 2 is maximum amplitude from daily low to high of 10 mg/l of dissolved oxygen.

Target 3 is a one third reduction in benthic algae and plants.

Target 4 is the Water Quality Standard dissolved oxygen value of 5.0 mg/l or higher for 16 hours a day and 4.0 mg/l daily minimum.

Target 5 is a BMIBI score greater than or equal to 59 and an FIBI score greater than or equal to 43 for non-riffle areas and 71 for riffle areas. This is the overall goal for this TMDL since this index was the tool used to assess the stream as impaired.

Modeling Approach – Linking Targets and Pollutants

The targets and existing conditions for this TMDL have been evaluated using monitoring data and the QUAL2K (Q2K) water quality model. The system hydrology was developed using data from two continuous stage/flow recorders located at sites 28 and 30 (see map) and GIS coverages, infrared aerial photography and 7.5 minute USGS topographic maps. The time of travel, velocity and depth were estimated using the manning equation within Q2K. The stream reaches are defined by the USGS map contour intervals and are shown in Figure A-1 in the Appendix. Figure 5 shows the layout and reference marker system for the modeled NFMR segment.

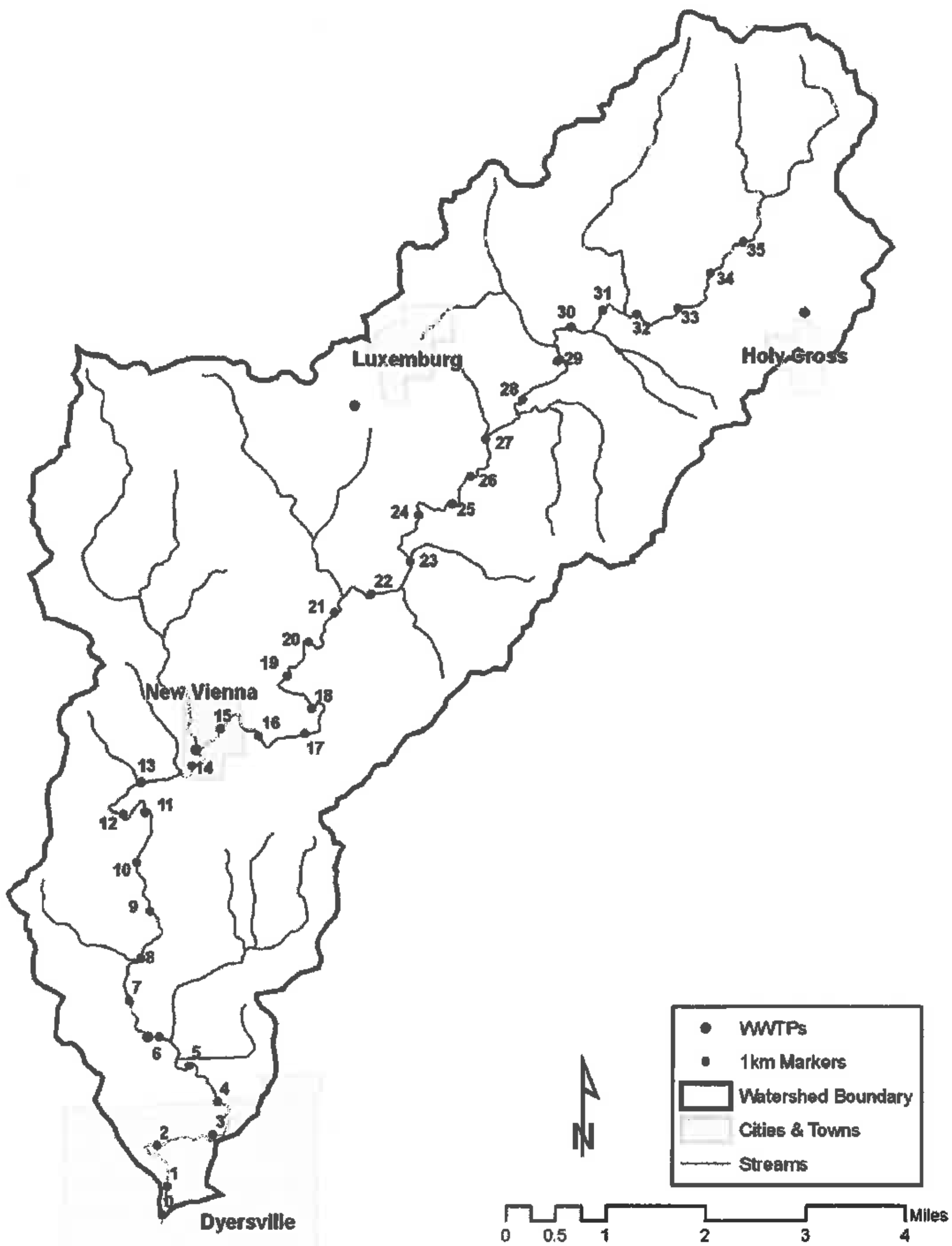


Figure 5 Kilometer reference markers for QUAL2K model

The data used to calibrate the model was continuous temperature and DO measurements (6 minute intervals) provided by data sondes installed at sites 28 and 30 from August 22 to August 29, 2005. The flow during this period was nearly constant at both sites; 3.8 cfs at site 30 and 6.9 cfs at site 28. This constant flow rate made the selection of Q2K a good choice since it is a static flow model.

The Q2K model was run for each 24-hour day (midnight to midnight) that had sonde temperature and DO data available. All variables were held constant except for cloud cover to adjust heat/light to the measured water temperature, sediment oxygen demand (SOD) to adjust to measured DO, and phosphorous to adjust algae biomass and DO. Figures 6 and 7 show the Q2K simulated values for temperature and DO plotted with the measured values for sites 28 and 30.

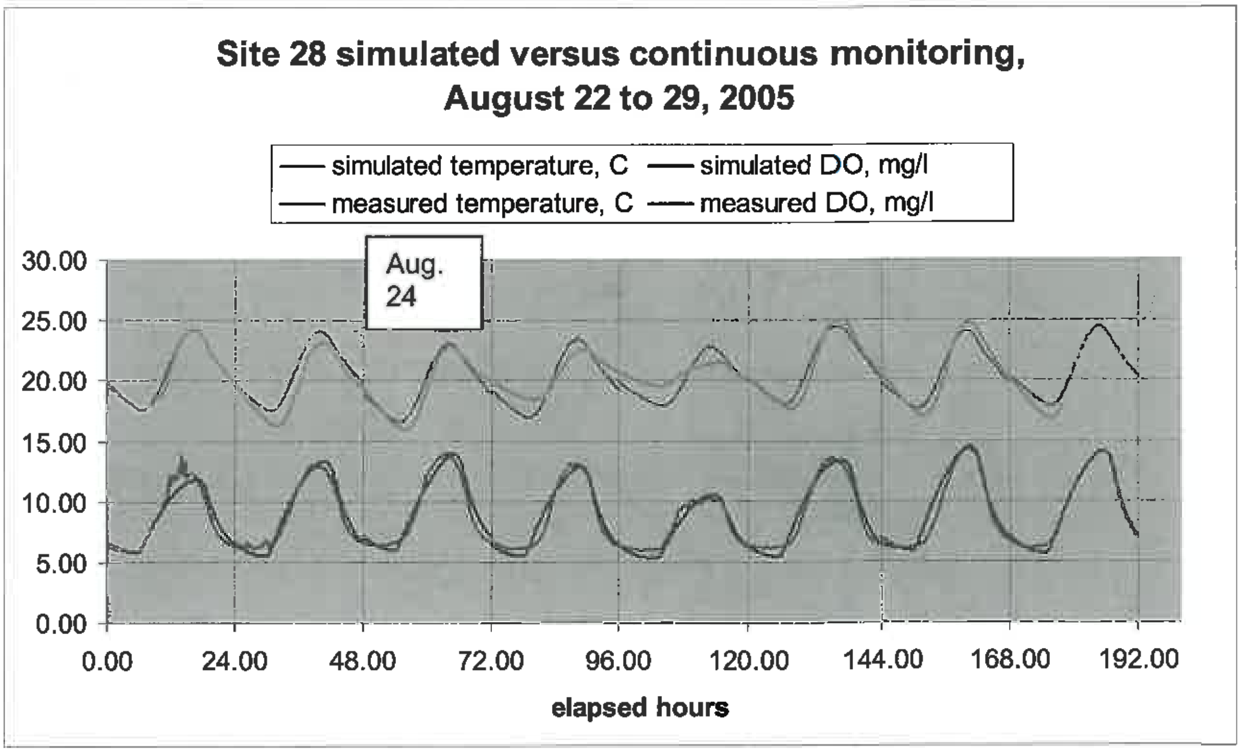


Figure 6 Simulated and measured temperature and DO for Site 28

Figures 6 and 7 also show the very high algal productivity at upstream Site 30 causing pronounced diurnal swings in DO and the less severe but still problematic DO amplitude at Site 28. These charts also show a minor rain event accompanied by a small streamflow increase that occurred August 26 and 27, 2005. This slight flow increase had surprisingly significant impact on DO causing it to decrease at all times of the day for Site 30 and to a lesser degree at Site 28 for peak DO. During the event the DO at Site 30 drops dramatically even dipping below 5 mg/l two nights in a row. This happens because the very supersaturated conditions that exist when it is sunny and the turbidity is lower disappear, reducing daytime photosynthetic oxygen production while the nighttime algal respiration continues depleting the already reduced DO inventory.

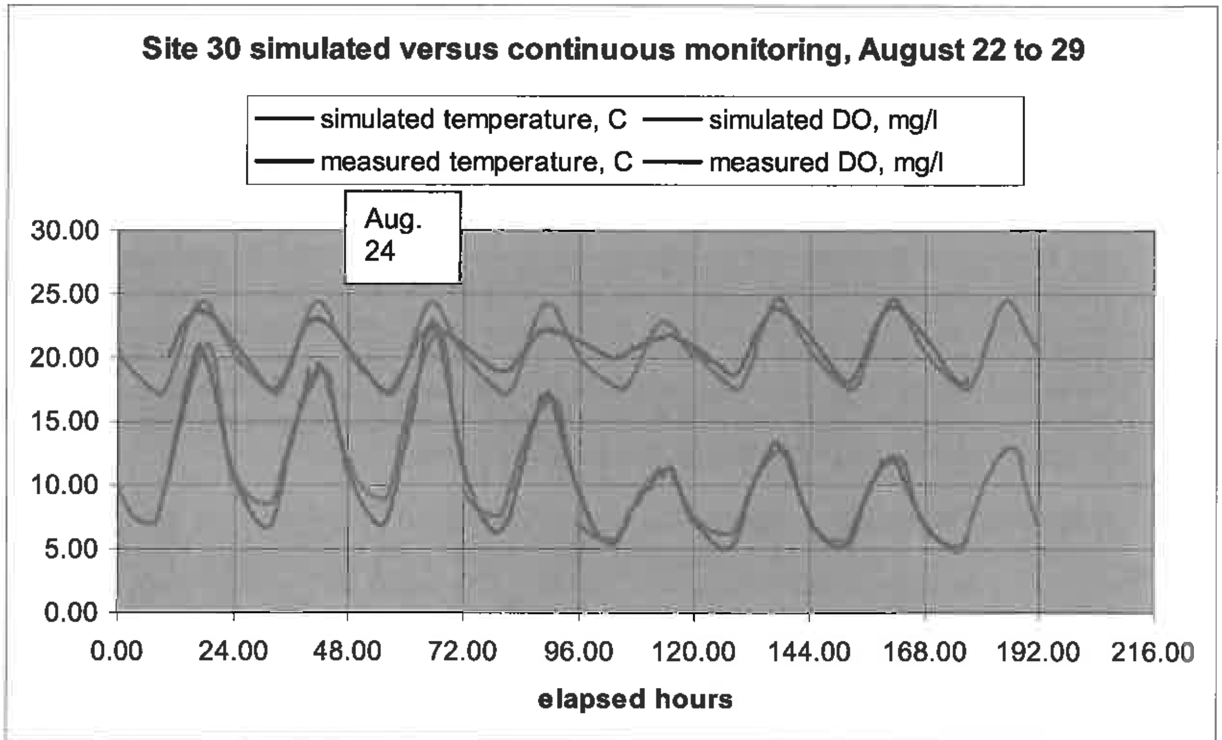


Figure 7 Simulated and measured temperature and DO for Site 30

The Q2K modeling has been performed to demonstrate the following circumstances related to the stream impairment:

- That the excessive mass of photosynthesizing benthic algae and plants creates a system that is overly sensitive to small perturbations and causes diurnal DO amplitudes that lower FIBI and BMIBI scores.
- That the excessive mass of algae and plants and photosynthesis associated DO amplitude can be decreased by a reduction in total phosphorous concentration.
- That chlorophyll (algae/plants) and DO can be estimated along the length of the North Fork Maquoketa for both existing and target conditions and the difference quantified.
- That the impact of a point source in the watershed, the recently constructed New Vienna wastewater treatment facility, can be estimated.
- That the impact from simulated episodic slug loads such as recent manure spills can be described and load reductions estimated.

Design Season and Conditions: After review of flow data and time of the year when an impairment is most likely, the SI shows that the stream is most sensitive to problems at the end of the summer when the algal and plant biomass is at its peak, the temperature is the highest, baseflow is generally the lowest and the risk from episodic loads is the greatest. The continuous sonde temperature and DO data collected in August 2005 is representative of these conditions and the date of August 24, 2005 has been selected as representative of the collected data and the design conditions.

Conceptual setup: The modeled segment of the North Fork Maquoketa runs from a point near the headwaters to Dyersville. It includes the entire impaired segment and consists of a single HUC 12 watershed. The stream model is 35.5 km long and the two monitoring sites, 28 and 30, are located at kilometers 5.42 and 18.40, respectively, going upstream from km zero in Dyersville. The model headwater flow at km 35.5 is based on the ratio of area to flow since there is not any monitoring data available for this location. The flow measured at Site 30 is incrementally added to the headwater flow from km 35.5 to km 18.40. The difference in measured flow between Site 30 downstream to Site 28 (3.11 cfs) is added incrementally from km 18.40 to km 5.42.

The August 24, 2005 diel data for Site 30 was used to establish the temperature and DO conditions upstream from the site to km 35.5 at the end of the modeled segment. The Site 30 values for phosphorous, SOD, and cloud cover for the segment from km 35.5 to km18.40 were then fixed for the August 24, 2005 Site 28 diel data calibration. Consequently, the Site 28 model runs included the results from the Site 30 calibration. This means that the longitudinal profile charts of the parameters and variables in the Site 28 model runs are calibrated for the data from both sites.

Waterbody Pollutant Loading Capacity: The loading capacity of the impaired segment of the North Fork Maquoketa River is the total phosphorous (TP) load that reduces excessive benthic algae and plants. The algae and plants create physical habitat and dissolved oxygen conditions that make significant contributions to depressed FIBI and BMIBI scores indicative of biological impairment.

3.3.2 Pollution Source Assessment

Existing Loads: The existing daily load for the NFMR is shown in Table 11. The existing loads have been distributed as the headwater load, the load from Site 30 upstream to the headwater (diffuse flow 1), the load from Site 28 upstream to Site 30 (diffuse flow 2), and the load from km marker zero in Dyersville upstream to Site 28 (diffuse flow 3). Figure A-4 in Appendix A shows the parts of the watershed drained by each of these model flows. The estimated daily TP load from the New Vienna wastewater treatment plant is also shown.

Table 11 Existing TP loads for the NFMR

Flow name	flow, L/d	TP existing conc., ug/l	TP existing load, lb/day
headwater	2,332,800	320	1.65
diffuse flow 1	6,972,480	540	8.30
diffuse flow 2	7,594,560	415	6.95
diffuse flow 3	3,170,880	415	2.90
total	20,070,720		19.80
New Vienna wwtp	129,600	4340[1]	1.24

1. Estimated from typical wwtp effluent (about 5 mg/l), no monitoring data available.

The chart shown in Figure 8 shows the modeled longitudinal profiles for daily maximum, mean, and minimum DO along the NFMR from the headwater to Dyersville. DO saturation is also shown.

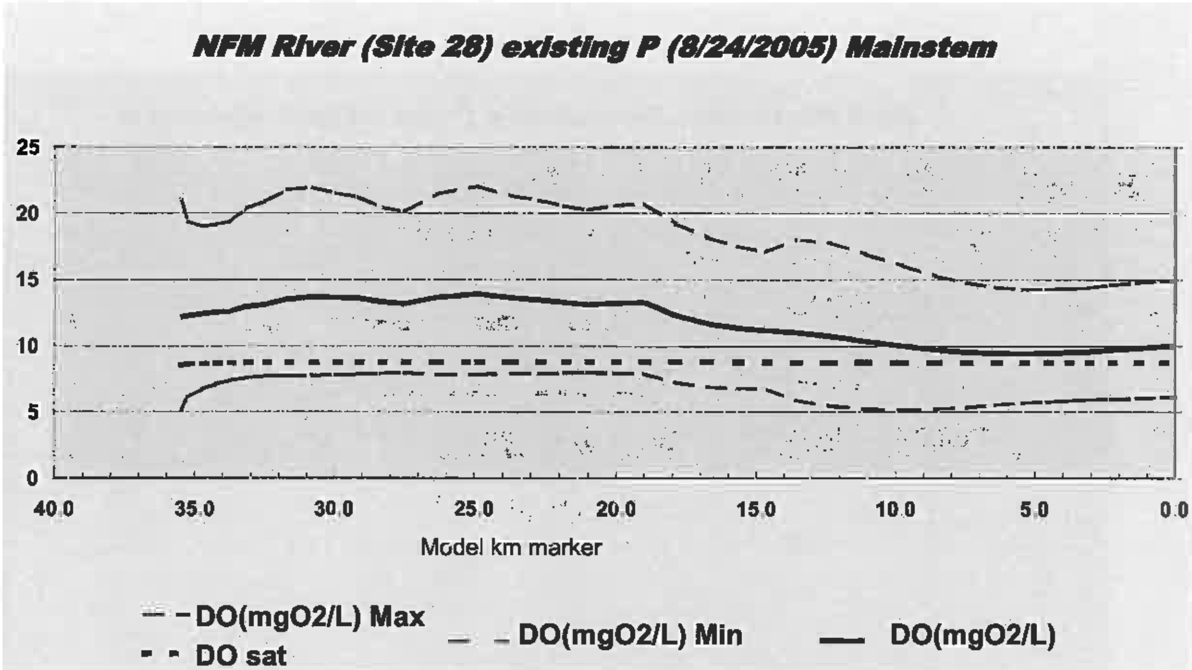


Figure 8 NFMR modeled longitudinal existing DO profile, length units are km

The important locations along the profile are:

- Headwater - 35.50 km
- Site 30 - 18.40 km
- New Vienna wwtp - 13.94 km
- Site 28 - 05.42 km
- Dyersville - 00.00 km

Figure 8 shows that for existing conditions:

- Maximum DO is well above saturation in the upper half of the stream and is 250 % of saturation upstream of Site 30 as shown by the maximum DO curve.
- The difference between max and min DO (amplitude) is greater than the target value of ten.
- The estimated load from the New Vienna wwtp treatment plant has a noticeable affect on the DO profile downstream from it.
- Going downstream the values for minimum DO decrease, dropping as low as 5.1 mg/l in the early morning as shown by the minimum DO curve in Figure 8 at km marker 10.

Figure 9 shows the modeled benthic algae corresponding to the DO in Figure 8. The algae are represented by the amount of benthic chlorophyll required to provide the oxygen production actually measured at Sites 30 and 28. The large mass of filamentous algae represented here affects benthic physical habitat and available food sources for other aquatic life depressing NFMR FIBI and BMIBI scores.

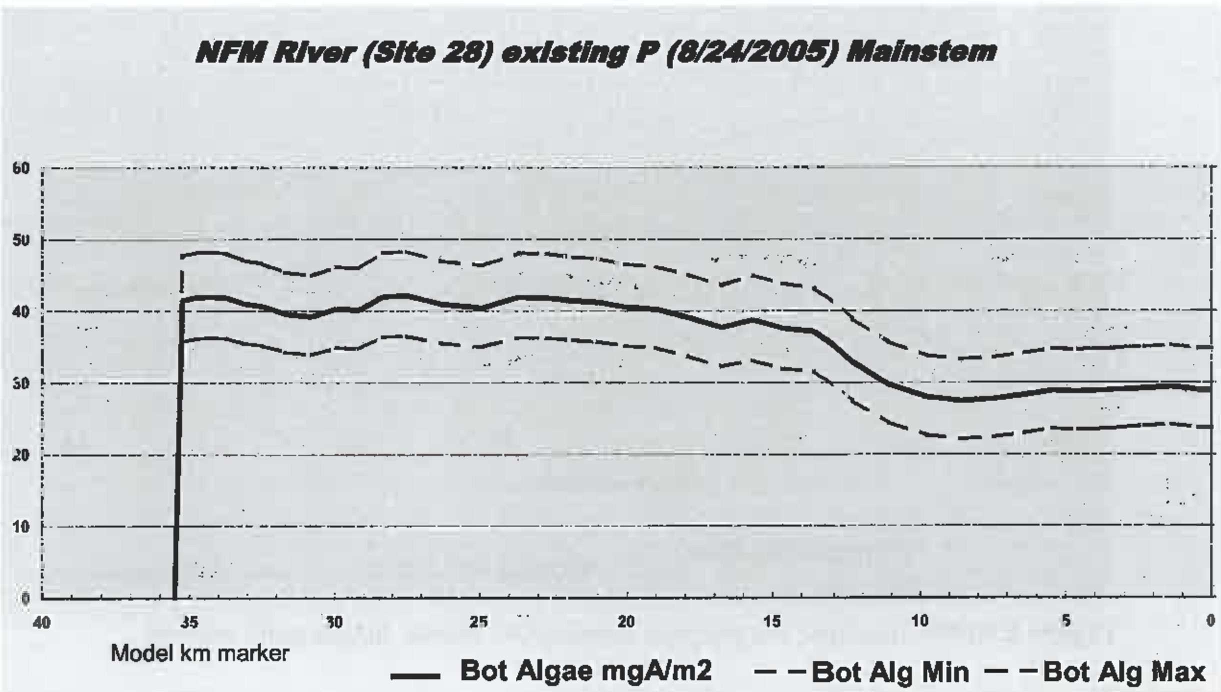


Figure 9 Modeled existing benthic algae longitudinal profile - as chlorophyll

Identification of Pollutant Sources

Most phosphorous is delivered to the stream from watershed non-point sources. Figure 10 shows the annual total phosphorous (TP) loads estimated by both the EPA and WILMS Export Loading Coefficients for the watershed landuses. It also shows the estimated TP from open feedlots estimated by the acres of feedlot in the watershed multiplied by an export coefficient for this use. As can be seen, most nonpoint source TP is from row crop landuses and open feedlot runoff. Besides row crop uses and other agriculturally related TP sources there are septic tank systems, and wildlife and pet feces. These are relatively small contributors with less impact than agricultural loads.

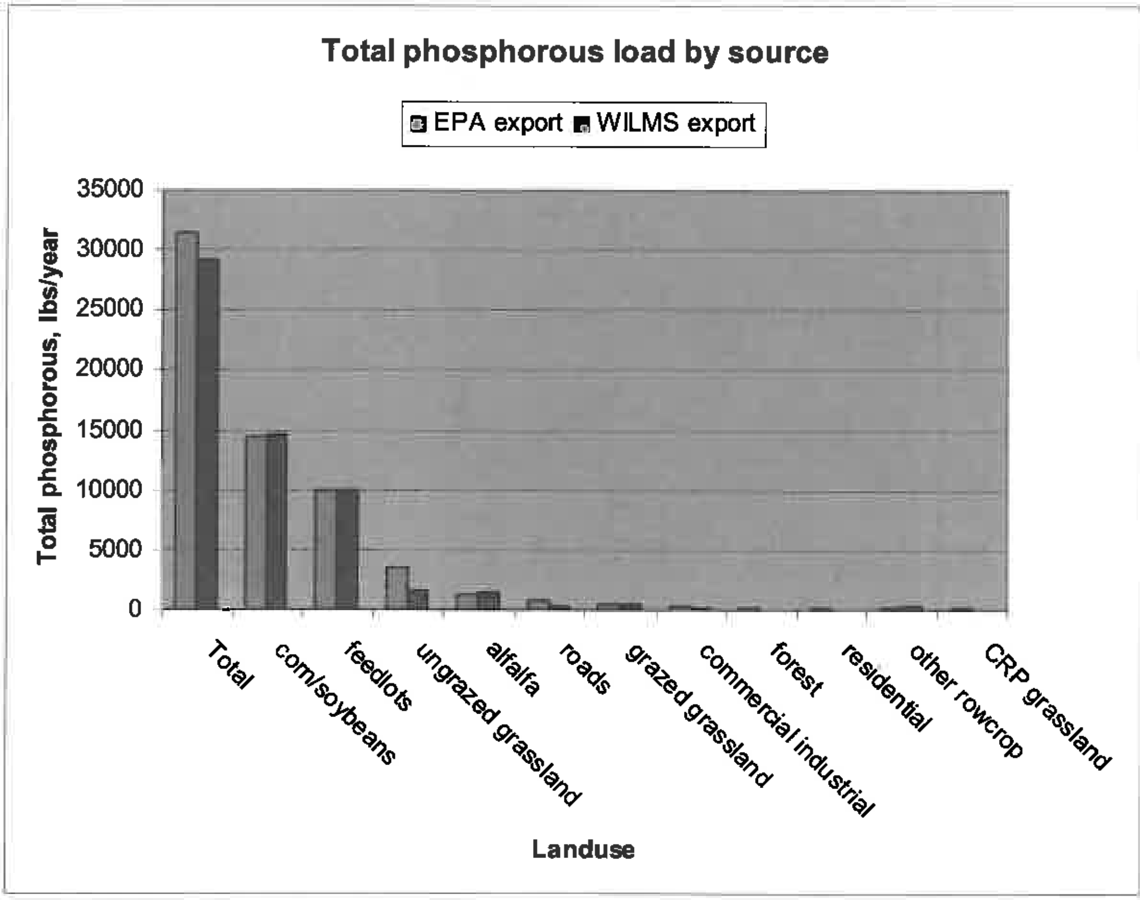


Figure 10 Total phosphorous sources by landuse and export coefficients

Departure from Load Capacity

The Q2K model was repeatedly run with all variables except for phosphorous held constant from the model runs used to calibrate to existing conditions. Phosphorous was reduced until the daily DO amplitude was less than 10 mg/l, the minimum night-time DO was 5.5 mg/l, and the algae/plant chlorophyll was reduced by one-third along the modeled NFMR segment. The results from this modeling are shown in Figures 11 and 12.

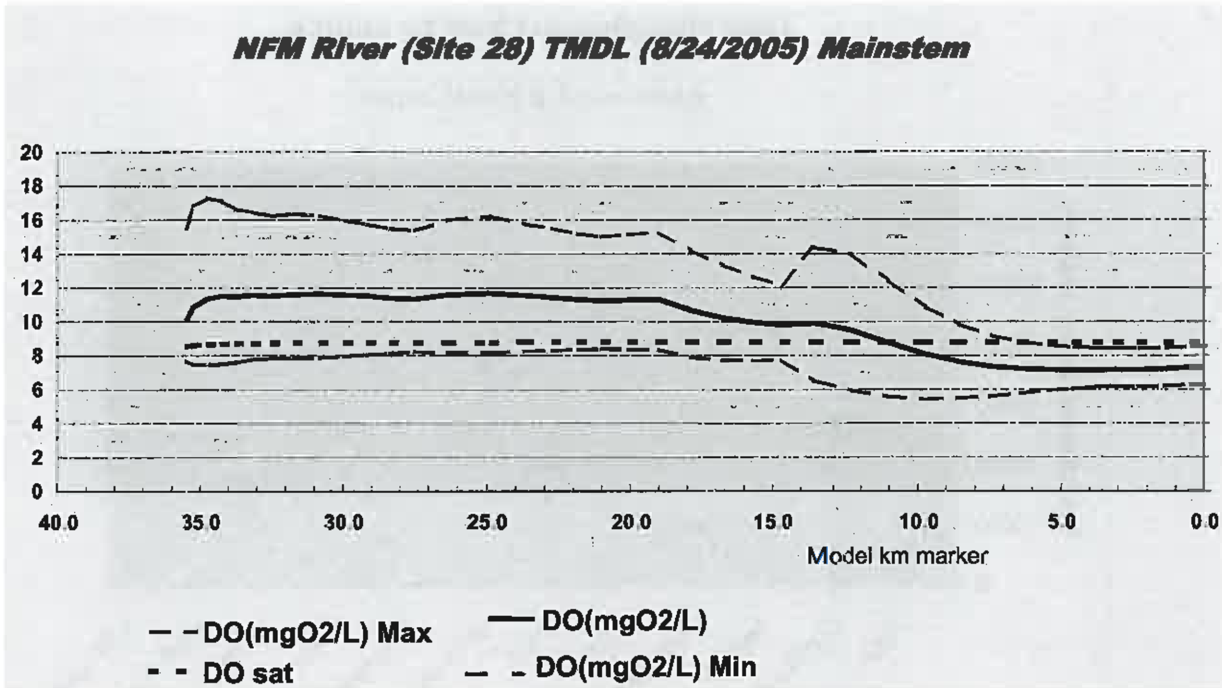


Figure 11 NFMR modeled longitudinal target DO profile; length units are km

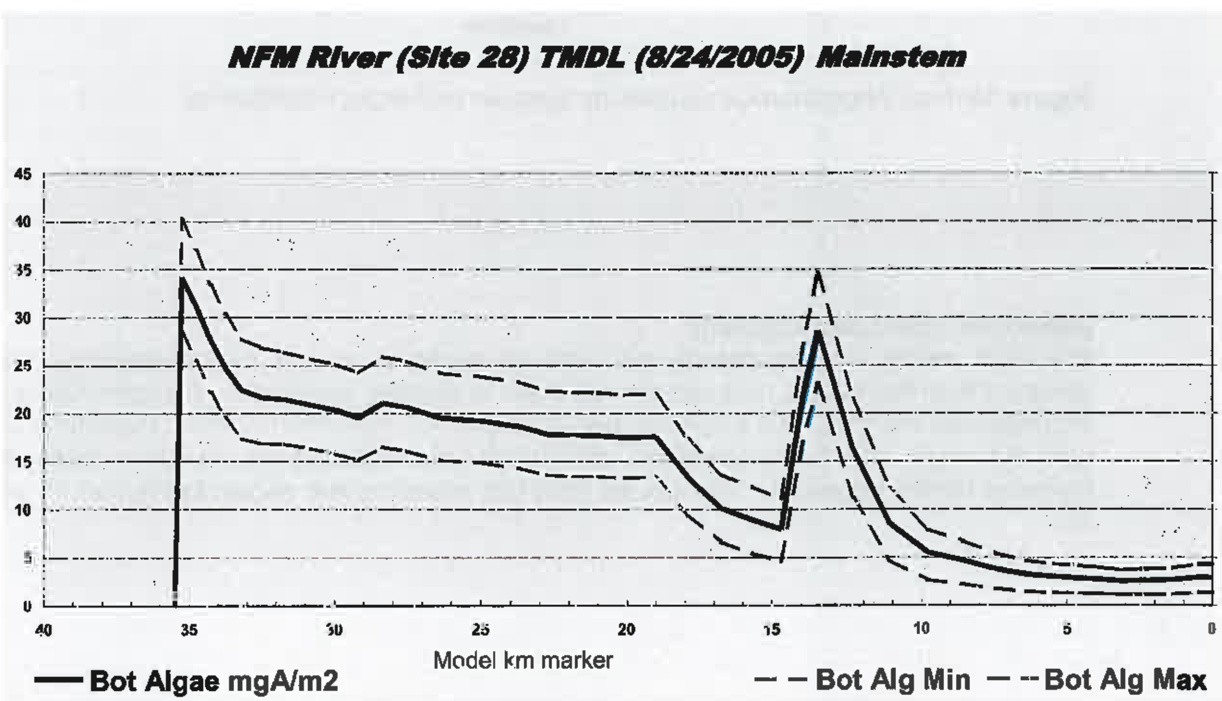


Figure 12 Modeled target benthic algae longitudinal profile - as chlorophyll

The target daily load for the NFMR is shown in Table 12. As with the existing loads in Table 11, the target loads have been distributed as the headwater load, the load from Site 30 upstream to the headwater (diffuse flow 1), the load from Site 28 upstream to Site 30 (diffuse flow 2), and the load from km zero in Dyersville upstream to Site 28 (diffuse flow 3). The last column in this table shows the difference between the existing phosphorous load and the target phosphorous load in pounds per day for the modeled sub-segments as well as the total for the entire HUC 12 watershed.

Table 12 Target TP loads for the NFMR

Flow name	Flow, L/d	TP target conc., ug/l	TP target load, lb/day	TP departure from capacity, lb/day[1]
headwater	2,332,800	100	0.51	1.13
diffuse flow 1	6,972,480	125	1.92	6.38
diffuse flow 2	7,594,560	125	2.09	4.86
diffuse flow 3	3,170,880	125	0.87	2.03
New Vienna wwtp	129,000	NA	1.24	0.0
Watershed total	20,070,720	NA	6.64	14.40

1. This is the mass phosphorous reduction needed to achieve the TMDL targets for daily DO amplitude, DO minimum, and decreased benthic algal mass.

3.3.3 Pollutant Allocations

Wasteload Allocations

The New Vienna wwtp is the only permitted point source in the watershed that discharges continuously to the NFMR. To evaluate the downstream impact of the wwtp TP loads the Q2K model was run both with and without estimated plant loads for both existing and target stream conditions. The daily peak and minimum DO concentrations were estimated 2 km downstream of the wastewater treatment plant discharge (model km marker 11.74). Table 13 shows the modeled impact of the wwtp TP load for existing and target conditions.

Table 13 New Vienna wwtp TP impacts on downstream DO amplitude

Model Output Condition and Figure Number	NV wwtp TP load as a % of the total	Peak DO, mg/l	Minimum DO, mg/l	24 hour DO amplitude, mg/l, (target = 10 mg/l)
Existing conditions, Figures 8 and 9	1.24 lb/day, 6% of load	16.95	5.23	11.72
Target conditions, with wwtp TP load, Figures 11 and 12	1,24 lb/day, 18% of load	12.38	5.58	6.80
Target conditions without wwtp TP loads, Figures 13 and 14	NA	11.37	7.87	3.50

The DO amplitude target is 10 mg/l and it is exceeded at this location in existing conditions but not at target conditions either with or without the wwtp load. For bottom algae the target is a one third reduction. The modeled algae reduction at the 2 km downstream location is over 50% from existing conditions to the target conditions with existing wwtp loads. Also, the estimated wwtp TP load is only 6% of the total watershed load (total load = 21.04 lb/day) and was estimated as the potential maximum that could be discharged from the wwtp, i.e., it was conservatively assumed that there would be no TP removal in the treatment process.

There are not any monitoring records for phosphorous from the old New Vienna trickling filter plant or for the aerated lagoon that recently replaced it in 2006. The TP loads have been estimated from typical per capita values as well as typical effluent concentrations from wastewater treatment plants. Most phosphorous discharged in plant effluent is soluble (inorganic in the model) and it has been assumed that the soluble fraction is 80%. The plant phosphorous calculation is as follows:

Effluent TP per capita = 1.5 gram/day
Population = 376
Total daily load = 564 grams/d = 1.24 lb/day
Daily plant flow = 34,400 gal/d = 130,000 l/d
Effluent concentration = 4.34 mg TP/L

The assumed phosphorous effluent concentration for the Q2K modeling is 5 mg/l with 4 mg/l as soluble (inorganic in the model) and 1 mg/l as particulate (organic in the model) phosphorous. The modeling charts showing the differences between existing DO and algae conditions and target DO and algae conditions demonstrate that the impact from wwtp loads for existing conditions is minimal due to the high NPS loads but that it is much more apparent with the reduced target loads.

The wwtp effluent total phosphorous will need to be monitored to establish the actual daily load. The total phosphorous WLA for the New Vienna wastewater treatment plant is based on the existing estimated average daily load. It is 564 grams/d (1.24 lb/d) or the monitored daily load when this data becomes available.

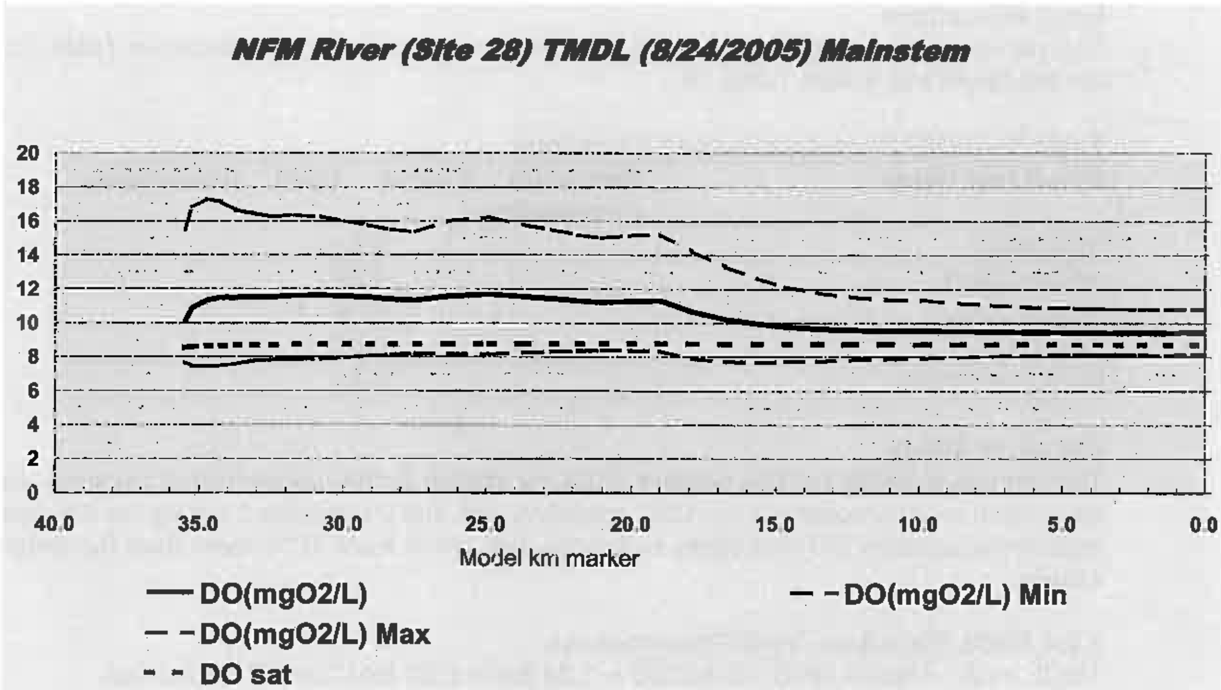


Figure 13 Modeled longitudinal <u>target</u> DO profile without the New Vienna wwtp

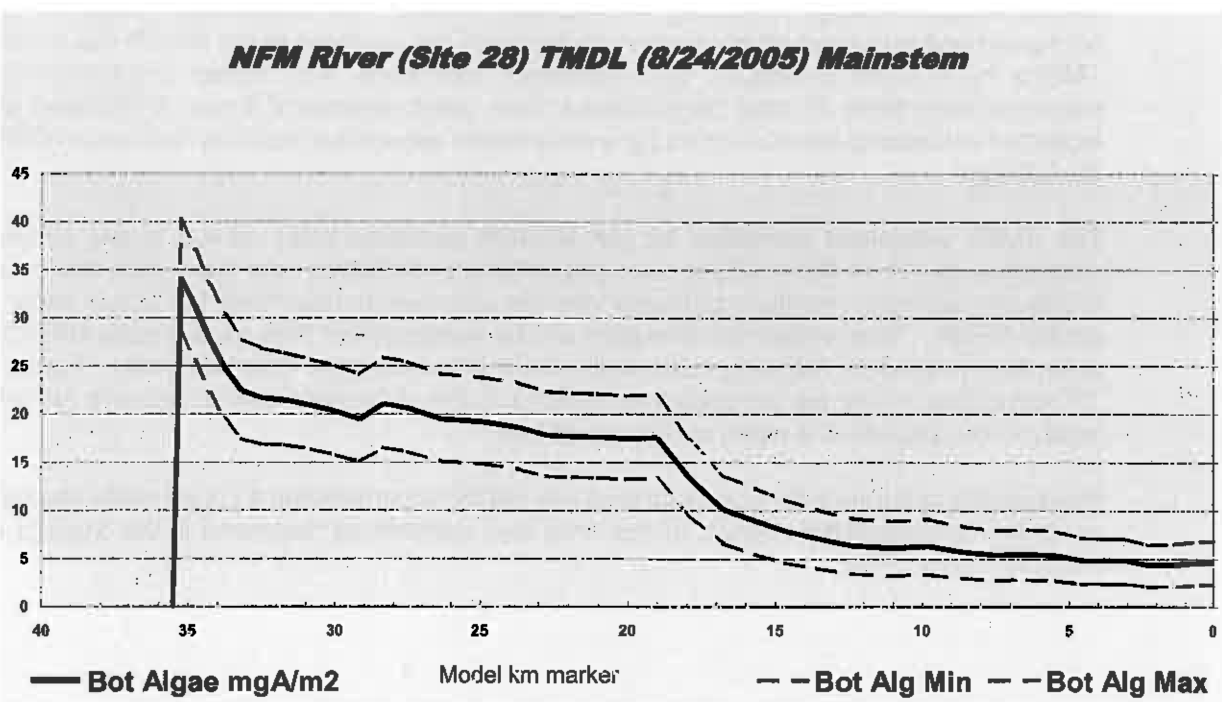


Figure 14 Modeled <u>target</u> benthic algae longitudinal profile <u>without</u> the NV wwtp

Load Allocations

The non-point source phosphorous load allocations for this TMDL, shown in Table 13, are the target loads from Table 12.

Table 14 NFMR Phosphorous Load Allocations

Flow/Load Name	**Non-Point Source Load Allocations, pounds/day**
headwater	0.51
diffuse flow 1	1.92
diffuse flow 2	2.09
diffuse flow 3	0.87
Watershed total	5.40

Margin of Safety

The margin of safety for this nutrient TMDL is implicit in that conservative assumptions have been made throughout the Q2K modeling and that the modeled values for the load allocations produce DO and algae estimates that are at least 10% lower than the target values.

3.2.4 TMDL Equation - Total Phosphorous

TMDL = LA + WLA + MOS = 5.40 lb/d + 1.24 lb/d = 6.64 lb/d Total Phosphorous

3.2.5 Reasonable Assurance

Reasonable assurance means a demonstration that the wasteload and load allocations will be realized through regulatory or voluntary actions. For waterbodies impaired by both point and non-point sources, such as the impaired segment of the NFMR that these TMDLs have been developed for, wasteload allocations may reflect anticipated or expected reductions of total phosphorous from other sources if those anticipated or expected reductions are supported by a reasonable assurance that they will occur (CFR 40-130.2g).

The TMDL wasteload allocation for the NPDES permitted point source in the NFMR watershed is set to the existing total phosphorous discharge and says that the new facility should begin monitoring effluent total phosphorous to determine the actual impact on the NFMR. This wasteload allocation will be implemented through the Iowa NPDES permitting procedure following rules in the Iowa Administrative Code (567-64). Further TP reductions below the wasteload allocations in this document cannot improve NFMR ability to comply with the water quality standards.

Reasonable assurance for non-point sources will be accomplished through methods and projects that reduce the impacts of row crop and livestock as described in the Section 4 Implementation Plan.

3.4 Ammonia TMDL

3.4.1 TMDL Target

The stressor identification process for the impaired segment of the North Fork Maquoketa River found that excessive ammonia causing toxic conditions for fish and a depleted dissolved oxygen condition was a primary stressor in the river that depresses FIBI scores. The targets for ammonia toxicity and dissolved oxygen concentration are those found in the Iowa water quality standards described in Section 3.1 and listed in Tables 8 and 9. Because of the episodic nature of the discharges that caused these fish kills, the total ammonia target for this pollutant is the acute criterion (at pH=9.0 and temperature = 20C) of 1.32 mg/l. The target for dissolved oxygen is the WQS minimum of 4.0 mg/l where the oxygen sag from the slug load is lowest, at model km marker 11.

Modeling and Conceptual Approach

Manure spills from storage facilities and runoff from open feedlots and fields have been identified as some of the biggest water quality issues in the NFMR watershed. There have been several instances in which there were severe violations of the water quality standards, generally for ammonia toxicity, caused by spills and runoff that led to fish kills. State and federal programs that regulate manure application and open feedlots are meant to alleviate these problems. Spills and runoff that cause fish kills can lead to enforcement and fines. The following approach is not meant to suggest that spills and runoff are acceptable conditions, but to define loads that would not necessarily cause impairments and to show that these non-violating loads are quite low, much lower than for an actual manure spill or runoff incident.

The approach used to establish existing conditions and the ammonia concentration that would not cause a violation of the acute WQS was to simulate a spill in the NFMR with high concentrations of ammonia and BOD. To do this, the Q2K model developed for the nutrient TMDL oxygen dynamics simulation was used in conjunction with an ammonia slug load discharge to the stream at model km marker 20. The simulated discharge flow would be equivalent to the runoff from a quarter acre in a 2-year return 24-hour rain (3 inches). The total ammonia concentration in the discharge was set at 45 mg/l, about the same as in untreated wastewater. Since there would also be an organic heterotrophic oxygen demand in the runoff, a CBOD concentration of 100 mg/l was also included in the slug load. The organic load was reduced to 25 mg/l CBOD to calculate the ammonia concentration that does not violate the acute WQS.

To obtain the maximum daily load, the ammonia concentration in the discharge to the stream was reduced in model runs until it was at least 10% less than the WQS acute criterion of 1.32 mg/l along the entire length of the stream below the discharge. Ten percent is the margin of safety. The 45-mg/l total ammonia concentration was reduced in the simulation to 10 mg/l. At this discharge concentration, the total ammonia was low enough and the DO concentration was high enough to meet the water quality standards along the impaired segment downstream of the discharge. The model results and the WQS targets are shown in Figures 15 and 17 for total ammonia and dissolved oxygen.

Figure 15 shows the results of modeling these two discharges for the length of the impaired segment and compares them to the acute and chronic WQS values at a pH of 9.0 and a temperature of 20C. Ammonia also causes an oxygen demand through the process of nitrification. Figure 16 shows the DO along the length of the impaired segment. From this model output it can be seen that the lowest point of the downstream oxygen sag is at Model km marker 11. The modeled 24 hour simulation at the km marker 11 DO sag low point is shown in Figure 17 for both the 45 mg/l and the 10 mg/l concentrations used to generate the ammonia slug loads.

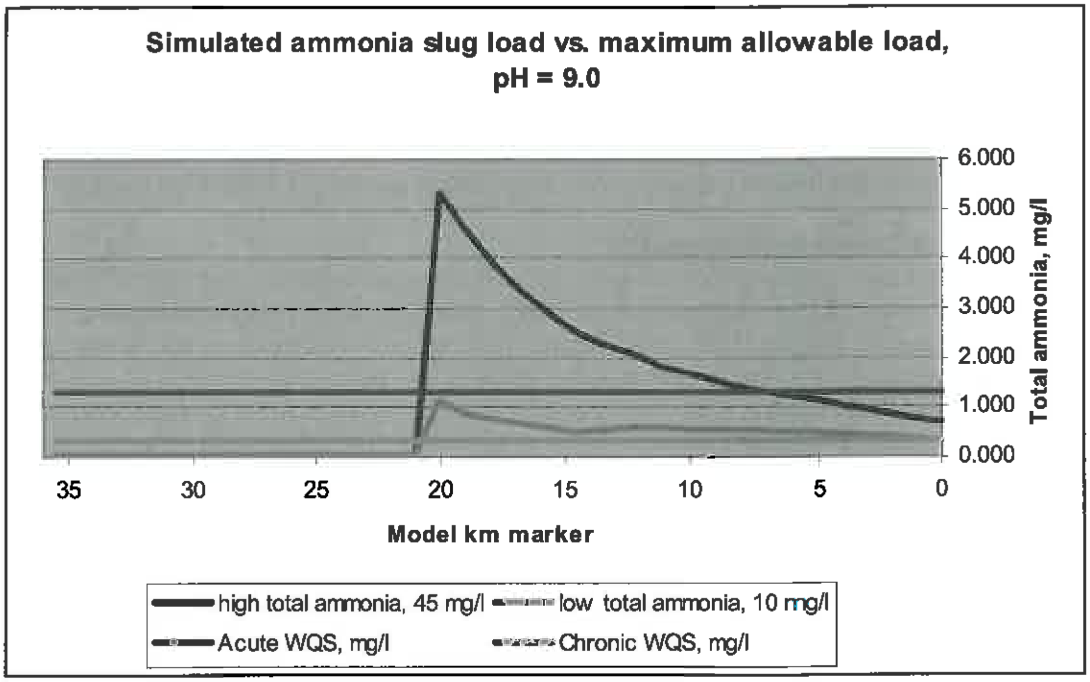


Figure 15 Simulated ammonia slug discharge at Model km marker 20

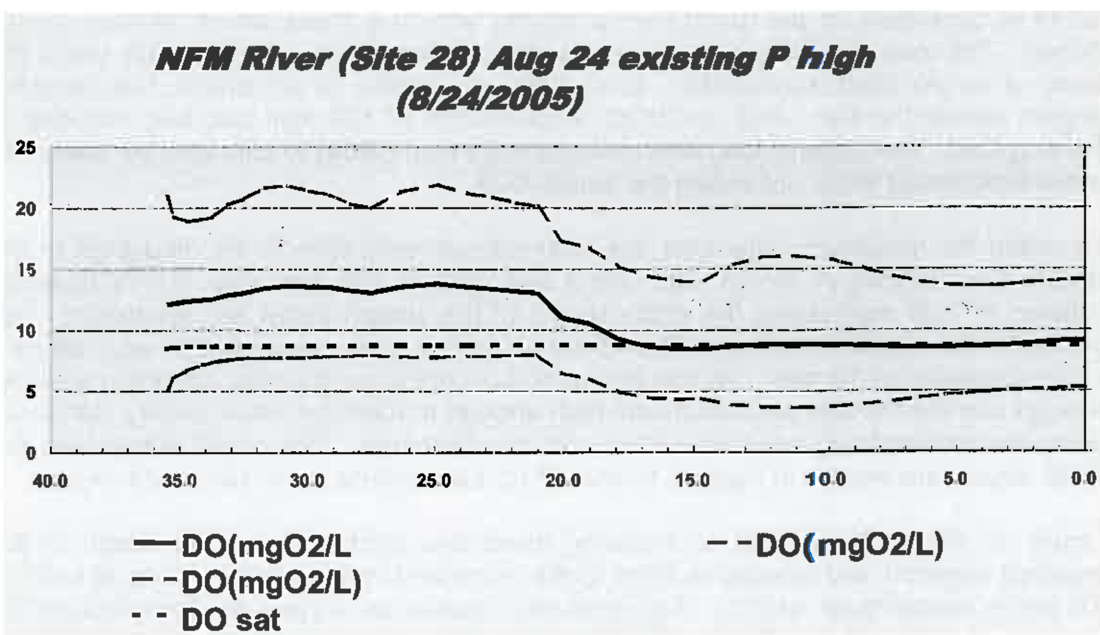


Figure 16 DO profile for simulated ammonia slug discharge at Model km marker 20

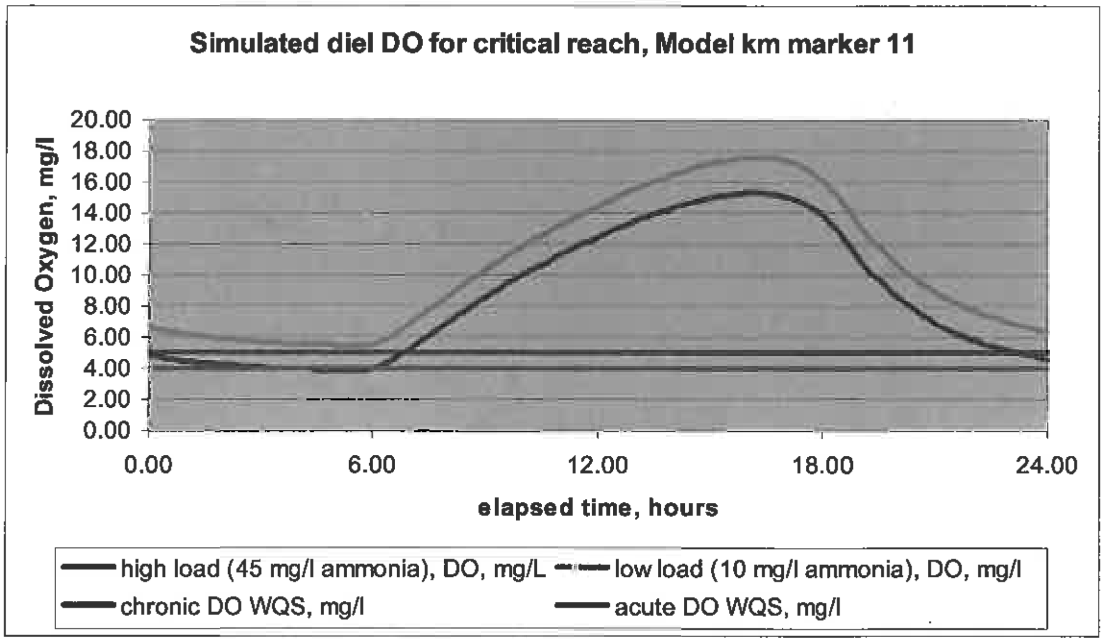


Figure 17 Diel DO cross-section at the oxygen sag low point, Model km marker 11 (See Figure 16).

For a high ammonia slug load, Figure 17 shows that the DO concentration dips below the 4.0 mg/l WQS criterion in the early AM and then rises quickly with algal productivity. When the ammonia concentration is reduced to 10 mg/l, the DO remains above 5.0 mg/l at all times of the day, well above all WQS DO criteria.

Waterbody Pollutant Loading Capacity

The ammonia toxicity loading capacity of the NFMR is defined by the table of ammonia concentrations and pH in the water quality standards (Table 8) for a given stream flow or volume. The oxygen demand loading capacity is defined by the minimums in the water quality standards (Table 9).

3.4.2 Pollution Source Assessment

The slug discharges that have caused reported fish kills in the impaired segment of the NFMR have been from manure related runoff or fertilizer spills in the middle third of the stream. There are at least 66 open feedlots of varying size in the watershed, some on sloping ground, near NFMR tributaries, and with minimal containment.

Existing Load

The existing load is that from the slug of ammonia in the simulated spill. The simulated ammonia concentration is 45 mg/l at a 24-hour flow of 23,000 gpd (10 l/s). The total daily load from this flow and concentration is 9 lb ammonia/day. Figure 18 shows the impact of the simulated ammonia load on the NFMR for the design model conditions. As can be seen, the total ammonia concentration immediately peaks and then gradually drops downstream from the point of discharge.

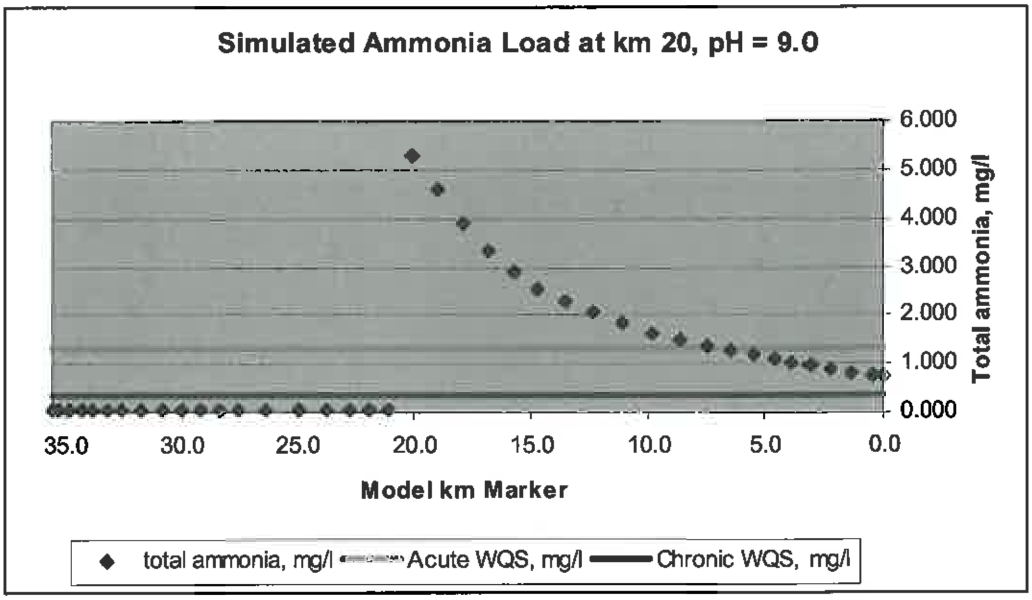


Figure 18 Simulated Ammonia Slug Load, "Existing Conditions"

Departure from Loading Capacity

The total ammonia load capacity for the impaired NFMR segment is the load that does not cause a condition that exceeds the acute WQS for the simulated design conditions. Figure 19 shows the simulated total ammonia concentration along the length in the stream when the discharge concentration is 10 mg/l. The departure from loading capacity is the difference between the loads at the 45 and the 10-mg/l ammonia concentrations calculated as a mass/day for the 23,000-gpd discharges, i.e., 8.63 - 1.92 = 6.71 pounds total ammonia per day.

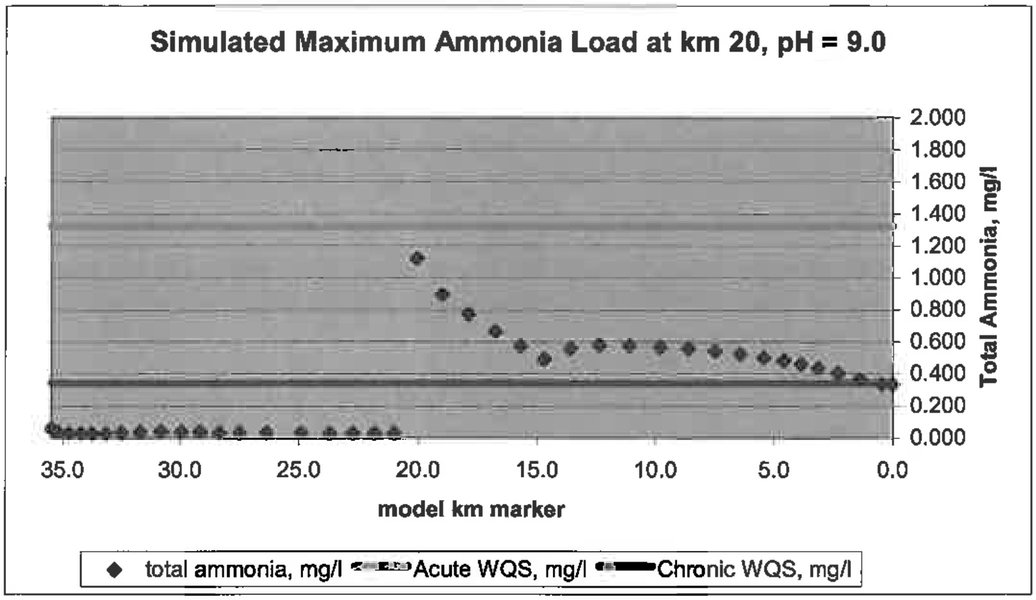


Figure 19 Simulated Ammonia Load reduced to meet acute total ammonia WQS

3.4.3 Pollutant Allocations

Wasteload Allocation
There are no point sources in the watershed that are significant sources of episodic slug ammonia discharges and, therefore, there are no wasteload allocations for episodic slug ammonia loads.

Load Allocation
The load allocation for ammonia is the slug ammonia load that will meet the water quality standard numeric limits for ammonia toxicity and dissolved oxygen along the entire length of the impaired segment of the NFMR. For the simulated discharge of 23,000 gallons per day to the stream the load allocation would be for a concentration of 10-mg/l total ammonia or a daily load of 1.9 pounds of ammonia.

Margin of Safety
The margin of safety for slug ammonia loads to the impaired segment of the NFMR is an explicit ten percent of the WQS acute criterion for total ammonia at pH = 9.0 and temperature = 20C. The criterion is 1.32 mg/l and 10% MOS is 0.13 mg/l.

4. Implementation Plan

The following implementation plan is not a required component of a Total Maximum Daily Load but provides department staff, partners, and watershed stakeholders with a framework for improving NFMR water quality. Currently there is an EPA funded assessment project called the Upper North Fork Maquoketa River Watershed Comprehensive Plan, headed by the Limestone Bluffs RC & D, that includes the impaired segment covered by these TMDLs.

The stressor identification process for the impaired segment of the North Fork Maquoketa River identified three pollutants and associated stream conditions as the causes of the biological impairments. The three pollutants are streambed silt, high phosphorous concentrations that cause excessive algae growth, and ammonia concentrations that are toxic to aquatic life and cause dissolved oxygen depletion. The associated conditions are suspended solids, embeddedness of coarse streambed materials, large diurnal DO amplitude caused by excessive bottom algae, and episodic fish kills. Reducing the loads from these three pollutants will improve the biological condition of the stream.

The reductions in watershed loads of both sediment and phosphorus will require land management changes that take time to implement. Reducing erosion would also significantly reduce total phosphorous.

A detailed field assessment of the NFMR watershed that would identify and locate existing erosion controls has not yet been performed. Therefore, the erosion modeling shown in Appendix A, Figure A-3, does not include controls that may already be in place. Nonetheless, the Figure A-3 sediment delivery map does show the areas where the potential for sediment delivery is the greatest. These are also the locations where erosion controls would have the most impact if they have not already been constructed.

Funding is needed for administration and producer implementation. A program of no-till plus nitrogen, phosphorous and manure management coupled with sediment management may very well be needed. This will require farm operator education, involvement and funding. Therefore, the watershed may need to be designated a priority watershed by the Soil and Water Conservation District. Funding for manure storage and other feedlot runoff controls may also be needed as a priority in the watershed.

If erosion reduction goals are to be realized, specific objectives and a schedule to reach them can provide a framework for understanding the nature and extent of the erosion management problem. Below is a basic example of a timetable and long-term annual average erosion reduction targets:

- The current loading of sediment is 87,500 tons per year.
- Reduce loading of sediment to 65,000 tons per year by 2015, a reduction of 25% from the current load estimate.
- Reduce loading of sediment to 42,500 tons per year by 2020, a reduction of 35% from the year 2015 load estimate.
- Reduce loading of sediment to 20,200 tons per year by 2025 a reduction of 52% from the year 2020 load estimate.

The reduction to 20,200 tons per year, the TMDL target, is a total decrease of 77% from the current average annual loading of 87,500 tons per year.

4.1 Sediment

Channel erosion: Channel erosion has been identified as a sediment source. Areas of severe channel erosion should be identified and targeted for restoration activities. Suggested controls are:

- Installation of structures to reduce peak flows during runoff events.

- Exclusion of livestock from the stream to increase bed and bank stability.
- Installation of stream bank protection measures such as vegetation and graded rock.
- Stabilization of stream banks by shaping and removing overhangs unless there are indications that the bank has been stabilized by dense tree or sod root systems.

Overland sheet and rill erosion: Erosion control activities, including the maintenance of installed structures, need to continue in the watershed. The watershed should be periodically evaluated and erosion control activities focused on identified and targeted sediment contributors. Suggested controls are:

- Agricultural management practices such as no-till farming that will increase crop residue.
- Construction of terraces and grassed waterways.
- Installation of riparian buffers along stream corridors.
- Construction of grade stabilization structures.
- Implementation and enforcement of erosion control measures at development sites.

4.2 Nutrients

Best management practices to reduce nutrient delivery, particularly phosphorus, should be emphasized in the NFMR watershed. Many of these practices involve erosion control and would be applicable for sediment reduction as well. For agricultural land uses, these practices include the following:

- Nutrient management on production agriculture ground to achieve the optimum soil test category. This soil test category is the most profitable for producers to sustain in the long term.
- Incorporate or subsurface apply phosphorus (manure and commercial fertilizer) while controlling soil erosion. Incorporation will physically separate the phosphorus from surface runoff.
- Continue encouraging the adoption of reduced tillage systems, specifically no till and strip tillage.
- Initiate an incentive program for fall-seeded cover such as hairy vetch or fall rye. The incentives should be directed at fields with low residue producing crops such as soybeans or low residue crops after harvest such as corn silage fields. This practice increases residue cover on the soil surface and improves water infiltration.
- Fencing of livestock from the stream, alternative water sources, and buffer strips along the stream corridor.
- Improvements in manure containment and management for open feedlots.

Best Management Practices (BMPs) for controlling nutrient delivery associated with residential and commercial runoff are also important. These practices include:

- Addition of landscape diversity to reduce runoff volume and/or velocity through the strategic location of filter strips, rain gardens, swales, and grass waterways.

- Installation of terraces, ponds, or other erosion and water control structures at appropriate locations within the watershed to control erosion and reduce delivery of sediment and phosphorus to the stream.
- Use of low or no-phosphorus fertilizers on residential and commercial lawns.
- Use of appropriate erosion controls on construction sites to reduce delivery of sediment and phosphorus to the stream.

4.3 Episodic Ammonia Toxicity

As previously noted in this report, accidental manure spills from storage facilities and open feedlots and precipitation event runoff from manure applied to fields and from open feedlots have caused water quality violations. These violations have led to fish kills (see Figure 4) in the impaired segment of the NFMR. The most immediate threat to aquatic life from a spill or runoff to the stream is from un-ionized ammonia followed by oxygen demand.

Preventing accidental spills from stored manure requires increased vigilance by producers and manure application contractors to the condition of their manure handling equipment and storage structures. It also requires preparedness to control accidental spills should they occur.

Control of open feedlots means that there should not be any contaminated runoff. Precipitation runoff carrying manure must be contained in structures at the site. Runoff from areas upland of open feedlots needs to be diverted around them. Open feedlots with greater than 1,000 cattle are required to obtain NPDES discharge permits that limit discharges to zero.

5. Monitoring

The Upper North Fork Maquoketa River Watershed Comprehensive Plan assessment project by the Limestone Bluffs RC & D, including the impaired segment covered by this group of TMDLs, continues. Part of this watershed assessment effort should include water quality monitoring.

The existing ambient monitoring being done by the IDNR ambient monitoring provides only minimal information for water quality assessment and evaluation of the effectiveness of watershed best management practices. To further evaluate NFMR pollutant problems, effectively manage their impact, and design solutions through improvements to controls, additional targeted monitoring is needed.

A plan for future water quality monitoring should include the following to enhance hydrologic and water quality modeling and evaluation of the problems in this segment of the NFMR:

- Install two autosamplers with stage measurement at the same locations, sites 28 and 30 from April to November in conjunction with continuous dissolved oxygen and temperature data collection. This will provide refined calibration for the Q2K modeling for total phosphorous and algae.

- Install an autosampler with stage measurement upstream of site 30 from April to November in conjunction with continuous dissolved oxygen and temperature data collection. This will provide additional data on the locations and nature of upstream pollutant sources and more refined data on the headwaters component in the water quality model. .

- Install an autosampler with stage measurement on Coffee Creek just upstream of its confluence with NFMR from April to November in conjunction with continuous dissolved oxygen and temperature data collection. The Coffee Creek sub-watershed is fairly large and it would be useful to separate loads from it from those in other parts of the watershed.

- Install an autosampler with stage measurement just upstream of Hewitt Creek from April to November in conjunction with continuous dissolved oxygen and temperature data collection. This will provide data for the target watershed separate from the Hewitt Creek watershed.

- More frequent sampling at the autosampler sites during a wider range of flow conditions, especially at high flows during the rising part of the hydrograph. This would provide a more accurate picture of what the actual loads are from non-point sources.

- In addition to QUAL2K, use other water quality models and analytical methods to evaluate existing and new data to provide further insight into the nature of the NFMR water quality problems.

- Perform annual follow-up biological assessments near locations where autosamplers are installed.

- Get actual flow and concentration data from manure runoff and the stream during accidental releases to improve ammonia and oxygen demand impact modeling.

- Perform an annual trend analysis on the load estimates to provide information on the effectiveness of implemented BMPs. This could be part of an ongoing data analysis program that includes a statistical design for the number of samples required to achieve desired confidence in the results.

Phasing TMDLs is an iterative approach to managing water quality that is used when the origin, nature and sources of water quality impairments are not completely understood. In the first phase, the waterbody load capacity, existing pollutant load in excess of this capacity, and the source load allocations are estimated based on the resources and information available.

This report contains specific and quantified targets for reducing pollutant concentrations in the river and allocates allowable loads to all sources. These three TMDLs represent a first phase in the development of NFM River water quality improvements. The value of these evaluations and the effectiveness of their follow-ups are dependent on local activities to improve conditions in the watershed. Without the efforts of watershed citizens, implementation of practices that will remedy the NFMR impairment may not occur. What is needed in follow-up activities are stakeholder driven solutions and more effective management practices. Implementing targeted monitoring will determine what management practices result in load reductions and the attainment of water quality standards. Summarizing, renewed targeted monitoring will:

- Assess the future beneficial use status;
- Determine if water quality is improving, getting worse, or staying the same;
- Evaluate the effectiveness of implemented best management practices.

6. Public Participation

TMDL staff held a public meeting in New Vienna on May 18, 2005, to describe the Stressor Identification process and to request local knowledge on past and present conditions in North Fork Maquoketa River. The 25 attendees at this meeting included farmers, city residents, officials from the Cities of New Vienna and Holy Cross.

A draft of the TMDL was presented at a second local public meeting in New Vienna at 7:00 PM on December 4, 2006. Among the thirty attendees were farmers, city officials, and representatives from Iowa State University Extension and the Iowa Department of Agriculture and Land Stewardship Division of Soil Conservation. Comments received were reviewed and given consideration and, where appropriate, incorporated into the TMDL.

7. References

1. U. S. Environmental Protection Agency, Office of Water. 2000. Stressor Identification Guidance Document. EPA 822-B-00-025. United States Environmental Protection Agency, Washington DC. Available at: http://www.epa.gov/ost/biocriteria/stressors/stressorid.pdf (verified June 1, 2005).

2. Iowa Administrative Code Chapter 567-61: Iowa Water Quality Standards. 2/15/2006

3. Surface Water Classification Document May 2004. Water Resources Section, Water Quality Bureau, Environmental Services Division. Iowa Department of Natural Resources, Des Moines, Iowa.

4. Stressor Identification for the North Fork Maquoketa River, October, 2006. Developed by the Watershed Improvement and Watershed Assessment Sections, Iowa Geological Survey and Land Quality Bureau, Environmental Services Division, Iowa Department of Natural Resources, Des Moines, Iowa

5. USDA Natural Resources Conservation Service. 2000. Field Office Technical Guide. "Predicting Rainfall Erosion Losses, the Revised Universal Soil Loss Equation (RUSLE)".

6. Renard, K. G., G. R. Foster, G. A. Weesies, D. K. McCool, and D. C. Yoder. 1997. Predicting soil erosion by water: A guide to conservation planning with the Revised Universal Soil Loss Equation (RUSLE). U.S. Department of Agriculture, Agriculture Handbook No. 703. 404 pp.

7. USDA Natural Resources Conservation Service. 1998. Field Office Technical Guide. "Erosion and Sediment Delivery".

8. Johnson, H. P. and J. L. Baker. 1983. Field-to-Stream Transport of Agricultural Chemicals and Sediment in an Iowa Watershed; Part 1: Data Base for Model Testing (1976-1978). Iowa Agricultural and Home Economics Experiment Station, Ames, IA PB82-254046.

9. QUAL2K FORTRAN Stream Water Quality Model, Version 2.04, Steve Chapra, Hua Tao, Greg Pellitier

10. Chapra, S.C., Pelletier, G.J. and Tao, H. 2006. QUAL2K: A Modeling Framework for Simulating River and Stream Water Quality, Version 2.04: Documentation and Users Manual. Civil and Environmental Engineering Dept., Tufts University, Medford, MA., Steven.Chapra@tufts.edu

11. Upper North Fork Maquoketa River Watershed Comprehensive Plan, Assessment and Management Strategies, Draft Version, prepared by the Limestone Bluffs RC&D with assistance from Northeast Iowa RC&D. Draft, October 2006

Appendix A – Watershed Maps

This appendix contains several maps of the impaired segment of the North Fork Maquoketa River watershed that show the ten foot elevation changes along the stream segment model, land use, estimates of erosion potential, and modeled sub-basins.

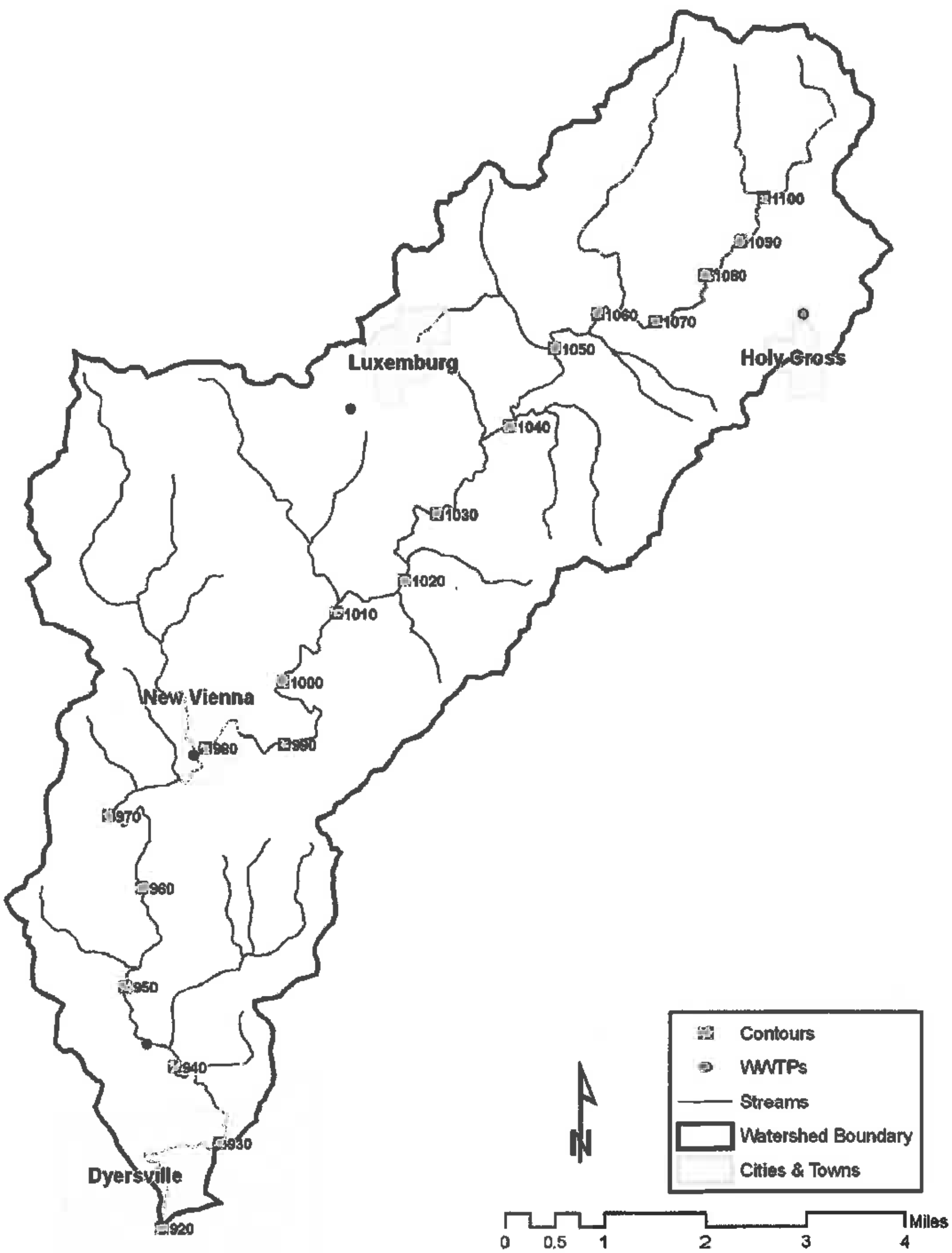


Figure A-1 Elevation contours used to define Q2K model reaches.

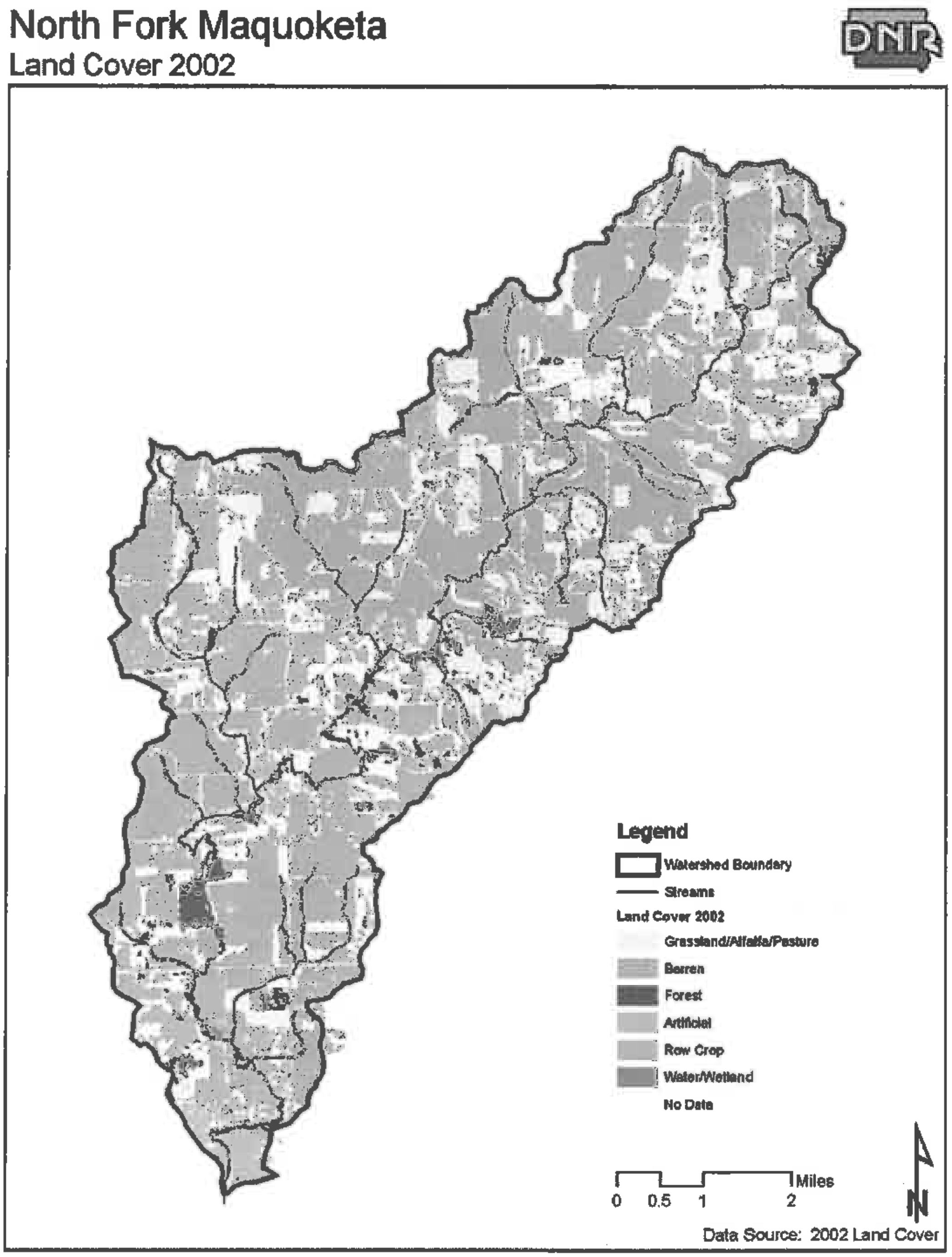


Figure A-2. North Fork Maquoketa River watershed 2002 Land uses from the IDNR Coverage.

North Fork Maquoketa
Sediment Delivery

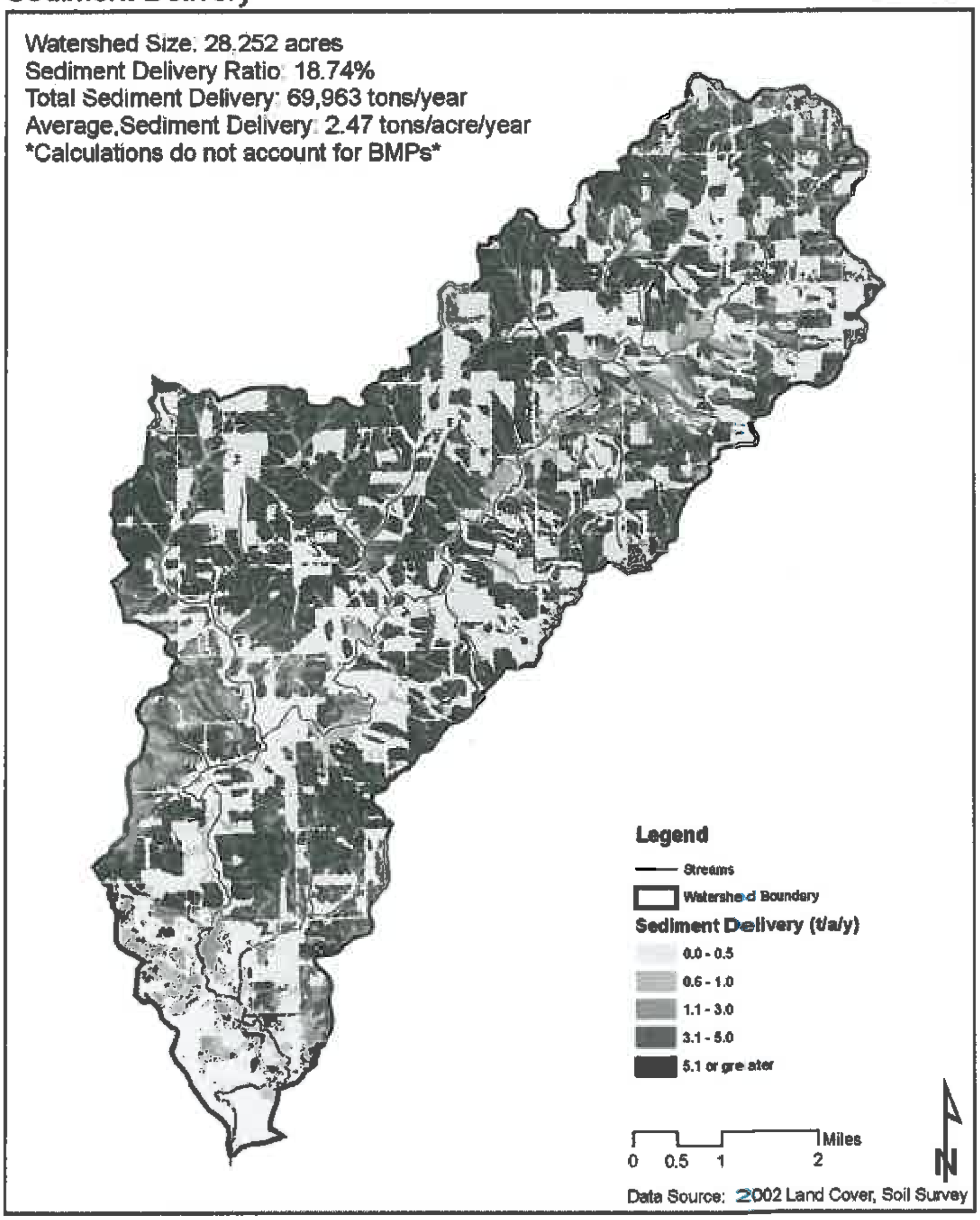


Figure A-3 This map shows sheet and rill erosion for the watershed that incorporates the estimated sediment delivery ratio. Watershed practices that reduce sediment erosion and delivery to the stream have not been included in the evaluation.

Figure A-4 Modeled Sub-basins based on the locations of the monitoring sites and the data generated from these sites. The sub-basins are labeled using the corresponding monitoring site name.

Total Maximum Daily Load
For Ammonia and NOx
Rock Creek
Clinton County, Iowa

December 2000

Iowa Department of Natural Resources
Water Resources Section

TMDL for Ammonia and NOx
Rock Creek
Clinton County, Iowa

Waterbody Name:	Rock Creek
IDNR Waterbody ID:	IA 01-MAQ-0010-0
Hydrologic Unit Code:	HUC11 07080101030
Location:	Sec. 23, T81N, R5E
Latitude:	41 Deg. 47 Min. N
Longitude:	90 Deg. 16 Min W
Use Designation Class:	B (LR) (aquatic life)
Watershed Area:	10,688 acres
Segment Length	9 miles
Major River Basin:	Copperas-Duck
Receiving Water Body:	Mississippi River via Schricker Slough
Pollutant:	Ammonia and NOx
Pollutant Sources:	Contaminated Site Agricultural Non Point Sources
1998 303d Priority:	High

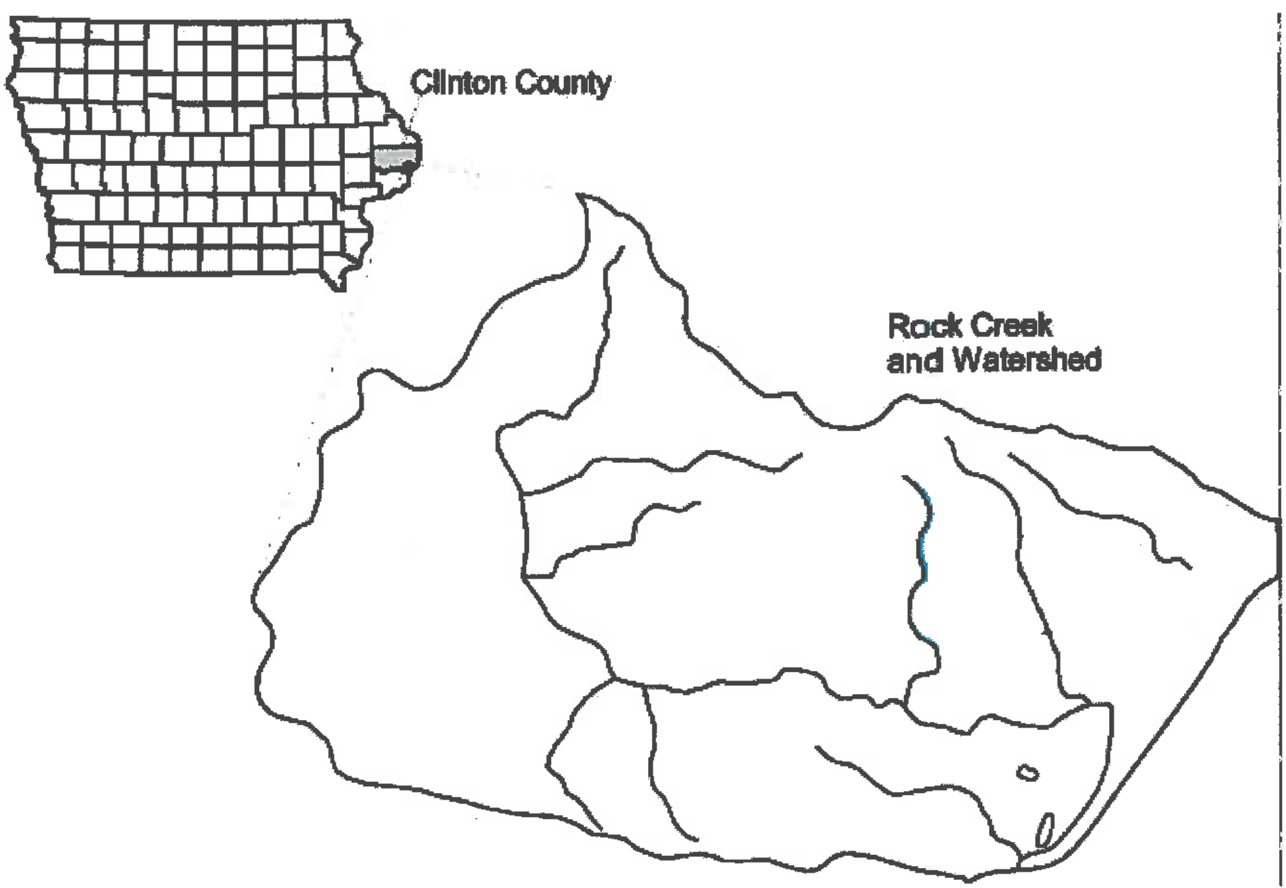


Table of Contents

1. Description of Waterbody and Watershed

Rock Creek is located in eastern Clinton County, in east central Iowa. Rock Creek is located in the Copperas-Duck watershed (HUC 8: 07080101) and drains approximately 16.7 mi^2 (10,688 acres) (Larimer, 1974) of Clinton County at the Highway 67 bridge. Rock Creek flows east-southeast before draining into the Mississippi River. Figure 1 shows the location of the watershed.

The landuse of the Rock Creek watershed is predominately agriculture. Based on IDNR 1992 landuse data, the Rock Creek watershed is composed primarily of agricultural lands (90%), with 4% urban and 6% forest and wetlands.

2. Applicable Water Quality Standards

The Iowa Water Quality Standards (Iowa, 1996) list the designated uses for this basin as Aquatic Life (Class B(LR) - Limited Resource) and general uses of secondary contact recreation, crop irrigation, agricultural uses, domestic uses, and livestock watering.

According to the 1998 303(d) list, the waters in this basin are impaired by toxic levels of ammonia nitrogen (NH_3-N) and elevated levels of nitrate/nitrite nitrogen (NO_x-N). Rock Creek has exceeded the criteria for Ammonia Nitrogen – Limited Resource Streams (Table 3c, Iowa, 1996). This criteria is variable and dependent on temperature and pH. There are no numeric criteria for nitrate or nitrite nitrogen in the Iowa Water Quality Standards for Class B waters.

3. Current Water Quality Conditions and Desired Endpoint

The Nitrate/Nitrite (NOx) TMDL is bundled with the ammonia TMDL because the pollutants are so closely related. In the nitrification process, ammonia is oxidized, broken down to nitrite and then to nitrate. Further, there is a statistical relationship between the increase in NOx and the increase in ammonia around the PCS Nitrogen facility. By limiting the amount of ammonia that can complete the nitrification cycle, the amount of nitrites and nitrates will also be limited.

Data for this basin are limited, with no USGS or STORET data sources available from the Rock Creek subbasin. The monitoring data used in this report are from monitoring reports for Schricker Slough, located below the mouth of Rock Creek in the Mississippi River. The monitoring data is part of a Long Term Resource Management Program (LTRMP) effort. Stream flow data were derived from a nearby watershed.

3.1 Water Quality Data

Long-term monitoring data for Schricker Slough are available from 1993-present (Gritters, 1997, 2000). The monitoring data were collected upstream of PCS Nitrogen, downstream of PCS Nitrogen, and in Schricker Slough. Reported nitrogen species are ammonia and nitrate/nitrite. Sampling on May 21, 1997, was performed at four additional stations, including a sample upstream of PCS Nitrogen on the tributary where it is located (Figure 2). On May 3, 2000, staff from IDNR and US Fish and Wildlife inspected the watershed. Photographs were taken at six sites, along with field measurements for temperature, pH, and nitrate at four sites, and channel geometry and velocity at three sites. Water quality data from several monitoring stations and monitoring wells, and the field data from May 3, 2000, were used to establish the background concentrations.

3.2 Water Quality Analysis

Water quality samples from May 21, 1997, for the upstream and downstream sites were similar to the LTRMP data. No other sample data were available for the small unnamed north/south creek referred to as Ammonia Creek. Table 1 presents the data for May 21, 1997, from upstream to downstream LTRMP data. The portion of the watershed in which monitoring data were collected is shown in Figure 2. The impact of PCS Nitrogen on in-stream ammonia and nitrate/nitrite is well demonstrated by these sample data. LTRMP data confirm this impact. Monitoring data for ammonia and nitrate/nitrite are shown in Figures 3 and 4 respectively.

Water quality standards are violated downstream of PCS Nitrogen for ammonia. Under the Long Term Resource Monitoring Program, biweekly samples are collected in Schricker Slough and at two sites in Rock Creek, one above PCS Nitrogen and one below PCS Nitrogen. During the sampling, field data were collected, including temperature and pH. The ammonia criteria for Rock Creek was calculated from the equation used to derive Table 3c of the Iowa Water Quality Standards (Iowa, 1996). This was done for each temperature and pH of the monitoring data and the criteria compared to the ammonia concentration in the stream. Tables 2 and 3 summarize the monitoring data for the two LTRMP Rock Creek sites. The data from upstream of PCS Nitrogen show no ammonia concentrations near toxicity values, whereas 6 of 82 samples at the downstream station exceeded the calculated chronic criteria.

3.3 USGS Flow Gauge Data

The Rock Creek basin does not have a stream flow monitoring gauge. Crow Creek, which is located approximately 20 miles downstream on the Mississippi River, has flow records and is similar to Rock Creek in shape, drainage area, and landuse characterization. The landuses in Rock Creek were compared to landuses in Crow Creek using the 1992 IDNR landuse data. The comparison shows Rock Creek is 90% agricultural while Crow Creek is 77% agricultural. It is recognized that landuse in both of these watersheds may have changed since the data was collected in 1992. The proximity of Crow Creek to Rock Creek and the similarity of land uses support the use of Crow Creek as a surrogate gauge to calculate flows in Rock Creek. Daily flows for the Crow Creek gauge (USGS station 05422470 Crow Creek at Bettendorf, Iowa) were used to estimate the flow of Rock Creek on days with monitoring data and summary statistical data were used to estimate the median flows for Rock Creek. The median flow is the stream flow that 50 percent of measured flows exceed. The critical flow for Iowa streams is the 7Q10 flow, a 7-day average low flow expected to occur once in 10 years. For Rock Creek, a protected low flow of 0.5 cfs has been established in lieu of the 7Q10. Therefore, the critical low flow is 0.5 cfs.

3.4 Ammonia Endpoint

Elevated ammonia levels can cause aquatic toxicity and lower in-stream dissolved oxygen due to conversion of ammonia to nitrate. Iowa's numeric criteria for ammonia nitrogen are for acute and chronic toxicity and are based on pH, temperature, and water quality classifications (Iowa, 1996). As part of the Iowa DNR wasteload allocation procedures, a summer water temperature of 23.8 °C and a pH of 8.2 are used to determine the critical conditions. The summer critical period has been chosen since in-stream reaction rates are greatest and the DO saturation value is smallest at that time. The chronic criterion will be used as the basis for the selected endpoint. Table 3c of the Iowa Water Quality Standards does not list criteria for 23.8 °C and pH of 8.2. However, the DNR has calculated a corresponding criteria of 1.84 mg/L as N using the criterion's equation. Therefore, the selected endpoint is 1.84 mg/L. For Phase I of this TMDL , this will be achieved at the outlet of the constructed wetland. To achieve and maintain this ammonia concentration, the ammonia load capacity for Rock Creek is 5.0 pounds per day at the protected flow of 0.5 cfs. For Phase II, the same ammonia endpoint will be achieved in Rock Creek following complete mixing with Ammonia Creek at a location approximately 200 feet downstream.

For use in assessment of future monitoring data, seasonal ammonia endpoints are also provided based on other critical stream flow and instream pH and temperature conditions. These example endpoints are discussed in the Stream Loading section.

3.5 Nitrate Endpoint

The water quality standard for nitrate/nitrite for Class B(LR) use is a narrative standard that states: waters shall be free from substances attributable to wastewater discharges or agricultural practices in concentrations or combinations, which are acutely toxic to humans, animals or plant life. Rock Creek was listed on the 1998 303(d) for NOx (nitrate/nitrite) based on best professional judgement (BPJ). It was believed the fish community would be negatively impacted by very high levels of nitrate/nitrite found in the water column. After further investigation through fish collection it was determined, based on BPJ, that no significant adverse impacts were affecting the fish community. However, reductions in NOx should benefit the overall aquatic system.

4. Source Assessment

4.1 Point Sources

Data retrieved from the EPA Permit Compliance System (USEPA, 2000) show four permitted facilities located in the Rock Creek watershed. The four facilities are the City of Low Moor (IA0040100), Equistar Chemicals, L.P. (IA0000191), DuPont (IA0001066), and PCS Nitrogen Fertilizer, L.P. (IA0003522). The locations of the four facilities are shown in Figure 5. Review of the facility information indicates that only the City of Low Moor discharges to Rock Creek. The remaining facilities discharge to the Mississippi River. Table 4 summarizes the Permit Compliance System monitoring data and permit limits for the City of Low Moor. Although the City of Low Moor has no monitoring data or permit limits for nitrogen compounds, wastewater treatment plants (WWTPs) do discharge nitrogen compounds. The Low Moor WWTP is a controlled discharge lagoon that is to discharge twice per year, usually in the spring and fall. This discharge may or may not be occurring at the 7Q10 or protected flow. Considering the size of the Low Moor discharge, the in-stream effects for this point source will be minor.

4.2 Nonpoint Sources

<u>4.2.1 Groundwater Contamination Sites</u>

Although Equistar, DuPont, and PCS Nitrogen NPDES outfalls do not discharge to Rock Creek, these three sites are considered contaminated sites. The Equistar and Dupont sites are considered Superfund sites. As contaminated sites, all three have the potential to contribute pollutants to Rock Creek through groundwater contamination. Documents for Equistar and DuPont were obtained from the US EPA, Iowa DNR was responsible for supplying data for PCS Nitrogen.

The data for the DuPont facility are contained in the Record of Decision (USEPA, 1988) and the 5-year review (USEPA, 1995). The DuPont facility is located on the Todtz farm property near Murphy's Lake. The site history includes sand and gravel mining from 1959 to 1969 and then a municipal landfill from 1969 to 1975. In 1971, DuPont began disposing of cellophane wastes, which continued until 1975. The landfill has been capped and the groundwater is still being monitored. No nitrogen parameters are included in the monitoring requirements and no nitrogen monitoring results were included in the 1995 five-year review document. Based on the topography and proximity to several lakes and ponds, groundwater and pollutants leaving the Todtz farm property would be intercepted prior to reaching Rock Creek.

The data for the Equistar facility is contained in the latest 5-year review document (USEPA, 1999). The Equistar facility is located on a tributary stream of Rock Creek in an industrial park. The facility has had several owners since polyethylene manufacturing began in 1967, and it is still operating. The areas of concern at this site include storage and loading areas, a former landfill, and surface impoundments on the property. Organic chemicals, including non-aqueous phase liquids, are being recovered from the groundwaters of this site. No nitrogen parameters are included in the monitoring requirements, nor were any nitrogen monitoring results included in the 1999 five-year review document. Because the contaminants for this site are organic chemicals, there is an insignificant chance of additional nitrogen reaching the tributary and Rock Creek from this facility.

The PCS Nitrogen facility is located within 0.5 miles of the Equistar complex. This facility has been owned by a variety of companies that manufactured nitrogen fertilizer. PCS Nitrogen purchased the site in March 1997, but closed the plant in August 1999 due to economic problems. PCS Nitrogen is now closed and much of the manufacturing system has been removed. Historic spills of chemicals, including urea, have led to a groundwater contamination problem around this site. LAW Engineering estimates 96 lbs/day of ammonia enters Rock Creek from an unnamed creek commonly referred to as Ammonia Creek (LAW Engineering memo to PCS, cited in Gritters, 2000). No NOx loading estimates are available. Using LTRMP data from site 3 on May 21, 1997 (Tables 2 and 3), an estimate for the typical nitrate concentration of 38 mg/L yields a nitrate loading of 12.3 lbs/day at the estimated flow in Ammonia Creek of 0.06 cfs. This load reflects both, background nitrate/nitrite and that portion contributed by the

PCS Nitrogen site. Listed in Table 5 are the descriptions for four surface water monitoring stations on the PCS Nitrogen property and an in-stream station 1,000 feet downstream of the southern boundary. Figure 6 shows these stations and the LTRMP monitoring stations. Sampling data collected by LAW Engineering at these five stations are available for the six dates shown in Table 6. The data from site 3 compare well with the data from the LTRMP upstream station, with nitrate values within the LTRMP data range. The ammonia values are frequently higher than the LTRMP data range. The data from site 5 were compared to the LTRMP downstream station and show trends similar to site 3. Without a site map showing groundwater flow directions, the influence of past spills cannot be determined. Elevated groundwater levels during the spring and surface runoff from precipitation could have spread the plume in the past 30 years to influence sites 1 and 3.

4.2.2 Agriculture and Background

Although agriculture dominates the landscape of the Rock Creek watershed, it does not appear to be a primary contributor to the ammonia in Rock Creek. LTRMP monitoring upstream of PCS Nitrogen shows a mean ammonia concentration of 0.09 mg/L (Table 2). However, agricultural lands and drainage tiles are known to convey elevated levels of nitrate to receiving waters. Ammonia nitrogen, nitrite and nitrate nitrogen will be monitored upstream of PCS Nitrogen during phase 1 of this TMDL. This will allow a more accurate identification of ammonia, nitrite, and nitrate levels from agriculture and background sources.

5. Pollutant Loading Scenario

The TMDL process is designed to establish the total loading a stream can assimilate without causing violation of the water quality standards. The allocation of that loading may be assigned equally to all sources, or the allocation may be adjusted to account for the economic and technologic ability of the discharger. The allocation for Rock Creek must account for the impacts of historical spills to the lands adjacent to PCS Nitrogen and the influence of agricultural tile drains and other diverse sources.

5.1 Seasonal Considerations

Analysis of the long-term monitoring data shows that the highest in-stream ammonia and nitrate concentrations occur during the summer when low-flow conditions typically occur. However, to facilitate the potential of other critical conditions, seasonal ammonia nitrogen endpoints using seasonal pH and temperature values and alternative stream flow regimes will be calculated. The critical condition will be determined based on Phase 1 monitoring data. The initial stream allocations will be made using the protected flow.

Based on the LTRMP and PCS Nitrogen data, current ammonia and NOx loading to Rock Creek for the critical conditions were determined. The current loadings are presented in Table 7. The current loading for the various seasonal example conditions (noted in Table 8) will not be calculated. Very limited monitoring data were available to calculate the current loading levels for these example conditions. Monitoring data will be collected during Phase I to assist in projecting the current loading at these example conditions.

5.2 Estimated Nonpoint Load

The estimated Nonpoint Load for ammonia and nitrate/nitrite was developed from LTRMP monitoring data. As noted in Table 2, various statistical summaries of the monitoring data are provided. For purposes of the critical load allocation, the August to October Mean monitoring concentrations were considered to represent the stream conditions during the low stream flow (Protected Flow) conditions. At the Protected Flow regime, the background nitrate/nitrite concentration was 5.73 mg/l (15.4 lbs/d) (Table 2). An ammonia concentration of 0.09 mg/L was used for the background agriculture concentration (Table 2). Therefore, the estimated background or nonpoint load for ammonia and NOx at the protected flow is :

- Ammonia: 0.2 pound/day (0.09 mg/l x 8.34 x 0.5 cfs/1.547 = 0.24 lbs/d)
- NOx: 15.4pounds/day (5.73 mg/l x 8.34 x 0.5 cfs/1.547 = 15.4 lbs/d)

5.3 Estimated Point Source Load

For the purposes of this TMDL discussion, the loadings from Ammonia Creek (and the PCS Nitrogen site) will be considered as a generalized point source. In actuality, the sources of ammonia and nitrate from the site may be from localized surface and ground water contributions. However, the impact to Rock Creek is similar to that of a point source loading.

As noted above, the LAW Engineering memo to PCS Nitrogen estimated the ammonia loading to Ammonia Creek at 96 pounds/day. This estimation is made from monitoring data collected very near the mouth of Ammonia Creek and is assumed to represent the loading to Rock Creek. No degradation or uptake is assumed to occur in the lower several feet of Ammonia Creek prior to mixing with Rock Creek.

The nitrate loading discussed above was with an estimated loading of 102 pounds/day projected for Ammonia Creek. The estimated loadings are presented in Table 7.

6. TMDL or Stream Allocation

6.1 Description of TMDL Allocation

Total Maximum Daily Loads (TMDLs) are composed of the sum of individual waste load allocations (WLAs) for point sources, load allocations (LAs) for nonpoint sources, and natural background levels. In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving water body. Conceptually, this definition is denoted by the equation:

$$TMDL = Ó\ WLAs + Ó\ LAs + MOS$$

The TMDL is the total amount of a pollutant that can be assimilated by the receiving water while still achieving water quality standards.

For some pollutants, TMDLs are expressed on a mass loading basis (e.g., pounds or kilograms per day). In some cases a TMDL is expressed as another appropriate measure that is the relevant expression for the reduction of loadings of the specific pollutant to meet water quality standards or goals. This TMDL is expressed on a mass loading basis.

6.2 Phased TMDL

The Rock Creek TMDL is being established in two separate Phases that reflect the assessment of ongoing site remediation of the PCS Nitrogen releases to the creek. Phase 1 will include the initial period of time to allow for assessment and evaluation of the effectiveness of the recently developed and constructed site remediation efforts. During Phase 1, the ammonia endpoint in Rock Creek will be met in the stream below the constructed wetland complex. As discussed in the Implementation Section, water quality monitoring and stream flow measurements will be conducted at various locations, including the discharge from the wetland complex. The monitoring data will be assessed to determine if compliance with the endpoint is achieved. It is anticipated that Phase 1 will encompass a 2-4 year stream assessment and monitoring period discussed in the Implementation Section.

Phase II will reflect the potential conditions where the endpoint has been met at the discharge of the wetland complex, but the instream conditions in Rock Creek below Ammonia Creek are still exceeding the ammonia endpoint. This phase would indicate that additional control methods are needed to assure total protection of the designated reach of Rock Creek. Additional assessment and evaluation of needed controls would be conducted during Phase II. This phase will continue until the endpoint has been achieved in Rock Creek after complete mixing with Ammonia Creek.

6.3 Selecting a Margin of Safety

The MOS is part of the TMDL development process. There are two basic methods for incorporating the MOS (USEPA, 1991):

- Implicitly incorporate the MOS using conservative model assumptions to develop allocations.
- Explicitly specify a portion of the total TMDL as the MOS, allocating the remainder to sources.

For the Rock Creek watershed, an implicit MOS has been included. One of the implicit factors for this TMDL is the selection of the critical instream conditions for calculating the ammonia TMDL. The statewide value used in the conventional wasteload Allocation process and described in the rule-referenced document to the Water Quality Standards (Iowa, 1996) lists the August instream pH of 8.2 and an in-stream temperature of 23.8 °C. The mean temperature for both monitoring stations is less than 20 °C, so using a higher temperature for the criteria results in a more stringent TMDL. In the calculations of loads, a protected flow of 0.5 cfs was used instead of the 7Q10 flow of 0.9 cfs occurring at the mouth of Rock Creek. This protected flow of 0.5 cfs is calculated for the headwaters of Rock Creek. It is assumed that the corresponding low flow in Rock Creek at the confluence with Ammonia Creek, approximately four miles downstream, is substantially greater than the 0.5 cfs protected flow at the head waters, resulting in the implicit margin of safety.

6.4 Stream Loading Capacity

The TMDL process is designed to establish the total loading a stream can assimilate without causing violation of the water quality standards. The allocation of that loading may be assigned equally to all sources, or the allocation may be adjusted to account for the economic and technologic ability of the discharger. The allocation for Rock Creek must account for the impacts of historical spills to the lands adjacent to PCS Nitrogen and the influence of agricultural drains.

For a stream dominated by point sources, the critical condition is usually the summer low-flow period. The 7Q10 flow in many streams is established as the critical low flow regime. However for some designated streams experiencing very low stream flows a minimum flow, or "protected flow" has been established. For Rock Creek the Protected flow of 0.50 cfs is established. The critical pH of 8.2 and critical temperature of 23.8 °C will be applied at the Protected Flow regime.

In the consideration of seasonality, several different instream conditions and flow regimes were also included in this TMDL discussion. It is possible that other seasons and/or stream flow regimes may be more critical than the assumed summer low flow condition. The example stream capacities are presented in the following table (Table 8).

<u>6.4.1 Load Allocation (nonpoint sources)</u>

Due to the elevated current loading from Ammonia Creek for both ammonia and nitrate/nitrite during the critical summer period, the load allocation is considered to be equal to the current loading. Truly for the conditions associated with Rock Creek this is justified from an economic and technical standpoint. Thus, the load allocation for ammonia and NOx at the protected flow is:

- Ammonia: 0.2 pound/day
- NOx: 15.4 pounds/day

6.4.2 Waste Load Allocations (point source)

The waste load allocations for ammonia and NOx were calculated using the critical stream flow and instream conditions. For ammonia, the Water Quality Standards chronic criteria noted in Table 3c (IDNR, 1996) was used as the targeted in-stream concentration. Since this TMDL is being completed in two phases, for Phase I the chronic numerical criterion will be achieved at the overflow from the downstream wetland complex. Under Phase II, the chronic numerical criterion will be achieved after mixing of Ammonia Creek and Rock Creek. Complete mixing of Ammonia Creek with Rock Creek is expected to occur 200 feet downstream of the confluence of Ammonia Creek. This analysis is based on the best professional judgement of IDNR staff and knowledge of the natural hydro-geological conditions in Rock Creek.

As noted above, the ammonia wasteload allocation used the chronic ammonia criterion in Iowa's Water Quality Standards (Iowa, 1996). Since the chronic criterion is a function of stream pH and temperature conditions, applicable pH and temperature values were selected. Due to the limited monitoring values in Rock Creek, statewide pH and temperature values were selected (Table 8). At a pH of 8.2 and a summer temperature of 23.8 °C, the chronic criterion is 1.84 mg/l or 5.0 pounds/day (Table 8). For ammonia, the distribution of the ammonia TMDL will be to allocate the Load Allocation to the nonpoint loading and reduce the Wasteload Allocation to the remaining capacity as noted in Table 8.

For nitrate/nitrite, the Wasteload Allocation is based on the expected reduction for the instream ammonia concentrations. Under the critical low flow condition of 0.5 cfs (Aug-Oct Mean values in Tables 2 and 3), the difference in ammonia concentration between Rock Creek downstream and upstream of PCS Nitrogen currently averages 2.34 mg/l (2.43 – 0.09 = 2.34). Under the critical summer low flow conditions, the ammonia WLA concentration in Rock Creek would be limited to 1.75 mg/l (1.84 - 0.09 = 1.75) (Table 8). The difference between the observed concentration and the WLA would require a 25% reduction in ammonia concentrations. If the NOx is assumed to respond in a similar manner, the TMDL at summer low flow would be calculated as follows:

12.95 mg/l, existing downstream nitrate concentration (Table 3)
- 5.73 mg/l, upstream nitrate concentration (or nonpoint concentration) (Table 2)
= 7.22 mg/l, current nitrate waste load estimate

Assuming a corresponding 25 percent reduction in the nitrate concentration, the wasteload allocation is calculated as:

7.22 (75%) = 5.41 mg/l, WLA nitrate concentration
+ 5.73 mg/l, LA nitrate concentration
= 11.14 mg/l, TMDL concentration

Therefore, at the protected flow of 0.5 cfs, the NOx TMDL would be:

14.6 pounds per day, as the Nox Wasteload Allocation
(5.41 mg/l x 8.34 x 0.5 cfs x .646 mgd/cfs = 14.6 #/d)
+15.4 pounds per day, as the NOx Load Allocation
(5.73 mg/l x 8.34 x 0.5 cfs x .646 mgd/cfs = 15.4 #/d)
= 30.0 pounds per day, as the NOx TMDL

The Wasteload Allocations, Load Allocations, and TMDLs for ammonia and nitrate/nitrite at the protected flow are shown in Table 9. It is important to note that the expected 25% reduction in the NOx to Rock Creek may be significantly greater when the ammonia wasteload allocation is achieved. The above nitrate/nitrite calculations will be refined when the phased monitoring efforts are implemented.

7. Implementation

The Iowa Department of Natural Resources recognizes that an implementation plan is not a required component of a Total Maximum Daily Load. However, the IDNR offers the following implementation strategy as a guide to improve water quality in Rock Creek.

The PCS Nitrogen site is the major source of ammonia and nitrogen to Rock Creek. PCS Nitrogen has been very cooperative in the remediation of the contaminated site. There are already a number of remediation practices in place at the site. Upon discovery of the groundwater contamination, a subsurface drainage system from a sump in the loading area was eliminated. This sump is believed to have been the primary source of groundwater contamination. An approximately 300 foot long groundwater recovery trench connected to three sumps that operate continuously has been installed along Ammonia Creek. Contaminated water from this drain is pumped to the plant's wastewater system and through the NPDES discharge directly to the Mississippi River. In addition, PCS Nitrogen has also planted hybrid poplar trees along Ammonia Creek to uptake nitrogen, and conducted tests by adding molasses to the subsurface to create anaerobic conditions favorable for denitrification. Over 100 acres of farmland that is part of the site, has been taken out of crop production and native grasses and woodlands are being established. The native plants will absorb nitrogen, nitrogen input for crops will be ceased, and the area will provide an attractive wildlife habitat. PCS Nitrogen closed this plant in 1999, and is in the process of dismantling it.

Perhaps the main feature of this remediation project is the establishment of a wetland on Rock Creek, downstream of the PCS Nitrogen site. This wetland was the cooperative result of PCS Nitrogen, a private landowner, the DNR Fisheries and Wildlife staff, and others. The wetland provides an environmentally favorable method for naturally removing nitrogen compounds. It is hoped that the wetland will permanently remove nitrogen compounds from the water, as opposed to intercepting contaminants and discharging them to the Mississippi River.

Other possible alternatives for cleanup of the PCS Nitrogen site include planting of additional hybrid poplar trees, soil testing and removal of highly contaminated soils, and continued attempts at inducing in-situ denitrification. The construction of riffles in Rock Creek would help to aerate the water and promote the oxidation of ammonia. Extraction of contaminated groundwater with pumping wells before it enters Rock Creek is technically feasible. However, there is concern of influencing other contamination plumes nearby if this is done. Handling of extracted groundwater may also pose a problem, since removal of nitrogen compounds from it is probably not practical, and discharge to the Mississippi River is a less than perfect option. Land application of this extracted water does not seem feasible.

In addition to the cleanup efforts at PCS Nitrogen, there is currently a water quality project in the watershed administered by the Clinton County Soil and Water Conservation District. This project is funded with Watershed Protection Funds and tentatively approved to be sponsored by Clean Water Act Section 319 and the Division of Soil Conservation Water Protection Fund. The Rock Creek Water Quality Project is addressing non-point source issues including nutrient management and soil erosion in the watershed. This will be done by promoting and cost sharing a variety of best management agricultural practices, including, but not limited to, conservation tillage, vegetative filter strips, riparian buffers, nutrient and pest management, wetland construction, grade stabilization structures, streambank stabilization, livestock exclusion, and construction of animal waste systems.

Under Phase I, an assessment of the Rock Creek water quality will begin in 2001. This assessment will determine the current nitrogen loading (ammonia, nitrite, and nitrate) to Rock Creek from the entire watershed. The assessment will also help determine the impact of the PCS Nitrogen site on the water quality of Rock Creek, and also to determine the effectiveness of the wetland at assimilating nitrogen compounds (ammonia, nitrite, and nitrate). This monitoring will continue for two to four years. After the monitoring is complete, the level of impairment will be reassessed. Following the Phase I assessment, it will be determined if the ammonia endpoint has been achieved at the discharge of the wetland complex. If the endpoint has not been achieved at the discharge of the wetland complex, then additional control measures will be implemented to achieve the endpoint. Following achievement of the endpoint at the wetland complex discharge, Phase II will be initiated. It is expected that Phase II will begin in 3-5 years following adoption of this TMDL.

Additional monitoring and evaluation of data will continue into Phase II as the ammonia endpoint will be met in Rock Creek below the mixing zone with Ammonia Creek. It is anticipated that a significant reduction of ammonia (and NOx) loading from the PCS Nitrogen site will occur during the implementation of Phase I efforts. Thus it is possible that no Phase II efforts will be needed if Phase I monitoring data demonstrates that the endpoint was achieved at both the Wetland complex discharge and in Rock Creek below the confluence with Ammonia Creek.

8. Public Participation

A public meeting was held in Camanche on March 7, 2000 regarding the Rock Creek TMDL. A second public meeting was held regarding the Rock Creek watershed prior to the final TMDLs being submitted to EPA. Comments were received until December 15, 2000 and, where appropriate, incorporated into the final document.

9. References

Gritters, Scott. 1997. Evaluation of Water Quality in Shricker's Lake and Its Tributary Rock Creek. Draft report. Iowa Department of Natural Resources Long-term Monitoring Division.

Gritters, Scott. 2000. Evaluation of Water Quality, Fish, and Macroinvertebrates in Rock Creek. Iowa Department of Natural Resources Long-term Monitoring Division.

Iowa. 1996. *Iowa Administrative Code 567, Chapter 61, Iowa Water Quality Standards.*

Larimer, O.J. 1974. *Drainage Areas of Iowa Streams.* Prepared by the U.S Geological Survey, Water Resources Division.

USEPA. 1988. Record of Decision for the DuPont Impoundment of the Todtz Farm Site Camanche, Iowa. U.S. Environmental Protection Agency, Washington, DC. October 1988.

USEPA. 1991. *Guidance for Water Quality-based Decisions: The TMDL Process.* EPA 4404/4-91-001. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

USEPA. 1995. *Five-Year Review DuPont/Todtz Site Camanche, Iowa.* U.S. Environmental Protection Agency, Region 7. Kansas City, KS. September 1995.

USEPA. 1999. *Five-Year Review Report Chemplex Site.* U.S. Environmental Protection Agency, Region 7. Kansas City, KS. June 1999.

USEPA. 2000. *Permit Compliance System (PCS).* Retrieved February 2000. U.S. Environmental Protection Agency, Office of Water Regulations and Standards, Monitoring and Data Support Division, Washington, DC.

USGS. 1979. *Annual and Seasonal Low-Flow Characteristics of Iowa Streams.* U.S. Geologic Survey Open File Report 79-555. U.S. Geological Survey, Reston, VA.

10. Appendix I Figures and Tables

Figure 1. Location of Rock Creek Watershed.

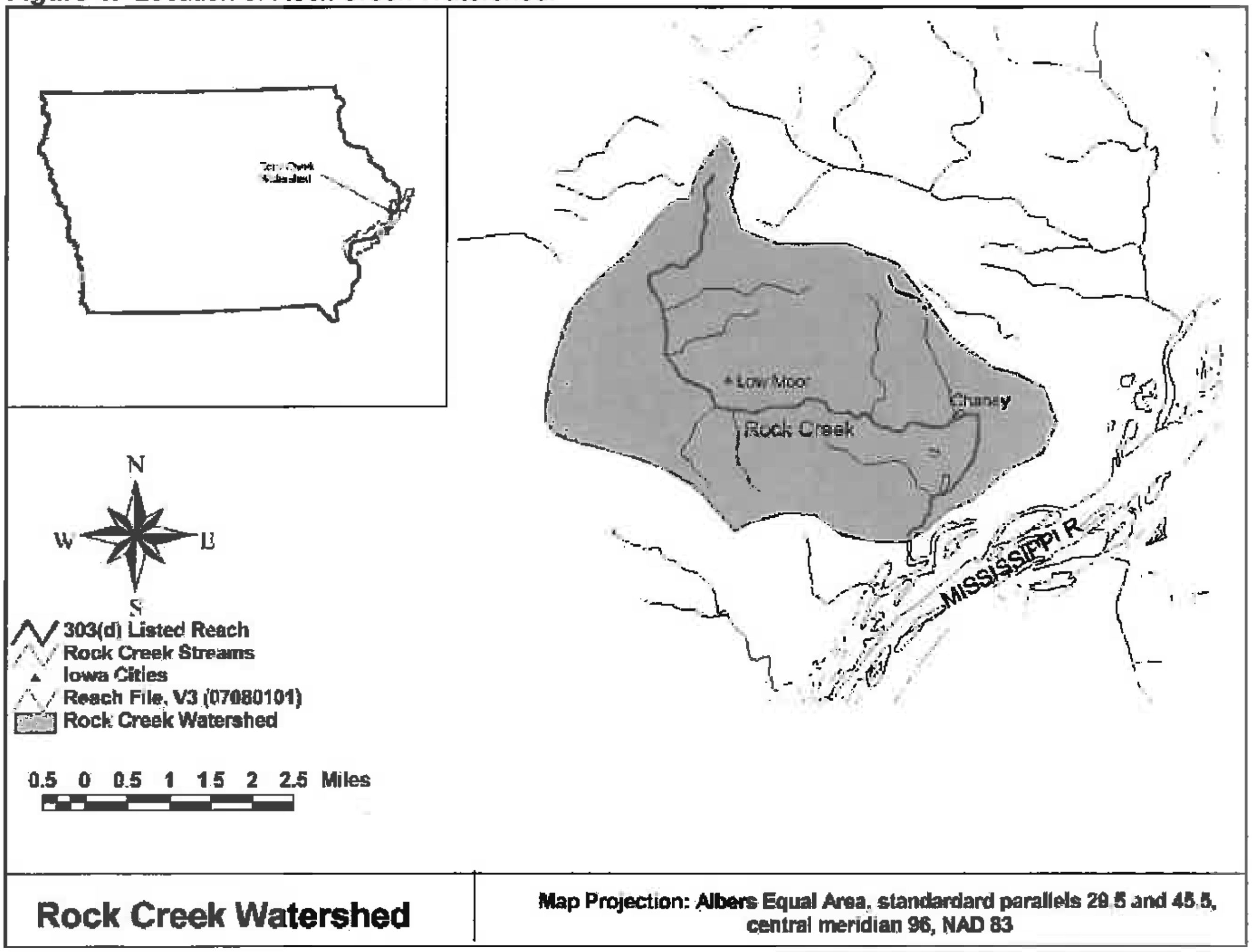


Figure 2. Monitoring Stations for May 21, 1997

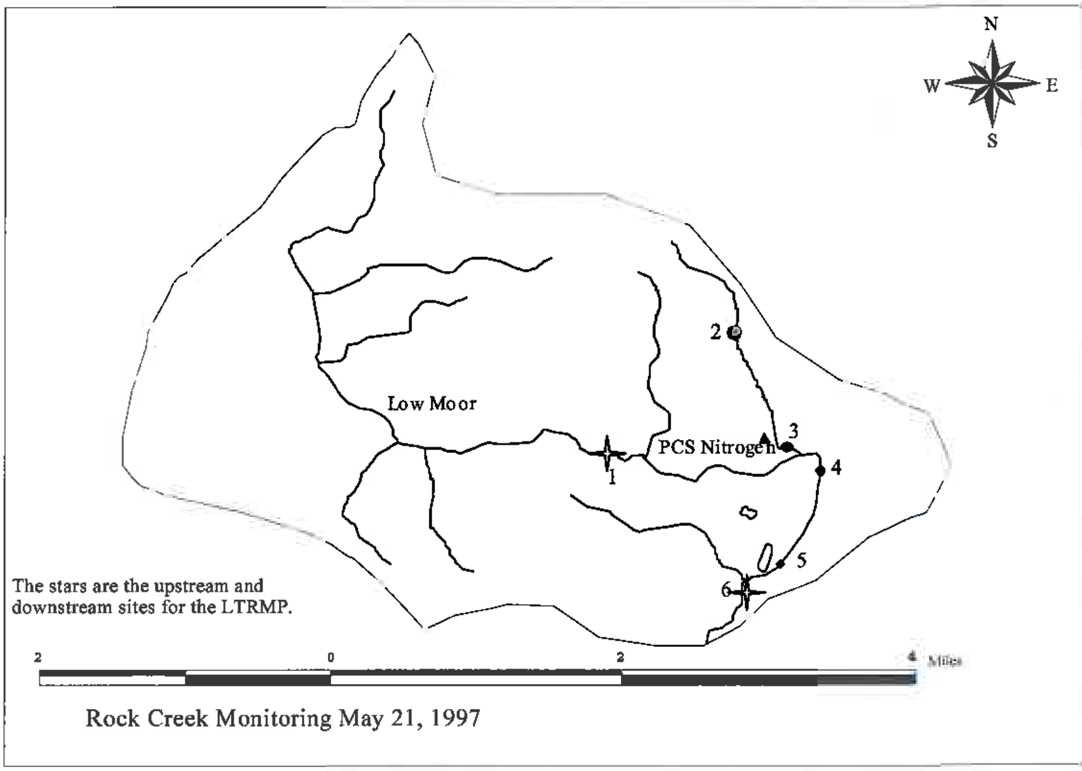


Figure 3. LTRMP Ammonia Monitoring

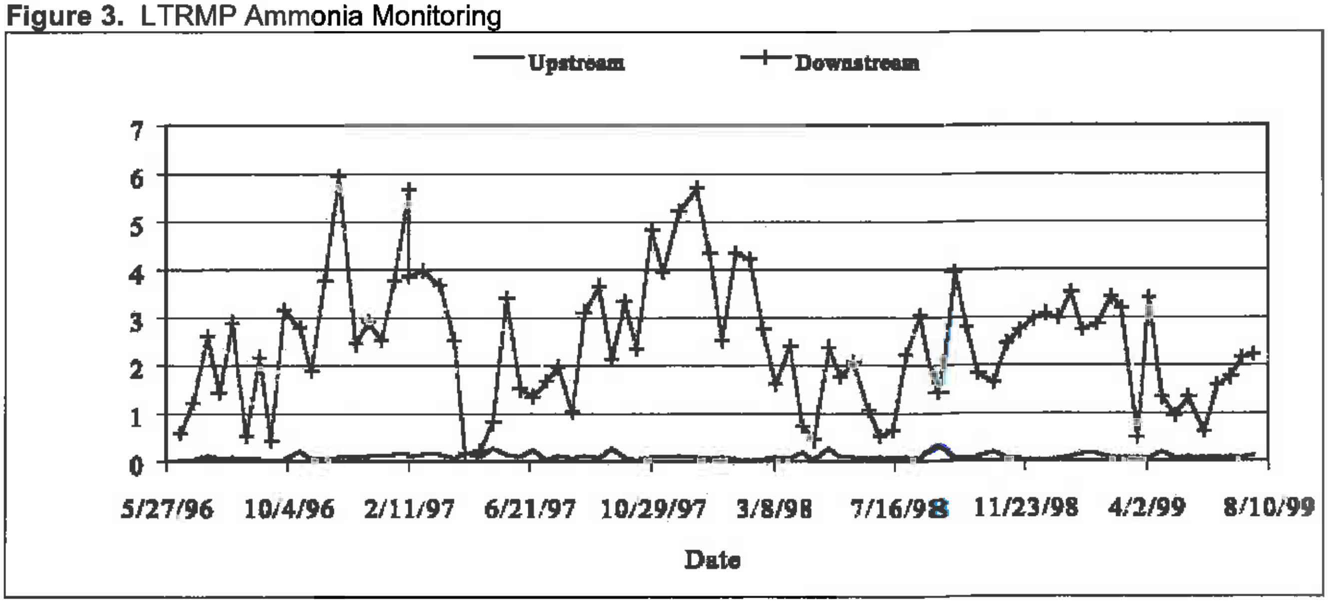


Figure 4. LTRMP Nitrate Monitoring

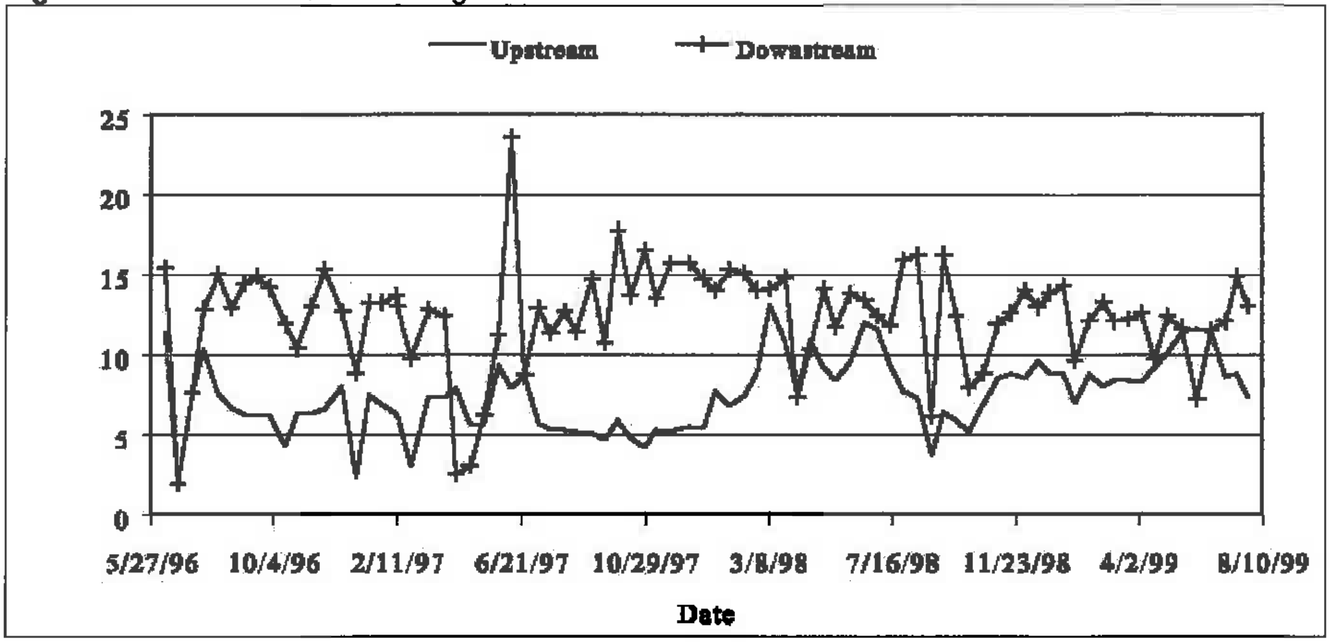
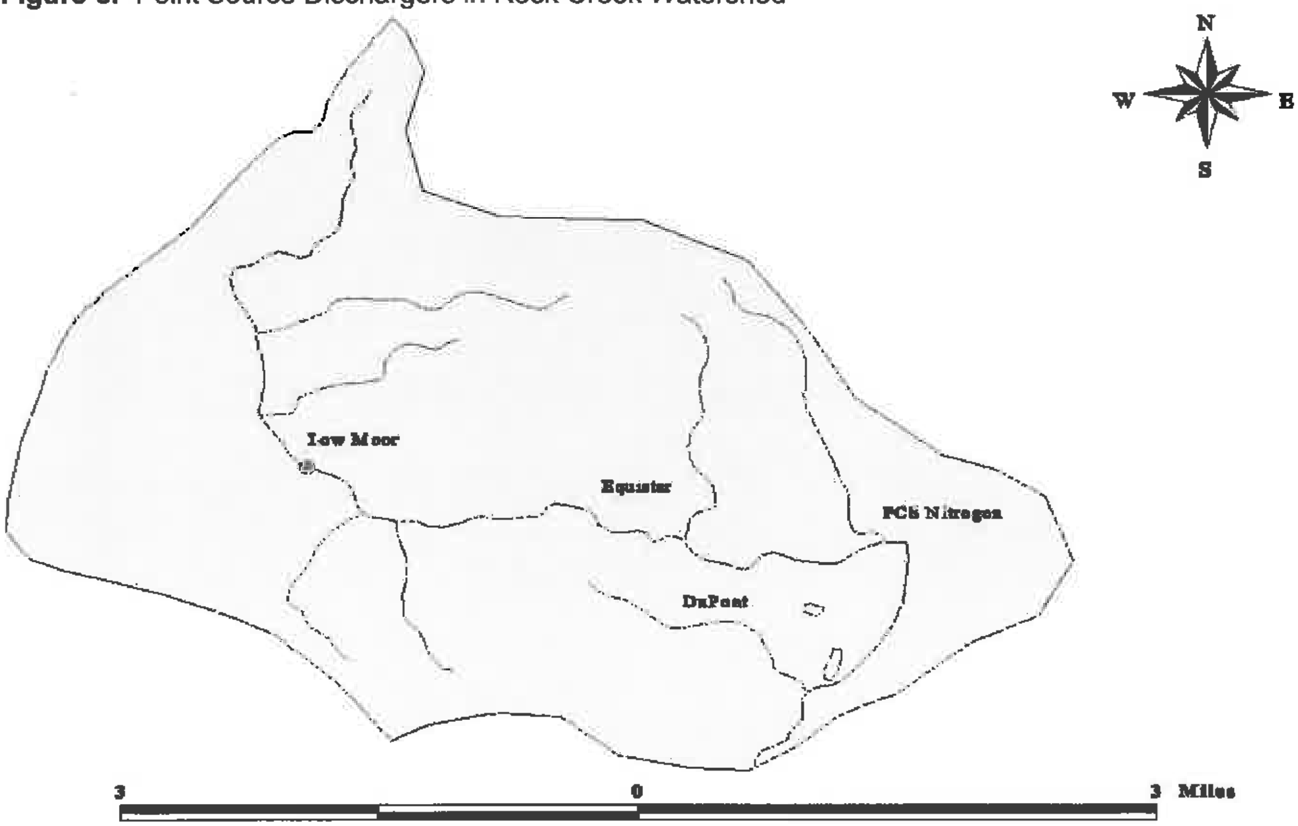
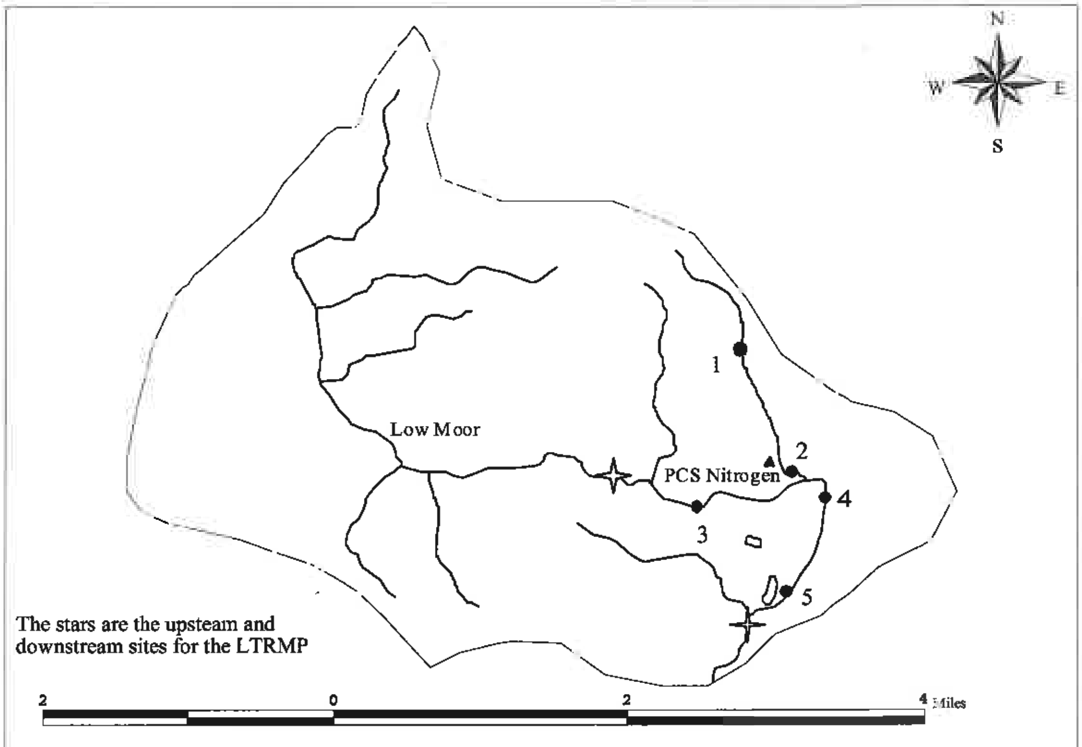


Figure 5. Point Source Dischargers in Rock Creek Watershed



Point Source Locations

Figure 6. Monitoring Sites for PCS Nitrogen Surface water



PCS Nitrogen Monitoring Sites

Table 1. Rock Creek Monitoring for May 21, 1997

Site	Site Name	Ammonia (mg/L)	Nitrate (mg/L)
1	Rock Creek Upstream	0.2	7.4
2	Ammonia Creek	0.2	17
3	Ammonia Creek below PCS Nitrogen	15	38
4	Rock Creek below Ammonia Creek	3.5	13
5	Rock Creek 1 mile below Ammonia Creek	2.9	12
6	Rock Creek at Hwy 67	2.2	10

Table 2. Rock Creek Monitoring Upstream of PCS Nitrogen

Parameter	Minimum	Mean	Aug-Oct Mean	Maximum
Temperature (°C)	0.40	11.47	15.87	20.80
pH	7.10	7.80	7.77	8.50
Nitrate (mg/L)	1.99	7.48	5.73	13.15
Ammonia (mg/L)	0.01	0.09	0.09	0.32

Table 3. Rock Creek Monitoring Downstream of PCS Nitrogen

Parameter	Minimum	Mean	Aug-Oct Mean	Maximum
Temperature (°C)	0.10	11.96	16.75	27.30
pH	6.00	7.34	7.37	8.30
Nitrate (mg/L)	0.01	12.31	12.95	23.62
Ammonia (mg/L)	0.14	2.44	2.43	5.93

Table 4. Permit Compliance System Monitoring Data Statistics for the City of Low Moor

Permit	Parameter	Max	Mean	Min	Limit	Count
IA0040100	Flow (MGD)	0.048	0.014	0.008	0.064	45
	BOD_5 (mg/L)	24.1	19.10	14.0	30.0	7
	Ammonia	None	None	None	None	None
	Nitrate	None	None	None	None	None

Table 5. PCS Nitrogen Monitoring Stations

Station	Location
Site 1	Northern property boundary on Ammonia Creek 2/3 miles above Rock Creek
Site 2	Ammonia Creek 1/4 miles above Rock Creek
Site 3	Western property boundary on Rock Creek 3/4 miles above Ammonia Creek
Site 4	Rock Creek 1/10 miles below Ammonia Creek
Site 5	Rock Creek 1,000 south of PCS property boundary

Table 6. Monitoring Data for PCS Nitrogen Facility

Parameter	Site 1	Site 2	Site 3	Site 4	Site 5
October 7, 1996					
NO_3 mg/L	19.50	40.30	6.07	14.80	15.10
NO_2 mg/L	ND	0.70	ND	ND	4.91
NH_3 mg/L	1.80	44.00	0.43	5.01	4.70
December 3, 1997					
NO_3 mg/L	10.90	58.10	7.80	19.80	10.20
NO_2 mg/L	ND	0.21	ND	0.10	ND
NH_3 mg/L	2.50	28.00	2.65	8.90	6.10
December 5, 1997					
NO_3 mg/L	18.80	68.40	5.70	18.20	13.80
NO_2 mg/L	ND	0.20	ND	0.10	ND
NH_3 mg/L	ND	26.50	ND	5.55	3.90
December 7, 1997					
NO_3 mg/L	19.10	63.40	6.00		14.50
NO_2 mg/L	ND	0.20	ND	ND	ND
NH_3 mg/L	0.22	27.00	0.14	5.70	4.70
June 24, 1999					
NO_3 mg/L	25.00	32.40	11.60	14.10	13.10
NO_2 mg/L	0.10	0.10	ND	ND	ND
NH_3 mg/L	0.11	9.80	1.64	7.20	2.90

Table 7. Estimated Current Concentrations and Loadings for Rock Creek

Nonpoint Sources (Upstream Conditions)					Ammonia Creek				
Flow	Ammonia		Nitrate		Flow	Ammonia		Nitrate	
(cfs)	(mg/L)	(lbs/day)	(mg/L)	(lbs/day)	(cfs)	(mg/L)	(lbs/day)	(mg/L)	(lbs/day)
0.5	0.1	0.3	6.4	17.3	0.06	-	96	38	12.3

Table 8. Ammonia Wasteload Allocations and Load Allocations at Various Conditions

	Stream Condition		Water Quality Criterion		Allocations	
Season & Stream Flow	pH	Temp. (°C)	NH3-N (mg/l)	NH3-N (#/day)	WLA NH3-N (#/day)	LA NH3-N (#/day)
Summer @ Prot. Flow (0.5 cfs)	8.2	23.8	1.84	5.0	4.8	0.2
Winter @ Prot. Flow (0.5 cfs)	7.8	0.6	4.63	12.5	12.3	0.2
Fall @ Prot. Flow (0.5 cfs)	8.1	6.0	2.45	6.6	6.4	0.2
Summer @ Mean Flow (4.4 cfs)	8.2	23.8	1.84	43.6	41.5	2.1
Summer @ Annual Average. Flow (9.6 cfs)	8.2	23.8	1.84	95.2	91.3	3.9

Table 9. Wasteload Allocations (WLA), Load Allocations (LA) and TMDLs at protected flow for Rock Creek

Parameter	TMDL (#/d)	WLA (#/d)	LA (#/d)
Ammonia	5.0	4.8	0.2
Nitrate/Nitrate	30.0	14.6	15.4

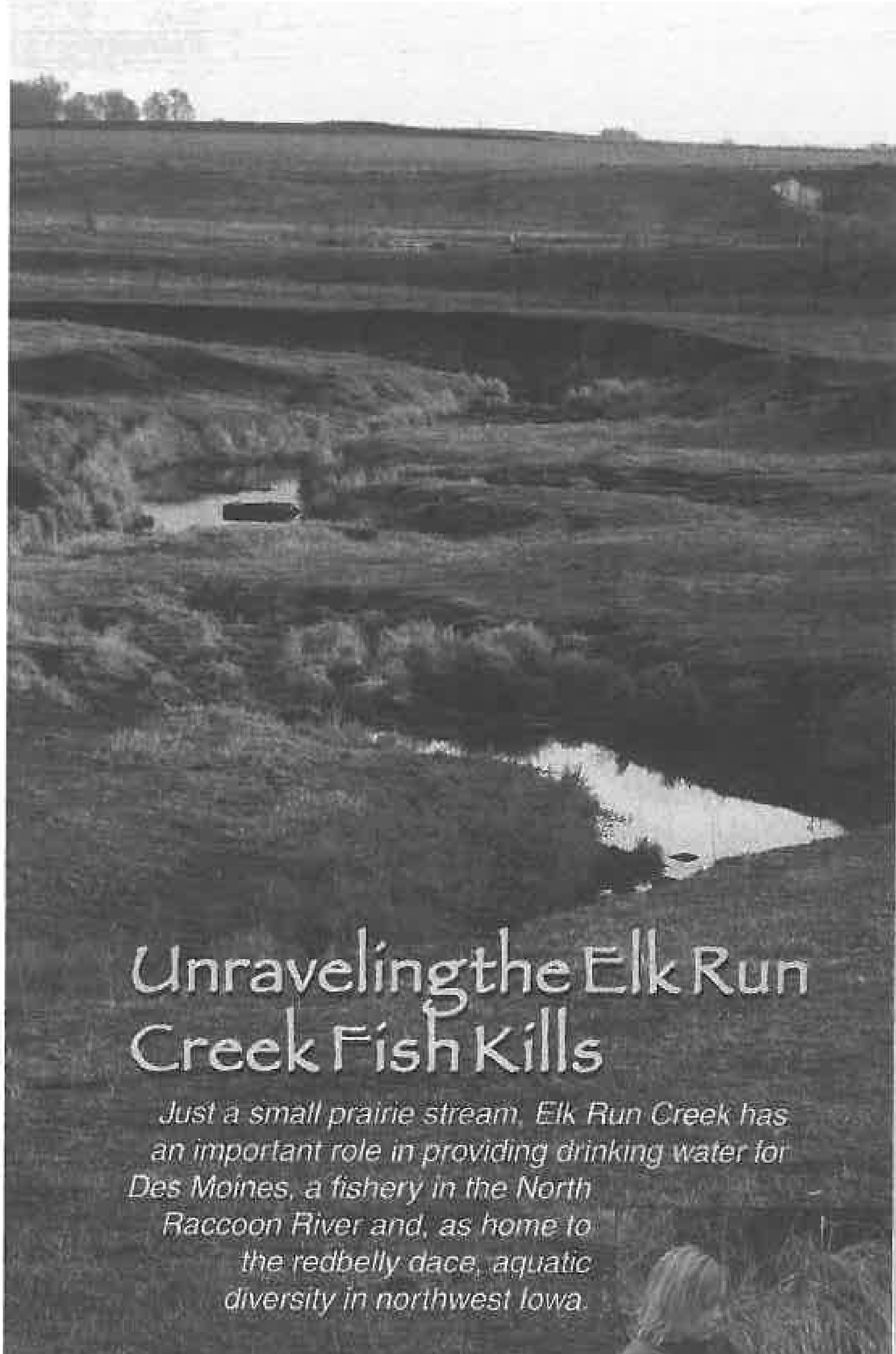
Summary of the frequency of violations of chronic criteria for ammonia in Iowa streams and rivers for three Section 305(b)/303(d) listing cycles.

Summary prepared by Ken Krier, John Olson and Tom Wilton, Iowa DNR, March 18, 2011.

	Section 303(d) listing cycle:		
	2002	**2006**	**2010**
No. of samples analyzed for ammonia	3397	4146	4431
No. of samples violating chronic criteria for ammonia	15	10	8
Percent of samples in violation:	0.4%	0.2%	0.2%
No. of monitoring stations sampled for ammonia:	160	152	149
No. of monitoring station with violations of chronic criteria for ammonia	12	9	4
Percent of stations in violation:	7.5%	5.9%	2.7%
Maximum no. of violations per site per listing cycle:	3 (Rock Creek, Clinton Co.)	2 (Milford Creek, Dickinson Co.)	5 (unnamed trib to Silver Cr., Clayton Co)

Note: All violations were for Iowa's chronic criteria. Listing cycles cover non-overlapping data years from 1999-2008.

ID	Waterbody ID	class	Waterbody Name	Impairment	Category	Year	Comments	2002 Categories	Field9
186	EL1-22000	Stream	Union Creek	Ammonia	4B	2004	effluent not ambient	Part 4	
249	EL4-30000	Stream	Elkhorn River	Ammonia	5	2004		Parts 1 & 4	
479	LP1-21010	Stream	Shonka Ditch	Ammonia	4B	2004	effluent not ambient	Part 4	
1401	RE3-10000	Stream	Republican River	Ammonia	4B	2004	effluent not ambient	Part 4	
1540	SP2-10000	Stream	Lodgepole Creek	Ammonia	4B	2004	effluent not ambient		
187	EL1-22000	Stream	Union Creek	Ammonia	4B	2006	effluent not ambient		
522	LP2-10000	Stream	Salt Creek	Ammonia	5	2006			
571	LP2-20000	Stream	Salt Creek	Ammonia	5	2006			
612	LP2-20900	Stream	Antelope Creek	Ammonia	5	2006			
694	LP2-L0140	Lake	Olive Creek Lake	Ammonia	5	2006			
731	LP2-L0260	Lake	West Twin Lake	Ammonia	5	2006			
1541	SP2-10000	Stream	Lodgepole Creek	Ammonia	4B	2006	effluent not ambient		
480	LP1-21010	Stream	Shonka Ditch	Ammonia	4B	2008	effluent not ambient, NPDES Permit Information		
523	LP2-10000	Stream	Salt Creek	Ammonia	5	2008			
572	LP2-20000	Stream	Salt Creek	Ammonia	5	2008			
732	LP2-L0260	Lake	West Twin Lake	Ammonia	5	2008			
573	LP2-20000	Stream	Salt Creek	Ammonia	5	2010			
695	LP2-L0140	Lake	Olive Creek Lake	Ammonia	4R	2010			
733	LP2-L0260	Lake	West Twin Lake	Ammonia	5	2010			



Unraveling the Elk Run Creek Fish Kills

Just a small prairie stream, Elk Run Creek has an important role in providing drinking water for Des Moines, a fishery in the North Raccoon River and, as home to the redbelly dace, aquatic diversity in northwest Iowa.

Article by Karen Grimes
Photos by Clay Smith

Alison Manz taking water samples near a tile outlet that flows into Elk Run Creek.

Alison Manz started out looking for a dead cow. What she found instead, on that otherwise inconspicuous prairie stream, was an unforgettable scene of aquatic devastation.

"I've heard others describe it, but I've never been there before at the start of a fish kill and seen the fish leaping out of the water and dying on the banks of the creek," she said.

It is not something she wants to see again.

It was Oct. 26, 2004, when the Atlantic DNR field office received an anonymous complaint about a dead cow in Elk Run Creek. When Manz, an environmental specialist, responded she had no idea this investigation would involve two fish kills and consume more than 300 staff hours.

On Nov. 1, she drove to the creek, a small stream draining about 35 square miles of Sac, Carroll and Calhoun counties. She stopped on Phoenix Avenue and walked up the creek, looking for the cow. Instead, she found herself in the midst of waters suddenly full of small minnows rising to the surface, gasping for air, many of them turning belly up and dying.

Half a mile up the stream, Alison found the source of the pollution—an underground tile—part of a vast network of underground clay tile or plastic pipe used to drain cropland. Manz found manure-smelling brown water flowing out of the tile drain and into the creek. Field tests confirmed why the fish were dying—elevated ammonia levels coming from the tile outlet flowing into the

Green biodegradable dye helped traced the miles-long underground connection between tile inlets (above) and tile outlets (right) that flow into the stream.

stream below. Laboratory test results showed fecal coliform levels of more than 18 million colonies per 100 milliliters of water, confirming manure as the pollutant.

When she called in the fish kill to the Atlantic field office, Kirk Mathis and Jerry Jordison went to work pulling maps and aerial photos, trying to match tile drainage areas with possible sources of manure.

Within days, DNR specialists found another fish kill as they investigated the first one. Unfortunately, DNR records show two other fish kills, in the fall of 1998 and 1999. The DNR investigated both kills, but was unable to identify all the pollutant sources.

"This has been a problem watershed for a number of years," said Wayne Gieselman, administrator of DNR environmental services.

"As a result of our efforts and with the help of Des Moines Water Works, we were able to identify a number of issues that need to be addressed," Gieselman said.

Neighbors and interested citizens concur, the creek has had ongoing water quality problems, including turbidity and some fish kills. In late July 2004, Des Moines Water Works notified the field office that routine water quality tests showed Elk Run Creek also had high nitrite levels. Manz took water samples from the stream, but was unable to determine the pollution source.

When two fish kills occurred only eight days apart, the DNR devoted extensive resources to find the problem. Tracking down the source of the tile runoff took an intensive two-month investigation as six staff members searched for pollutants that ran literally for miles underground.

The search developed into an environmental CSI or Crime Scene Investigation, using modern technology such as dye tests, smoke machines, aerial photos and maps of county-maintained tile lines. The DNR specialists also used old-fashioned, but intense, on-the-ground investigative skills, talking with livestock producers, brainstorming potential pollutant sources, taking water samples and walking more than eight miles of creek banks.

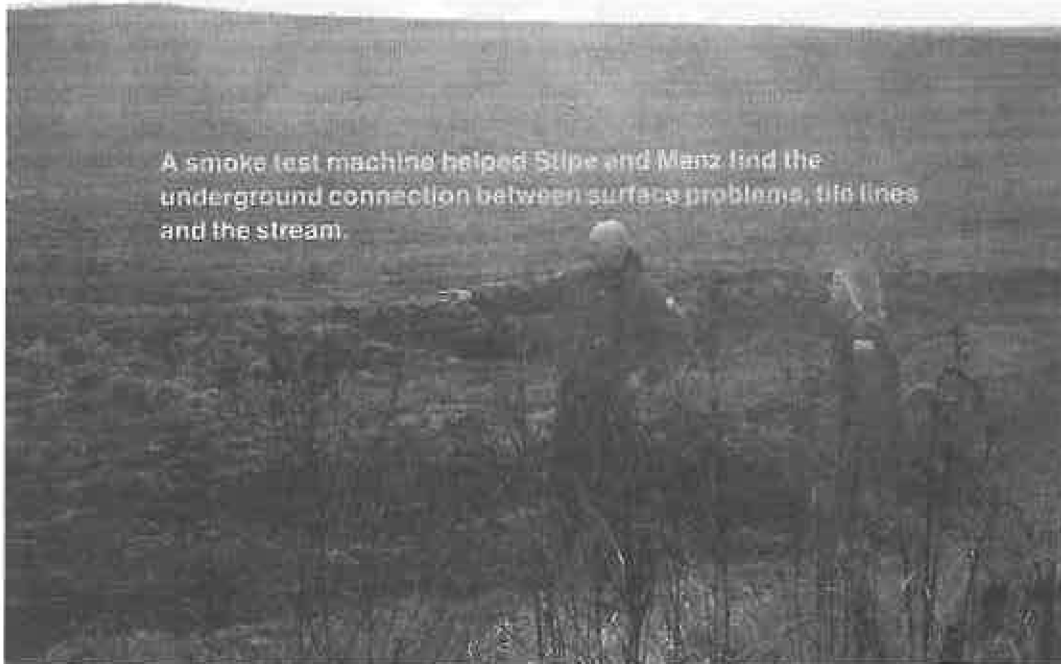
"The fish kills generally happen about five days after a rain," said Dan Stipe, supervisor of the Atlantic DNR field office. "The topography is so flat that the stream and tiles flow, pool, then become a trickle or a few riffles, then it backs up again. It makes it difficult to find the source."

It took an all-out detective effort to identify sources of the underground polluted runoff, because the usual clues from surface runoff were missing.

Manz and other specialists confirmed the runoff was from animal manure, but as they walked the creek, they found other problems. A slight blackish sludge turned out to be a septic tank discharge.

In Carroll County, they found a manure stockpile close to the stream, but no evidence that runoff from the stockpile was entering the creek. The owner moved the stockpile to prevent future problems.

"You know when you've solved the mystery that you have actually made a difference. That's what it's all about – protecting the environment," Stipe said.



A smoke test machine helped Stipe and Manz find the underground connection between surface problems, tile lines and the stream.

In the end, unraveling the county tile line maps (right) proved to be the key to the puzzle. An extensive county drain tile system underlies the land surface in Carroll County. Landowners have also installed subsurface drain tiles to allow crop planting in the spring.

Stipe and his staff used the Carroll County drain tile map to investigate more than 20 square miles of the watershed. They visited every animal feeding operation that could potentially be contributing to the fish kill via an underground connection. When they found evidence of surface runoff, they used smoke tests, dye tests, trenching and water test results to determine if runoff from that site was reaching the stream. After two months, the DNR linked manure from several open feedlots to the two fish kills. One lot was located more than three miles from Elk Run Creek.

But, perhaps more important, the DNR investigators found a disturbing pattern of manure storage on open feedlots. In lot after lot, the DNR saw improperly built manure storage structures. While cattle manure does

Drainage tile map showing Elk Run Creek in blue and subsurface county drain tile lines in white.

Why is Elk Run Creek Important?

DNR water quality specialists documented a remnant population of southern redbelly dace in Elk Run Creek during a water quality survey in the early 1990s. To them, Elk Run Creek symbolizes the diversity of aquatic life that once existed in small streams across northern Iowa.

A small minnow, the redbelly dace prefers small streams with cool, clear water. It is found mostly in northeast Iowa, with scattered populations in northwest Iowa.

"From the fisheries standpoint, I like to compare the rivers to a big tree," says Lannie Miller, longtime DNR fisheries biologist from Lake View. "The little tiny branches are the small streams like Elk Run Creek that feed into the bigger rivers like the Des Moines and the Raccoon. These are the prime areas of productivity."

"Minnows go up these small streams in the spring and spawn and grow and move downstream in the fall. The minnows overwinter in the bigger rivers. As any fisherman knows, predator fish go on a feeding frenzy when there is this sudden influx of food in the fall. Minnows, chubs and suckers are coming out of the small feeder creeks in the fall to provide that forage," says Miller.

"If we keep polluting, damming or channelizing these small feeder streams that are the nursery and spawning areas," says Miller, "the minnows can't get up the streams or they are dead. But what these little streams are vital for is literally the base of production. When someone pollutes the little streams, it affects the whole system. If you cut off so many branches of a tree, it eventually dies."

not have a high level of ammonia initially, if the solids sit and cook with the liquids, the bacteria in the mix converts the manure into ammonia which can be toxic to aquatic life. With the first rainfall, liquids wash out of the basin — a lethal mix when a tile line intake is located close to a basin and carries manure and high ammonia levels to a stream.

Solving the problem will not be easy, because so many lots have the same construction. The seasonally high ground water level is within feet of the surface, so soils are often saturated and that's why the area is so heavily tiled, according to Claire Hruby, a DNR geologist.

But Stipe plans to discuss the DNR findings with Carroll County cattle producers at a public meeting scheduled in April.

"Overall, I feel we will be able to greatly improve the quality of this water body as a result of our efforts," Stipe said. "By taking a proactive approach and working with producers we can prevent future problems. Better water quality will result."

Barb Lynch, chief of DNR field services, is pleased with the investigation that finally determined several sources of an ongoing water quality problem. She plans to pursue similar problems throughout the state.

"I plan for our field offices to target small watersheds that have ongoing water quality problems where the pollutant sources are unknown," she said. "As Dan and Alison have shown, it takes an intensive effort to find these sources, but the positive results for water quality will benefit all Iowans."

Karen Grimes is an information specialist for the department.

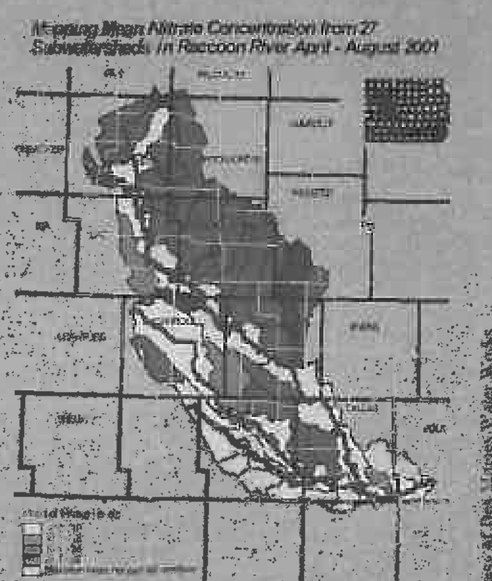
Two fishkills in Elk Run Creek were traced to runoff from open cattle feedlots that entered subsurface tile drains and flowed to the creek.

Importance to Des Moines

Elk Run Creek is one of approximately 30 small watersheds that flow into the Raccoon River, the primary drinking water source for six counties and more than 25 communities, including Des Moines. The Des Moines Water Works is responsible for treating the water and ensuring the safety and quality of the water to 350,000 people, according to Linda Kinman with the water works. Volunteer water quality monitoring shows that Elk Run Creek is one of four small watersheds that flow into the North Raccoon River that have extremely high levels of nitrate, from 20 to 36 ppm.

The U.S. Environmental Protection Agency sets minimum standards that drinking water must meet. In 1989 and 1990, the Des Moines Water Works exceeded the maximum contaminant level (MCL) of 10 ppm for nitrate levels in drinking water and had to publicly notify its customers. To avoid exceeding the MCL for nitrate, the water works plant built one of the largest nitrate removal facilities in the world costing $3.7 million.

These small watersheds have a cumulative effect that can be good or bad for water quality in the larger rivers. "We're all connected and in the grand scheme of things, water should leave our land as good as when it arrived," says Wayne Gieselman, DNR administrator of environmental services.



Elk Run Creek watershed is located in north central Carroll County.

Courtesy of Des Moines Water Works

COMPLAINANT'S
EX. NO. 39

FW: Hearing on the "bad advice" bill
Manz, Alison [DNR] to: Dan Breedlove 03/18/2011 03:49 PM

-----Original Message-----
From: Alison Manz [mailto:Alison.Manz@dnr.state.ia.us]
Sent: Tuesday, March 14, 2006 11:21 AM
To: Gieselman, Wayne [DNR]
Cc: Dan Olson; Dan Stipe; Jerry Jordison; Kristi Burg; Matt Rhodes; Rhonda Pahl; Ryan Young; Thad Nanfito; Kristi Burg; Matt Rhodes; Rhonda Pahl
Subject: Re: Hearing on the "bad advice" bill

Wayne-

Interesting comment by Joe Turner (Moran Feedlot). I spoke w/ him last Friday and he wanted me to send him a letter stating that confinements and open lots were considered separate operations. I told him (and I quote) "There is a 'bad advice' bill being proposed to the legislatures. Because there are many situations that could occur in determining a confinement vs an open lot I won't be sending you a letter because I don't know your specific proposal. However, I will fax you the rules/requirements/definitions that state the difference in operations and the separation distances. When you receive that information and if have questions on the specific rules please call me."

Now I'm glad I just gave him the rules.

Alison

>>> Wayne Gieselman 3/14/2006 8:34 AM >>>
As you may know, the House Ag committee held a hearing last night related to the DNR providing bad advice to livestock producers. The bill is Senate File 2294 and House File 2744. I will give you a rundown on the comments that were presented last night. The DNR and the Attorney General are both registered in opposition to the bill. I may not get spelling right because in some instances I couldn't quite make out names. I'm sharing this because it has a direct reflection and impact on the department. In some cases, my comments may not make much sense to you, but I'm doing my best to report what I heard. I fully expect that we will continue to work with producers in the same way that we always have.

John Fluit, Lyon County. Is one of the 6 pilot AT sites. NRCS held back money on him and he had to spend $260,000 to install his system. He only got $100,000 from NRCS. The DNR is running the livestock industry out of Iowa. The EPC makeup should be changed. Gene Tinker, AFO director, and Deb Frundle, head of water quality, both told him his system was OK. Then the NRCS told him it wasn't.

Vern Tigges, Carroll County, and ICCI. The DNR are enforcers and should not be ginving any advice of any kind to producers. We should enforce the laws as written.

Viola Faust, Adair County. The DNR is OK and should do more to enforce the law.

Gerritt Englin, Farmers Coop. Society, Sioux County. The rules should not change and once a facility is in compliance they should not be held to any new rules that may come about. He also talked about administrative orders and referral to the Attorney General, although I was not clear on his point. I'm guessing it goes to the level of fines that can be imposed.

Stewart Melvin, consulting engineer for a number of feedlots. He also talked about changing expectations and rules. He specifically sited the Chris Petty case in southern Iowa. (Long history. Stricker has background.) He talked about Mr. Petty getting a letter from DNR on March 1 telling him that he had to be in full compliance by March 22, including engineering plans, permits and construction.

Marian Cooper. Hardin County. Recited all the reason that the attorney general is opposed to the bill. Also talked about producers being able to get declaratory orders as they do in flood plain and alluvial determinations. Made statements about the DNR giving advice to producers to help them avoid compliance with the law. Cited alleged instances of DNR specialists calling producers to remind them of deadlines, etc. She also commented about industry having to comply with changing standards and agriculture should meet the same requirements. She is opposed to the bill, but also harbors a distrust of the department because we are too lax on producers.

Kevin Schilling, Greenfield. Basically stated that changes in rules are a part of life and that producers should take responsibility for their actions. Said industry had to comply with requirements and so should farmers.

Howard Mogler, Rock Rapids. Says he has received confiliting information about counting cattle in open lots versus in confinement. (This was stated by three different producers.) He has volunteered to have the DNR do water monitoring weekly, bi-weekly, whatever we want to do on Mud Creek. The DNR says the Big Sioux is impaired and therefore, all streams leading into it are impaired. He was at the TMDL meeting last week.

Marty Danzer, Carroll County. Went to a meeting in Carroll on Feb 7 attended by legislators. DNR is driving the livestock industry out of Iowa. Events happen on feedlots that are beyond a producers control. He was talking about runoff caused by a heavy rain. He believes the DNR is circumventing the law when we take enforcement actions on producers.

Doug Pudenz, Carroll County. He supports the law proposal.

Joe Tirner, consultant. Mostly talked about getting conflicting information regarding counting cattle in open feedlots and confinement. I think he was referring to the Moran feedlot.

Scott Remington. Winterset. Opposes the law. Believes producers try to avoid complying with the law. (This one was tough for me. I couldn't quite follow it.) Apparently he was involved in a lawsuit regarding embryonic transplants. The commodity groups did not help him and he lost a great deal of money because of actions taken by the AG. However, he trusts the AG and the DNR to do the right thing.

George Naylor, Greene County. Believes that the corporate giants have transferred their environmental liability to producers. Suggested that the Legislature could hold Smithfield, Iowa Select, etc accountable for environmental performance at produciton sites where their pigs are located. Industry has to meet standards. So should ag. Opposes the law.

Julie Smith, League of Cities. Says the DNR gives much helpful advice to cities. However, if livestock producers reap a benefit from the bad advice bill, then it should also apply to cities, particularly in view of the passage of the new water quality standard rules that were passed yesterday by ARRC.

Emily Piper. Rural Water, Gets much valuable information and assistance from DNR. Dnr is is relyed on for information. However, there are distict differences in the advice received depending on which field office region you are in and which specialist you talk to . Referred to the great "pressure loss" debate with rural water. If livestock producers get this benefit, so should other regulated entities.

Larry Harriman, Jefferson Co? He went to local DNR office for advice in putting up a confinement. He kept getting referred to a higher authority and ended up with Legal. His complaint was more to the affect that we were trying to make sure he was getting correct advice and kept getting shuffled. He wanted the advice from the first person he talked to.

Mike Blaser, Des Moines. Says that DNR staff is knowledgable and professional and, in fact, do know the rules that they enforce. Did point to instances of conflicting information. Said the IRS had a way of assuring that the agency would back it's advice in a written form. However, it takes 8 months or longer to get the advice. He supports the bill.

There may also be other written comments. The chair mentioned that individuals had expressed great concern about retribution by the DNR and wanted to remain anonymous.

That's about as good as I can do for a summary. This bill may pass the House. We don't think it will get beyond that.

Wayne Gieselman
Division Administrator
515-281-5817 DM
fax 515-281-6794