Total Maximum Daily Load For Pathogen Indicators Black Hawk Creek, Iowa

2006

Iowa Department of Natural Resources
Watershed Improvement Section

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1. INTRODUCTION AND SUMMARY

One segment on Black Hawk Creek was included in the 2004 Iowa 303(d) List as impaired by excessive indicator bacteria (fecal coliform) (Table 1). As such, total maximum daily loads (TMDLs) must be developed in accordance with the Clean Water Act (CWA). Based on the strategy of a basin wide approach as well as the hydrologic connections, TMDLs have been developed and included for the waterbody. In 2004, the Iowa Department of Natural Resources (IDNR) opted to convert from fecal coliform to *E. coli* bacteria as the indicator for primary contact recreation assessment. Although *E. coli* may be a better indicator of human health issues, because of data considerations and the fact that the TMDL is expressed as a percentage reduction in loading and the target is set at the *E. coli* standard, the analyses in this TMDL were based on fecal coliform. This document presents a TMDL for indicator bacteria that is designed to allow the Black Hawk Creek segment IA 02-CED-0370_ 1 to fully support the primary contact recreational designated use. The information contained herein should be considered 1 TMDL.

Required components 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 in compliance with the Clean Water Act. 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:

Table 1 Impaired segment description

Black Hawk Creek Segment	Segment description*	Segment length	County
IA 02-CED-0370_ 1	Mouth(S22,T89N, R13W, Black Hawk Co.) to Hwy 58 in E 1/2, S27, T88N, R14W, Black Hawk Co.	11.4 miles	Black Hawk County

*Data from Iowa 305(b) Assessment Database for 1992- 2004 available at http://www.iowadnr.com/water/tmdlwqa/wqa/303d.html#2004

2. Identification of the pollutant and applicable water quality standards:
The pollutants causing the water quality impairments are pathogen indicators (fecal coliform). Designated uses assigned to the above-identified segments include: primary contact recreation and aquatic life. The Class A (primary contact recreation) uses remain assessed (monitored) as "not supported" due to consistently high levels of indicator bacteria. The Class B(WW) aquatic life uses were assessed (monitored) as "fully supported/threatened." The applicable water quality standards for bacteria are a season geometric mean of 126/100ml for *E. coli* and a single maximum value of 235 counts/100 ml.

3. Quantification of the pollutant load that may be present in the waterbody and still allows attainment and maintenance of the water quality standards:
Because bacteria are expressed as a density of bacterial colonies (e.g., counts per 100 ml), mass load is not relevant to assessing the level of contamination. The targets are therefore still

expressed as counts per 100 ml as is the standard. However, these concentrations are compared against the existing data at various flow conditions in a duration analysis.

4. Identification of pollution source categories:
Both point and nonpoint sources of pathogen indicators have been identified as the cause of the primary contact recreation use impairment for the impaired segment of Black Hawk Creek.

5. Wasteload allocations for pollutants from point sources:
The wasteload allocations for point source dischargers to Black Hawk Creek will be equivalent to the water quality criteria associated with the primary contact recreation beneficial use. Therefore, the WLA is a monthly geometric mean of 126 counts per 100ml and a maximum daily value of 235 counts /100 ml for facilities discharging directly to the impaired reaches or a higher value for those contributing to tributaries of the impaired reaches.

6. Load allocations for pollutants from nonpoint sources:
The load allocations assigned to this TMDL will be based upon the 126/100 ml – applicable target water quality criteria for *E. coli* from Title 117.

7. A margin of safety:
This TMDL contains an explicit margin of safety. Specifically, the target was set for Fecal Coliform Bacteria at a level corresponding to the *E. coli* water quality standard.

8. Consideration of seasonal variation:
This TMDL was developed based on the Iowa water quality standards primary contact recreation season that runs from March 15 to November 15.

9. Allowance for reasonably foreseeable increases in pollutant loads:
There was no allowance for future growth included in this TMDL because current watershed land uses are predominantly agricultural and the addition/deletion of animal feeding operations (which could increase or decrease pathogen indicator loading) cannot be predicted or quantified at this time.

10. Implementation plan:
Although not required by the current regulations, an implementation plan is outlined in section 3 of this TMDL. Implementation of the reduction for *E. coli* will be carried out through a combination of regulatory and non-regulatory activities. Point sources will be regulated under the auspice of the National Pollutant Discharge Elimination System and the Rules and Regulations pertaining to Livestock Waste Control. Nonpoint source pollution will be addressed using available programs, technical advice, information and education and financial incentives.

The TMDL included in the following text can be considered a "phased TMDL" and as such is an iterative approach to managing water quality based on the feedback mechanism of implementing a monitoring plan that will determine the adequacy of load reductions to meet water quality standards and revision of the TMDL in the future if necessary. A description of the monitoring that is planned has been included.

Monitoring is essential to all TMDLs in order to:

- Assess the future beneficial use status;
- Determine if the water quality is improving, degrading or maintaining the current status;
- Evaluate the effectiveness of implemented best management practices.

The additional data collected should be used to determine if the implemented TMDL has been effective in addressing the identified water quality impairments, if the TMDL has accurately identified the required components (i.e. loading capacity, load allocations, etc.), and if revisions are appropriate.

2. BLACK HAWK CREEK, DESCRIPTION AND HISTORY

Black Hawk Creek and its watershed are (Table 2.1 and Figure 1) are located in the northeast quadrant of Iowa. The stream originates in Grundy County and flows into the Cedar River in the City of Waterloo in Black Hawk County. This TMDL covers the impaired segment IA 02-CED-0370 Segment 1 which runs from the Cedar River to Highway 58 (11.4 miles).

Table 2.1 Black Hawk Creek and its Basin

Waterbody Name:	Black Hawk Creek
Hydrologic Unit Code, 8 digit:	07080205
IDNR Waterbody ID:	IA 02-CED-0370 Segment 1
Location of impaired segments:	Mouth at Cedar River confluence to the Hwy 58 bridge just north of Hudson, Black Hawk Co.
Major Tributaries:	North Fork Black Hawk, Upper Black Hawk
Receiving Waterbody:	Cedar River
Impaired Segment Length	11.4 miles
Total Designated Use Stream Length:	38.3 miles
Watershed Area:	340 square miles draining 10 HUC 12s

2.1 The Stream and its Hydrology

Black Hawk Creek is a tributary to the Cedar River and flows generally eastward. The average precipitation in the Black Hawk Creek watershed is 33 inches per year. The creek and its tributaries drain three major basins (HUC 10s) that consist of ten sub-basins (HUC 12s) and the stream network is generally well defined and established. The two streams that combine to form lower Black Hawk Creek are North Black Hawk and upper Black Hawk Creeks. The tributaries to North Black Hawk Creek are South Fork North Black Hawk, upper North Black Hawk, and Willow Creeks. The tributaries to upper Black Hawk Creek are Mosquito, Munn's, Minnehaha, and Holland Creeks. The tributaries to lower Black Hawk Creek are Wilson and Prescott's Creeks.

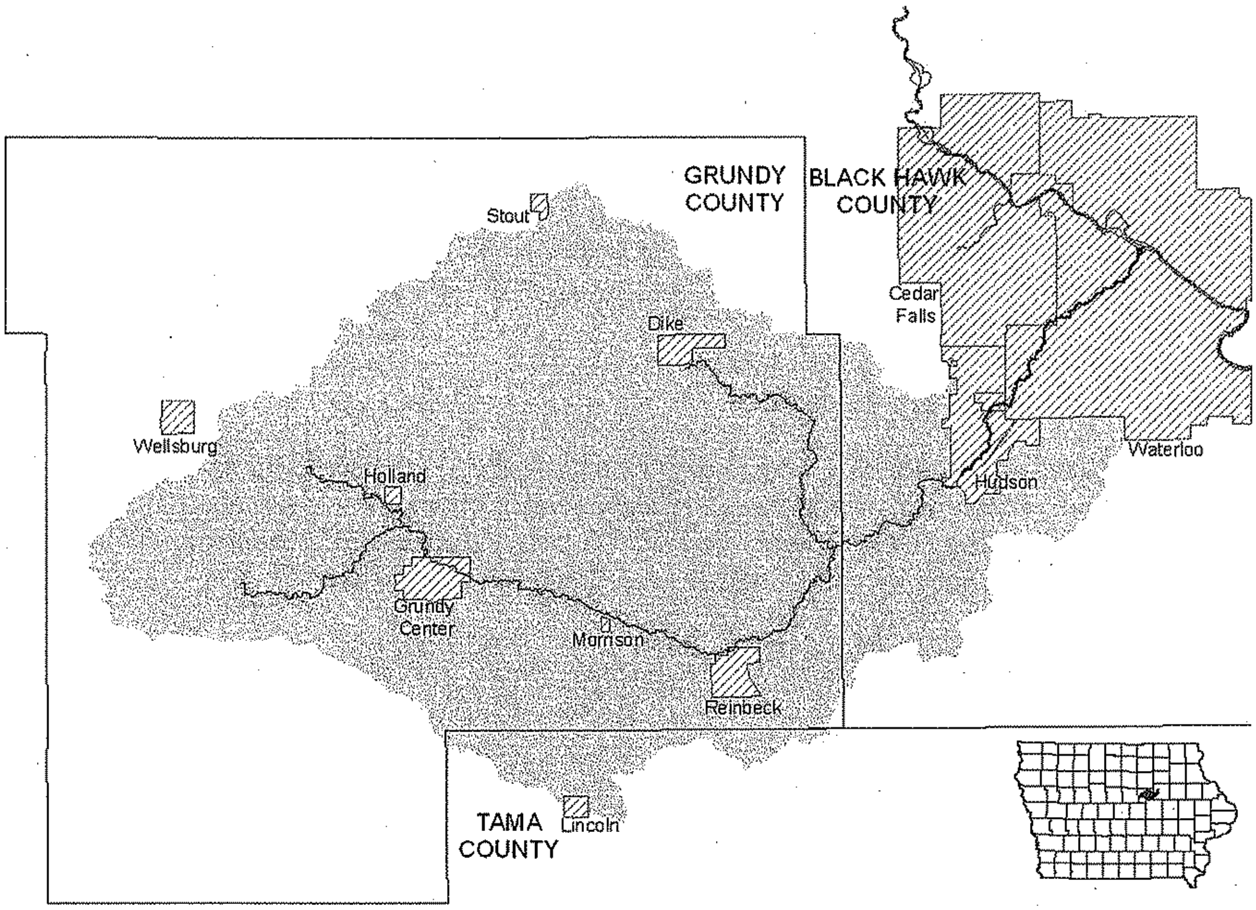


Figure 1 Black Hawk Creek and its watershed

There is a USGS discharge gage station for Black Hawk Creek at Hudson, Iowa. This gage was inactive for six years between 1995 and 2001. A regression analysis was used to synthesize flow estimates because of this data gap. The analysis was based on nearby Beaver Creek and showed a significant relationship between the flow rates of the two streams. The synthetic flow created was actual flow at the Black Hawk Creek gage or, if not available, the estimated flow from the regression equation.

Table 2.2 Regression Analysis

Site number	5463000	5463500
Station Name	Beaver Creek at New Hartford, IA	Black Hawk Creek at Hudson, IA
Latitude	423422	422448
Longitude	923704	922747
Altitude	882.44	865.03
HUC 8	07080205	07080205
Drain area	347	303
Discharge begin date	10/01/1993	9/16/2001
Discharge end_date	9/30/2004	9/30/2004

2.2 The Watershed

The total area of the Black Hawk Creek basin is 340 square miles and it is located in the Iowan Surface ecoregion. This ecoregion is geologically complex and is 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.

Agriculture is the primary land use in the project area including row crop farming, small grains, hay production and pasture land. Livestock feeding operations, including open feedlots, are found throughout the watershed with beef and hog operations the most common. Wildlife species present in the area include whitetail deer, red fox, beavers, raccoons, ring-necked pheasants, mourning doves, and numerous other species of songbirds, waterfowl, reptiles and amphibians.

Table 2.3 Land use in the Black Hawk Creek Watershed

Land Use	Acres	Percent
Built-up	10,839	5%
Cropland	173,431	80%
Pastureland	26,015	12%
Forest	4,336	2%

In general, the soils in the Black Hawk Creek watershed are the Iowan Erosion Surface comprised of shallow loess over glacial till and loamy glacial till. The loess thins going from west to east. Major soil associations include:

Tama – Muscatine – deep loess
Dinsdale- Klinger – thin loess over loamy glacial till
Kenyon- Floyd-Clyde – loamy glacial till

3. TMDL FOR BLACK HAWK CREEK PATHOGEN INDICATORS

3.1 Problem Identification

The 1998 Iowa Section 305b Water Quality Assessment Report divides Black Hawk Creek into two designated reaches. The first reach, IA 02-CED-0370, is divided into two segments, one of which is the impaired segment that is addressed by this TMDL. The second reach consists of one segment that is not impaired. The impaired segment is 11.4 miles long and extends from the Black Hawk Creek confluence with the Cedar River confluence upstream to Highway 58 just north of Hudson. Of the three designated use segments of Black Hawk Creek, only the impaired reach is classified A1 - Primary Contact Recreation. All three designated segments are Class B, Warm Water Aquatic Life and support this designated use.

The following paragraphs are from the 305b report and include the comments on the impaired Black Hawk Creek segment. The 305b assessment determined that IA 02-CED-0370 Segment 1 should be included on the Iowa 303d list of impaired waters for pathogen indicators.

Mouth to Hudson, Waterbody ID No.: IA 02-CED-0370_1
From the 1998 and 2004 305b assessment reports:

> Class A (primary contact recreation) uses were assessed (evaluated) as "<u>not supported</u>" based on levels of indicator bacteria that violate state water quality standards. The Class B (WW) aquatic life uses were assessed (evaluated) as "fully supported" based on results of ambient physical/chemical monitoring. Fish consumption uses remain assessed as "fully supported" based on the results of EPA/DNR fish tissue (RAFT) sampling in 1998 near Hudson. The source of data for this assessment is the results of IDNR/UHL monthly monitoring conducted from October, 1999 to September, 2001, at the IDNR ambient station at Ridgeway Avenue southwest of Waterloo, in support of TMDL development for this stream segment.

This segment of Black Hawk Creek is on the State of Iowa 303d list of impaired waters for fecal coliform bacteria. Fecal coliform bacteria sources could include wastewater treatment plant discharges, urban storm sewers, septic tanks, wildlife, runoff from fields where manure has been applied, and feedlots. Bacteria problems often accompany heavy rainfall events since the runoff transports accumulated fecal material to the stream.

Impaired Beneficial Uses and Applicable Water Quality Standards - Pathogen Indicator Water Quality Standards

The applicable designated uses and water quality standards for pathogen indicators are found in *Iowa Administrative Code 567, Chapter 61, Water Quality Standards.*

> 61.3(3)a. Class "A" waters. Waters which are designated as Class "A1," "A2," or "A3" in subrule 61.3(5) are to be protected for primary contact, secondary contact, and children's

recreational uses. The general criteria of subrule 61.3(2) and the following specific criteria apply to all Class "A" waters.

(1) The Escherichia coli (*E. coli*) content shall not exceed the levels noted in the Bacteria Criteria Table when the Class "A1," "A2," or "A3" uses can reasonably be expected to occur. Class A1 is Primary Contact Recreational Use, Class A2 is Secondary Contact Recreational Use, and Class A3 is Children's Recreational Use. When a waterbody is designated for more than one of the recreational uses, the most stringent criteria for the appropriate season shall apply.

Table 3.1 *E. Coli* Bacteria Criteria (organisms/100 ml of water)

Use	Geometric Mean	Sample Maximum
Class A1		
3/15 – 11/15	126	235
11/16 – 3/14	Does not apply	Does not apply
Class A2 (Only)		
3/15 – 11/15	630	2880
11/16 – 3/14	Does not apply	Does not apply
Class A2		
Year-Round	630	2880
Class A3		
3/15 - 11/15	126	235
11/16 - 3/14	Does not apply	Does not apply

Relationship of *E. coli* to fecal coliform

To explore the relationship of *E.coli* to Fecal Bacteria, a regression was performed on the data from Black Hawk Creek for the years 1993-2004. The following relationship was found which demonstrates that using fecal coliform information to assess current conditions and develop percentage reduction targets may be appropriate. The TMDL targets for fecal coliform are set at the same values as the *E. coli* standard based on this analysis. The *E. coli* is expected to be a subset of the fecal coliform and the ratio should not exceed 1, which is also the upper quartile as shown in statistics in Table 3.2.

Table 3.2 Relationship of *E. coli* to fecal coliform

Descriptive Statistics: Ratio of *E.coli* to fecal coliform bacteria								
Variable	**N**	**Mean**	**SE Mean**	**StdDev**	**Min.**	**Q1**	**Median**	**Q3**
Ratio	48	0.8557	0.0287	0.2498	0.00	0.6820	0.9221	1.0000

Data Sources

The water quality monitoring data used in the development of this TMDL project originates from sampling done at the IDNR ambient monitoring program site at the County Road D19 (Ridgeway Ave.) Bridge in Waterloo. This site is 4.6 miles upstream from the Black Hawk Creek confluence with the Cedar River. The flow data was collected at the USGS gage station at the Highway 58 Bridge north of Hudson, 6.8 miles upstream from the ambient monitoring site and 11.4 miles upstream from the Cedar River.

The Waterloo ambient site water quality data was collected from 1999 to 2004 and includes fecal coliform and E. coli bacteria concentrations and the site's measured flow at the time the sampling was done. The USGS gage flow data used in the modeling is the daily average flow from the Hudson station. This USGS gage began operating in 1952 but was discontinued from September 30, 1995 to September 7, 2001. Discharge values used for modeling the six year gap were estimated by regressing Beaver Creek gage data against the Black Hawk Creek gage data. The Black Hawk Creek flow data synthesized as previously described. The Waterloo monitoring site fecal coliform and instantaneous flow data are in Appendix B.

3.2 Pollution Source Assessment

Point Sources

Wastewater Treatment Plants

The point sources of *E. coli* bacteria in the Black Hawk Creek watershed include five municipal and one private wastewater treatment facilities. One of the facilities, in Hudson, currently has fecal coliform effluent limits in its permit and the others do not. Table 3.3 lists the Hudson permitted flow and fecal coliform concentration. Table 3.4 lists the other facilities in the watershed that currently have no fecal coliform permit limits, but are potential sources. The Dietrick Mobile Home Park and City of Holland wastewater treatment facilities are controlled discharge lagoon facilities that discharge only when receiving stream flows are high.

Table 3.3 Permitted facilities in Black Hawk Creek Watershed with fecal coliform limits

Facility Name	EPA NPDES ID	Receiving Stream	Facility Type	Population Equivalent	Design ADW Flow (MGD)	Design AWW Flow (MGD)	Fecal Coliform (#/100ml)[1]
Hudson wwtp	IA0027243	Black Hawk Creek	Aerated Lagoon w/ disinfection	5988	0.42	0.50	200, geometric. mean

1. Currently in Iowa NPDES permit limits for bacteria are in fecal coliform. The limits are for a geometric mean of 200 and a single sample maximum of 400 organisms per 100ml.

Table 3.4 Permitted facilities in Black Hawk Creek Watershed without fecal coliform limits

Facility Name	EPA NPDES ID	Receiving Stream	Facility Type	Design Population Equivalent	Design ADW Flow (MGD)	Design AWW Flow (MGD)
Dietrick M. H. Park wwtp	IA0061689	North Black Hawk Creek	Facultative Lagoon	162	NA	0.0112
Dike wwtp	IA0023311	North Black Hawk Creek	Activated Sludge	1719	0.139	0.342
Grundy Center wwtp	IA0024511	Black Hawk Creek	Activated Sludge (SBR)	7784	0.4	1.2
Holland wwtp	IA0041254	Holland Creek	Facultative Lagoon	340	NA	0.033
Reinbeck wwtp	IA0033308	Black Hawk Creeknb	Activated Sludge (SBR)	1970	0.23	0.49

Livestock Feeding Operations
Livestock operations in the Black Hawk Creek watershed range in size from small farms with a few animals to large feeding operations. 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. Runoff from open feedlots can deliver substantial quantities of pathogen indicators, nutrients and oxygen demanding materials to a waterbody depending on proximity to a waterbody and the number and type of livestock and manure controls. Open feedlots with more than 1,000 animal units are required to have an NPDES permit. There is one NPDES permitted open feedlot in the Black Hawk Creek watershed. In addition, Iowa has a voluntary open feedlot registration program.

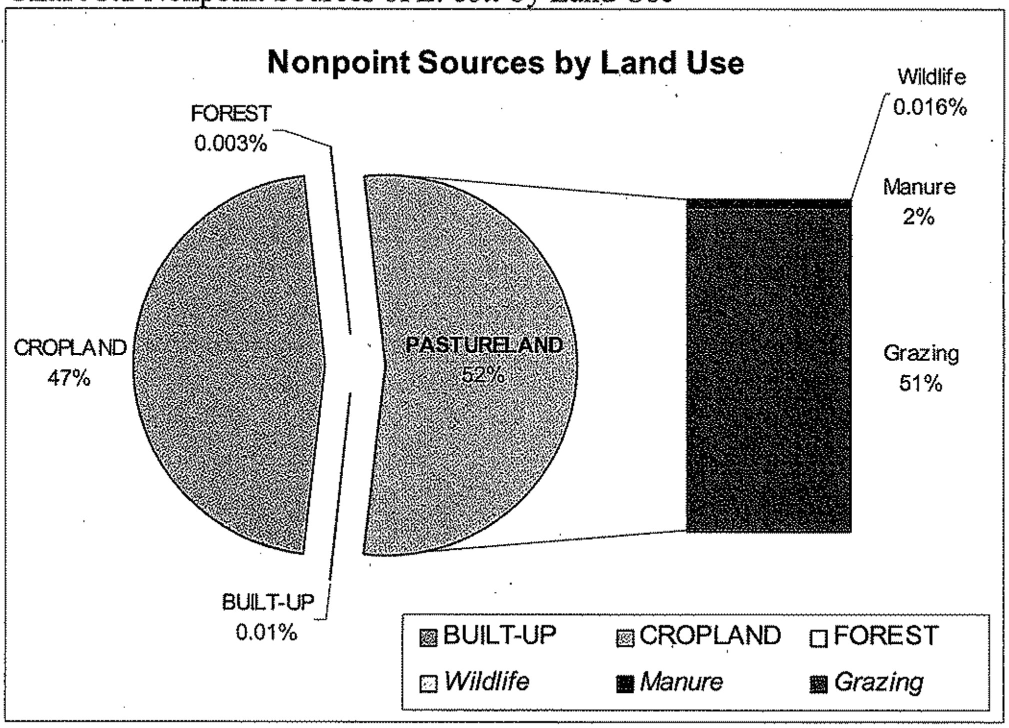
Confinement animal feeding operations (CAFOs) are animal feeding operations in which animals are confined to areas that are totally roofed. CAFOs typically utilize earthen or concrete structures to contain and store manure prior to land application. Nutrients and bacterial loading from CAFOs are delivered via runoff from land-applied manure or from leaking/failing storage structures. Currently, CAFOs with more than 500 animal units must have an approved manure management plan. Regardless of size, all CAFOs must report manure releases (IDNR CAFO website, 2005).

Nonpoint Sources
The nonpoint sources of *E. coli* include contributors that do not have localized points of release into a stream. In the Black Hawk Creek watershed these sources are:

- Land application of hog and cattle manure
- Land application of poultry litter
- Grazing animals
- Cattle contributions directly deposited in stream
- Failing septic systems
- Urban runoff

The contributions from each of these sources are estimated using information available. Chart 3.1 shows *E. coli* nonpoint contribution by land use. EPA contacted several agencies to refine the data assumptions made in determining the fecal loading. The IDNR and Iowa State University (ISU) wildlife biologists provided information regarding deer and geese populations in the watershed. County sanitarians estimated the failure of septic tank systems in the state. The Natural Resources Conservation Service (NRCS) and ISU researchers provided valuable information on manure application practices and loading rates for hog farms and cattle operations. The location and magnitude of these loads are related to the different land uses in the Black Hawk Creek Watershed. The IDNR TMDL Fact Sheet for the Black Hawk Creek provided land use cover data for the watershed, which was used in this TMDL.

Chart 3.1 Nonpoint Sources of *E. coli* by Land Use



Livestock Estimates for the Watershed
Table 3.5 provides the estimated number of animals in the Black Hawk Creek Watershed, including dairy cows, beef cattle, and hogs. The animal inventory estimates are based on the 2002 Census of Agriculture, which was conducted in December of that year. Participants were asked to report the number of animals present at that time. Although livestock inventory can 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.

Table 3.5 Estimated animals in the watershed.

Diary Cows	Beef Cattle	Hogs	Chickens	Sheep	Horses
496	13,318	101,664	1,145	1,425	383

Land Application of Manure and Litter
Land application of manure is a potential contributor of bacteria to receiving waterbodies due to rain event runoff. Manure application rates vary according to management practices currently used in the area. Most manure is applied during the months of October, November, and December in this area of Iowa. It is assumed that cattle manure is applied to cropland and pastureland, hog and poultry litter is only applied to cropland, most poultry litter is used as fertilizer, and horse manure is applied only to pastureland. Chart 3.3 compares the percentages of *E. coli* contribution between the various types of land application manures, poultry litter and wildlife.

While manure application is one aspect of the bacterial loading, other factors also affect the observed concentrations. As mentioned in the TMDL, runoff conditions are strongly tied to elevated bacteria levels, but the cause and effect relations to manure applications timing was not established. Chart 3.2 depicts the bacterial observations throughout the year suggesting that there is decreased concentration in January and February, perhaps due to frozen conditions, bacterial activity, and lack of direct runoff.

Chart 3.2 Bacteria data by month

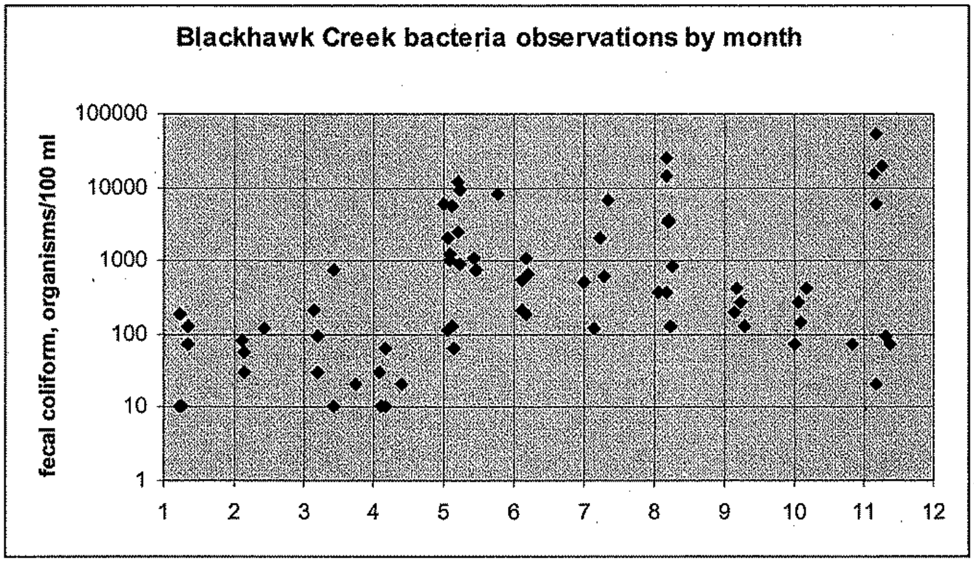
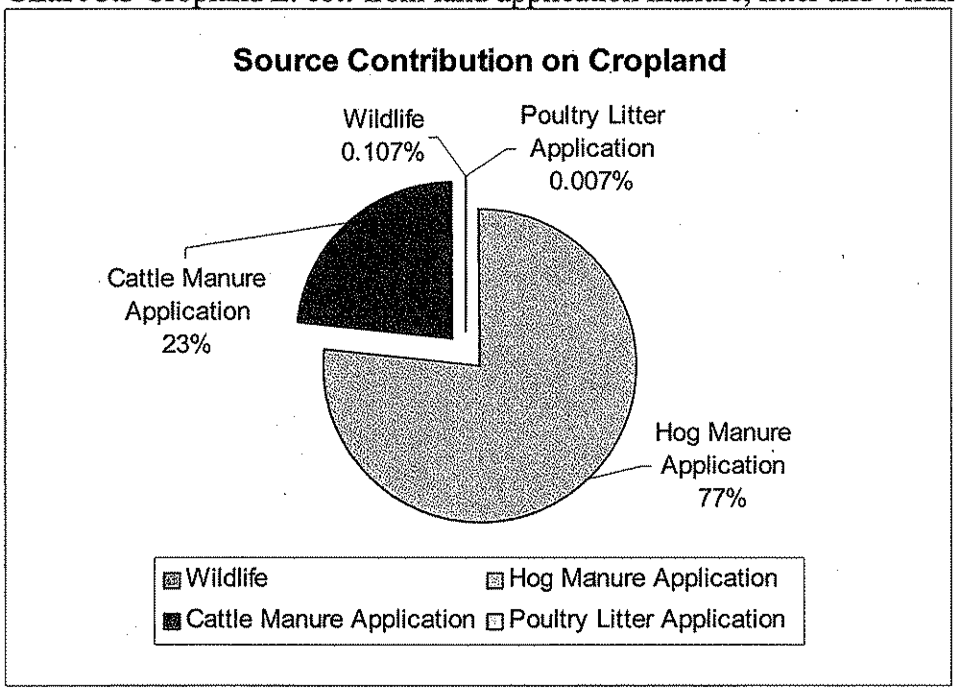
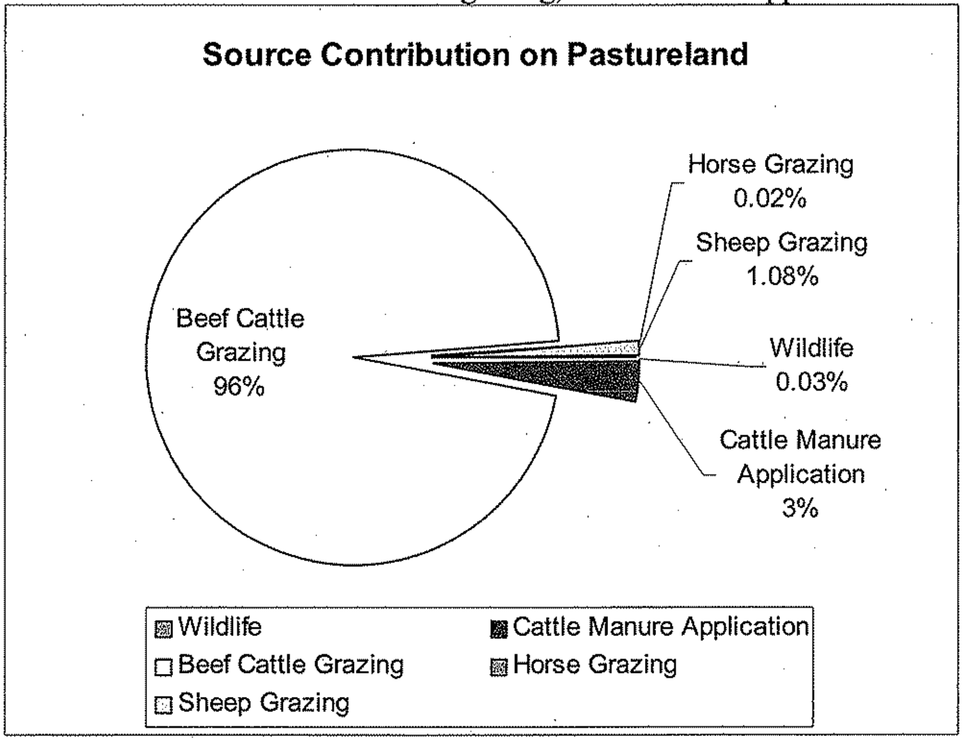


Chart 3.3 Cropland *E. coli* from land application manure, litter and wildlife.



Grazing Animals
Cattle, horses, and sheep spend time grazing on pastureland and deposit manure onto the land. During a rain event, a portion of this fecal matter is available for wash-off and delivery to receiving waterbodies. Chart 3.3 shows pastureland *E. coli* sources by percentage of contribution.

Chart 3.4 Pastureland *E. coli* from grazing, cattle manure application and wildlife.



The bacterial tool described below is used to estimate source contributions assuming that dairy cattle are confined in feedlots, and thus their waste is applied as manure. Access to pastureland for grazing cattle varies throughout the year. According to researchers at Iowa State University, cattle are 80% confined from January to March. During the spring and summer months (April through October) they spend 100% of their time grazing. In November and December, they have slightly reduced access and spend approximately 80% of their time grazing (Russell, personal communication). The grazing schedule for sheep is similar to cattle except that sheep tend to be fully confined during the months of January through March. It is assumed that horses are primarily grazing and spend negligible time confined. As such, they directly deposit manure to pastureland.

Cattle Contributions Deposited Directly In-stream
Cattle often have direct access to streams that run through pastureland. In Iowa the majority of cattle have direct access to a stream (approximately 90%). *E. coli* bacteria deposited in these streams by grazing cattle are modeled as a direct input of bacteria to the stream. Preliminary research data in Iowa indicate that cattle spend one to six percent of their time in streams from April through December (Russell, personal communication). For this particular watershed reducing the cattle contribution estimate by 76% provided a much better model results.

Failing Septic Systems

Septic systems may deliver bacteria loads to surface waters due to malfunctions, failures, or direct pipe discharges. Properly operating septic systems treat the wastewater and dispose of the water through a network of perforated pipes in trenches called a lateral field. The systems can fail when the field lines are broken, or the underground substrate is clogged or flooded. The septic water reaches the surface and is then available for wash-off into the stream. Direct bypasses from septic tanks to a stream also lead to bacteria contamination. In efforts to keep wastewater from seeping up in a drain field, pipes are sometimes laid from the septic tanks or the field lines to the nearest stream.

Another consideration is the use of individual onsite wastewater treatment plants that are sometimes used when a septic tank and lateral field cannot be constructed to code. These can provide adequate treatment if properly maintained but often are neglected over the long term. Although required, disinfection is not usually provided.

The number of septic systems is estimated from the watershed area normalized count of septic systems in each county (based on 1990 U.S. Census). EPA contacted county sanitarians for estimated rates of failure and normalized the rates based on the percentage of each county contained in the watershed to obtain an estimate for the Black Hawk Creek Basin. It is estimated that 60 percent are currently failing in the watershed. Table 3.5 displays information regarding septic systems in the watershed. The failure rates were obtained from county sanitarians. All other data were obtained from the U.S. Census Bureau (1990).

Table 3.5 Septic system information for each county in the Black Hawk Creek watershed

Black Hawk Creek	Counties			
	Black Hawk	Grundy	Tama	Total
Septic tanks	646	968	51	1,665
Household size	2.49	2.33	2.35	2.39
Persons served	12,841	4,461	6,517	3,987
Failure rate	6%	90%	25%	70%

Built-up Areas

Pathogen contributions from urban areas may come from runoff through stormwater sewers (e.g. residential, commercial, industrial, and road transportation), illicit discharges of sanitary wastes, and runoff contribution from improper disposal of waste materials. The failure of sewer and septic systems and subsequent migration with stormwater runoff is also a potentially significant source. Ten incorporated communities are entirely or partially in the watershed and the built-up land use is 5% of the watershed. There is a land use map in Appendix A.

Table 3.6. Land use in the Black Hawk Creek Watershed.

Land Use	Acres	Percent
Built-up	10,839	5%
Cropland	173,431	80%
Pastureland	26,015	12%
Forest	4,336	2%

Natural Background Conditions - Wildlife

Wildlife in the Black Hawk Creek Watershed contributes *E. coli* bacteria onto the land surface where it is available for wash-off during a rain event. In the Black Hawk Creek model, wildlife is accounted for by considering contributions from deer, geese, and raccoons. Countywide deer population estimates were obtained from IDNR wildlife biologists. These estimates were used calculate an estimate for the watershed based on the percentage of each county within the watershed. The deer population is estimated to be 15 animals per square mile for this area. Geese populations are difficult to estimate. The estimate of 3 geese per square mile was used based on other Iowa TMDLs and conversations with wildlife biologists. Information regarding raccoon populations was obtained from Iowa State University researchers. The raccoon population in this part of Iowa varies seasonally from approximately 15 animals per square mile to 75 animals per square mile (Clark, personal communication). The tool used to estimate the bacteria contribution from various sources is limited in its ability to represent seasonal variation. Due to this, an average value of 45 animals per square mile was used for pastureland and forest cover. The minimum density estimate of 15 animals per square miles was used for cropland with the understanding that it may be marginal or unsuitable habitat during portions of the year.

While these methods may overestimate the populations, they compensate for the unavailability of data for other wildlife such as ducks, beaver, opossum, squirrel, and rabbit. The estimates assume that the wildlife population remains constant through the year; that wildlife is present on all land classified as forest, pasture, cropland, and wetlands; and that the wildlife is evenly distributed to the land use types.

3.3 TMDL Target

Modeling Approach

The modeling approach uses a flow duration analysis to display excursions above the standard at different flow conditions. The flow was both measured and simulated for a period from 1993 to 2004 at the Black Hawk Creek Gage located near Hudson. Because this location integrates the whole watershed, it is used as the target location for the impaired segment of this TMDL. The result of this synthesis is shown in Figure 2.

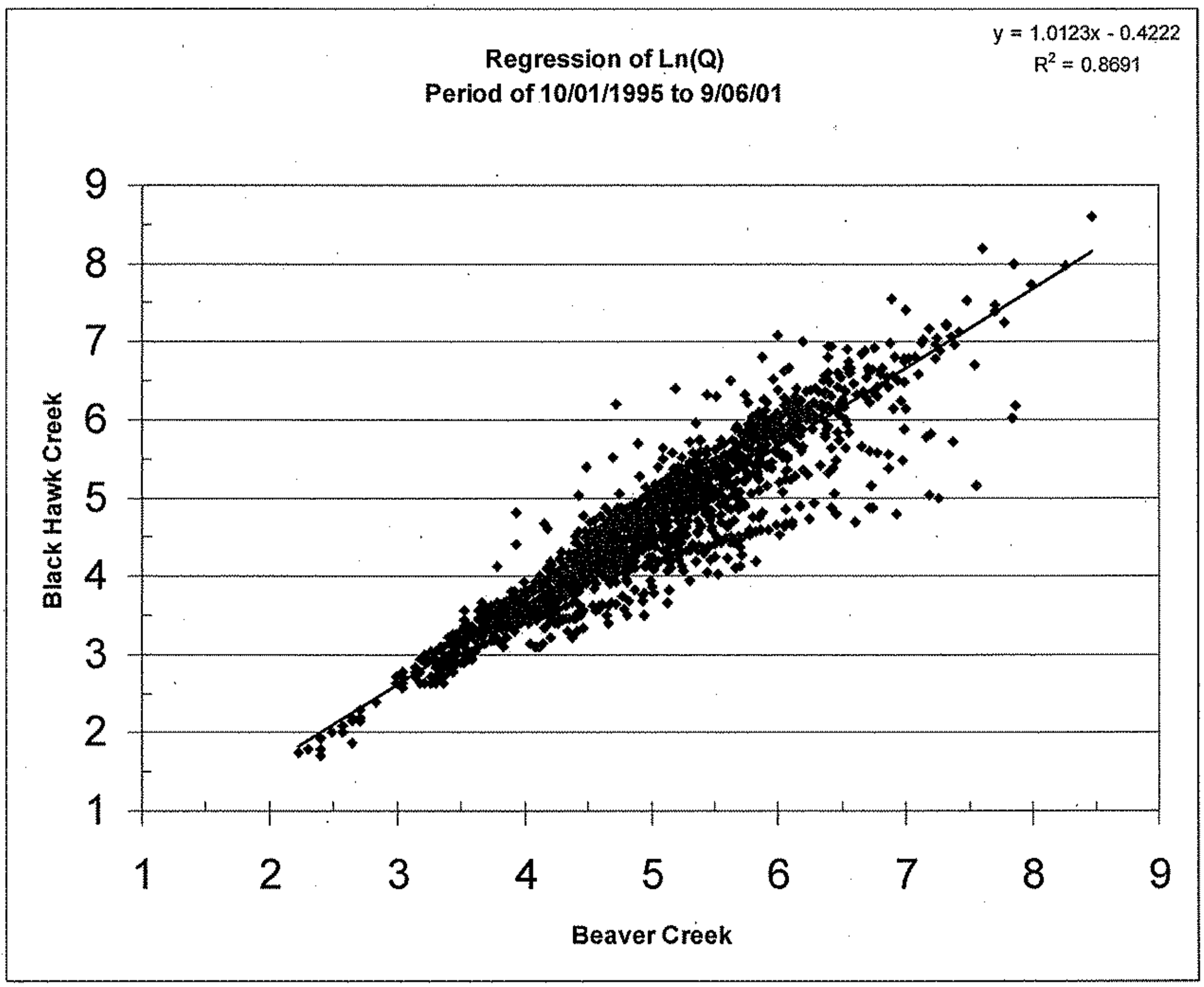


Figure 2 Relationship used to extend Black Hawk Flow Record

Figure 3 shows the distribution of flow. The data is plotted against a statistically derived scale (Pearson Probability). A naturally flowing system will plot near a straight line. Although this is generally the case for this analysis, the extreme high flow deviation from a straight line may be an artifact of the flow regression.

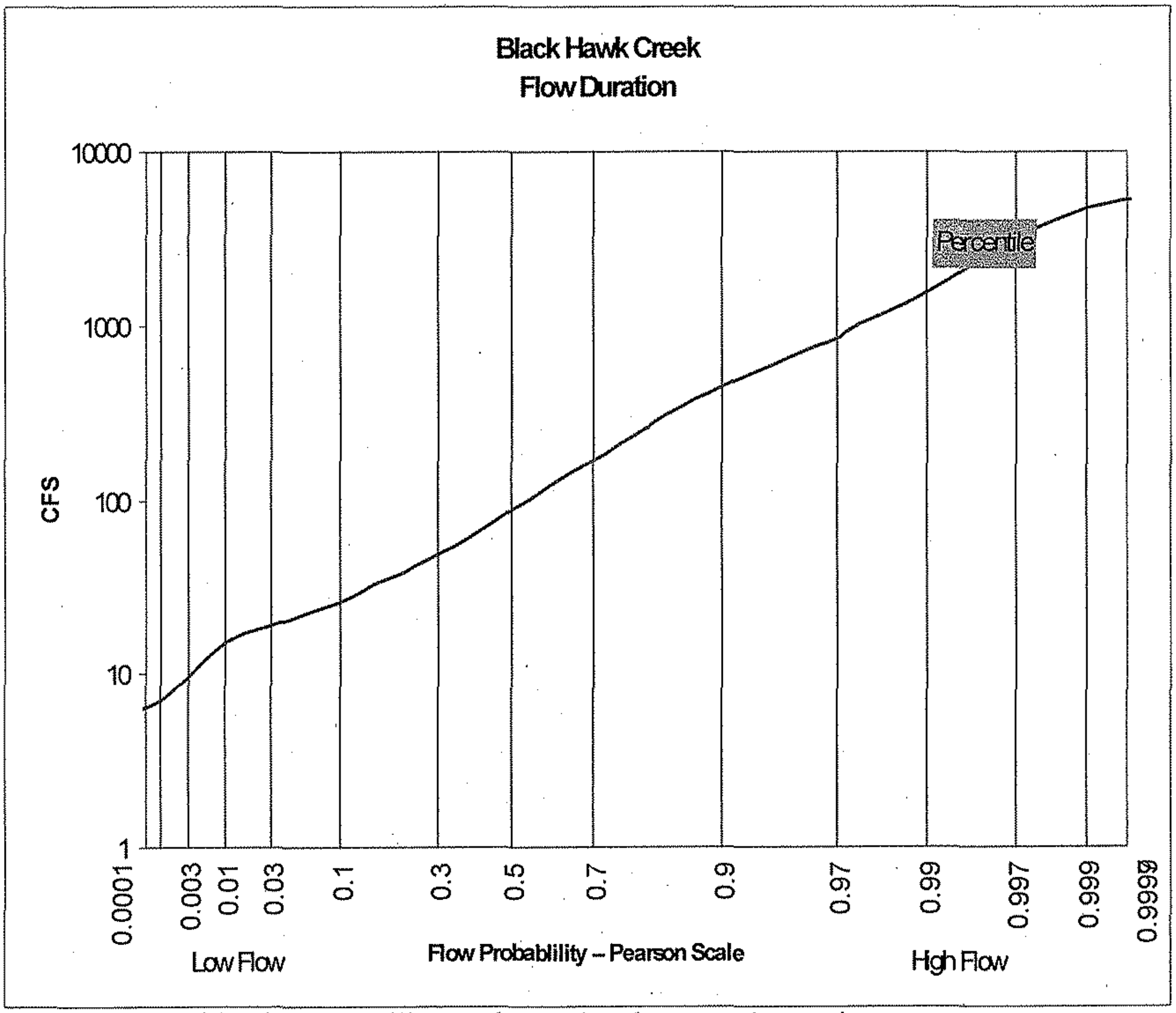


Figure 3 Probability that flow will exceed the value shown on the y-axis

The flow record was evaluated to separate baseflow from surface runoff. A digital filter technique (Eckhardt, 2004) was used to separate the hydrograph. An example of the baseflow separation is shown in Figure 4.

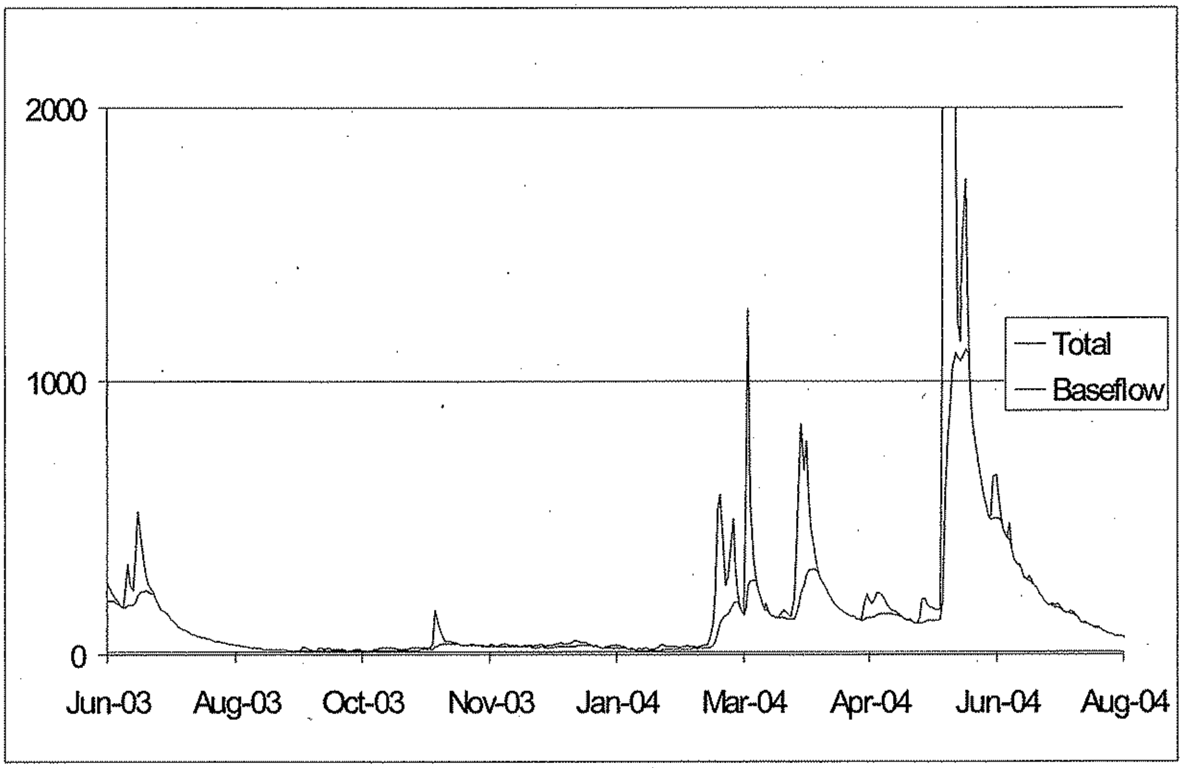


Figure 4 Example time period depicting the baseflow separation

Source inventory results were used to estimate nonpoint source loading by using EPA's "Bacterial Indicator Tool" (BIT) Spreadsheet. The nonpoint source daily loading from the BIT was assumed to contribute only during surface runoff conditions as identified by the baseflow separation, otherwise it was allowed to accumulate on the land surface to a maximum multiple of the daily generation determined by optimizing the model efficiency calculation.

This approach is similar to that used in the HSPF (Bicknell, 2000) model and is consistent with that taken in other TMDLs across the country, such as described in the State of Virginia guidance on TMDL development (Virginia, 2003). Contributions of bacterial contamination during baseflow periods were attributed to cattle in the streams, septic tanks, and a generalized loading that includes contribution from point sources. A *release rate first order equation* was used to simulated how land manure would be released (Shelton, 2003) and another *first order decays for transport of the bacteria* was also used (EPA 2001). To estimate travel times, time of concentration was estimated (Neitsch, 2000.)

Waterbody Pollutant Loading Capacity

As previously explained, waterbody loading capacity cannot be reasonably expressed as a mass per time. Because the risk and corresponding water quality criteria associated with bacteria are based on epidemiological studies relating illness rates to concentration, this TMDL is expressed as a relationship of concentration at a continuum of flow conditions, as shown on the duration curve in Figure 3.

Existing Load

Existing loads are shown in Figure 5. Percent surface runoff is also shown to demonstrate the strong relationship between bacterial concentration and the presence of surface flow. The TMDL target concentrations of bacteria are displayed for both the single sample maximum (SSM) and the geometric mean (GM). Figure 5 shows that when flow is less than the 50th percentile, there are few excursion of the single sample maximum (SSM), whereas at flows above this percentile, surface runoff is much higher as well as the frequency of exceedance of the criteria. The conclusion is that control of nonpoint sources will be required to achieve the standard.

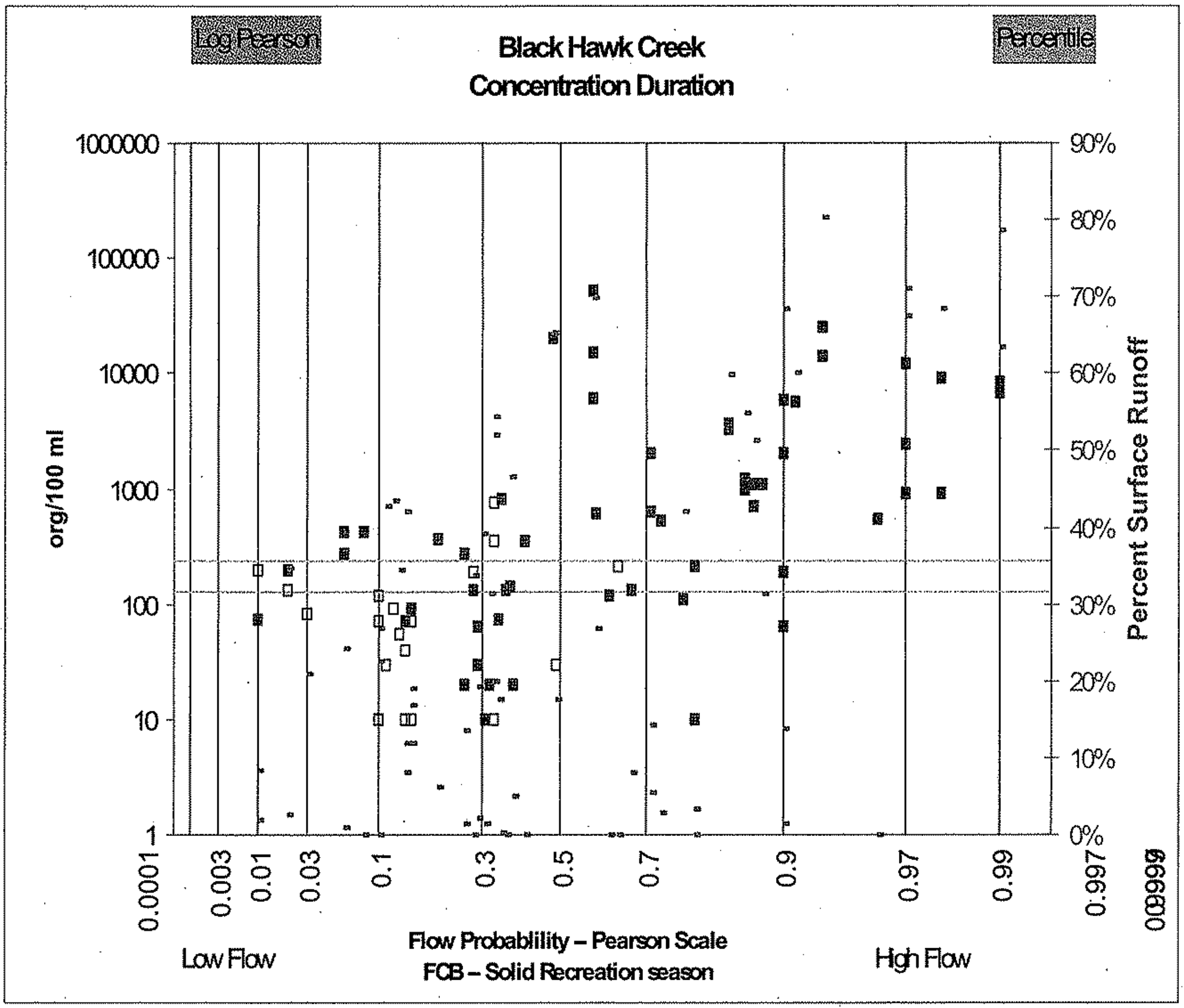


Figure 5 Sample results shown for various flow conditions and the estimated percent coming from surface runoff using the baseflow separation

Linkage of Sources to Target

To link the sources to the target, modeling was performed, as previously described. The results show a relationship between predicted and observed values. This is shown in Figure 6 as a Nash-Sutcliffe efficiency of 0.29, which is below a desired level of acceptance. However, regression analysis of the observed versus the predicted values were statistically significant and had an correlation coefficient of 0.34, thereby explaining over one-third of the sample variability. (wikipedia,2006 (http://en.wikipedia.org/wiki/Nash-utcliffe_efficiency_coefficient)):

The Nash-Sutcliffe model efficiency coefficient is
assess the predictive power of hydrological models. It is

$$E = 1 - \frac{\sum_{t=1}^{T}\left(Q_o^t - Q_m^t\right)^2}{\sum_{t=1}^{T}\left(Q_o^t - \overline{Q_o}\right)^2}$$

where Qo is observed discharge, and Qm is modelled discharge. Qt is

Norma	Logs	
8.64E+0	244.810	Numerat
4.07E+0	344.155	Denominat
-	29%	Nash Sutcliffe

Figure 6 Model efficiency calculation

Other measures of modeling effectiveness were calculated and are included in the spreadsheet model. Figure 7 shows the modeled fecal coliform concentration geometric means for the synthetic Hudson gage flow data.

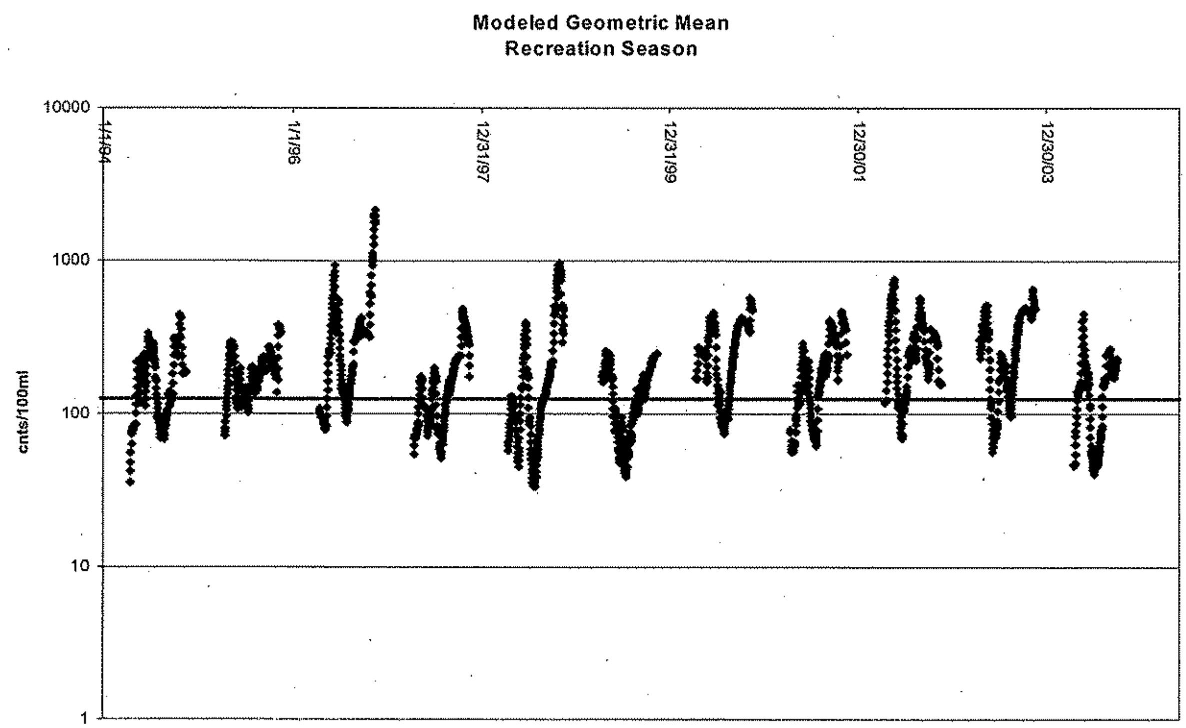


Figure 7 Modeled fecal coliform concentrations versus the *E. coli* geometric mean standard

3.4 Pollutant Allocations

Wasteload Allocations

The wasteload allocations for the six treatment facilities discharging to Black Hawk Creek or its tributaries are in Table 3.7. If a wwtp discharges directly to Black Hawk Creek then the wasteload allocation is the same as the *E. coli* water quality standard, a geometric mean of 126 organisms/ 100 ml and a single sample maximum of 235 organisms/ 100 ml. These values present the same risk for pathogen exposure as fecal coliform values of 200 organisms/ 100 ml and 400 organisms/ 100 ml, respectively. The wasteload allocations for facilities that are a distance from the impaired segment are calculated using the standard bacteria die-off equation. This equation incorporates the decay coefficient and velocity shown in Table 3.7. Currently Iowa wasteload allocations are for *E. coli* and NPDES permit bacteria limits are in fecal coliform concentrations.

Table 3.7 Permitted Wastewater Treatment Plant (wwtp) Wasteload Allocations (WLA)

NPDES Permitted Municipal/Semi-Public Treatment Facilities			Decay Coefficient, 1/day			0.96
			Stream Velocity (miles per day)			16
City Name	**EPA NPDES ID**	**Receiving Stream**	**Miles to Impaired Reach**	**Fraction after Decay**	***E. coli* WLA**	
					Geometric mean	**Sample Max.**
Hudson wwtp[1]	IA0027243	Lower Black Hawk Creek	0	1	126	235
Dietrick Mobile Home Park wwtp	IA0061689	North Black Hawk Creek	22.2	0.136	293	546
Dike wwtp	IA0023311	North Black Hawk Creek	29.7	0.102	389	726
Grundy Center wwtp	IA0024511	Black Hawk Creek	37.4	0.076	521	971
Holland wwtp	IA0041254	Holland Creek	43.7	0.060	663	1287
Reinbeck wwtp	IA0033308	Upper Black Hawk Creek	20.2	0.146	507	272

1 The Hudson wwtp currently has a wasteload allocation for E. coli as shown above and an NPDES permit limit for fecal coliform that is for a geometric mean of 200 organisms/100 ml and a sample maximum of 400 organisms/100 ml.

Residential, roadway, and commercial land uses may represent non-point pollutant sources for pathogens. Built-up or urban land use, in Blackhawk Creek watershed, is 5% of the total watershed. The Waterloo stormwater MS4 permit covers 62 square miles in the Blackhawk Creek watershed. A portion of the load associated with urban stormwater runoff is transported outside of the watershed and is delivered to Cedar River. A portion is also delivered to Blackhawk Creek. One large (90 inch) outfall and 31 small (15 inch) outfalls, of the MS4 permit discharges into Blackhawk Creek. This is compared to three large outfalls and 67 small outfalls, discharging into the Cedar River. The Blackhawk Creek outfalls represent about 20-25% of the total MS4 permitted load, or approximately 13-16 square miles of the built-up area. The Blackhawk Creek part of the Waterloo MS4 stormwater discharge permit represents 4.7%, of the total Blackhawk Creek watershed area.

The WLA targets for the MS4 permit are assumed to be in the same ratio (an 85% reduction in rain driven surface runoff loads and a 98% reduction in continuous bacterial loads) as defined in the load allocation for non point sources. To achieve this WLA the State of Iowa has issued an MS4 stormwater permit with associated best management practices (BMPs) that are anticipated to control these source contributions.

There is only one permitted open feedlot in the watershed. The wasteload allocation for this feedlot is in Table 3.8.

Table 3.8 Permitted open feedlot WLA

Facility Id	Facility Name	Operation Id	Operation type	Waste load Allocation[1]
61302	Sunny Brook Farm Feedlot	57363	Beef Cattle - Mature	No discharge

[1] No discharge resulting from precipitation events less than or equal to the 25 year, 24 hour precipitation event.

Load Allocation
The load allocation that achieves the water quality standard geometric mean of 126 E. coli organisms/ 100 ml has been modeled and the results are shown in Figure 8. The load reduction required to meet this allocation is the difference between the modeled existing conditions in Figure 7 and the modeled allocation in Figure 8. Reductions are required for non-point source loads such as manure applied to cropland and pasture, and wildlife feces. These loads are transported by precipitation events. Other non-point source loads are relatively constant such as cattle in streams and failed septic tanks. To achieve the *E. coli* water quality standard, there must be an 85% reduction in rain driven surface runoff loads and a 98% reduction in continuous NPS bacterial loads (e.g., septics and cattle in the stream). These reductions result in the modeled *E. coli* values shown in Figure 8 that are below the geometric mean limit for all flow conditions.

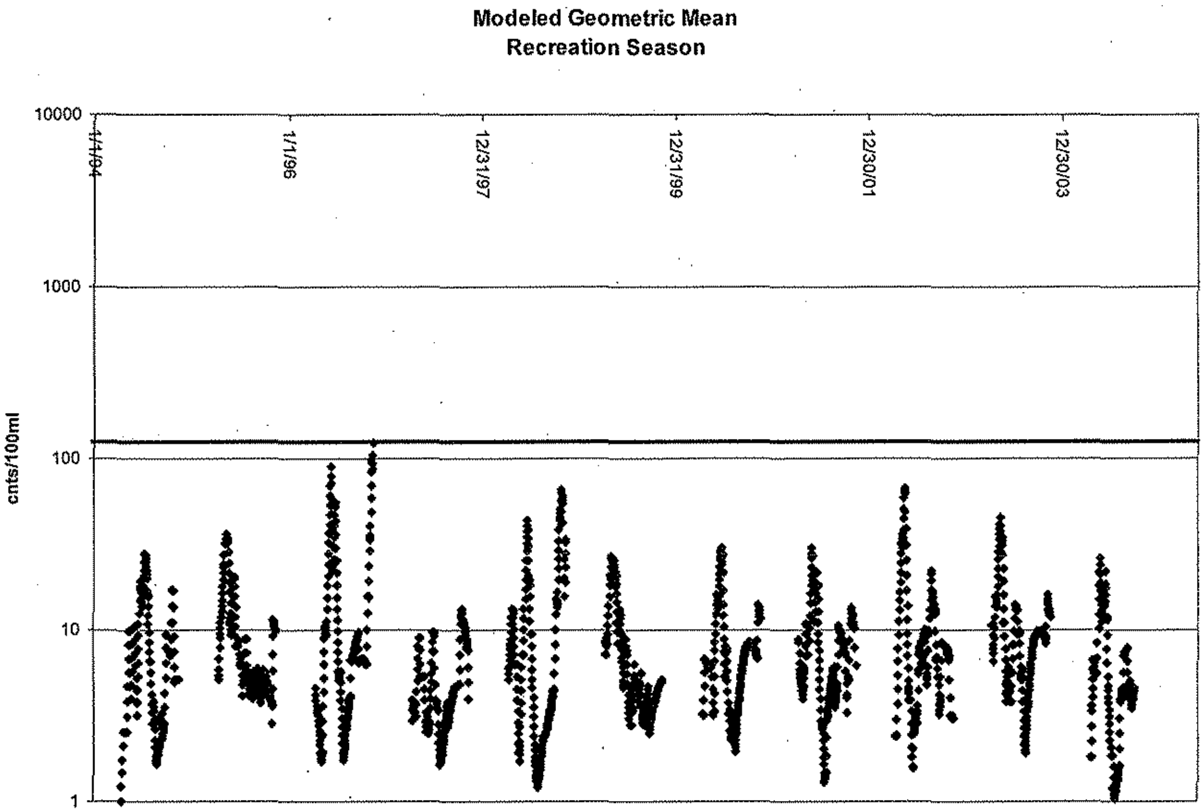


Figure 8 Expected concentrations based on the TMDL reductions in loads

3.5 Margin of Safety
In 2004, the Iowa Department of Natural Resources (IDNR) opted to convert from fecal coliform to *E. coli* bacteria as the indicator for primary contact recreation assessment. Although *E. coli* may be a better indicator of human health issues for primary contact recreation assessment, it is not used in this TMDL. Because of the data consideration that *E. coli* is a subset of fecal coliform, it follows that in a given sample, the *E.coli* level will always be less than the corresponding fecal coliform level. This TMDL is expressed as a percentage of reduction in

loading to achieve a fecal coliform target that is set at the *E. coli* standard. The margin of safety is thereby explicit due to targeting fecal coliform reductions at the *E.coli* standard level.

3.6 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 Black Hawk Creek that these TMDLs have been developed for, wasteload allocations may reflect anticipated or expected reductions of pathogen indicators 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 allocations for the NPDES permitted point sources in the Black Hawk Creek watershed require that wastewater treatment plants effluent meet the water quality standards for discharges directly to Black Hawk Creek. For wastewater treatment plants that discharge to a tributary of Black Hawk Creek, the effluent must meet the water quality standards where it flows into Black Hawk Creek as calculated in this report.

These wasteload allocations are implemented through the Iowa NPDES permitting procedure following rules in the Iowa Administrative Code (567-64). For NPDES permitted Iowa feedlots in the Black Hawk Creek watershed, no discharge is allowed and the wasteload allocation is zero. This means that no permitted point sources are allowed to discharge pathogen indicators at a concentration that causes a violation of the pathogen indicator water quality standards. Further pathogen indicator reductions below the wasteload allocations in this document cannot improve Black Hawk Creek compliance with the water quality standards.

Reasonable assurance for non-point sources will be accomplished through methods and projects that reduce the impacts of livestock as described in the Section 4 Implementation Plan.

4. IMPLEMENTATION PLAN

An implementation plan is not a required component of a TMDL document but is a useful and logical extension of TMDL development. Implementation plans provide IDNR staff, partners, and watershed stakeholders with insight into water quality problems and can point towards a strategy for improvement.

This strategy should guide the stakeholders and the IDNR in the development of a priority based watershed plan that will implement best management practices with the goal of improving the water quality of the Black Hawk Creek and meeting the TMDL targets.

The analysis and modeling of the Black Hawk Creek watershed shows that controlling livestock manure runoff and cattle in streams would need to be a large part of a plan to reduce bacteria. Best management practices include feedlot runoff control; fencing off livestock from streams; alternative livestock watering supply; and buffer strips along the stream and tributary corridors to slow and divert runoff. In addition to these sources, failed septic tank systems need to be repaired and wastewater treatment plants need to control the bacteria in their effluent.

As noted in Section 2, open feedlots for cattle with a capacity of 1000 head or more are registered with IDNR. As part of an agreement with EPA, called the Iowa Plan for Open Feed Lots, these operations will be required to have complete runoff controls (to the 25 year, 24 hour storm) or reduce their operations to under 1000 head in 2006. As part of an implementation plan the department can see how many of these plan on implementing run-off controls and how many will be reducing below 1000 head. This is improved control that should make it possible, with adequate monitoring, to see improvements in water quality downstream of these feedlots. Since feedlots can have major impacts these changes may provide significant pollutant reductions.

It would be useful to create a local watershed advisory committee that could identify high priority areas within the Black Hawk Creek watershed where resources can be concentrated for the greatest effect. The areas with greatest impact on the stream are adjacent to streams. In addition, priority best management practices should be identified for implementation. Since the impairment problem occurs at many flow conditions, solutions will need to be implemented for non-point sources with event driven transport, non-point sources that behave like continuous sources such as cattle in streams and failed septic tank systems, and continuous point sources such as wastewater treatment plants.

5. MONITORING

Monitoring of Black Hawk Creek will continue to be done at the Waterloo ambient monitoring site by IDNR. Data collected at this site is used by the IDNR for its biannual water quality assessments (305b report) of Black Hawk Creek. IDNR will continue monthly ambient monitoring at this site.

Due to resource limitations, there are not any plans to continue targeted TMDL monitoring of the mainstem Black Hawk Creek or its major tributaries. The existing monthly monitoring being done by IDNR provides only minimal information for evaluation of the effectiveness of watershed best management practices. To really understand the Black Hawk Creek pollutant problems and effectively manage their impact through improvements to controls, additional targeted monitoring is needed.

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 Phase 1, 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 TMDL represents Phase 1 in the development of a project to improve Black Hawk Creek water quality. 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 Black Hawk Creek impairment may not occur. What is needed in a second phase are stakeholder driven solutions and more effective management practices. Continuing 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.

The first phase of the Black Hawk Creek watershed improvement plan is contained in this TMDL that sets specific and quantified targets for pathogen indicator concentrations in the stream and allocates allowable loads to all sources. An effective Phase 2 will require the participation of the watershed stakeholders in the implementation of pollutant controls and continued water quality evaluation. This will require targeted monitoring, thorough appraisal of the collected data, readjustment of allocations, and modification of management practices as shown to be necessary.

6. PUBLIC PARTICIPATION

The department has put together and implemented a plan to inform the public and stakeholders and get input and response for the Black Hawk Creek watershed TMDL project report and activities. The plan included a public meeting held on June 6, 2006 at the Grundy County SWCD office in the USDA Service Center in Grundy Center. It was held in conjunction with the regularly scheduled Grundy County SWCD meeting. The Black Hawk Creek watershed is located in Grundy, Black Hawk, and Tama Counties. The water quality problems in the watershed were discussed at these meetings and comments made have been considered during the development of this document.

A second public meeting was held in the watershed on August 3, 2006 to present and discuss the draft TMDL. The purpose of this meeting is to provide information related to the draft TMDL and to obtain public and stakeholder input and comment on TMDL development and conclusions. Comments received will be reviewed and given consideration and, where appropriate, incorporated into the TMDL.

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8. APPENDIX A – WATERSHED MAPS

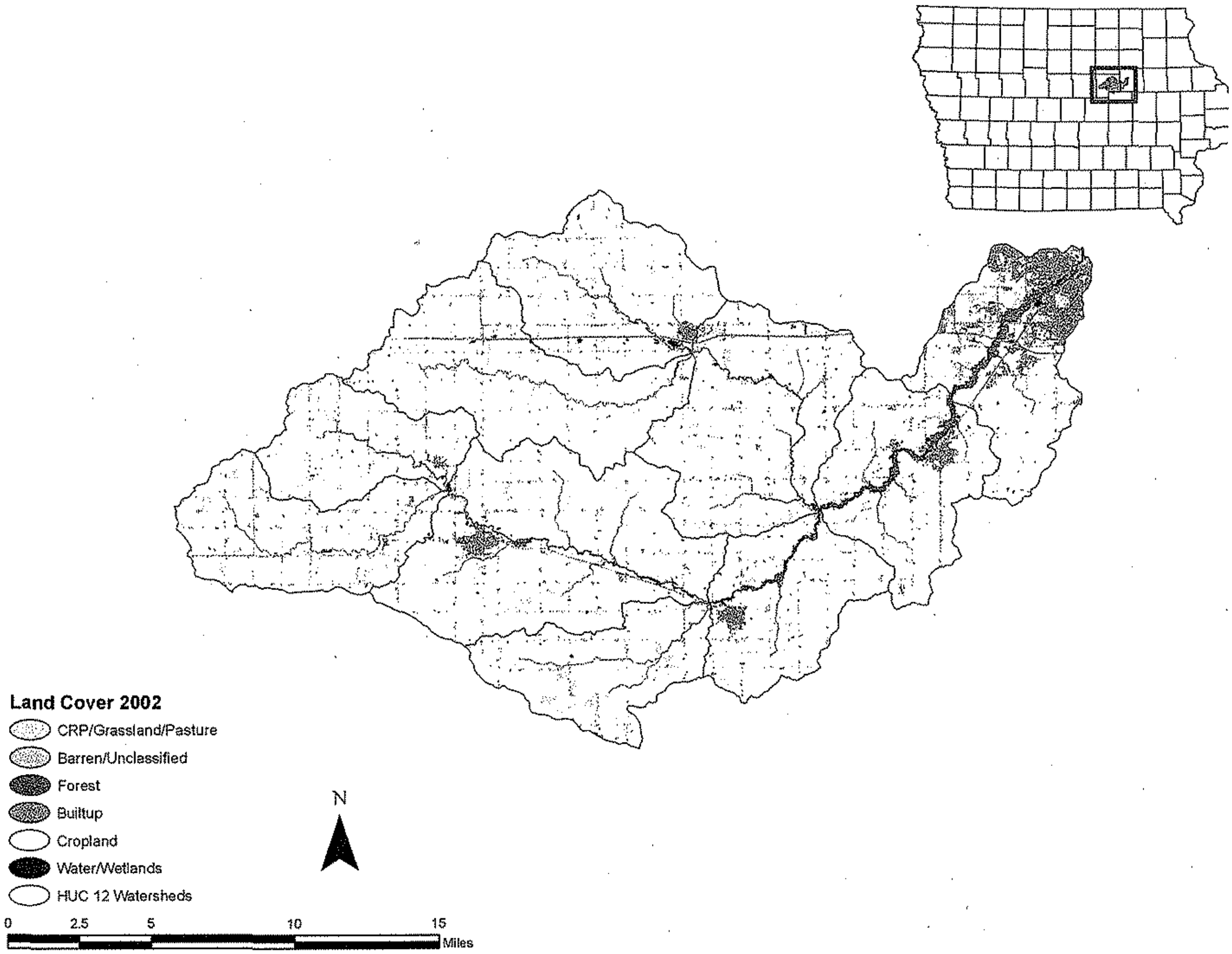

Figure A1 Landuse in the Black Hawk Creek watershed

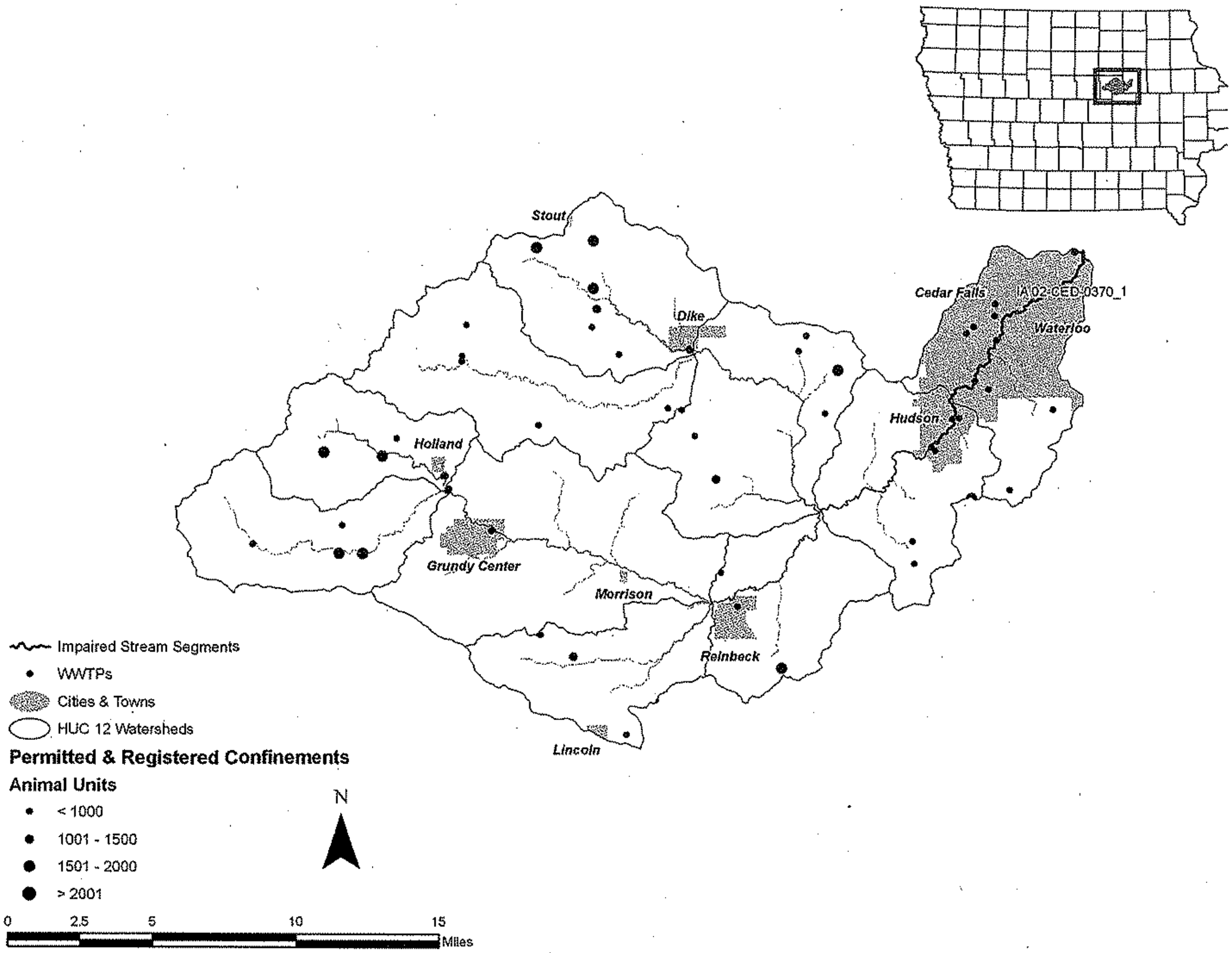

Figure A2 Black Hawk Creek watershed HUC 12's and the impaired segment

9. APPENDIX B - MONITORING DATA

The following tables contain the data from the Black Hawk Creek IDNR Ambient Monitoring at the Waterloo sampling site. Included in these tables are the fecal coliform data used to calibrate the model and the flow measured at the time of sampling. The water quality criteria for a fecal coliform geometric mean is 200 organisms/100 ml and for the single sample maximum is 400 organisms/ 100 ml.

Table B1 1999 Monitoring Data

Sampling Date	Fecal coliform, organisms/100 ml	Measured Instantaneous Flow, cfs
10/25/99	70	33
11/09/99	91	45
12/09/99	70	36

Table B2 2000 Monitoring Data

Sampling Date	Fecal coliform, organisms/100 ml	Measured Instantaneous Flow, cfs
01/11/00	70	58
02/03/00	81	32
03/23/00	20	58
04/12/00	20	43
05/04/00	64	35
06/05/00	1100	300
07/11/00	6700	3000
08/08/00	820	155
09/07/00	270	63
10/05/00	420	26
11/08/00	20000	135
12/13/00	200	32

Table B3 2001 Monitoring Data

Sampling Date	Fecal coliform, organisms/100 ml	Measured Instantaneous Flow, cfs
01/11/01	130	40
02/12/01	120	53
03/13/01	750	150
04/05/01	64	430
05/03/01	5700	350
06/05/01	190	340
07/04/01	120	130
08/02/01	360	90
09/05/01	430	29
10/02/01	270	63
11/05/01	20	70
12/06/01	350	57

Table B4 2002 Monitoring Data

Sampling Date	Fecal coliform, organisms/100 ml	Measured Instantaneous Flow, cfs
01/07/02	190	25
02/07/02	0	37
03/06/02	30	
04/03/02	10	59
05/02/02	110	210
05/13/02	1100	
05/14/02	720	350
06/06/02	640	170
07/09/02	620	120
08/05/02	370	38
09/09/02	130	45
10/03/02	140	55
11/11/02	73	60
12/05/02	10	42

Table B5 2003 Monitoring Data

Sampling Date	Fecal coliform, organisms/100 ml	Measured Instantaneous Flow, cfs
01/07/03	10	35
02/04/03	30	
03/06/03	91	
03/13/03	10	
04/03/03	30	37
05/01/03	5800	
05/02/03	2000	450
05/03/03	1200	340
05/03/03	1000	
05/06/03	12000	880
05/06/03	2400	
05/07/03	910	820
05/07/03	9200	940
05/07/03	900	
06/03/03	210	240
07/01/03	520	190
08/07/03	130	53
09/04/03	200	20
10/01/03	73	15
11/04/03	15000	
11/05/03	52000	170
11/05/03	6000	
12/03/03	40	27

Table B6 2004 Monitoring Data

Sampling Date	Fecal coliform, organisms/100 ml	Measured Instantaneous Flow, cfs
01/08/04	10	
02/04/04	55	
03/04/04	210	150
04/05/04	10	200
05/03/04	130	100
05/24/04	8300	2500
06/03/04	550	730
07/07/04	2000	190
08/03/04		60
08/05/04	25000	
08/05/04	14000	490
08/06/04	3600	
08/06/04	3300	
09/08/04		62
10/06/04		22
11/03/04		42