Water Quality Improvement Plan for

McLoud Run

Linn County, Iowa

Total Maximum Daily Load
for Thermal Modifications

Iowa Department of Natural Resources
Watershed Improvement Section
2007

Table of Contents

List of Figures 4
List of Tables 6
General Report Summary 7
Technical Elements of the TMDL 9
1. Introduction 11
2. Description and History of McLoud Run 12
2.1. McLoud Run 12
Hydrology. 12
Morphometry & Substrate. 12
2.2. McLoud Run Watershed 13
Land Use. 13
Soils, climate, and topography. 14
3. Total Maximum Daily Load (TMDL) for Temperature 16
3.1. Problem Identification 16
Applicable water quality standards. 16
Data sources. 17
Interpreting McLoud Run data. 18
3.2. TMDL Target 20
General description of the pollutant. 20
Selection of environmental conditions. 21
Waterbody pollutant loading capacity (TMDL). 21
Decision criteria for water quality standards attainment. 23
3.3. Pollution Source Assessment 23
Existing load. 23
Departure from load capacity. 23
Identification of pollutant sources. 24
Allowance for increases in pollutant loads. 27
3.4. Pollutant Allocation 28
Wasteload allocation. 28
Load allocation. 28
Margin of safety. 28
3.5 TMDL Summary 29
4. Implementation Plan 30
4.1. Past work in the McLoud Run Watershed 30
4.2. General Approach & Reasonable Timeline 30
4.3. Best Management Practices 32
Upland BMPs for heat load reduction. 32
In-stream BMPs for heat load dissipation. 32
Scenario modeling. 33
4.4. Reasonable Assurance 35
5. Future Monitoring 36
5.1. Monitoring Plan to Track TMDL Effectiveness 36
5.2. Idealized Plan for Future Watershed Projects 37
General data needs. 37

Monitoring design. 38
6. Public Participation 41
6.1. Public Meetings 41
6.2. Written Comments 41
7. References 42
8. Appendices 45
Appendix A --- Glossary of Terms and Acronyms 45
Appendix B --- General and Designated Uses of Iowa's Waters 51
Appendix C --- Water Quality Data 54
Appendix D --- Modeling Equations and Methodology 60
Storm Water Management Model (SWMM) Modeling. 60
Flow and temperature mathematical calculations. 61
Temperature Urban Runoff Model (TURM) Modeling. 63
HeatSource Modeling. 65
Appendix E --- Additional Maps & Figures 69
Appendix F --- Public Comments 75

List of Figures

Figure 1.	A trout angler enjoying Iowa's only urban trout stream, McLoud Run (Image courtesy of NRCS).	7
Figure 2.	McLoud Run (images courtesy of Coe College).	8
Figure 3.	The McLoud Run watershed in Linn County, Iowa.	13
Figure 4.	Selected temperature violations in McLoud Run in 2003.	17
Figure 5.	Location of continuous temperature loggers and fish kill segment.	18
Figure 6a.	Thermal enrichment at the "upper" monitoring site in McLoud Run on August 11^{th}, 2003.	19
Figure 6b.	Thermograph at the "lower" monitoring site for the same date depicting no water quality standard violation.	20
Figure 7.	Maximum heat load capacity curve for McLoud Run based on variable flow conditions.	22
Figure 8.	Stormwater outfalls and culverts in Cedar Rapids.	25
Figure 9.	Runoff temperature modeling using the Temperature Urban Runoff Model (TURM).	26
Figure 10.	Estimated total heat load potential for lumped land use categories in the McLoud Run watershed (2-year return storm).	27
Figure 11.	Alternative riparian vegetation modeling scenarios for McLoud Run.	34
Figure 12.	Predicted stream temperatures during thermal shock event under two alternative vegetation scenarios.	35
Figure 13.	Major tributary basins in the McLoud Run watershed.	40
Figure C-1.	Thermograph at the upper monitoring site on July 20, 2003.	57
Figure C-2.	Thermograph at the lower monitoring site on July 20, 2003.	57
Figure C-3.	Thermograph at upper monitoring site on August 26, 2003.	58
Figure C-4.	Thermograph at lower monitoring site on August 26, 2003.	58
Figure C-5.	Thermograph at the upper monitoring site on August 3, 2004.	59
Figure C-6.	Thermograph at the lower monitoring site on August 3, 2004.	59
Figure D-1.	SWMM hydrograph model calibration for McLoud Run.	60
Figure D-2.	SWMM simulation for 7/20/2003 temperature violation.	61
Figure D-3.	SWMM simulation for 8/11/2003 temperature violation.	61
Figure D-4.	Flow duration curve for McLoud Run using limited data.	63
Figure D-5.	HeatSource model calibration (summer 2003).	67
Figure D-6.	Estimated heat loads at the lower temperature logger in McLoud Run during dry weather conditions.	68
Figure E-1.	Estimated time of concentration (travel time) of stormwater runoff in McLoud Run.	69
Figure E-2.	Total potential heat loads by land use category in McLoud Run watershed for a 2-year return storm.	70
Figure E-3.	Potential heat loads in McLoud Run watershed normalized by time of delivery.	71

Figure E-4. Major stormwater drainage areas in McLoud Run. 72
Figure E-5. Average estimated amount of connected impervious area in land use parcels. 73
Figure E-6. City boundaries in McLoud Run watershed. 74

List of Tables

Table 1.	Land use distribution in the McLoud Run watershed.	14
Table 2.	Selected TMDL values for various flow conditions.	23
Table 3.	Stormwater NPDES-permitted point sources in the McLoud Run watershed.	24
Table 4.	General timeline for McLoud Run watershed plan.	31
Table 5.	Monitoring timeline.	37
Table 6.	Description of major tributary basins shown in Figure 11.	40
Table B-1.	Designated use classes for Iowa water bodies.	52
Table C-1.	Violation of state water quality standard for temperature on July 20, 2003.	54
Table C-2.	Violation of state water quality standard for temperature on August 11, 2003.	55
Table C-3.	Violation of state water quality standard for temperature on August 26, 2003.	55
Table C-4.	Violation of state water quality standard for temperature on August 3, 2004.	56
Table D-1.	TURM meteorological input parameters.	64
Table D-2.	TURM inputs by land use category.	65
Table D-3.	Physical parameters for calibrated HeatSource model.	66

General Report Summary

Figure 1. A trout angler enjoying Iowa's only urban trout stream, McLoud Run (Image courtesy of NRCS).

What is the purpose of this report?

This report serves dual purposes. First, it is a resource to be used by water quality action groups, individual citizens, watershed planners, and local and state government officials. It can help these groups identify the key causes and solutions to the temperature impairment in McLoud Run for future watershed work. Second, this report satisfies the Federal Clean Water Act requirement to establish a Total Maximum Daily Load (TMDL) for impaired waters.

What's wrong with McLoud Run?

McLoud Run is being adversely impacted by heated runoff from urban areas. In August 2001, 184 trout were found dead along a 1.5-mile stretch of the stream after a brief summer rain event. These fish died as the result of heat shock when a sudden spike in temperature stressed the fish. Data from stream monitoring in more recent years shows that the problem continues to exist.

What is causing the problem?

During the summer, parking lots, roof tops, buildings, and other unnatural surfaces capture and retain heat. When extremely hot weather is followed by summer rains, heated stormwater runoff is quickly delivered to the stream causing its temperature to rise rapidly. Trout, being a sensitive fish, do not tolerate extreme changes in water temperature and poor water quality.

What can be done to improve McLoud Run?

To help McLoud Run, stormwater runoff from rain events needs to be cooled off, slowed down, and allowed to infiltrate (soak into the soil). Local homeowners in the watershed can help by using practices such as rain gardens that capture and hold runoff, allowing it to seep into the ground. Business owners and government officials can help by limiting the size and connectivity of parking lots within the watershed, and by installing strips of grass vegetation along the length of the stream to cool and slow down runoff. Reflective or light-colored paint and more urban shade trees should be used in parking areas throughout the watershed to reduce heating on hard surfaces. Other options for parking lots and paved areas include pervious pavement and detention basins to capture & delay stormwater runoff. Habitat improvements in the stream, such as bank hides, riffle and pool sequences, and channel re-meandering will help buffer the thermal shock and allow more fish to survive these events. Finally, regular and continuous monitoring of the stream needs to be done. This will help determine whether the problem persists as improvements are made in the watershed and will also help diagnose problematic areas.

Who is responsible for a cleaner McLoud Run?

There is no single, identifiable source of the heat pollution in McLoud Run that can be dealt with directly. City and state government agencies are working together to better understand where the dominant sources of pollution in McLoud Run are, but everyone who lives or works in the watershed and who cares about McLoud Run is responsible for helping the stream. People and groups who live outside of the watershed can help by informing and educating others about the issues, causes, and potential solutions to the problems. Improvements to the stream will happen most quickly if local interest spurs voluntary action among people living and working in the watershed.

Figure 2. McLoud Run (images courtesy of Coe College).

Technical Elements of the TMDL

Name and geographic location of the impaired waterbody:	McLoud Run, located in Cedar Rapids, IA, from the mouth (SW ¼ S16, T83N, R7W) to the headwaters (SW ¼ S5, T83N, R7W).
Waterbody segment identification number:	02-CED-0218_0
Surface water classification and designated uses:	Primary contact recreation (Class A) and warmwater aquatic life (Class B).
Impaired use(s):	Warmwater aquatic life (Class B).
TMDL priority level:	High priority stream.
Identification of the pollutant and applicable water quality standards:	Temperature (heat) delivered via surface runoff. State water quality standards for all Class B streams allow for a maximum increase of 1°C per hour.
Quantification of the pollutant load that may be present in the waterbody and still allow attainment and maintenance of water quality standards:	The total maximum daily load for heat in McLoud Run (corresponding to a maximum temperature increase of 1°C per hour) ranges from 6.0×10^5 to 3.3×10^7 kilojoules/day, depending on streamflow conditions (Table 2).
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:	Estimated heat loads in McLoud Run have been as high as 6.5×10^6 kilojoules/day (based on measured increases in temperature of up to 10.6°C per hour), requiring a 91% reduction in heat delivery to attain water quality standards under critical environmental conditions.
Identification of pollution source categories:	The heat pollution in McLoud Run originates from dispersed, impervious areas throughout the watershed delivered via point source stormwater outfalls. These outfalls are covered by NPDES (MS4) permits for the cities of Cedar Rapids and Hiawatha.

	Specifically, pollution sources consist of unnatural hard surfaces (parking lots, roofs, roads, etc.) that collect and retain heat during the day and transmit that heat to the stream via surface runoff.
Wasteload allocations for pollutants from point sources:	Equivalent to TMDL. Ranges from 6.0 x 10^5 to 3.3 x 10^7 kilojoules/day, depending on streamflow conditions.
Load allocations for pollutants from nonpoint sources:	The entire McLoud Run watershed area is covered by NPDES MS4 permits, thus the load allocation for nonpoint sources is zero.
A margin of safety:	Implicit, based upon conservative assumption of instantaneous heat delivery and even mixing at steady state (low flow) conditions.
Consideration of seasonal variation:	The TMDL was calculated for a range of seasonal flow conditions using a load duration curve approach. Calculated TMDL values correspond to low flow conditions when the stream is most vulnerable to thermal shock.
Allowance for reasonably foreseeable increases in pollutant loads:	No allowances for an increase in pollutant loads were given, since the watershed is essentially fully developed by urban and residential land uses.
Implementation plan:	A general implementation plan is provided in Chapter 4 of this document to provide guidance for local citizens, government, and water quality groups.

1. Introduction

The Federal Clean Water Act of 1972 requires that all states develop lists of impaired waters which are not meeting designated water quality standards. This list is commonly called the 303(d) list. In addition, a Total Maximum Daily Load (TMDL) report must also be developed for each impaired waterbody that appears on the list.

A TMDL is a calculation of the maximum amount of pollution a waterbody can tolerate without exceeding its water quality standards. The report must allocate portions of the total maximum daily load to nonpoint and point sources (called the load allocation and wasteload allocation, respectively), allow for a margin of safety, and account for seasonal variations in hydrology and pollutant loading. Usually, TMDLs are expressed in units of mass per day.

This document is the TMDL report for McLoud Run, located in Linn County, Iowa. McLoud Run was first listed as impaired in 2002 for thermal modifications, and has remained on the state's impaired waters list since then. The reason for its listing was a fish kill that occurred on August 2, 2001, in which heat shock killed 184 trout. As an impaired water, a TMDL must be developed for temperature (heat) pollution in McLoud Run.

There are two primary purposes of this report: a) serve as a resource for guiding future water quality projects in the McLoud Run watershed to address stream temperature issues, and b) satisfy federal requirements that a Total Maximum Daily Load be developed for all impaired waters. Local citizens, water quality groups, and governments should find it useful for outlining the causes, nature of, and solutions to the thermal enrichment problems that exist in the stream.

This TMDL report is most functional as a resource that can be used to guide on-the-ground, grassroots projects that are coordinated and targeted to address activities in the entire watershed. Neither this report nor government action alone can explicitly fix the impairment in McLoud Run; for that it will take citizen activism and involvement. The water quality in McLoud Run is a direct reflection of the surrounding land which drains to it and how it is managed, and as such, local landowners, businesses, tenants have the most power in deciding how good its water quality is.

2. Description and History of McLoud Run

McLoud Run is located in Linn County, Iowa, in the city of Cedar Rapids. It flows for a length of 4 miles (6.4 km) before joining the Cedar River in the heart of the metropolitan area. The stream fills an important recreational and cultural niche in the community and is touted as Iowa's only urban trout stream.

Historically, the stream was used by local residents as a source of cold water for home use, and according to Murray and Murray (1950), a state fish hatchery was located there in the 1870's (St. Clair, 2006). Over time, the stream's primary uses shifted to those of the present day, where it serves as both a recreational resource and drainage system for the cities of Cedar Rapids and Hiawatha.

2.1. McLoud Run

Hydrology. McLoud Run is a perennially-flowing stream that is influenced by both surface and groundwater sources. During storm events, McLoud run exhibits extreme flashiness as water levels rise quickly with rapid surface runoff delivery (St. Clair, 2006). Average annual flow in the stream is approximately 2 cubic feet per second (cfs), but can vary widely (Bickner, 2001). During extremely dry conditions, steady flows of 0.2-0.5 cfs are commonly measured, with less than 0.1 cfs being the measured minimum (see flow duration curve in Appendix D). However, stream discharge during storm events can rapidly increase from less than 1 cfs to 30-45 cfs. Peak storm flows have been measured as high as 112 cfs (monitoring data from 7/11/2006-9/14/2006). After storm events, flow in McLoud Run often quickly returns to normal. During base flow conditions, a perennial spring discharges cold groundwater to the stream which makes it suitable for a trout stocking program by the Iowa Department of Natural Resources (IDNR) (St. Clair, 2006; Bickner, 2001).

The flashy conditions exhibited by McLoud Run are due to the high percentage of impervious surfaces in its watershed, along with a well-engineered drainage system. Because McLoud Run is situated in an urban setting, flooding is a concern and the stream provides the primary drainage mechanism for many municipal storm sewers and portions of U.S. Interstate 380, as well as several other streets and highways along its course. Due to its engineered nature it is difficult to determine where the stream begins, and often it disappears from view as it flows for long stretches at a time in underground culverts. At its lower end (just before the mouth), a portion of the stream flow is diverted into Cedar Lake, but the gate is not controlled regularly. Thus, an unknown fraction of the flow from McLoud Run may be flowing into Cedar Lake at any given time, with the rest making it directly to the Cedar River.

Morphometry & Substrate. In the upper reaches (headwaters) of the stream, stream width tends to be very narrow (3-6 ft). Moving downstream, bankfull width widens to an average of approximately 25 ft near the mouth. Depths in the stream vary greatly, with generally shallow water (1-4 ft) in most areas. However, at least two uniquely deep pools (~ 8 ft) occur in the lower half of the channel and provide fish habitat. The stream has other diverse habitats which include prominent pool and riffle sequences, gravel and cobble substrate, and portions that flow directly over limestone bedrock (St. Clair, 2006). Just before the stream enters the Cedar River, it flows through a ¼-mile stretch of open concrete channel.

2.2. McLoud Run Watershed

Land Use. The land that drains to McLoud Run is dominated by urban and developed uses, with the entire 5-square mile watershed being bound by the City of Cedar Rapids and the City of Hiawatha (87 percent and 13 percent of the watershed area, respectively). Figure 3 depicts the watershed boundary for McLoud Run. Table 1 lists land use categories obtained from the City of Cedar Rapids and their distribution in the watershed. Land use data for the City of Hiawatha was interpreted from 2005 aerial photography according to the same categories.

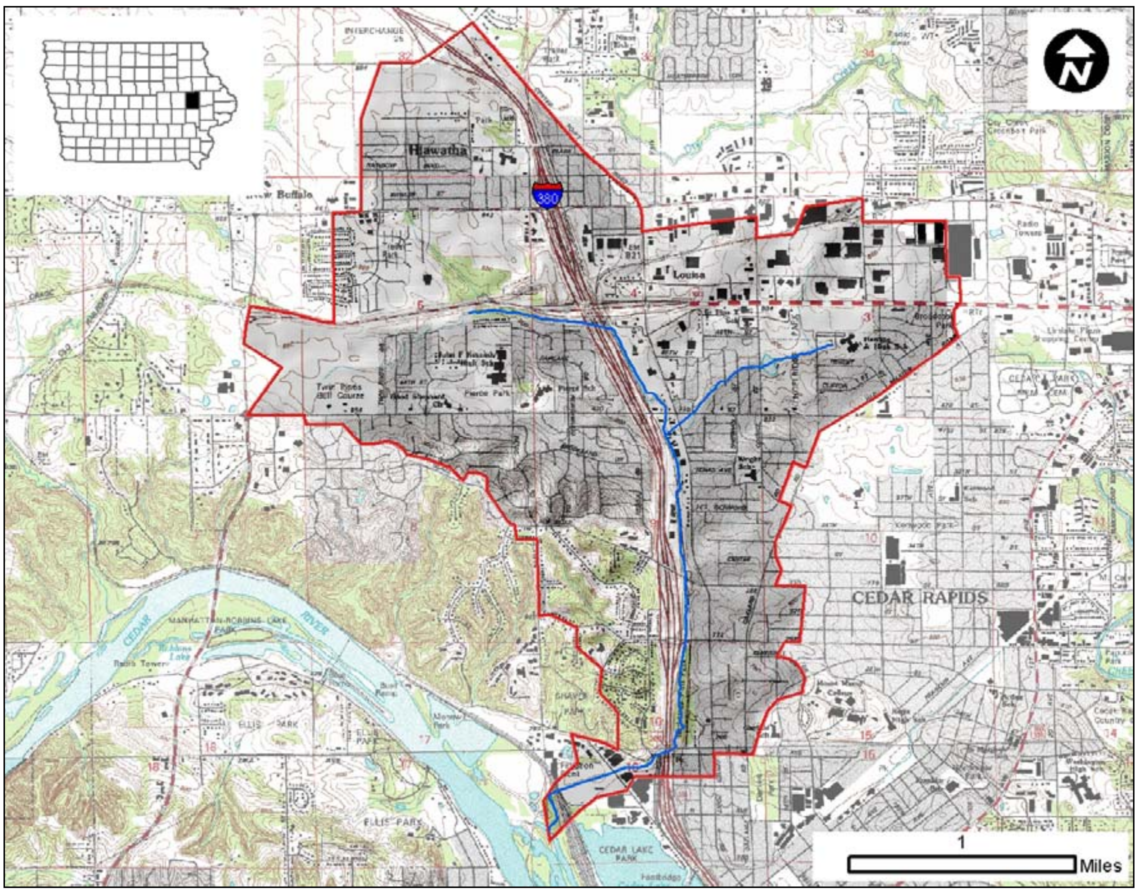

Figure 3. The McLoud Run watershed in Linn County, Iowa.

The major land use in McLoud Run's watershed is residential, classified as "low" or "medium" density. A significant portion is paved roadways, including residential streets, highways, and Interstate 380, the latter of which dissects the watershed from North to South right through the middle. Much of this interstate highway immediately borders the stream, and there is a two mile stretch of McLoud Run that is bordered by both the interstate highway and the Illinois Central Railroad (Bickner, 2001). Other prominent land uses include commercial businesses, parks/open spaces, and industrial complexes.

Table 1. Land use distribution in the McLoud Run watershed.

Increasing Amount ↓	Description	Acres	Percent of total (%)
	Agricultural/Conservation	10	0.3
	Office	69	2.2
	High Density Residential	76	2.4
	Institutional/Public	122	3.8
	Industrial	126	3.9
	Commercial/Industrial	141	4.4
	Parks and Open Spaces	316	9.9
	Medium Density Residential	344	10.8
	Commercial	353	11.0
	Roads	713	22.3
	Low Density Residential	923	28.9
	Totals:	**3,193**	**100**

Soils, climate, and topography. The McLoud Run watershed is positioned on the Iowan Surface Ecoregion (Level IV) (Chapman et al., 2001). This landform is broadly characterized by long, gentle slopes and mature drainage patterns. Rivers in this region have relatively low gradients, as there is little topographic relief. Geologic materials include limestone bedrock, glacial till, and loess (Prior, 1991). Karst features (e.g., sinkholes) are common in some areas, and McLoud Run is believed to be directly fed by groundwater discharge from a localized spring (St. Clair, 2006; Bickner, 2001).

Dominant soil types in the watershed include those in the Kenyon-Clyde-Floyd association, in which a "swell-and-swale" topography results in low gradient drainageways. According to Schermerhorn and Highland (1975), rocks and boulders (glacial erratics) are common and conspicuous features in this landscape. Slope classes in the watershed range from 0-2 percent to 9-18 percent, with the steepest areas occurring in the western half of the watershed. However, most of the upland soils in the watershed are paved over or built upon, and thus their contact with direct precipitation is limited. Soils along the stream itself are mainly Spillville series, developed in alluvium under prairie grasses.

Climate in the McLoud Run watershed is typical for the upper Midwest: summers can be hot and winters can be cold, and rapid changes in weather conditions are frequent throughout the year. Temperatures of 90°F or greater occur on 22 days per summer, on average. Annually, the hottest day in summer averages 97°F. Long term average annual precipitation in Linn County is 33.4 inches, with approximately 75 percent of that amount falling during the growing season (April – September) (Schermerhorn and Highland, 1975).

3. Total Maximum Daily Load (TMDL) for Temperature

A Total Maximum Daily Load (TMDL) is required for McLoud Run by the Federal Clean Water Act. This chapter will quantify the maximum amount of heat that McLoud Run can tolerate without violating the state's water quality standards.

3.1. Problem Identification

Applicable water quality standards. As of March 22, 2006, McLoud Run is designated for primary contact recreation (Class A1) and warm water aquatic life (Class B(WW-1)) uses by Iowa's water quality standards (IAC, 2006)[†]. Specific temperature criteria apply to all Class B waters in the state of Iowa. The Iowa water quality standards (IAC, 2006) state that:

"No heat shall be added to interior streams…that would cause an increase of more than 3°C. The rate of temperature change shall not exceed 1°C per hour. In no case shall heat be added in excess of that amount that would raise the stream temperature above 32°C."

These criteria are based on acute changes in water temperature resulting from direct, anthropogenic additions of heat to the stream (point source). For the purposes of TMDL development in McLoud Run they do not apply to chronic heating of the stream from natural solar inputs (background sources) or nonpoint source inputs. Since it is necessary to include an associated time interval to go along with any change in water temperature, the applicable water quality standard for McLoud Run is given as a maximum temperature increase of 1°C per hour.

Problem statement. Temperature in McLoud Run is exceeding the state's water quality standard of a maximum increase of 1°C per hour. The first evidence of this was documented in an Iowa DNR report of a fish kill which occurred on August 2, 2001 (Bierman, 2001). According to that report, over 180 trout were killed after a late summer rain event washed heated surface runoff into the stream, raising water temperatures by 19°F (equivalent to 10.6°C increase) in one hour. This prompted the Iowa DNR to include McLoud Run on its 2002 impaired waters list (303(d) list).

Investigation into the matter provides evidence that the August 2, 2001 fish kill was not a one-time anomaly. Figure 4 depicts more temperature violations in McLoud Run for the days of July 20th, August 11th, and August 29th of 2003. All three were brought about by rain events during warm weather. In these instances, hourly temperature increases of up to 8°C can be seen. At least five violations occurred during the period of record in 2003 and 2004 (which span approximately four months in 2003 and seven months in 2004). Although none of these violations (since 2001) have resulted in fish kills, data indicate that the water quality standards are not being met and thus a TMDL is required.

[†] Final use designations are dependent on Use Attainability Analysis. For background information on use designations for Iowa's water bodies, see Appendix B.

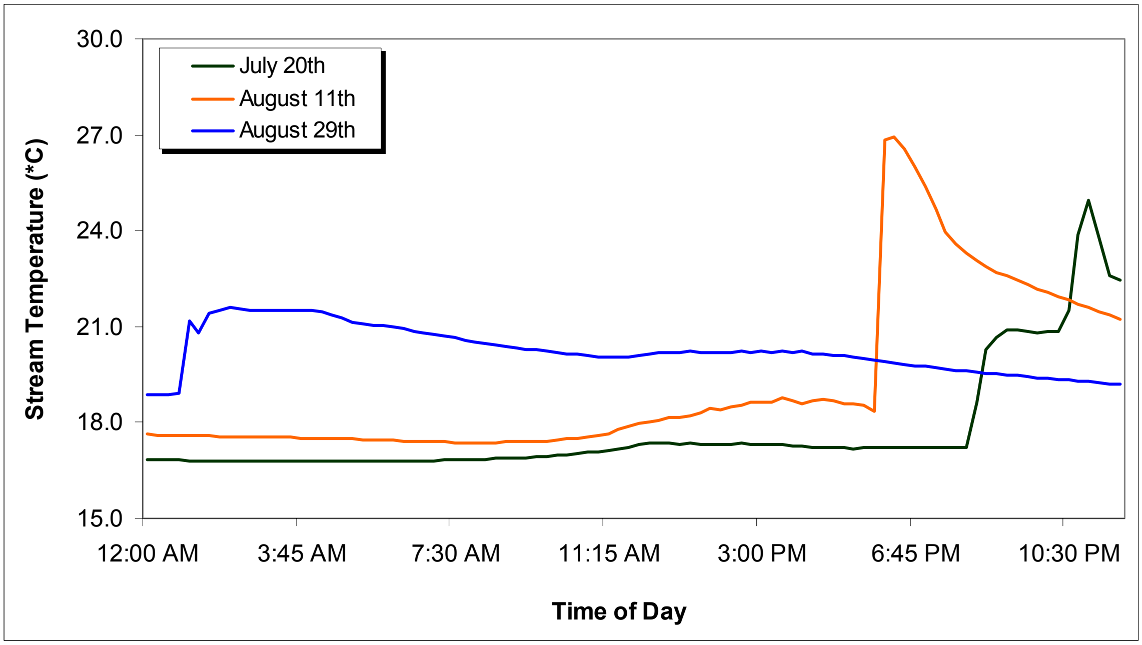

Figure 4. Selected temperature violations in McLoud Run in 2003.

Data sources. Stream temperature data was provided by a number of sources, including the City of Cedar Rapids; Coe College; and Iowa DNR Fisheries Bureau. Of these three sources, data from the third was the only one that could be used to identify specific violations of the water quality standards, because it was the only of the three which logged stream temperature continuously throughout the day (at fifteen minute intervals) to measure rapid changes in water temperature (see Appendix C). The City of Cedar Rapids temperature data consisted of single instantaneous samples taken after storm events as part of their MS4 (Municipal Separate Storm Sewer System) permit (required by the National Pollution Discharge Elimination System (NPDES)). The data from Coe College consisted of daily or weekly monitoring done during the summers of 2002-2005, which was being collected for various student research projects and educational purposes. The Coe College and City of Cedar Rapids data provided supporting evidence for characterizing the ambient stream temperature conditions in McLoud Run. The City of Cedar Rapids also provided continuous data for the flow rates in McLoud Run.

The continuous temperature devices maintained by Iowa DNR are usually deployed in early summer and left to collect data through autumn. They are located at two sites, about one mile apart, with the lower (downstream) site being near the south end of McLoud Run Park and the upstream site being near the railroad trestle which crosses McLoud Run (Figure 5). These sites shall henceforth be referred to as the “lower” and “upper” monitoring stations, respectively. Unfortunately, vandalism and/or theft have been prevalent and the most recent data available for development of this TMDL was from the 2003 and 2004 season.

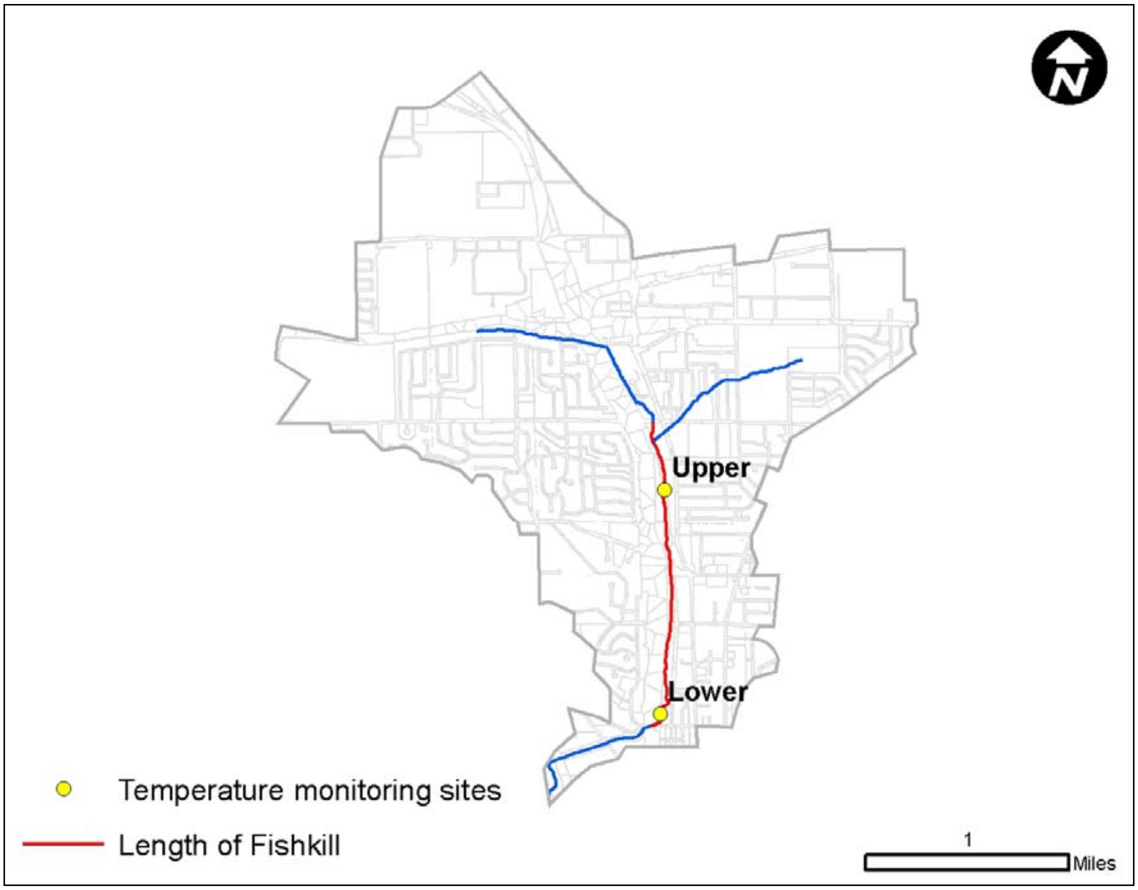

Figure 5. Location of continuous temperature loggers and fish kill segment.

Climate data was obtained from two sources: 1) precipitation data from the City of Cedar Rapids, which maintains a continuously-logging rain gage near McLoud Run; and 2) meteorological data from the Iowa Ag Climate Network (IEM, 2006) for the station based in Cedar Rapids.

Geographic data was also used to assist the development of this TMDL. The City of Cedar Rapids provided detailed spatial coverages of land use, parcel boundaries, watershed boundaries, storm sewer pipe and outfall locations, and other supporting data. Aerial photography (also from the City of Cedar Rapids) consisted of 6" resolution color images taken in 2005. Finally, a 30 m (100 ft) resolution digital elevation model (DEM) was obtained from the United States Geologic Survey (USGS) via the IDNR GIS Library (IDNR, 2006). This DEM was used for modeling purposes explained in section 3.3 and Appendix D of this report.

Interpreting McLoud Run data. Appendix C provides data for selected violations of the hourly temperature water quality standards in McLoud Run. These violations are the result of extreme temperature spikes which directly follow rain events during the summer (e.g., the 2001 fish kill). Figure 6a shows a good example of this "thermal enrichment" for August 11, 2003. Note that a small rainfall at 5:00 AM had no effect on stream temperature, but that an event later in the day at 6:00 PM coincided with an extreme rise in stream temperature. Similar instances can be documented for other dates at this upper monitoring site, and are included in Appendix C.

Data indicate that the upper thermograph site is being more acutely affected by thermal enrichment than the lower monitoring site. Figure 6b shows that, for the same violation shown in Figure 6a, there is no change in stream temperature associated with the rain event at the lower monitoring site. This is common for the documented violations on other dates, as well. This is probably due in part to the upper monitoring site's close proximity to the natural spring which feeds cold groundwater to the stream of constant temperature. However, it could also imply that the source of pollution is in close proximity to the stream and probably close to the monitoring device itself. The minor amounts of rainfall (between 5/100th and ½ inch) which are associated with the rapid and extreme temperature spikes in the stream would support this notion. Heavier and longer duration rains could be expected to deliver heat to the stream initially, but would gradually cool paved surfaces and dilute heat loads as stormwater volume increases.

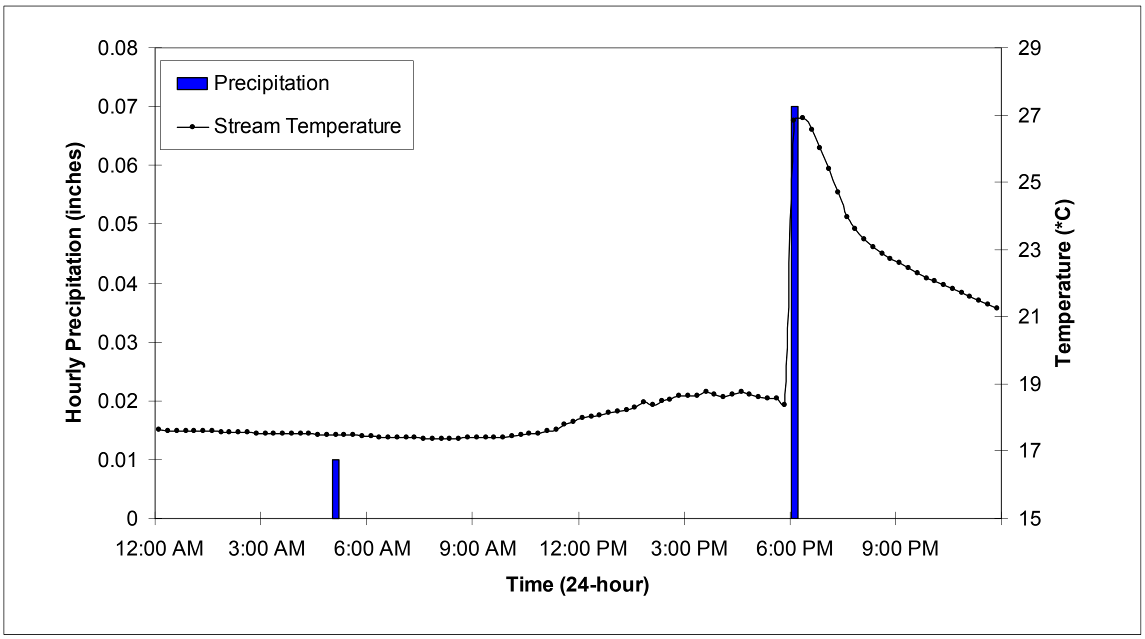

Figure 6a. Thermal enrichment at the "upper" monitoring site in McLoud Run on August 11th, 2003.

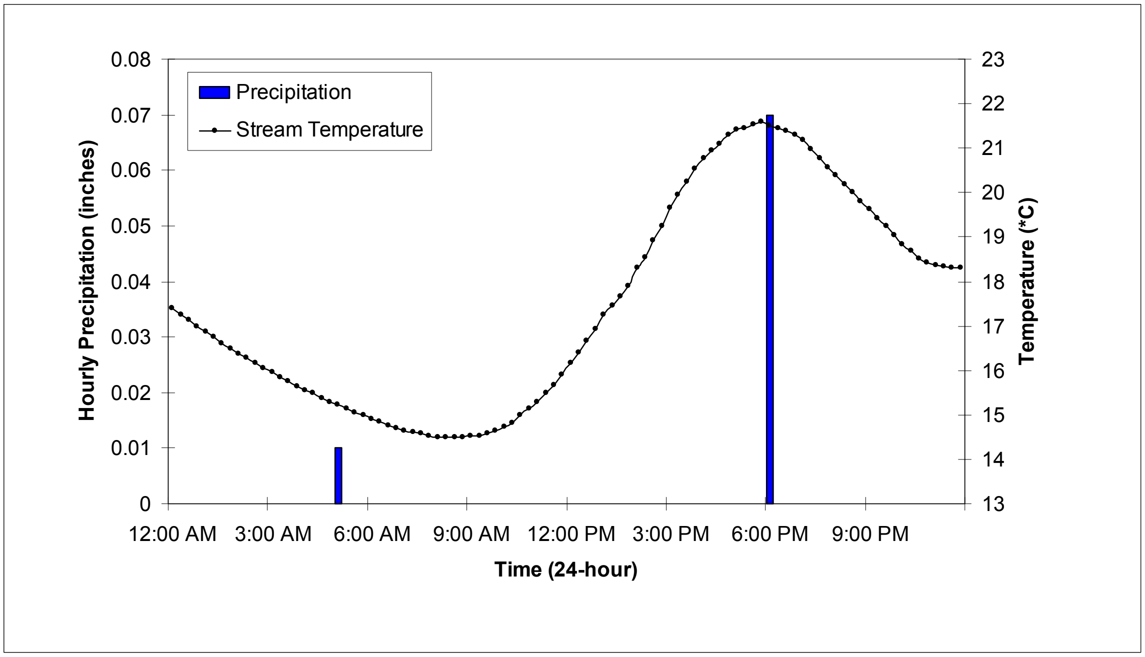

Figure 6b. Thermograph at the "lower" monitoring site for the same date depicting no water quality standard violation.

Overall, the information and data indicate that McLoud Run is experiencing temperature fluctuations harmful to aquatic life, and that the upstream monitoring site is being influenced more acutely, while the impacts at the downstream monitoring site tend to be diminished somewhat. On certain occasions, though, the downstream monitoring site also experiences violations of the hourly water quality standard for temperature.

3.2. TMDL Target

General description of the pollutant. Temperature is a critical physical factor affecting aquatic life and the stream ecosystem (Allen, 1995). Stream temperature is best conceptualized as a concentration of heat energy in the water, as the following relationship shows:

Water temperature α *heat energy/water volume* (Poole and Berman, 2001)

This means that stream temperature is dependant upon both the heat load and volume of water (discharge). Additions of water at a lower temperature would dilute the heat concentration and result in a lowering of stream temperature. Additions of heat energy to a stream without water would increase the concentration of heat energy in that stream and increase its temperature. Streams can gain or lose heat energy through additions or losses of water (mass transfer), or by interactions with the atmosphere and surrounding environment (heat transfer). Examples of the former include tributary inflows, surface runoff, and groundwater discharge, while the latter include solar radiation, longwave (thermal) radiation, streambed conduction, stream/air convection, and evaporation (Boyd and Kasper, 2003). Riparian vegetation insulates and moderates water temperature, and the width of the channel is determinant of the amount of surface area exposed to heat exchange processes. Hyporheic flow (dynamic flow exchanged between the stream channel and alluvial aquifer) is an important buffering agent of stream temperature as heat and mass transfers occur at varying spatial and temporal scales (Poole and Berman, 2001).

Selection of environmental conditions. As the previous section suggests, stream temperature is a complex and dynamic property that is dependent upon a host of physical variables (e.g. air temperature, humidity, wind speed, solar radiation, stream bed substrate, flow rate, depth, etc.). Furthermore, quantitative models for predicting stream temperature are generally limited to one dimension in space (longitudinal from upstream to downstream) and are unable to portray dynamic heat transfer from upland areas to the stream during storm events. Therefore, specific environmental conditions are chosen which are representative of the situation when violations are occurring or are most likely to occur. The "critical" conditions also serve to characterize the stream for modeling purposes.

The critical environmental conditions for McLoud Run are when the stream is at base flow (low flow) discharge and when extreme heat (air temperatures over 90°F) occurs for multiple days. Temporally, these conditions may occur between the months of April to October (conservatively). Any amount of rain that falls under these circumstances is included in the critical conditions, as only minor amounts (as little as ½ inch) are needed to cause extreme stream temperature spikes.

To support the development of existing load and TMDL calculations, the Storm Water Management Model (SWMM) (USEPA, 2005) was used to predict stream flow response to single storm events during dry weather conditions in the McLoud Run watershed (Appendix D). The results from this exercise show that maximum temperature spikes occurred while the stream was still at low flow conditions or before peak flow on the storm hydrograph, meaning that the maximum heat load is delivered to the stream very quickly and while it is most vulnerable to thermal shock.

Waterbody pollutant loading capacity (TMDL). The amount of heat pollution McLoud Run can tolerate corresponds with the state's numerical water quality standard of a maximum increase in stream temperature of 1°C per hour (associated with point source discharges). Since water temperature is an intensive property that is independent of water volume, similar to pH or concentration, and because TMDLs are typically expressed as a mass quantity per day, it is necessary to convert units from temperature to heat loads while accounting for varying streamflow conditions. Therefore, a curve-based TMDL/loading capacity approach was utilized along with a simple heat balance equation to relate changes in water temperature and discharge to mass heat load. Appendix D provides information on the heat balance equation used to calculate this TMDL, which has been widely used by others in surface water quality modeling and heat budget calculations (Chapra, 1997; Bedient and Huber, 1992; Thomann and Mueller 1987; Van Buren, 1999).

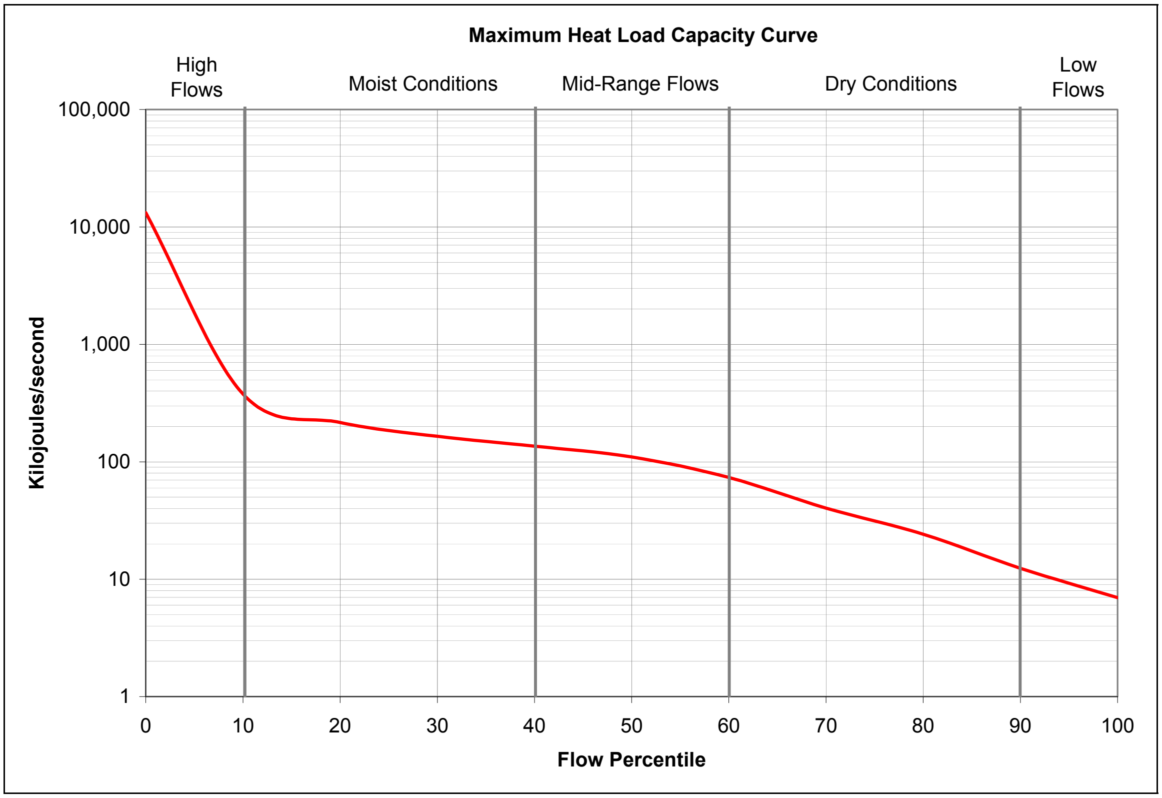

Figure 7. Maximum heat load capacity curve for McLoud Run based on variable flow conditions.

Figure 7 shows the thermal TMDL for McLoud Run graphically, based on a limited continuous flow record. This approach allows the maximum heat capacity of the stream to vary as a function of flow conditions. Although the allowable heat capacity varies, at no point is temperature allowed to increase more than 1 degree Celsius per hour. Table 2 provides selected TMDL values from this graph for commonly used flow ranges/percentiles. During the most extreme conditions (less than 0.1 cfs), the TMDL for McLoud Run is equal to 7 kilojoules per second, or 6.0 x 10^5 kilojoules (KJ) per day.

The time step conversion of heat loads from per second to per day is done here only for necessary compliance with the Clean Water Act; in reality, the thermal enrichment problems being experienced in McLoud Run occur on a very rapid time step. However, for all practical purposes, compliance with state water quality standards must be based on stream *temperature* change on an hourly time interval, not loading (kilojoules).

A major assumption associated with calculated TMDL values is that mixing of heat occurs instantaneously and evenly throughout the water body, and that heat is delivered while the stream is still at low-flow conditions (steady-state model). These assumptions provide an implicit margin of safety and afford the stream the highest degree of protection, and are described in more detail in section 3.4.

Table 2. Selected TMDL values for various flow conditions.

Flow Percentile	Flow Conditions	Discharge Range†	Maximum Temp. Change	Maximum Loading Capacity (Kilojoules/second)	TMDL (Kilojoules/day)
0-10%	High Flows	> 3.19 cfs	1° C/hour	377	3.3×10^7
10-40%	Moist Conditions	1.15 – 3.19 cfs	1° C/hour	136	1.2×10^7
40-60%	Mid-Range Flows	0.62 – 1.15 cfs	1° C/hour	73	6.3×10^6
60-90%	Dry Conditions	0.10 – 0.62 cfs	1° C/hour	12	1.1×10^6
90-100%	Low Flows	0.06 – 0.10 cfs	1° C/hour	7	6.0×10^5

†Based on one season of flow data (2006). Table values may need adjusted as more data is collected.

Decision criteria for water quality standards attainment. To determine whether or not the water quality standards have been attained in McLoud Run, continuous temperature monitoring should be performed at no longer than hourly intervals during critical environmental conditions (as specified in this report). Water quality standards will be considered attained when they are no longer being regularly violated by thermal loading during summer storm events or when thermal shock no longer poses a threat to aquatic life.

3.3. Pollution Source Assessment

Existing load. The current (existing) heat load carried by McLoud Run is estimated to be as high as 75 KJ per second, or 6.5×10^6 KJ per day. This estimate is made using observed temperature violations in McLoud Run on the day of the 2001 fish kill, as well as subsequent temperature spikes observed in 2003 and 2004. It is equivalent to a 10.6° C hourly increase in stream temperature at extremely low flow conditions (less than 0.1 cfs, based on the recorded minimum).

Departure from load capacity. Under the most extreme environmental conditions, the maximum loading capacity for heat in McLoud Run is seven kilojoules per second, or 6.0×10^5 KJ per day. Observed heat loads delivered to the stream have been as high as 75 kilojoules per second, or 6.5×10^6 KJ per day. Therefore, a 91% reduction in heat load delivery is needed for water quality standards to be attained under the worst possible conditions.

A heat load reduction of 91% does not represent an ultimatum that must be achieved. Rather, it represents the maximum range of departure between estimated current conditions and the desired future conditions under extreme circumstances. However, ultimate improvement of water quality and success in McLoud Run should be based on the attainment of water quality standards as outlined in Section 3.2 of this document, not on calculated heat load reductions.

Identification of pollutant sources. Typically, sources of pollutants are categorized by two general groups: point sources and nonpoint sources. Point source pollutants come directly from a pipe and are legally permitted under the National Pollution Discharge Elimination System (NPDES). Nonpoint sources are diffuse in nature, originate from dispersed areas, and are not easily regulated.

There are no wastewater point sources that discharge to McLoud Run[‡]. However, both the City of Cedar Rapids and the City of Hiawatha have Municipal Separate Storm Sewer System (MS4) permits, which are considered point sources by definition. An MS4 permit is a specific type of NPDES permit which deals with stormwater runoff conveyed through artificial drainage mechanisms; thus, nonpoint source runoff is collected, concentrated, and discharged to the stream via storm sewer outfalls, ditches, and pipes. The MS4 permit requires that the cities of Cedar Rapids and Hiawatha develop a Storm Water Pollution Prevention & Management Program (SWMP), reduce pollutants in discharges through the use of Best Management Practices (BMPs), identify and eliminate illicit discharges, and implement public education programs on water pollution. It also requires that annual reporting and stormwater monitoring be done.

The municipal MS4 permits for these two cities cover all areas within incorporated city limits. This includes all residential areas, commercial businesses and offices, roads, and parking lots. In addition, there is one industry in the watershed (Rockwell Collins, Inc.) that is required to obtain coverage for "stormwater discharge associated with industrial activity" by Iowa's General Permit #1 for stormwater. In doing so, it is required to develop and follow a Stormwater Pollution Prevention Plan (SWPPP). The NPDES permits for stormwater in the McLoud Run watershed are shown in Table 3.

Table 3. Stormwater NPDES-permitted point sources in the McLoud Run watershed.

Name	NPDES #	Contributing Area (acres)	# Storm Sewer Outfalls Draining to McLoud Run
City of Cedar Rapids MS4	**5715005**	**2,778 (87% of watershed)**	**50 (includes road culverts)**
- Rockwell Collins, Inc.	Stormwater General Permit #1	Not available	Discharges to Cedar Rapids MS4
City of Hiawatha MS4	**5735000**	**415 (13% of watershed)**	**Not available**

[‡] Weyerhauser Co. is located in the watershed, but discharges to Cedar Lake via city sewer.

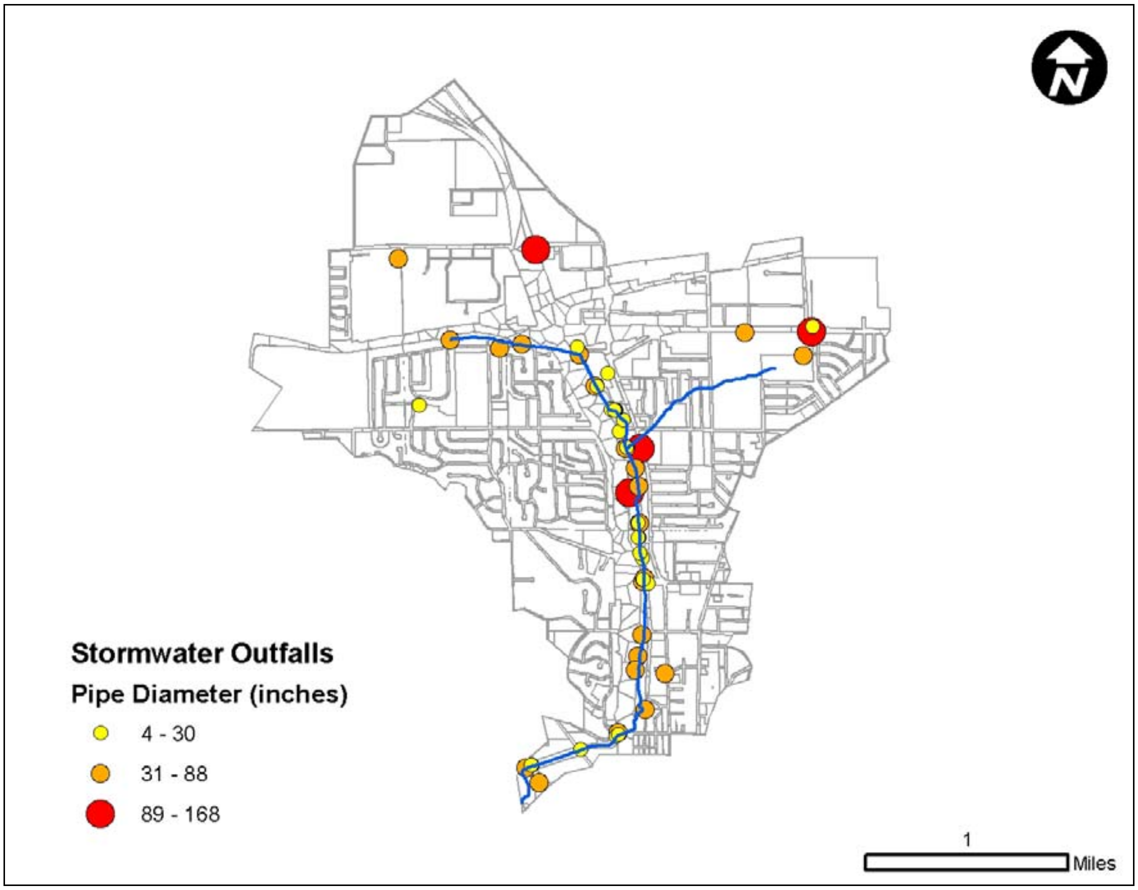

Figure 8. Stormwater outfalls and culverts in Cedar Rapids.

The heat loads being delivered through the MS4 stormwater system originate from dispersed, impervious areas that capture, retain, and transmit heat. These consist of unnatural surfaces in the watershed, such as roofs, metal structures, roads, and parking lots. These features capture and retain heat energy (even after diurnal solar energy inputs cease) and transfer it to surface runoff during rain events (Kieser et al., 2004). They also inhibit infiltration and promote rapid surface runoff, exacerbating the problem by delivering heat loads to the stream much faster than in natural watersheds.

To determine more specifically where the dominant sources are located in the watershed, it will require more comprehensive monitoring of stream temperature at multiple locations. However, models can be useful in shedding light on where the major sources may lie in the watershed relative to the stream channel. The Temperature Urban Runoff Model (TURM) is an excel spreadsheet model that was developed in Dane County, Wisconsin to predict the temperature of surface runoff from newly developed areas that are near coldwater trout streams. It is used by county government zoning officials to support decision making for proposed developments and whether or not they will have a detrimental impact on aquatic life (LCD, 2006).

This model was used to predict the surface runoff temperatures for varying land use classes in the McLoud Run watershed, and the results were classified into broad groups so that they could be visualized geographically. Figure 9 displays the results of this effort. The results are based on parcel size, percent of connected impervious area, time of concentration (normally defined as the maximum travel time for stormwater to reach the stream, but modified in this case to mean the minimum stormwater delivery time), and weather variables that were held constant throughout the watershed according to the critical environmental conditions. More details on this model can be found in Appendix D.

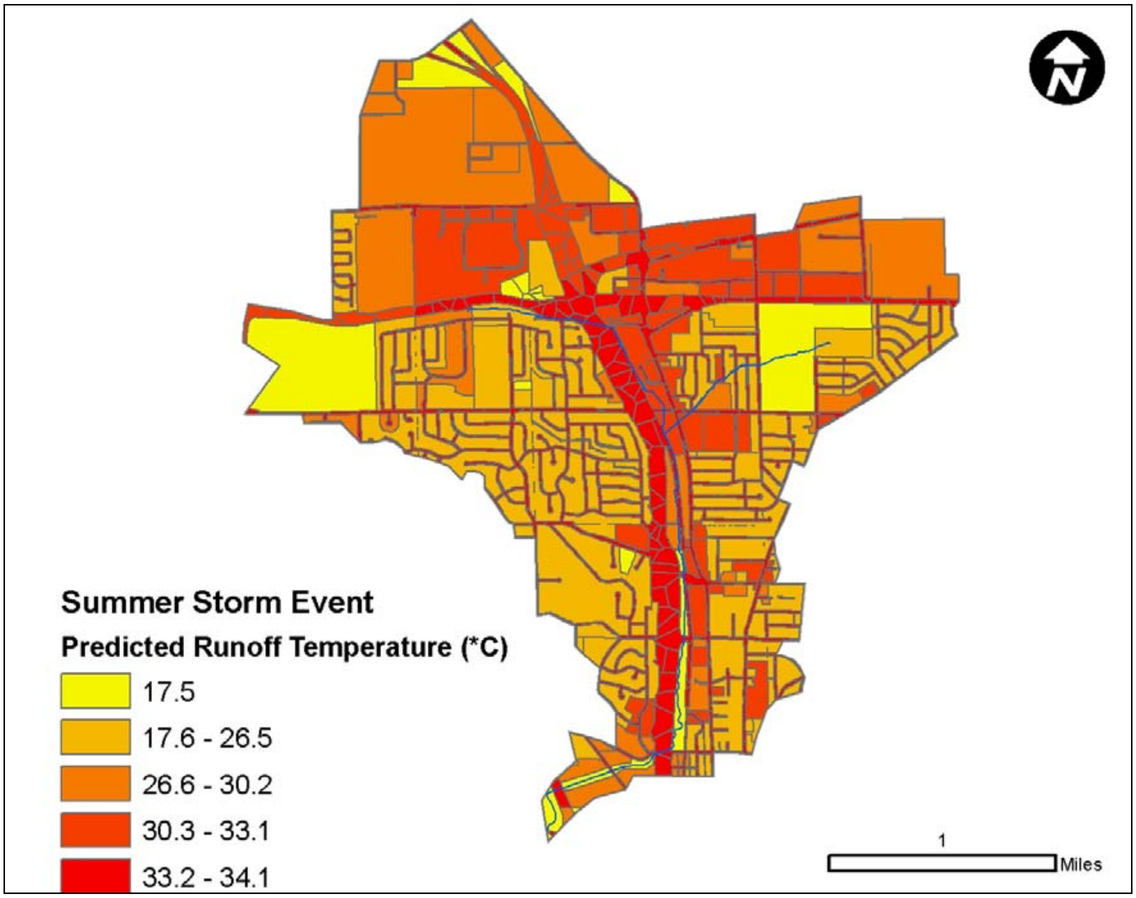

Figure 9. Runoff temperature modeling using the Temperature Urban Runoff Model (TURM).

The model results indicate that, as expected, areas that have large amounts of connected impervious area and which are closest to the stream (or connected via storm sewer) have the highest predicted runoff temperatures reaching the stream. Many of these areas are quite close to the stream, including business parking lots and Interstate 380.

Predicted runoff temperatures were then converted to heat loads and summed by land use categories to better understand the largest relative contributors (Figure 10). This was done by multiplying the predicted runoff temperatures by the predicted peak discharge rate for each land use parcel. Peak discharge rates were estimated using the rational equation for a 2-year, 2-hour rain event and using recommended runoff coefficients from the Statewide Urban Design and Specifications manual (SUDAS, 2006). Maps depicting the locations of these spatially explicit heat loads are shown in Appendix E.

These results can provide an indication of the relative differences among heat sources and help guide decision making and monitoring, but should be used with caution. Actual runoff temperatures may vary from those predicted, and the model has several limitations which are discussed in Appendix D. Nonetheless, the additional maps included in Appendix E related to this modeling should be helpful in targeting locations along the stream for monitoring and managing the stream impairment.

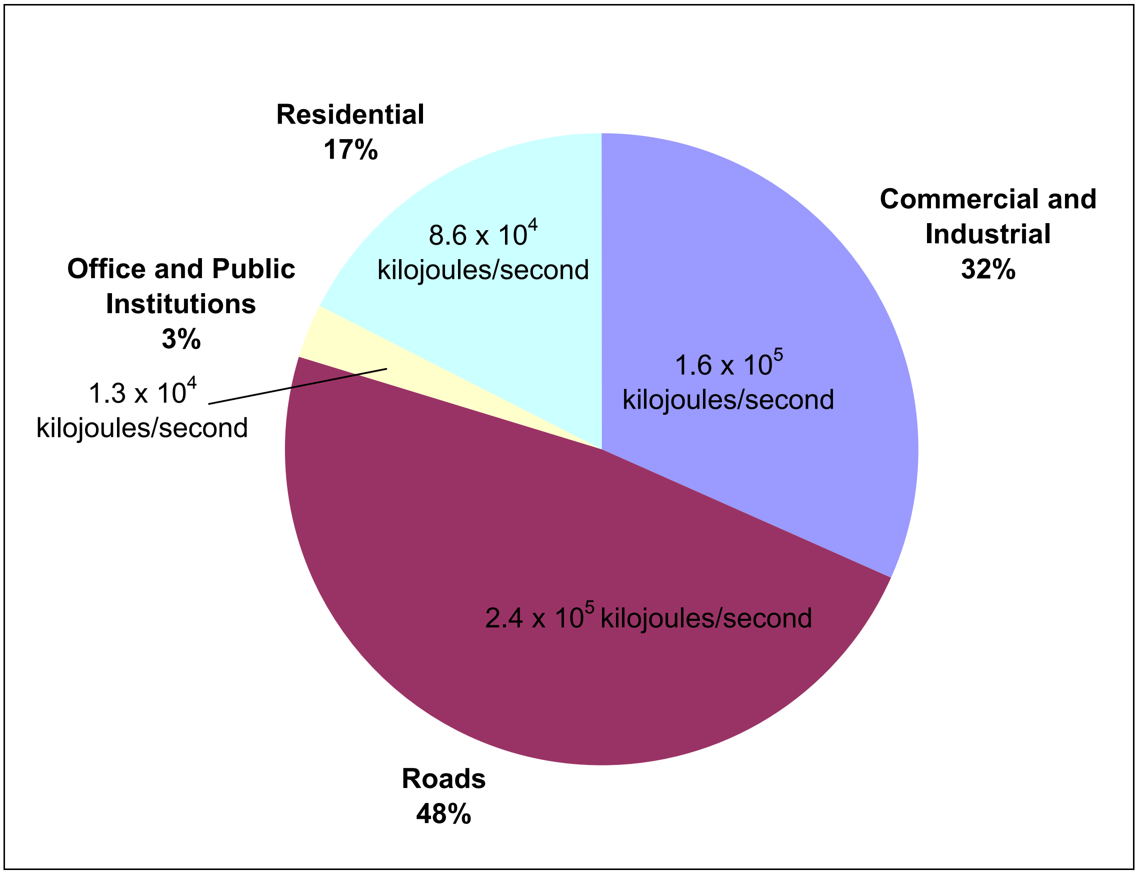

Figure 10. Estimated total heat load potential for lumped land use categories in the McLoud Run watershed (2-year return storm).

Allowance for increases in pollutant loads. It is important and necessary to consider any potential changes to the watershed and/or stream hydrology which may occur in the future and which could alter the criteria used to develop this TMDL. Since the McLoud Run watershed is almost completely urbanized and highly developed, it is assumed that little to no significant increases in imperviousness will occur in the future. Furthermore, city ordinance ensures that any new development or redevelopment comply with water pollution control measures both during and after construction activity (e.g. dry detention basins to capture surface runoff) (CCR, 2006). For these reasons, no significant increases in loads are foreseen.

The removal of riparian vegetation along McLoud Run, were it to occur, would result in increased solar radiation received by the stream would likely raise absolute water temperatures. However, modeling shows that the resulting increases would not be significant (even if all vegetation were removed), and would not result in acute changes in hourly temperatures to which the water quality standards apply (See Chapter 4 and Appendix D). Considering the important social and recreational roles that the greenbelt area (McLoud Run Park) plays, it is unlikely that permanent, major removals to the shading component along the stream will occur. Therefore, no significant increases in heat loads are foreseen.

3.4. Pollutant Allocation

Wasteload allocation. The wasteload allocation (WLA) of a TMDL specifies how much of the Total Maximum Daily Load is apportioned to point sources in the watershed. Since the entire McLoud Run watershed is covered by MS4 permits held by the City of Cedar Rapids and the City of Hiawatha, the wasteload allocation for heat in McLoud Run is equivalent to the TMDL, and varies with flow conditions (Table 2). Under the most extreme critical conditions, the WLA is 6.0×10^5.

Each city is assigned part of the total WLA based on the relative fraction of permit coverage within the watershed (percent of total watershed area lying in each respective city). Thus, the City of Cedar Rapids is assigned 87% of the total WLA and the City of Hiawatha 13% (5.2×10^5 and 7.8×10^4, respectively for critical conditions). In the future, targeted monitoring could determine if these allocations are equitable, and the two cities are encouraged to work together to find monitoring solutions. Industries covered by general stormwater permits are not given specific TMDL wasteload allocations since their discharge enters the city MS4 prior to reaching the stream.

Load allocation. The load allocation (LA) of a TMDL specifies how much of the Total Maximum Daily Load can be apportioned to nonpoint sources in the watershed. Since the entire watershed area is covered by NPDES permit and because the state water quality standards don't apply to natural background inputs of solar radiation alone, there will be no portion of the TMDL allocated to nonpoint sources. The load allocation of this TMDL is zero.

Margin of safety. A margin of safety (MOS) is a requirement of all TMDLs to account for any uncertainties in the data, modeling, or assumptions that were used. The margin of safety should ensure that the TMDL calculation is appropriate, and that if achieved, no violation of state water quality standards will occur unexpectedly. For this TMDL, an implicit margin of safety is employed, meaning that conservative assumptions were used throughout the development of the TMDL to afford the stream the highest degree of protection.

The conservative assumptions incorporated in this TMDL include:

1. Use of steady-state mathematical model to calculate the TMDL as a function of ambient low-flow conditions, when the stream is most vulnerable to thermal shock.
2. Instantaneous and even mixing of heat throughout the water column, which does not take into account the ability for pools, bank hides, and other structures to buffer heat loads and improve fish survivability.

3.5 TMDL Summary

The following equation represents the total maximum daily load (TMDL) for heat and its components in McLoud Run under the worst-case scenario:

TMDL = WLA + LA + MOS

6.0×10^5 KJ per day = 6.0×10^5 KJ per day + 0 + 0

This means that the Total Maximum Daily Load for heat that McLoud Run can tolerate (during critical conditions) is 6.0×10^5 KJ per day, otherwise a violation of the water quality standard will occur. Of this heat load amount, 100% of it is allocated to point sources, specifically, the City of Cedar Rapids MS4 and City of Hiawatha MS4. 87% of the WLA is allocated to the City of Cedar Rapids and 13% is allocated to the City of Hiawatha. No heat load is allocated to nonpoint sources or a margin of safety, which was set implicitly.

It should be reiterated that this TMDL, when expressed as a daily load, is a conceptual number necessary to meet federal Clean Water Act requirements. In reality, the heat load that the stream can tolerate without violating water quality standards must be considered on an hourly time interval, and must equate to heat concentration (i.e., temperature), not load.

4. 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 for decision-making support and planning purposes. 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.

4.1. Past work in the McLoud Run Watershed

In 2001, the City of Cedar Rapids and the Linn County Soil and Water Conservation District were jointly awarded a $680,000 grant from the Iowa DNR Section 319 Nonpoint Source Program. This project, which recently concluded, made significant advances in improving water quality in McLoud Run for a variety of pollutants (Wolter and Bruene, 2007). Notable achievements of the project include:

- Installation of 55 residential rain gardens that treat over 58,000 square feet of drainage area
- Construction of 75 bank hides for fish habitat
- Four thousand feet of streambank stabilization
- Two major stormwater detention structures
- More frequent street sweeping, dechlorination of flushed hydrant water
- Adoption of fertilizer and pesticide BMPs at Twin Pines golf course
- Public education through kiosks, flyers, a website, and annual "McLoud Run Day"

The impacts of these practices on the stream's temperature regime is uncertain, since monitoring equipment have been subject to vandalism, theft, and loss to major flows during recent years. With the project complete and new practices in place, a renewed monitoring effort in the stream is critical to evaluate changes and improvements. The monitoring plan outlined in Chapter 5 discusses what information is needed to determine whether or not these efforts have made a dramatic improvement in buffering the thermal shock or not.

Work in the McLoud Run watershed should not be considered done simply because the original 2001 project has ended. The following sections provide details on how to continue making improvements to McLoud Run until thermal shock is no longer negatively impacting aquatic life in the stream.

4.2. General Approach & Reasonable Timeline

To achieve meaningful and permanent improvements within the aquatic ecosystem, considerations must be given to the activities going on in upland areas of the watershed, where the root of the problem lies. Improvements made in the stream channel to support fish habitat will help trout survive in the short term, but will not correct the problems causing the thermal shock to McLoud Run and won't help other, less mobile aquatic life. For this, changes must be made on the land surfaces to reduce the amount or magnitude of heat being generated and retained by impervious surfaces, or capture and retain heated stormwater runoff and release it more slowly to the stream. Ideally, a plan would address both the upland and in-stream needs in a comprehensive fashion, since they are inextricably linked.

A general timeline is proposed in Table 3 to provide reasonable expectations for local stakeholders wishing to pursue this endeavor. The completion of these actions is heavily dependent on local government, citizens, and stakeholders taking initiative to make changes in the stream, its watershed, and the perceptions of local residents. The Iowa DNR and other government agencies are available to provide technical assistance in these efforts, but cannot directly force changes at the local level.

Table 4. General timeline for McLoud Run watershed plan.

Year (approximate)	Actions
2007-2008	Develop and implement monitoring plan to determine if problem still exists, better diagnose it, and identify major pollution sources.
2007-2010	Assess monitoring results to determine if further actions are needed. If so, identify major pollution sources/causes and Best Management Practices to be applied.
2010-2015	City government, businesses, and citizens work together to implement appropriate BMPs. Continue diagnostic monitoring and targeted BMP performance monitoring.
2010-2020	Continued monitoring and evaluation of BMP performance, installation of BMPs as needed, and ongoing assessment of water quality changes.

4.3. Best Management Practices

Best Management Practices (BMPs) are specific techniques that are employed by landowners, tenants, government officials, or other managers to satisfy multiple uses for social, environmental, and financial needs. In McLoud Run, two broad types of BMPs may help the situation: 1) upland (watershed) BMPs which deal with the nonpoint source areas that capture, retain, and transport heat to the stream during rain events, and 2) in-stream (channel) or riparian BMPs that work to dissipate or buffer the thermal shock and allow aquatic life to survive these events.

Upland BMPs for heat load reduction. These practices include techniques which either reduce heating or the retention of heat on unnatural surfaces or those which capture and retain stormwater and either cool it or release it more slowly to the stream. Options might include:

- Urban shade tree plantings
- Reflective/light color paint for impervious surfaces (parking lots and roofs)
- Rain gardens
- Filter strips, bioswales, and bioretention cells
- Stormwater detention systems
- Pervious pavement areas
- Green roofs

In-stream BMPs for heat load dissipation. BMPs in this category would include riparian corridor, streambed, and channel improvements that provide better habitat or stream temperature buffering capacity. Examples include:

- Bank hides
- Pool and riffle sequences
- Rock cribs
- Riparian tree shading
- Stream channel remeandering

With so many options and varying costs and returns on BMP investments, it is critical to understand how individual practices work and where they should be used. For instance, some studies have shown stormwater detention basins to actually increase the absolute temperature of water (comparing inflows vs. outflows) due to increased surface area and exposure to solar radiation (Kieser et al., 2004). However, such a practice may be quite useful for temporarily detaining stormwater and lowering the acute risk of thermal shock. Careful consideration needs to be given to which practices will have the most dramatic impact on the stream as the nature of the problem is concerned, where they can be most effective, and how socially and economically feasible they are.

Scenario modeling. To investigate one potential BMP scenario, computer modeling was used to predict the impacts that could be achieved by adding (or removing) trees for shade along the stream. The *HeatSource* model was developed in Oregon for use in fisheries applications where thermal modifications (primarily vegetation removal) have negatively impacted aquatic ecosystems (Boyd and Kasper, 2003). The *HeatSource* model estimates changes in heat loads by calculating effective shade over the stream. Effective shade is generally defined as the cumulative daily blockage of incoming solar radiation by both vegetation and topography, preventing it from reaching the surface of the stream. It is often used as a surrogate measure for heat loads in TMDLs from the Pacific Northwest and elsewhere around the country where riparian vegetation removal is determined to be the primary cause of impairment.

For McLoud Run, natural heat loads (received during dry conditions) were modeled and calibrated using real monitoring data to quantify relative amounts of the thermal energy in McLoud Run. Then, stream temperatures were estimated under thermal enrichment events that occurred during the month of August in 2003. In doing so, thermal enrichment associated with summer rain events is verified as the primary cause of the acute impairment by simple process of elimination. With this information, several different scenarios were played out to determine how changes in riparian vegetation would impact the stream temperature regime. Appendix D provides more details on the use of this tool in temperature modeling performed on McLoud Run.

Figure 11 shows four alternative modeling scenarios for McLoud Run during dry conditions: 1) the current situation as modeled and calibrated to real monitoring data ($R^2 = 0.93$, S.E. = 0.6), with an effective shade of 29%; 2) a feasible forested scenario, in which effective shade by riparian vegetation is increased to 57% (this represents maximum feasible potential for adding riparian vegetation); 3) the urban land use scenario, in which effective shade is decreased to 3% (representing what would happen if all riparian vegetation were removed); and 4) a maximum forest scenario, in which effective shade is increased to 95%. This last scenario is not a feasible alternative, but is shown here to depict the absolute maximum achievable results by manipulating riparian vegetation. Appendix D contains detailed information on these alternative modeling scenarios for McLoud Run.

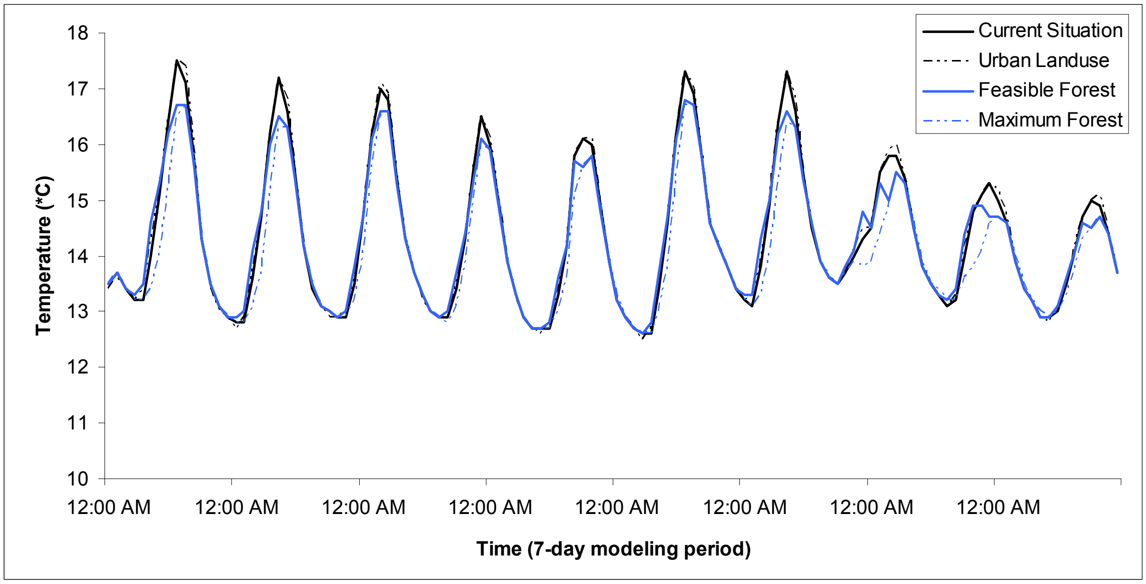

Figure 11. Alternative riparian vegetation modeling scenarios for McLoud Run.

This modeling suggests that during dry weather conditions, the maximum reduction in the total heat budget that could be achieved by increasing effective shade (from current levels of 29% to a maximum feasible riparian shading of 57%) over McLoud Run is minimal, corresponding to an absolute temperature difference of 0.8° C during peak afternoon hours. The "urban land use" scenario, in which all riparian vegetation is removed, tends to closely resemble the current temperature regime in McLoud Run. The "urban land use" and "maximum forest" scenarios represent extreme boundary conditions in terms of riparian shading, and offer a glimpse of the maximum degree to which riparian vegetation influences stream temperature between the two monitoring sites.

Figure 12 provides stream temperature simulations during the thermal enrichment event that occurred on August 11, 2003 for two of the previous scenarios: 1) the current (actual) conditions and 2) the maximum forest scenario. Essentially, the model shows that even if the stream was shaded under an extremely dense and lush forest, heat shock will occur unless extreme heat loads delivered from upland impervious areas are not dealt with. Tree plantings along the corridor to shade the stream could reduce chronic heating in the stream and delay rates in daily temperature gains, but would not be effective in buffering or cooling acute temperature shock once it is received. However, the model is not able to predict the effects of heat delivery from upland areas if trees were planted throughout the watershed, which could dramatically reduce heat loads delivered to the stream.

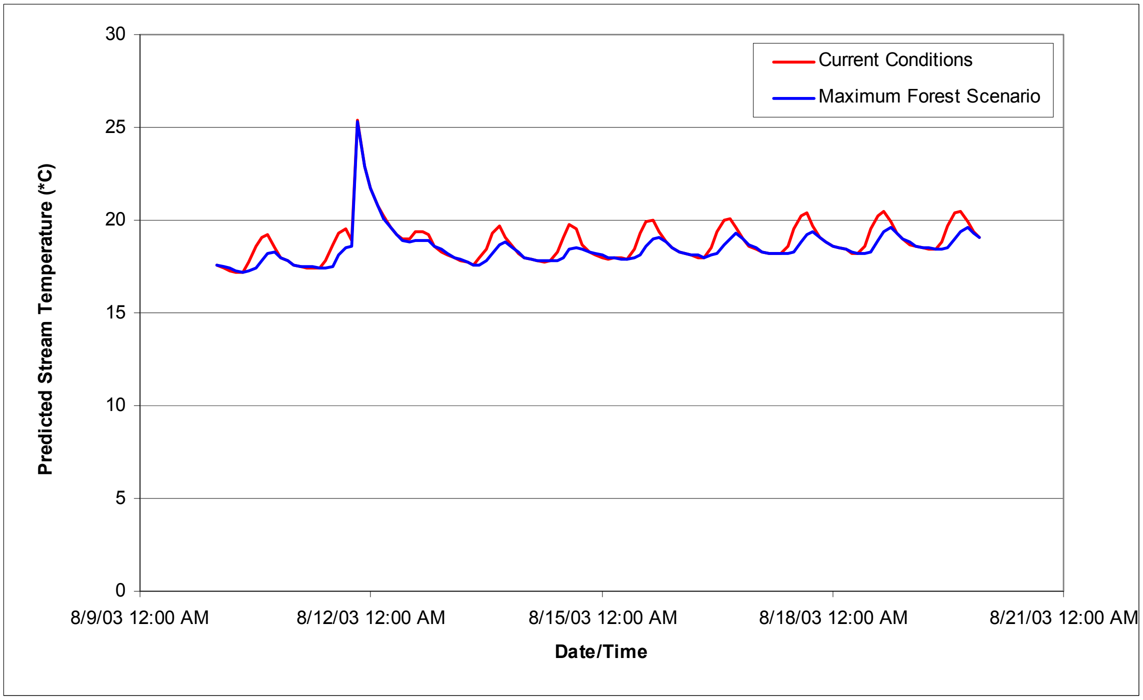

Figure 12. Predicted stream temperatures during thermal shock event under two alternative vegetation scenarios.

Clearly, alterations made to the riparian vegetation do not result in significant absolute temperature reductions according to *HeatSource* model predictions. Furthermore, since the applicable water quality standard deals not with absolute temperature but with acute changes in temperature, adding riparian shade to the stream would not be an effective solution for dealing with the heat delivered from rain events. A more logical approach would be to focus tree plantings in upland urban areas that are deemed to be dominant source areas of the heat load transferred to the stream via surface runoff.

4.4. Reasonable Assurance

This section is included to provide affirmation that the water quality targets and goals set forth in this TMDL have the potential to be realized in a reasonable time frame. As stated at the beginning of this report, McLoud Run plays an important role in the community and many groups of people are determined to protect it. According to city officials, McLoud Run Park receives approximately 60,000 visitors per year.

Although the McLoud Run 319 project has ended, interest in the stream remains strong. Both the City of Cedar Rapids and the City of Hiawatha have shown a dedication to maintaining and improving the aquatic health and recreational & educational resources of the stream. Adjustments in these cities' NPDES MS4 permits will be made following this TMDL to ensure that monitoring and BMPs are installed over time, and these cities are eager to cooperate. Mandatory use of BMPs will not be recommended until more monitoring can be done in the stream to determine where and which BMPs should be installed.

5. Future Monitoring

Water quality monitoring is a critical element in understanding the current conditions and variations of water resources. Monitoring is necessary to track changes in water quality and the effectiveness of improvements made in the watershed. Finally, it is needed to determine if the waterbody is supporting its beneficial uses and achieving goals set forth by this TMDL report.

5.1. Monitoring Plan to Track TMDL Effectiveness

A comprehensive monitoring plan is currently being designed by state and local government officials, along with help from other stakeholders. This monitoring plan will focus on two main themes:

1. Diagnostic monitoring to determine major pollutant sources and causes
2. BMP performance evaluation to determine the effect of individual and cumulative BMPs as they are implemented

The diagnostic monitoring will focus on getting a better understanding of the nature of the problem so that it can be corrected. Multiple locations are to be selected as both permanent and temporary sites for temperature loggers and flow gages. As data is collected and analyzed, site locations will be refined to better pinpoint the most dominant sources of heat load and understand what conditions need to be dealt with. Locations for temperature loggers and flow monitoring will include:

- Major and minor storm sewer outfalls
- Major lateral tributary inflows
- Paired upstream-downstream points along suspected reaches of dispersed/indirect heat entry

In addition, parking lot temperature sensors and rain gages may be deployed to assist in the diagnostic monitoring, and some flow and temperature data will be collected in a nearby "reference" watershed (with little or no urban development) to characterize a more natural thermal situation.

Targeted diagnostic monitoring and BMP performance monitoring will begin as soon as possible and remain in place until all potential pollution sources are identified, sufficiently quantified and controlled, and water quality standards are met. At such point in time, monitoring will enter a "maintenance" phase, with data collection only being done where local managers deem it necessary to sufficiently characterize the stream's thermal regime. A general timeline for this monitoring plan is presented on the next page in Table 5.

Table 5. Monitoring timeline.

Monitoring Phase	Timeframe	Description
Phase 1: Investigation	2007-2012	Implement monitoring plan, establish roles & responsibilities, build knowledge base for Phase 2
Phase 2: Adaptation	2008-2015	Continue investigating & diagnosing impairment, begin to narrow monitoring scope to better pinpoint sources and understand BMP performance
Phase 3: Maintenance	2015-ongoing	Migrate towards established, ongoing monitoring scheme with few changes necessary

5.2. Idealized Plan for Future Watershed Projects

The purpose of this section is to describe what an ideal future watershed monitoring plan in McLoud Run would consist of if adequate funding and resources were available. The reason for doing this is to provide information to future stakeholders who may want to add additional monitoring components to the current proposed plan (section 5.1) if additional funding resources become available. It also serves as an important guide for the parameters that are necessary for use by water quality modelers and hydrologists who ultimately use the data and relate it to state water quality standards.

General data needs. To sufficiently understand and model the processes driving stream temperature in McLoud Run, there are two required parameters:

i. Continuous stream temperature
ii. Continuous streamflow

Data for these two parameters should ideally be collected simultaneously at the same temporal interval/frequency to allow for the calculation of heat loads. To coincide with state water quality standards as given in Chapter 61 of Environmental Protection Commission [567], Iowa Administrative Code, the sample frequency for temperature and flow in McLoud Run should be no longer than one hour, but preferably at a higher resolution of 15-minute intervals.

In addition to the in-stream parameters, it would be useful to collect data on the following ancillary conditions for assessment purposes:

iii. Pavement and roof temperatures
iv. Rainfall amounts
v. Fish condition & distribution following summer storm events

These last three parameters are not seen as requirements for determining whether McLoud Run is meeting state water quality standards, but would be extremely useful in better understanding the causes, sources, and implications of the thermal shock in McLoud Run.

Monitoring design. This hypothetical plan is intended to be flexible so that managers may adapt and refine the monitoring design as change occurs and more information is gathered. Also, some specific details of the plan are left open to interpretation by local managers for the same reasons.

a) Timeframe: Monitoring should be done seasonally during the summer season, when the threat for thermal shock from stormwater runoff exists. Conservatively, this runs between the dates of April 1st and October 31st.
b) Permanent monitoring sites on the main branch: At least two locations should be established as permanent sites for monitoring continuous stream temperature on the main branch of McLoud Run[§]. These sites would provide a solid foundation for assessing support of designated uses, provide fixed upstream-downstream boundary conditions for potential modeling purposes, and characterize important differences between the sites. At least one of these sites should also be fitted to measure continuous streamflow (discharge) in sync with temperature. All sites would need to be stationed where vandalism, theft, and wash-away are minimal and where the stream maintains perennial flow.
c) Permanent monitoring sites on major tributaries: Permanent sites should be established in the vicinity of the five major tributary mouths (shown in Figure 13 and Table 6) to be monitored for continuous temperature throughout the summer. These temperature loggers should be set to record data in sync with the main stem temperature recorders. The sites would also need to be stationed where vandalism, theft, and wash-away will be eliminated.
d) Rotating sites for selected MS4 outfalls: Multiple MS4 stormwater outfall sites should be selected each year to be monitored continuously for water temperature of stormwater discharge (Figure 8). If possible, these sites should be equipped with continuous level or flow meters as well. As time goes on, local managers can determine which MS4 outfalls contribute to the stream impairment and which do not, thus narrowing the scope of future monitoring needs.
e) Rotating sites for in-stream BMPs: Multiple sites should be monitored for continuous stream temperature each year where in-stream best management practices are thought to reduce thermal shock to aquatic life. Such practices might include bank hides, deep pools, rock cribs, or riparian tree shading. Such data would be useful for researching the effectiveness of riparian BMPs for urban planning.
f) Temporary monitoring at major structural BMPs: To characterize the magnitude of thermal loading/reduction by major structural BMPs, temperature monitoring should be performed at the two major detention ponds in the watershed for several years each. These include Noelridge Pond and the I-380 wetland structure (a.k.a. "Wal-Mart detention pond"). For this, continuous stream temperature and flow

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[§] The two sites used by Iowa DNR fisheries for previous temperature monitoring may qualify for this need (See Figure 5).

should be monitored at both upstream (influent) and downstream (effluent) locations simultaneously.

g) Reference waterbody monitoring: For as long as monitoring exists in McLoud Run, stream temperature and streamflow should be monitored simultaneously and continuously in a nearby "reference" watershed, to be chosen by local managers. This reference watershed should have similar basin and stream channel characteristics to McLoud Run, but minimal urban development to afford the determination of an approximate "benchmark" thermal regime with which to compare McLoud Run.

h) Rainfall monitoring: Continuously operating rainfall monitoring should be done at one or more sites in both the McLoud Run watershed and the chosen reference watershed, in sync with stream temperature and stream flow monitoring. This will improve the accuracy of rainfall records during rain showers with extreme spatial variability.

i) Pavement temperature monitoring: Continuous temperature monitoring of paved & other impervious surfaces should be done on as many sites as possible, considering financial and logistical constraints. This monitoring is not seen as necessary for determining use attainability in the stream, but would be extremely valuable for identifying heat source areas. Figure 9 may help determine priority sampling areas.

j) Fish health and distribution monitoring: If possible, fish sampling should be done using an electroshock device immediately following rain events that occur during extreme summer heat conditions. The purpose of this would be to assess fish health, check for stress following summer rain events, and identify spatial distribution patterns throughout the stream by different species to learn more about the conditions in the stream during and after these events.

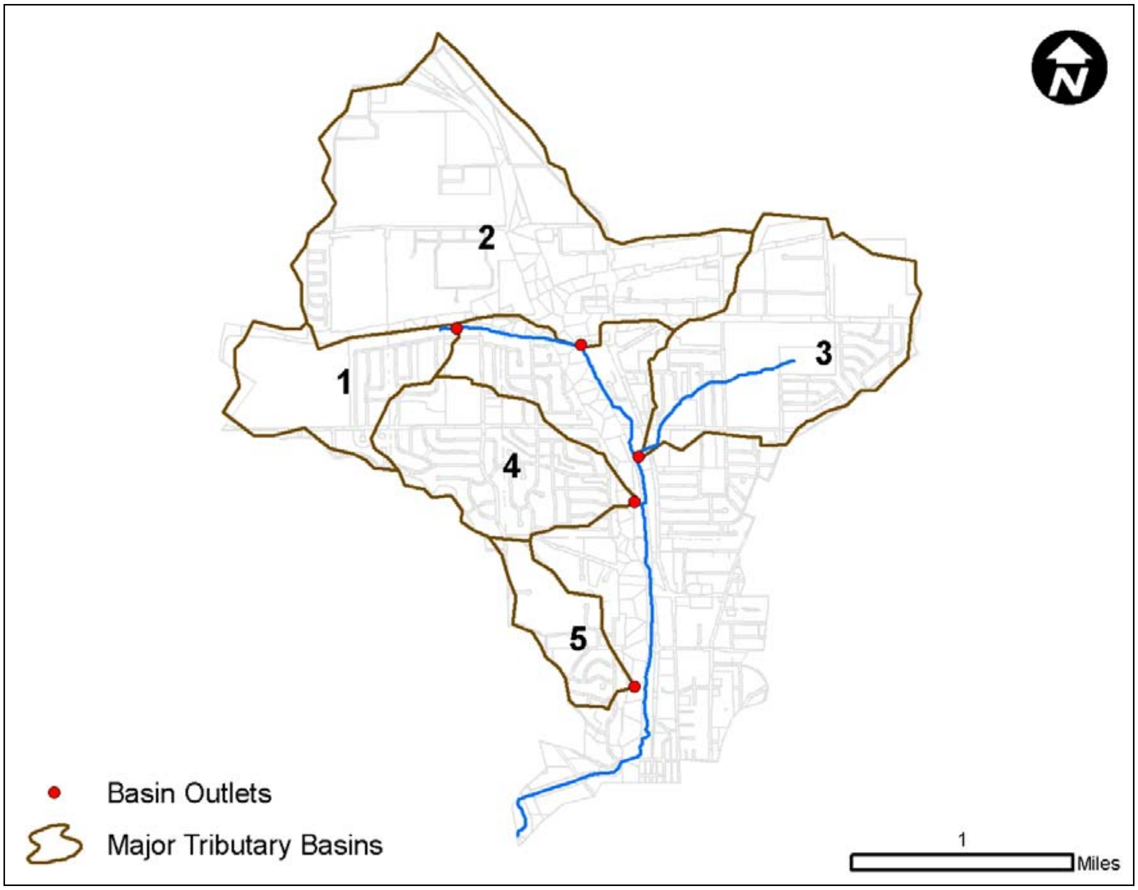

Figure 13. Major tributary basins in the McLoud Run watershed.

Table 6. Description of major tributary basins shown in Figure 13.

Basin # (From Figure 1)	Description	Drainage Area (acres)	Outlet Coordinates (UTM, NAD83, Zone 15 North)	
1	Twin Pines golf course & residential area	260	609,018 m	4,653,735 m
2	Wal-Mart & commercial areas, City of Hiawatha	986	609,582 m	4,653,698 m
3	Noelridge Park & industrial/commercial areas	538	610,434 m	4,652,832 m
4	Kennedy High School & residential area	339	610,440 m	4,652,521 m
5	Residential area	133	610,487 m	4,651,103 m

6. Public Participation

Public involvement is important in the TMDL process since it is the land owners, tenants, and citizens who directly manage land and live in the watershed that determine the water quality in McLoud Run. During the development of this TMDL, every effort was made to ensure that local stakeholders were involved in the decision-making process to agree on feasible and achievable goals for the water quality in McLoud Run.

6.1. Public Meetings

A meeting was held on October 2, 2006 at the Cedar Rapids Department of Water office in Cedar Rapids, Iowa. The purpose of this meeting was to invite public comment and suggestions for the development of this TMDL and to seek local knowledge and experience from concerned citizens and officials.

Sixteen people attended this first public meeting, representing city government officials from Hiawatha and Cedar Rapids, the Hawkeye Fly Fisherman Association, Iowa Chapter of the Sierra Club, Coe College, and local citizens. Comments and discussion in that meeting included themes ranging from the removal of riparian trees & vegetation to controlling and slowing urban development in the watershed. These comments have been addressed through verbal communication and throughout this document where appropriate.

Twenty people attended the second and final public meeting that was held May 2, 2007 in Cedar Rapids. Local interest in the stream remains strong, with future plans including watershed grant applications and the formation of a non-profit group devoted to McLoud Run.

6.2. Written Comments

The Iowa DNR received written comments from two government agencies regarding the McLoud Run Water Quality Improvement Plan: the City of Cedar Rapids and the U.S. Environmental Protection Agency. The content of these letters are included in Appendix F for reference.

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8. Appendices

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 water bodies (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 water bodies 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 livestock operation, either open or confined, where animals are kept in small areas (unlike pastures) allowing manure and feed become concentrated.

Base flow: The fraction of discharge (flow) in a river which comes from ground water.

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. A general term for any structural or upland soil or water conservation practice. For example terraces, grass waterways, sediment retention ponds, reduced tillage systems, etc.

CAFO: Confinement Animal Feeding Operation. An animal feeding operation in which livestock are confined and totally covered by a roof, and not allowed to discharge manure to a water of the state.

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 water body 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 water bodies 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 water bodies. The Iowa Department of Natural Resources submits an integrated report to the EPA biennially in even numbered years.

LA: Load Allocation. The fraction of the total pollutant load of a water body which is assigned to all combined *nonpoint sources* in a watershed. (The total pollutant load is the sum of the waste load and load allocations.)

Load: The total amount (mass) of a particular pollutant in a waterbody.

MOS: Margin of Safety. In a total maximum daily load (TMDL) report, it is a set-aside amount of a pollutant load to allow for any uncertainties in the data or modeling.

MS4 Permit: Municipal Separate Storm Sewer System Permit. An NPDES license required for some cities and universities which obligates them to ensure adequate water quality and monitoring of runoff from urban storm water and construction sites, as well as public participation and outreach.

Nonpoint source pollution: A collective term for contaminants which originate from a diffuse source.

NPDES: National Pollution Discharge Elimination System, which allows a facility (e.g. an industry, or a wastewater treatment plant) to discharge to a water of the United States under regulated conditions.

NRCS: Natural Resources Conservation Service (United States Department of Agriculture). Federal agency which provides technical assistance for the conservation and enhancement of natural resources.

Periphyton: Algae that are attached to substrates (rocks, sediment, wood, and other living organisms).

Phytoplankton: Collective term for all self-feeding (photosynthetic) organisms which provide the basis for the aquatic food chain. Includes many types of algae and cyanobacteria.

Point source pollution:	A collective term for contaminants which originate from a specific point, such as an outfall pipe. 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 water bodies. 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 water body 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 water body 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. *Storm water* 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 suitable for release to public waters.

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 water body 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 water body. (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 water bodies.

Watershed: The land (measured in units of surface area) which drains water to a particular body of water or outlet.

WLA: Waste Load Allocation. The fraction of waterbody loading capacity assigned to point sources in a watershed. 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: Waste Water Treatment Plant. General term for a facility which processes municipal, industrial, or agricultural waste into effluent suitable for release to public waters or land application.

Zooplankton: Collective term for all animal plankton 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. Changes that were made implemented a "top down" approach to use designations, meaning that all perennial waterbodies should be presumed "fishable and swimmable" until a UAA can be performed that may prove otherwise. For more information about Iowa's water quality standards and UAAs, contact the Iowa DNR's Water Quality Bureau.

Appendix C --- Water Quality Data

The following tables provide relevant data pertaining to the water quality impairment in McLoud Run.

Table C-1. Violation of state water quality standard for temperature on July 20, 2003.

Date/Time	Upper Thermograph (°C)	Lower Thermograph (°C)	Hourly Ending Precipitation (inches)
07/20/03 18:30:00.0	17.2	18.6	0
07/20/03 18:45:00.0	17.2	18.5	0
07/20/03 19:00:00.0	17.2	18.4	0
07/20/03 19:15:00.0	17.2	18.3	0
07/20/03 19:30:00.0	17.2	18.2	0
07/20/03 19:45:00.0	17.2	18.2	0
07/20/03 20:00:00.0	17.2	18.1	0.05
07/20/03 20:15:00.0	18.6	18.0	0
07/20/03 20:30:00.0	20.3	17.8	0
07/20/03 20:45:00.0	20.7	17.9	0
07/20/03 21:00:00.0	20.9	17.9	0
07/20/03 21:15:00.0	20.9	18.0	0
07/20/03 21:30:00.0	20.8	17.9	0
07/20/03 21:45:00.0	20.8	17.7	0
07/20/03 22:00:00.0	20.9	17.5	0
07/20/03 22:15:00.0	20.9	17.3	0
07/20/03 22:30:00.0	21.5	17.2	0
07/20/03 22:45:00.0	23.9	17.1	0
07/20/03 23:00:00.0	24.9	17.4	0.03
07/20/03 23:15:00.0	23.8	19.0	0
07/20/03 23:30:00.0	22.6	21.9	0
07/20/03 23:45:00.0	22.5	22.8	1.521

Table C-2. Violation of state water quality standard for temperature on August 11, 2003.

Date/Time	Upper Thermograph (°C)	Lower Thermograph (°C)	Hourly Ending Precipitation (inches)
08/11/03 16:30:00.0	18.7	21.1	0
08/11/03 16:45:00.0	18.7	21.3	0
08/11/03 17:00:00.0	18.6	21.4	0
08/11/03 17:15:00.0	18.6	21.4	0
08/11/03 17:30:00.0	18.6	21.5	0
08/11/03 17:45:00.0	18.4	21.6	0
08/11/03 18:00:00.0	26.8	21.5	0.07
08/11/03 18:15:00.0	26.9	21.4	0
08/11/03 18:30:00.0	26.6	21.4	0
08/11/03 18:45:00.0	26.0	21.3	0
08/11/03 19:00:00.0	25.4	21.2	0
08/11/03 19:15:00.0	24.7	21.0	0
08/11/03 19:30:00.0	24.0	20.8	0
08/11/03 19:45:00.0	23.6	20.6	0
08/11/03 20:00:00.0	23.3	20.4	0
08/11/03 20:15:00.0	23.1	20.2	0

Table C-3. Violation of state water quality standard for temperature on August 26, 2003.

Date/Time	Upper Thermograph (°C)	Lower Thermograph (°C)	Hourly Ending Precipitation (inches)
08/26/03 07:00:00.0	19.8	20.9	0
08/26/03 07:15:00.0	19.8	20.8	0
08/26/03 07:30:00.0	19.8	20.7	0
08/26/03 07:45:00.0	19.8	20.7	0
08/26/03 08:00:00.0	20.2	20.6	0.01
08/26/03 08:15:00.0	21.0	20.5	0
08/26/03 08:30:00.0	21.5	20.4	0
08/26/03 08:45:00.0	21.7	20.3	0
08/26/03 09:00:00.0	21.7	20.3	0.01
08/26/03 09:15:00.0	21.6	20.3	0
08/26/03 09:30:00.0	21.6	20.2	0
08/26/03 09:45:00.0	21.5	20.1	0
08/26/03 10:00:00.0	21.4	20.1	0
08/26/03 10:15:00.0	21.4	20.1	0

Table C-4. Violation of state water quality standard for temperature on August 3, 2004.

Date/Time	Upper Thermograph (°C)	Lower Thermograph (°C)	Precipitation (inches)
08/03/04 18:00:00.0	16.6	21.3	0
08/03/04 18:15:00.0	16.4	21.2	0
08/03/04 18:30:00.0	16.2	21.1	0
08/03/04 18:45:00.0	16.4	21.0	0
08/03/04 19:00:00.0	23.7	23.0	0.47
08/03/04 19:15:00.0	22.4	22.2	0.04
08/03/04 19:30:00.0	23.2	23.0	0
08/03/04 19:45:00.0	23.6	23.3	0.02
08/03/04 20:00:00.0	23.5	22.8	0.02
08/03/04 20:15:00.0	23.6	22.9	0.02
08/03/04 20:30:00.0	23.3	23.2	0.02
08/03/04 20:45:00.0	23.2	23.2	0
08/03/04 21:00:00.0	23.1	23.2	0

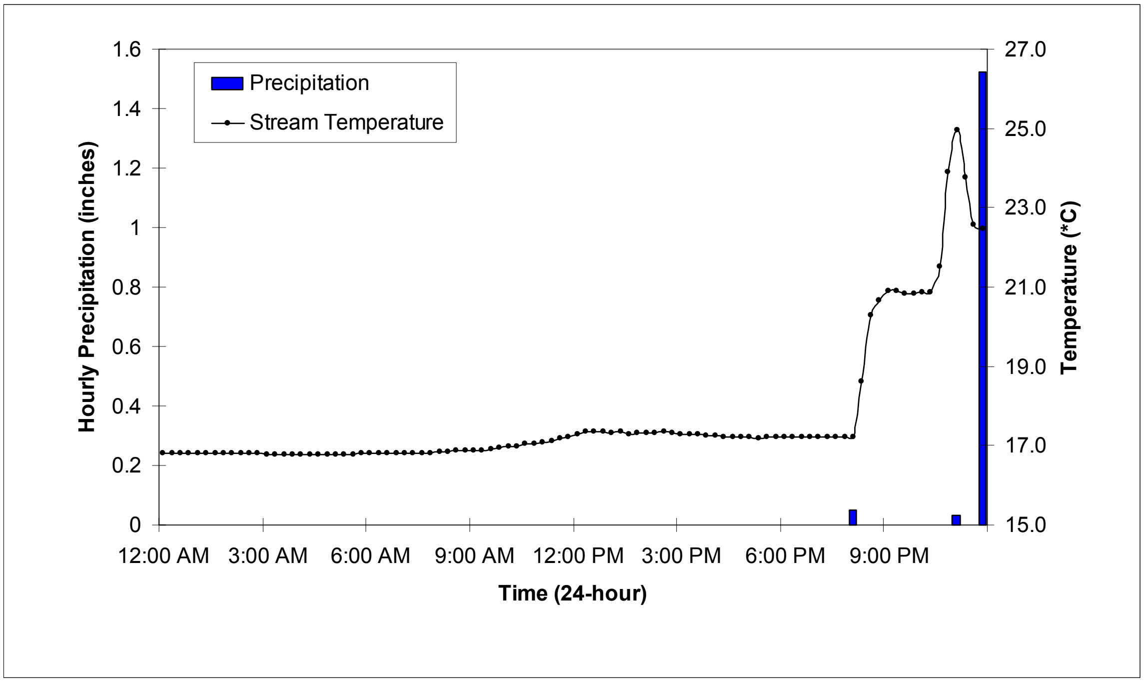

Figure C-1. Thermograph at the upper monitoring site on July 20, 2003.

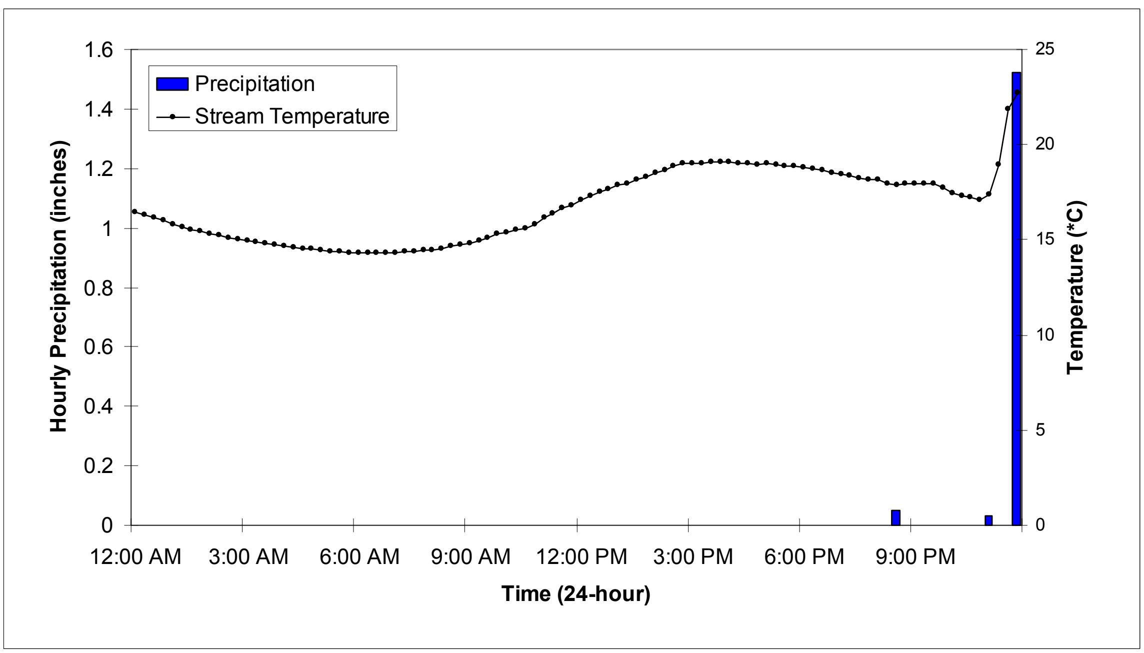

Figure C-2. Thermograph at the lower monitoring site on July 20, 2003.

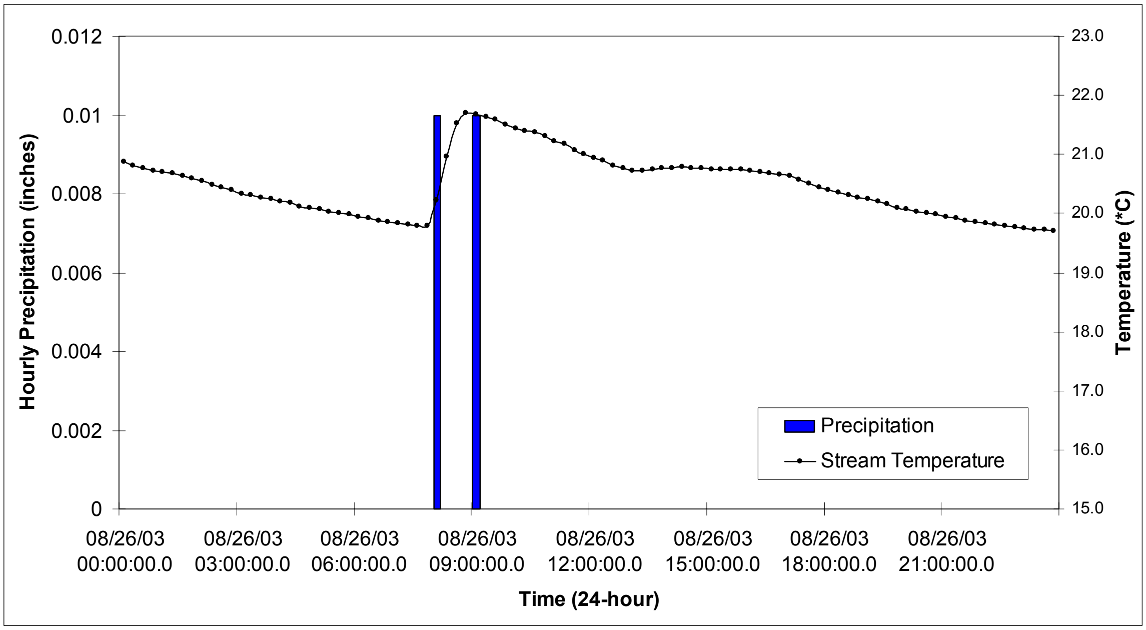

Figure C-3. Thermograph at upper monitoring site on August 26, 2003.

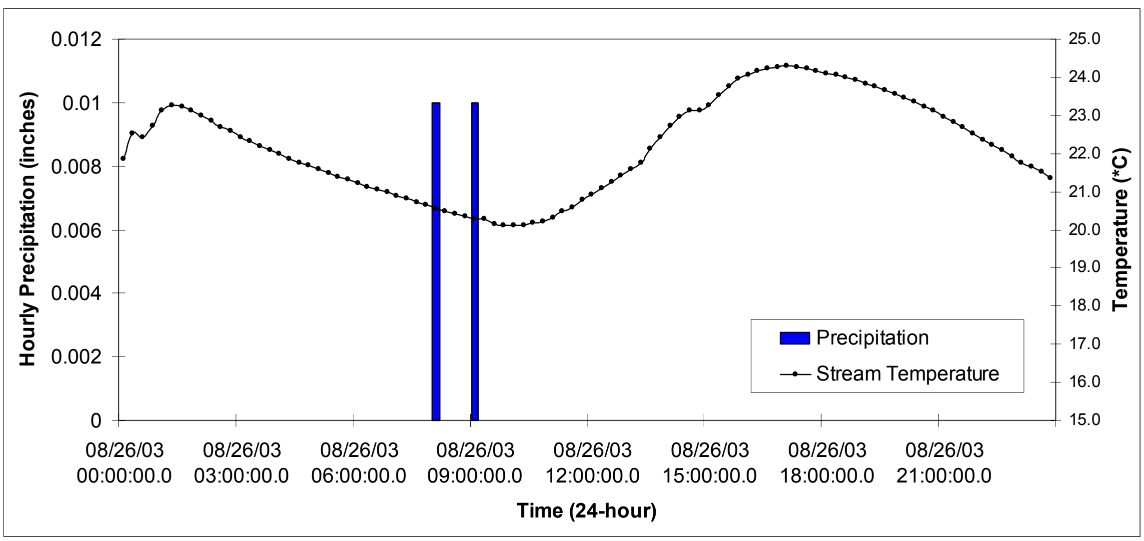

Figure C-4. Thermograph at lower monitoring site on August 26, 2003.

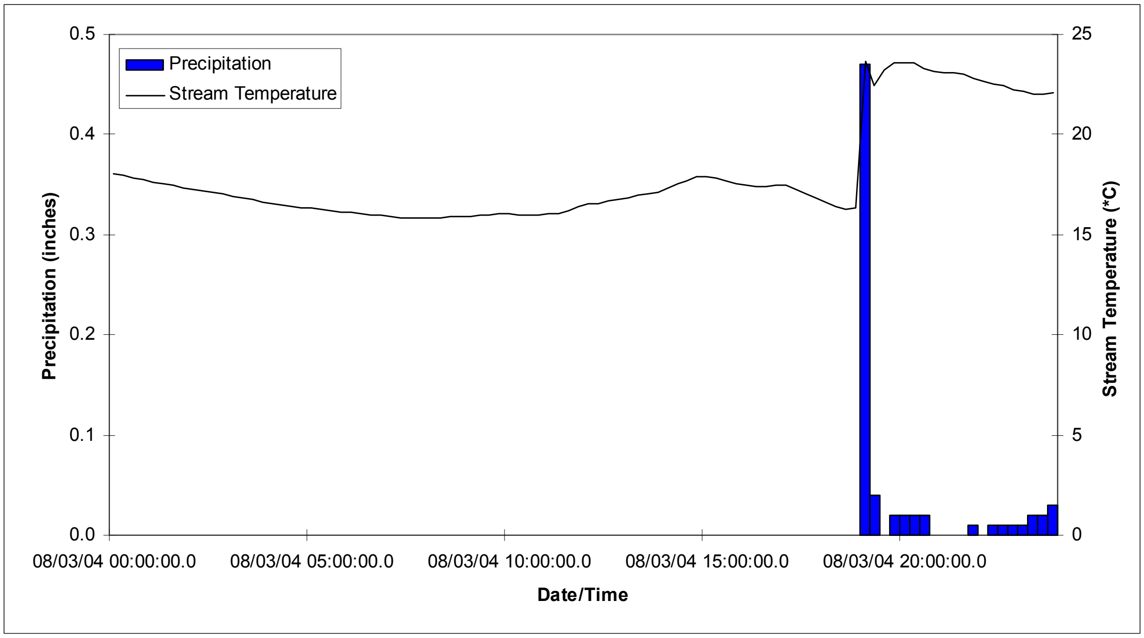

Figure C-5. Thermograph at the upper monitoring site on August 3, 2004.

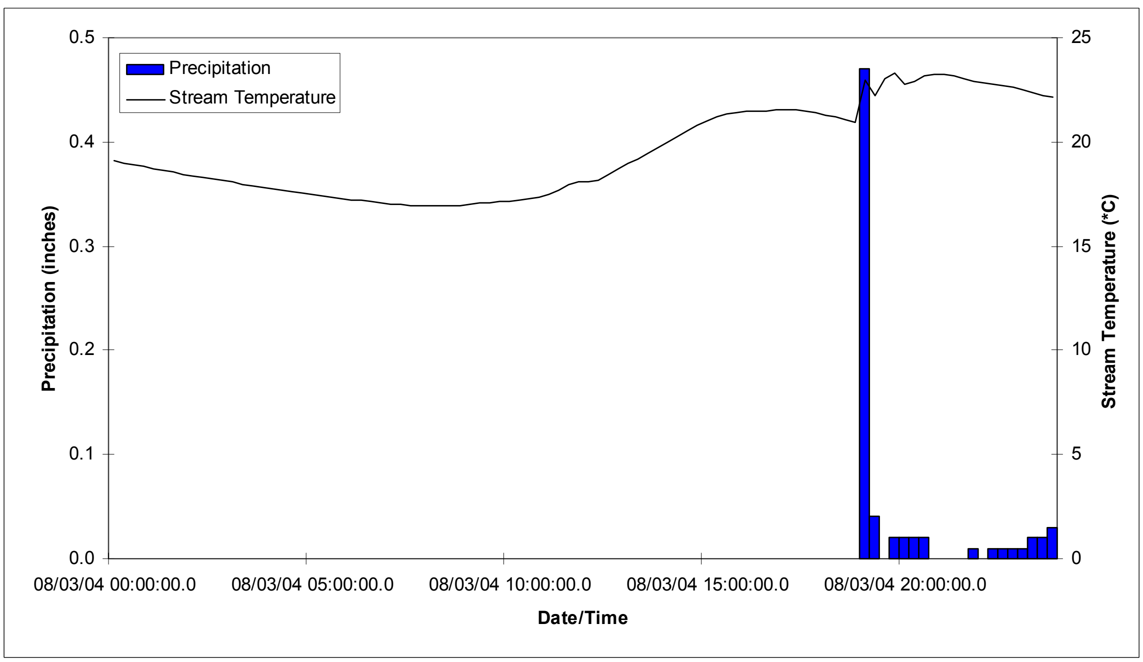

Figure C-6. Thermograph at the lower monitoring site on August 3, 2004.

Appendix D --- Modeling Equations and Methodology

Several models were used in the development of this TMDL. Models are important to support decision making, for prediction, and for analyzing alternative scenarios. However, all models are simplifications of the real world and must be used with caution when drawing conclusions from the results. Discretion and professional judgment should always be used when interpreting predictive modeling results.

Storm Water Management Model (SWMM) Modeling. The SWMM is an EPA model for simulating rainfall and runoff as well as water quality and quantity in urban areas (USEPA, 2005). For the McLoud Run TMDL it was used to simulate single storm events associated with water quality standard violations to determine at what point along the stream hydrograph the infractions were occurring. This information was used to assist in determining the critical environmental conditions for the TMDL.

Very little continuous flow data have been collected in McLoud Run, so model calibration was limited to one event. Figure D-1 shows the predicted and actual flows for the calibration event on August 9, 2006, which achieved a correlation coefficient of 0.87. Time steps were set to 15-minute intervals to correspond with actual flow and rain data.

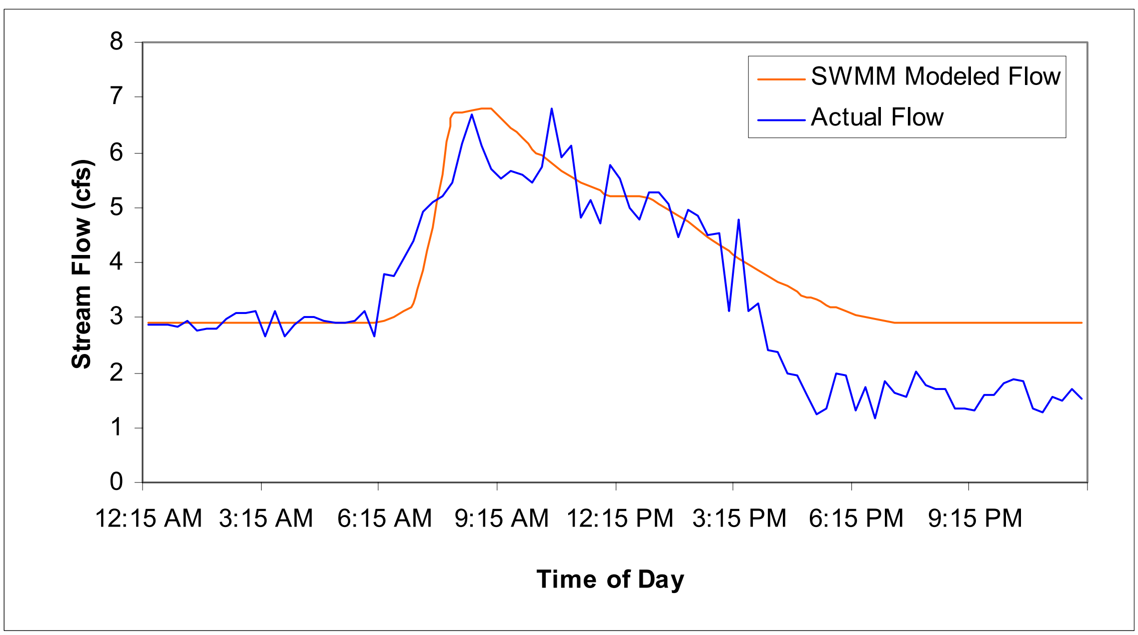

Figure D-1. SWMM hydrograph model calibration for McLoud Run.

Model parameters were adjusted to achieve the most realistic model, and that model was used to predict stream hydrographs for other real rain events that resulted in temperature infractions. Base flow conditions of 0.2 cfs were assumed (based on monitored data), and evaporation was set to 1 inch per day. The kinematic wave routing method and Horton infiltration model options were used.

SWMM model results indicate that stream temperature violations in McLoud Run are indeed occurring rapidly with the onset of rain, as shown in Figures D-2 and D-3.

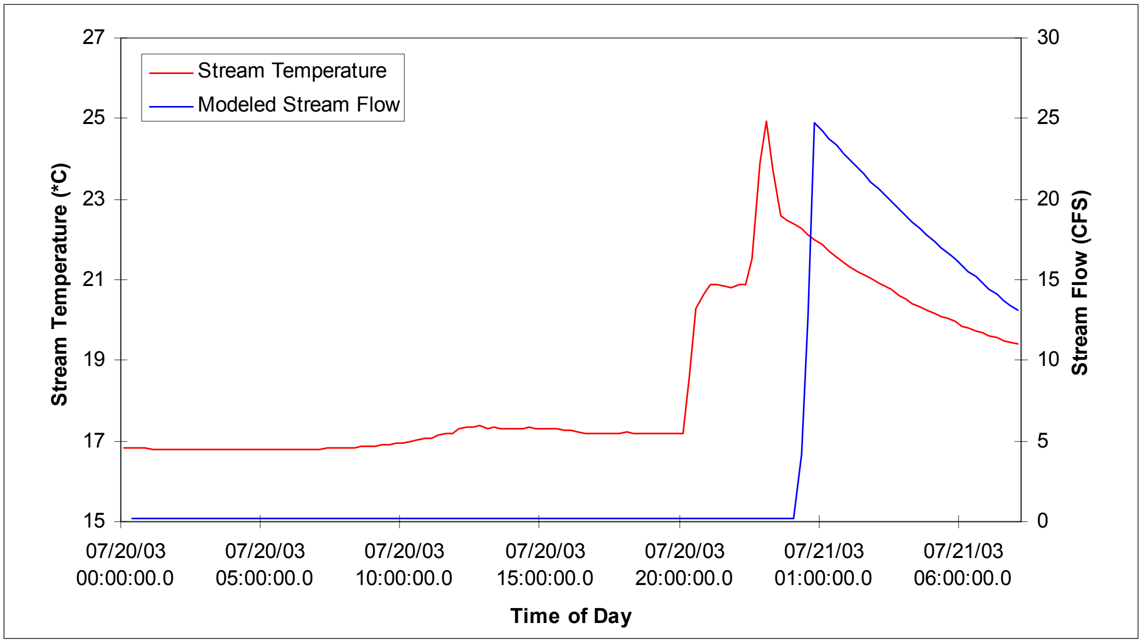

Figure D-2. SWMM simulation for 7/20/2003 temperature violation.

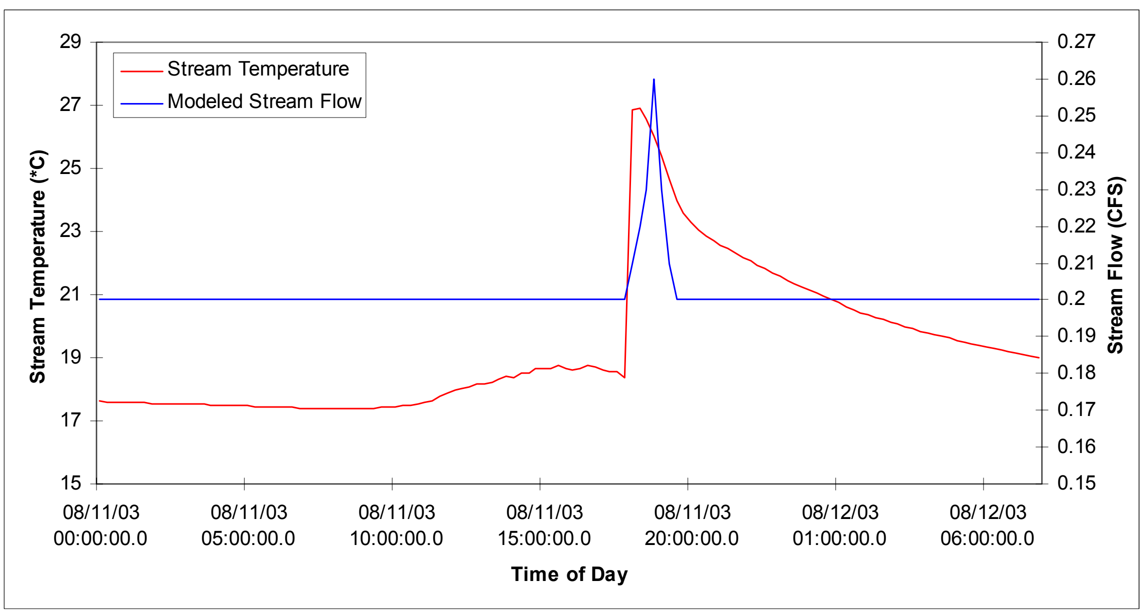

Figure D-3. SWMM simulation for 8/11/2003 temperature violation.

Flow and temperature mathematical calculations. Since water temperature is an intensive property that is independent of water volume, similar to pH or concentration, and because TMDLs are typically expressed as a mass quantity per day, it is necessary to convert units from temperature to heat load while accounting for variations in stream discharge. Therefore, a simple heat balance equation (Chapra, 1997) along with a duration curve was used to relate change in temperature to mass heat load and thus calculate the TMDL for McLoud Run:

$$T = \frac{H}{\rho C_p V}$$

where T = temperature, °C
H = heat, joules
ρ = density, kg m^{-3}
C_p = specific heat, J (kg °C)$^{-1}$
V = volume, m^3

The equation above is rearranged to the form:

$$H = \rho\ C_p V T$$

And for McLoud Run at critical flow conditions and using the state water quality standard,

$$H = (998.2\ \text{kg m}^{-3})(4182\ \text{J (kg °C)}^{-1})(0.0017\ \text{m3/s})(1°\text{C})$$

= 7,092 joules per second (7 kilojoules/sec.)

= 86,400 kilojoules per hour

= 612,790 kilojoules per day (TMDL)

A flow duration/flow exceedance curve was generated using limited continuous (fifteen minute intervals) flow data collected between July 11, 2006 and September 14, 2006. This curve (Figure D-4) plots flow data that is arranged in ordinal fashion from high to low across flow percentiles on the X-axis.

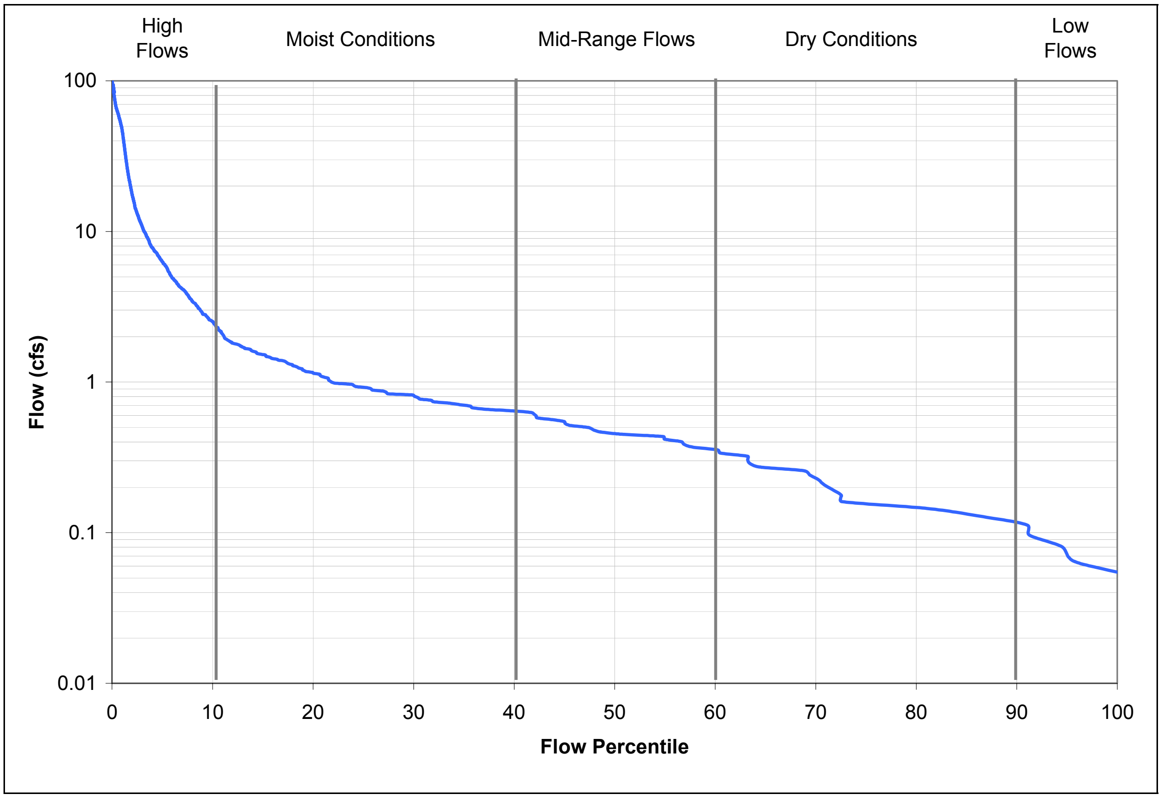

Figure D-4. Flow duration curve for McLoud Run using limited data.

To create the TMDL or maximum heat load capacity curve shown in Figure 7, the flow data in Figure D-4 was simply multiplied by the appropriate factors in the heat equation above. To give the appearance of a more smoothed line, only data from each 10^{th} percentile (0-10%, 10-20%, etc.) were used to plot the curve in Figure 7.

Temperature Urban Runoff Model (TURM) Modeling. The TURM was developed jointly at the University of Wisconsin-Madison and government officials in Dane County, Wisconsin (LCD, 2005). This is model is still in developmental stages and model developers urged that results be interpreted with discretion. Therefore, the TURM is used in this TMDL strictly for the purpose of visualization and supporting future monitoring and management plans, not for explicit prediction purposes.

The TURM is a spreadsheet-based model that allows the user to input parameters for a proposed urban development (size, percent of connected impervious area, and time of concentration) and various climate and rain event factors to predict the temperature of surface runoff once the site has been developed (parameters shown in Table D-1). To take this spreadsheet model and make it into a spatially explicit model, several generalizations and assumptions had to be made, which are described in the following paragraphs.

Table D-1. TURM meteorological input parameters.

Parameter:	Value:
Rainfall depth:	1.77
Rainfall duration:	2 hour
Hour of day that rain begins:	14:00
Time of Concentration (Tc):	Varies by parcel
Wind speed:	3.6 mph
Rain temperature (during storm):	90 deg. F
Initial temp. of impervious surfaces:	90 deg. F
Air temperature:	90 deg. F
Relative humidity:	90%

Determination of parcel size was done by a simple area calculation in GIS for each polygon in the GIS land use data coverage from the City of Cedar Rapids. To assign the percent of connected impervious area to all land use polygons, six-inch resolution, color aerial photography taken in 2005 was used to obtain a representative sample for all categories throughout the watershed (Table D-2). To overcome complications of the large, connected polygon along Interstate 380 and other major roadways, that polygon was split into thiessen (random) polygons which were all treated the same in terms of imperviousness. A map of the percent imperviousness for land use parcels throughout the watershed is included in Appendix E.

To calculate the time of concentration (defined for this effort as the minimum travel time in hours for stormwater runoff to reach McLoud Run), equations from Appendix B of the WINTR-55 User Guide were used (NRCS, 2003). A raster distance grid was created using GIS, and the minimum distance of each land use parcel from the stream was used to provide a conservative estimate. Manning's N roughness coefficients were assigned to the various land use categories using recommended values in the literature (SUDAS, 2006), and are shown in Table D-2. Average slope for each parcel was calculated in GIS from a 30 m resolution grid digital elevation model (DEM). Using this information, a sheet and rill time of concentration (TOC_{SR}) was calculated for all parcels in the watershed assuming a 1.77-inch rain event.

A GIS coverage of storm sewer locations for the City of Cedar Rapids existed, but was still in development. Nonetheless, the existing partial coverage was used to calculate a channel or pipe-based time of concentration (TOC_{Pipe}) for those parcels which are drained artificially in this manner, using the equations mentioned above and pipe/channel length. An average pipe velocity of 8 feet per second and Manning's roughness coefficient of 0.013 were assumed (SUDAS, 2006), and hydraulic radius was estimated from the pipe diameter (provided in dataset). Slope of the hydraulic grade line was estimated from the DEM slope grid.

Table D-2. TURM inputs by land use category.

Land use category	Average percent of connected impervious area	Manning's roughness coefficient (n)
Low Density Residential	25%	0.15
Medium Density Residential	45%	0.12
High Density Residential	65%	0.09
Office	40%	0.12
Commercial	60%	0.12
Residential Streets	85%	0.05
Interstate 380	75%	0.05
Commercial/Industrial	45%	0.12
Industrial	45%	0.05
Institutional/Public	25%	0.15
Parks and Open Space	0%	0.40

The total time of concentration was then calculated for each parcel by taking the sum of TOC_{SR} and TOC_{Pipe}, if the latter existed. A map depicting spatially explicit time of concentrations can be seen in Appendix E.

To migrate from the spreadsheet model to GIS, land use polygons were grouped into bins of similar TURM input parameters and the surface runoff temperatures were predicted in TURM. The predicted surface runoff values for these bins were then assigned to the land use coverage in GIS for easy display. The main disadvantage to this is the necessary simplification of spatial resolution.

The rational method was used to estimate peak flow in McLoud Run for a 2-yr return frequency design storm (1.77-inch, 2-hour duration) (SUDAS, 2006). Runoff coefficients were assigned to the GIS land use coverage according to recommended values from SUDAS (2006). Using this information, a storm event discharge volume could be calculated for each land use parcel using the following formula: Q (cfs) = Runoff Coefficient (unitless)* Rain Intensity (inches/hour) * Drainage Area (acres). Total peak flow at the watershed outlet using this method is estimated to be approximately 322 cfs, for a time of concentration of 1.94 hours (maximum travel time for watershed).

The quantity of water generated from each land use parcel at peak flow (Q) was multiplied by the predicted runoff temperature to create a map of total heat potential, shown in Appendix E (E-2). However, this map does not depict potential heat loads dynamically in time. Figure E-3 shows the potential heat loads normalized by delivery time to the stream, which was created by simply dividing the potential heat load by predicted minimum time of concentration.

HeatSource Modeling. The HeatSource model was developed in Oregon for use in anadromous fisheries applications where thermal modifications (primarily vegetation removal) have negatively impacted aquatic ecosystems (Boyd and Kasper, 2003). For this TMDL, heat loads were modeled and calibrated using real monitoring data to quantify relative amounts of the natural thermal load in McLoud Run (for periods of no rain), and also during storm events. The primary purpose of this exercise was to: 1) verify that the temperature violations in McLoud Run could not be caused by natural background heating, and 2) evaluate potential alternative scenarios which would either increase or decrease riparian tree cover and determine what (if any) impact that has on stream temperatures.

To set up the HeatSource model, boundary conditions were set at the upper and lower thermograph sites and nodes were established at 30 m intervals longitudinally moving downstream. A 30 m resolution DEM and land cover grid (IDNR, 2006) were used to calculate the effective shade to the stream (combination of topographic and vegetative shade). Physical parameters for each land cover category were set as specified in Table D-3.

Table D-3. Physical parameters for calibrated HeatSource model.

Land Cover Category	Height (m)	Density (%)	Overhang (m)
Trees	10	75	0.5
Grass	0.5	50	0.2
Commercial/Industrial Development	15	50	0
Residential Development	8	50	0

A dry period between 7/14 – 7/23 in 2004 was used to calibrate the model to baseline conditions (with no rain events), with model results shown in Figure D-5. This effort was also done to evaluate the magnitude of natural heat loads during dry periods on McLoud Run. Figure D-6 depicts these natural heat sources to the stream.

The calibrated model was then used to evaluate four alternative riparian vegetation scenarios:

1. The current situation, where tree cover is based on the 2002 land cover dataset and physical parameters are set to values in Table D-3. Maximum effective shade along McLoud Run equals 29% for this situation.
2. A "feasible forest" scenario, in which all available land (not currently in a "developed" land use) in the 300-foot riparian corridor is planted to trees. A second assumption is made that all trees are managed for maximum shading and grow to a height of 20 meters, have 75% canopy closure, and overhang the stream by 1 meter. This scenario would increase maximum effective shade to 57%.
3. An "urban" land use scenario, in which all riparian trees are removed and the watershed is pushed to 100% developed land uses. Maximum effective shade by riparian vegetation is decreased to 3% (only topographic shade remains).

4. A "maximum forest" scenario, in which the entire watershed is theoretically forested with 35 meter-tall trees, 95% canopy closure, and 4 meters of overhang. This scenario would increase maximum effective shade to 95%.

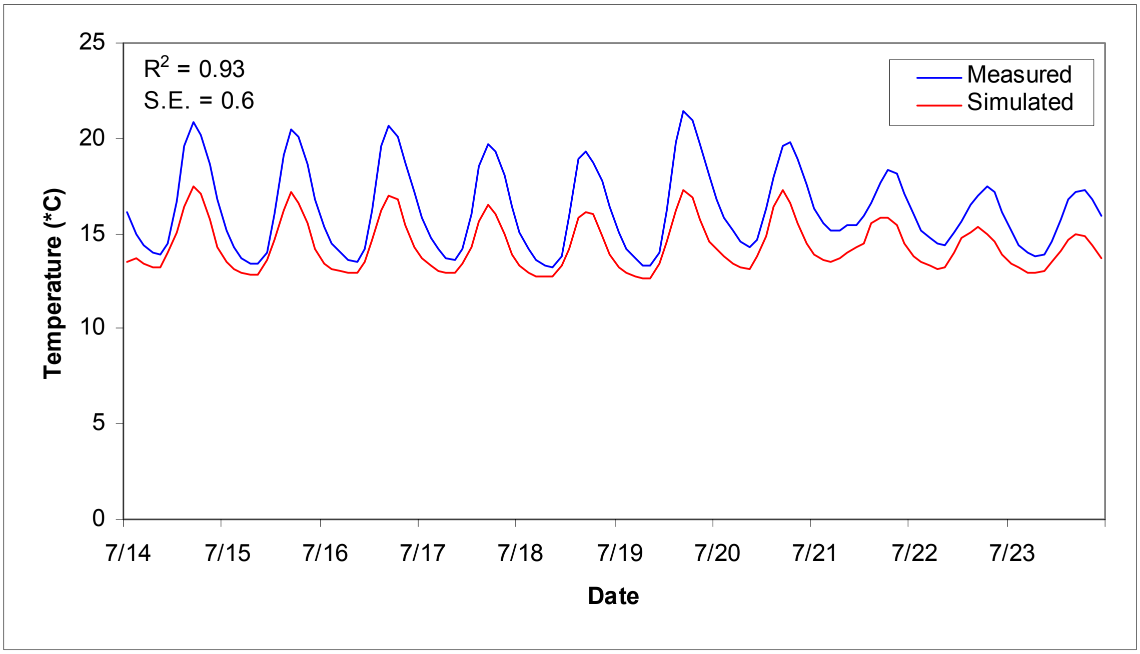

Figure D-5. HeatSource model calibration (summer 2003).

As Figure 9 in Section 4.2 showed, little can be done to change the thermal regime in McLoud Run by altering vegetation above the stream. This is true whether vegetation is removed or added, in minor amounts or to the extreme. The reason for this is that McLoud Run, being only 4.1 miles from initiation to mouth, does not experience sufficient travel time and exposure to the sun (or alternatively, blockage of the solar energy by riparian shade trees) to result in dramatic changes in water temperature.

Conclusions that can be drawn from the *HeatSource* modeling are as follows:

1. The major stream temperature violations that occur (with rain events) are too extreme to be caused by natural background pollution.
2. Of the potential natural background sources of thermal pollution in McLoud Run, incoming solar (shortwave) radiation accounts for the largest fraction.
3. Reduction of incoming solar radiation (by increasing riparian shade) will reduce absolute stream temperatures, but won't eliminate violations of the hourly water quality standards.
4. Additions of trees and shading above the stream (to reduce incoming solar radiation) will not have dramatic effects on stream temperature and won't alleviate thermal shock delivered to the stream during summer rain events.

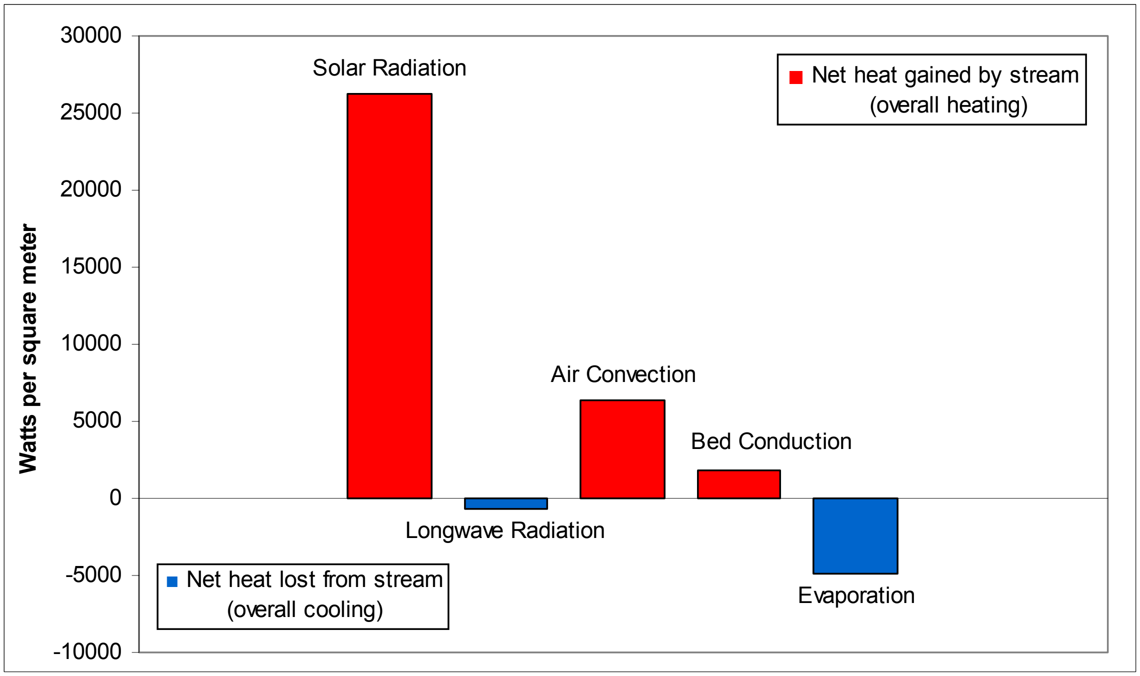

Figure D-6. Estimated heat loads at the lower temperature logger in McLoud Run during dry weather conditions.

Appendix E --- Additional Maps & Figures

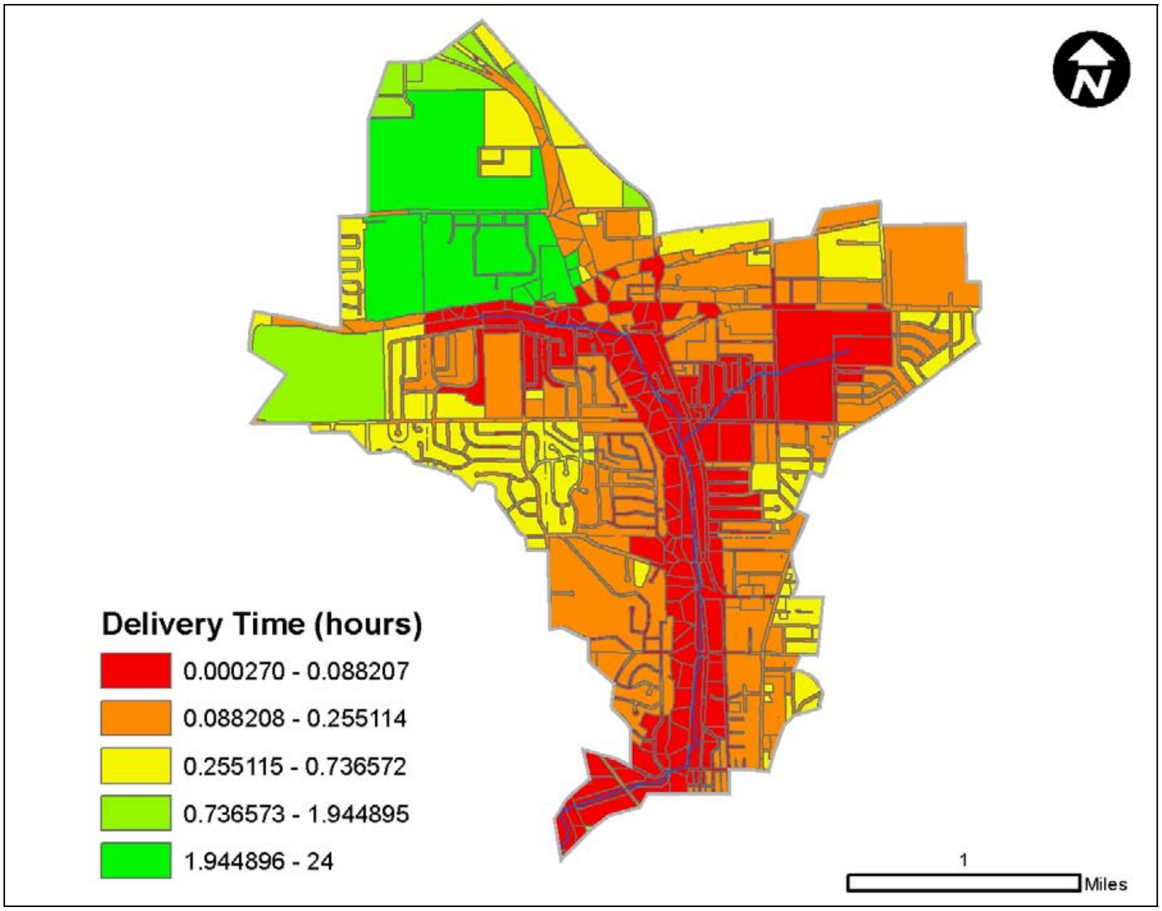

Figure E-1. Estimated time of concentration (travel time) of stormwater runoff in McLoud Run.

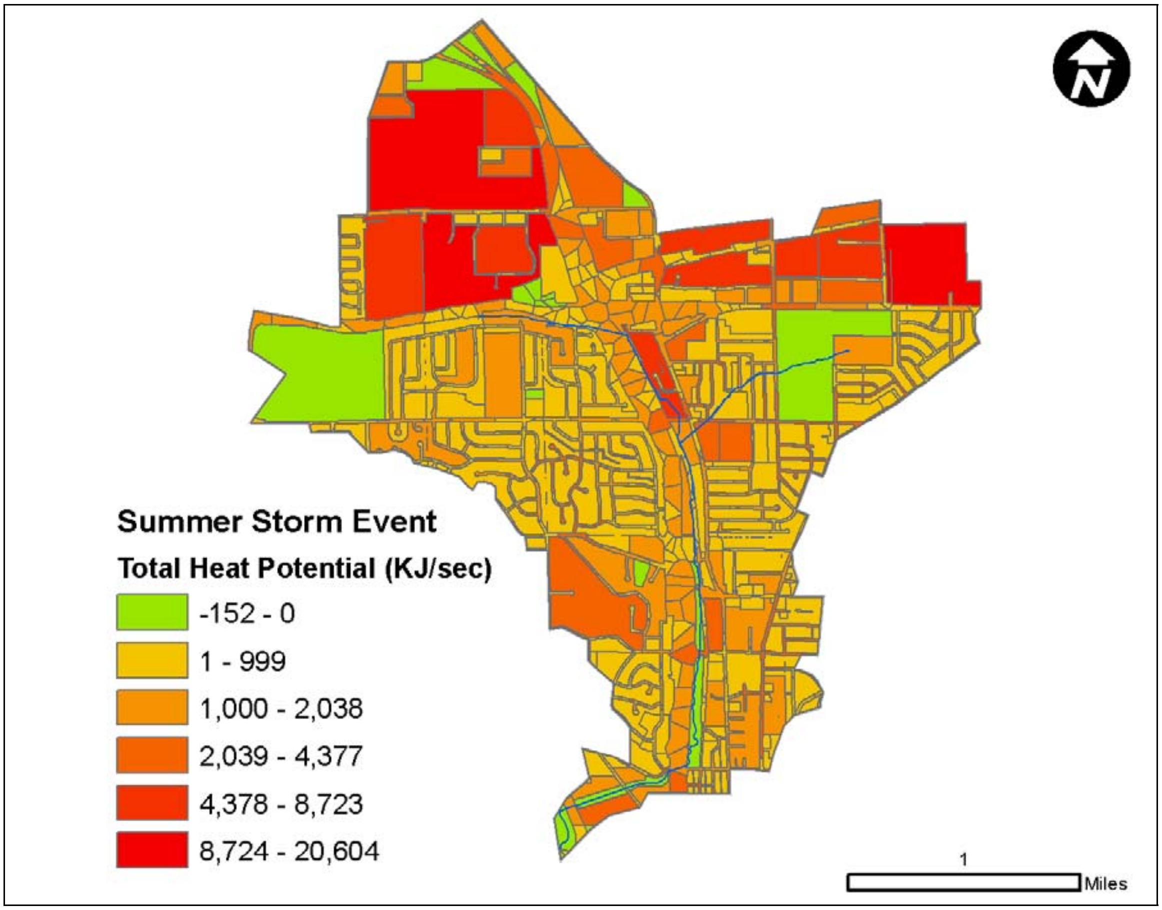

Figure E-2. Total potential heat loads by land use category in McLoud Run watershed for a 2-year return storm. Green areas indicate negative heat loads, where runoff temperature is predicted to be cooler than ambient stream temperature and thus a cooling effect (by dilution) results.

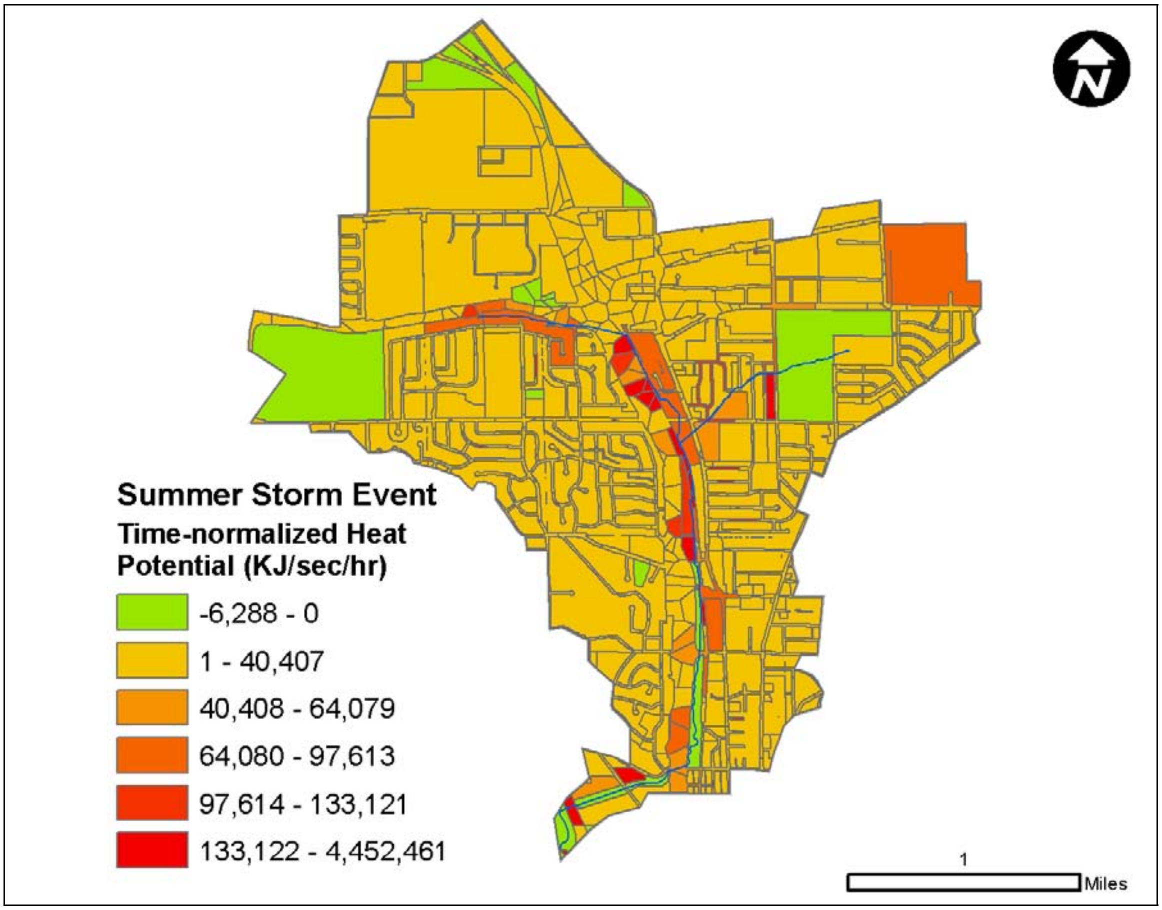

Figure E-3. Potential heat loads in McLoud Run watershed normalized by time of delivery.

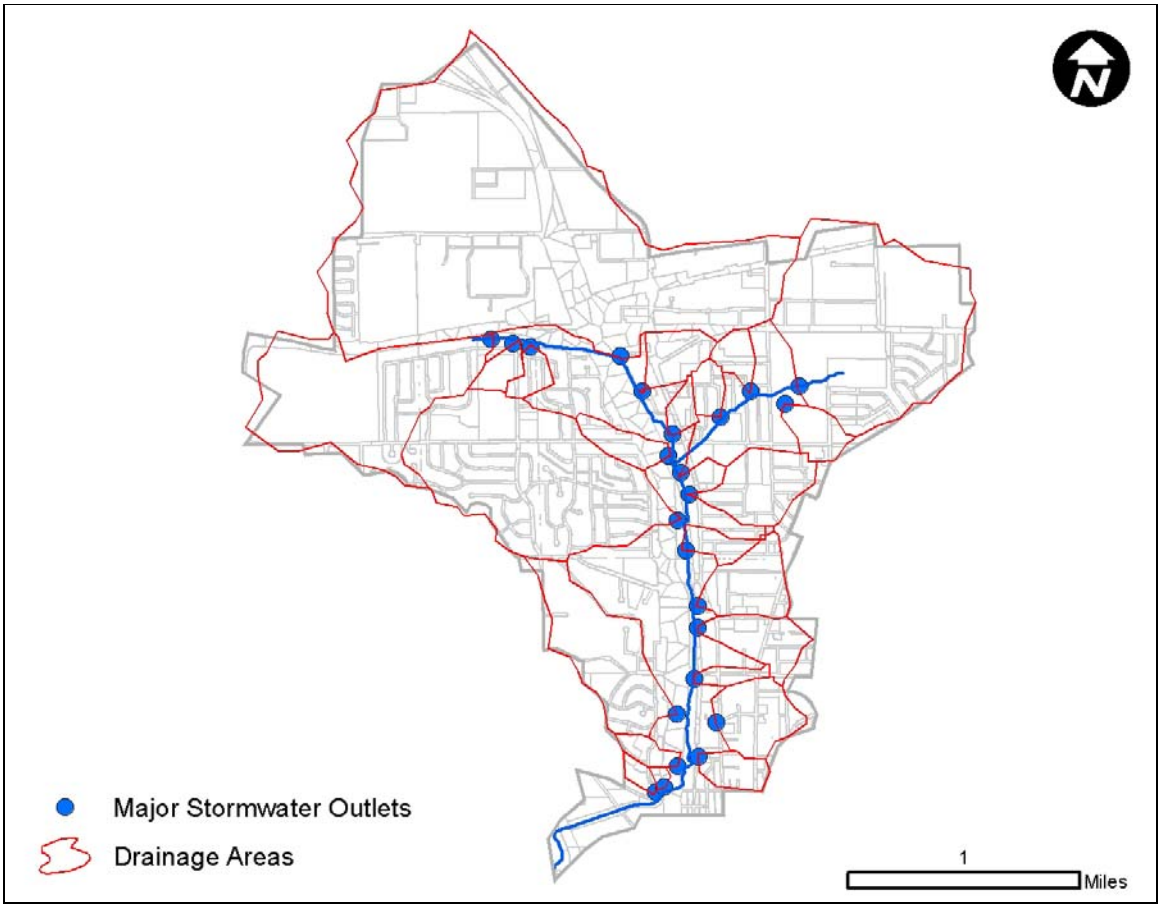

Figure E-4. Major stormwater drainage areas in McLoud Run.

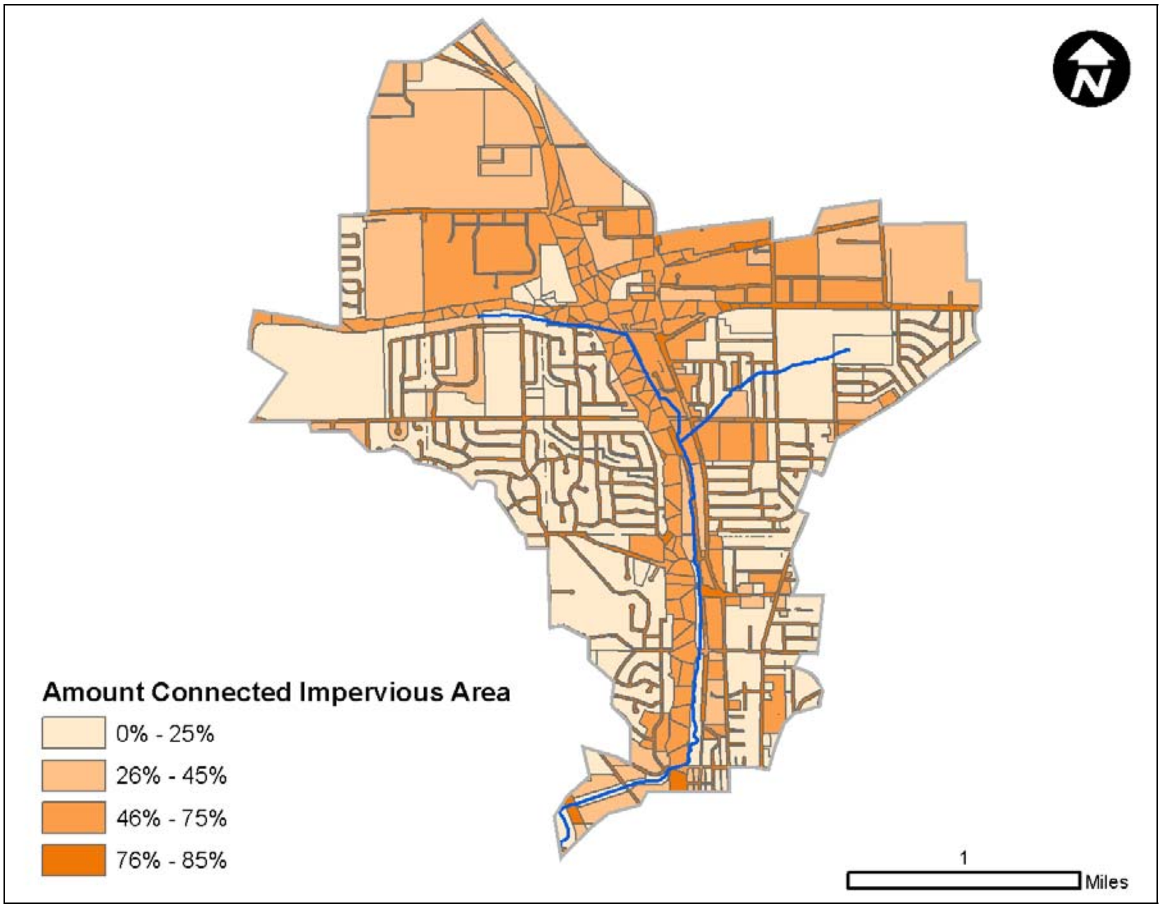

Figure E-5. Average estimated amount of connected impervious area in land use parcels.

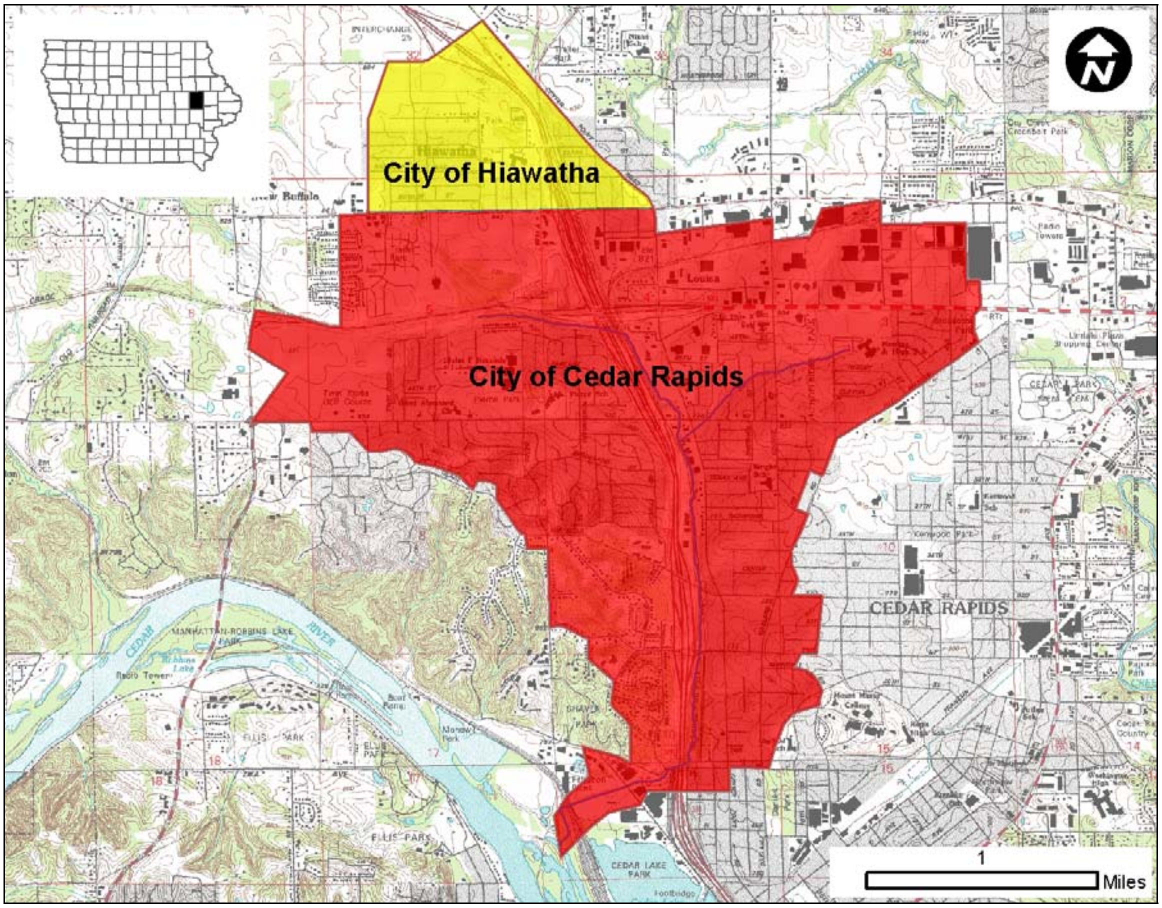

Figure E-6. City boundaries in McLoud Run watershed.

Appendix F --- Public Comments

A 30-day public comment period was held between April 19, 2007 and May 21, 2007. The content of written letters is included here for reference, along with how the comments were addressed.

Written comment #1	
From:	U.S. EPA Region 7 in Kansas City, MO
Date received:	May 9, 2007
Content:	See letter pasted below.
How comments were addressed:	Text was inserted into Page 9 of this report to address these comments.

Written comment #2	
From:	City of Cedar Rapids, Iowa
Date received:	May 21, 2007
Content:	See letter pasted below.
How comments were addressed:	A response letter was sent to the city to address their comments. The content of that letter is included in the following pages.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

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

MAY 04 2007

Mr. Chris Van Gorp,
TMDL/Water Quality Assessment Section
Iowa Department of Natural Resources
Henry A. Wallace Building
502 East 9th Street
Des Moines, Iowa 50319-0034

Dear Mr. Van Gorp:

RE: Comments on Draft TMDL public noticed on the IDNR website: McLoud Run.

The United States Environmental Protection Agency (EPA) is providing these comments on the proposed final Total Maximum Daily Load (TMDL) public noticed on the Iowa Department of Natural Resources (IDNRs) website: http://www.iowadnr.com/water/watershed/tmdl/publicnotice.html.

The McLoud Run TMDL public notice period was from April 19, 2007, to May 21, 2007; EPA's comments are in the enclosure.

EPA appreciates the opportunity to comment and the thoughtful effort that IDNR has put into this draft TMDL. We will continue to cooperate with and assist, as appropriate, future efforts by the IDNR to develop TMDLs.

If you have any questions or concerns in regards to this matter, please do not hesitate to contact Bruce Perkins, TMDL Team, at (913)551-7067.

Sincerely,

John DeLashmit
Chief
Water Quality Management Branch

Enclosure

cc: Allen Bonini
Iowa Department of Natural Resources

46090 MAY09'07 PM 4:03

(Written comment #1 page 1 of 2)

Enclosure

Regarding: Draft TMDL for McLoud Run – 02-CED-0218_0, for the impairment thermal modifications.

EPA has reviewed the draft document and has the following comments which need to be addressed in the final TMDL:

General Comments

Comment 1 - - The TMDL should include the segment identification number (02-CED-0218_0).

Comment 2 - - The TMDL should include the priority.

Comment 3 - - The TMDL should explicitly list the impaired use (aquatic life).

(Written comment #1 page 2 of 2)

TRANSMITTAL LETTER

CITY OF CEDAR RAPIDS
ENGINEERING DEPARTMENT
1201 6th Street SW
Cedar Rapids, IA 52404
Phone: (319) 286-5802
FAX No.: (319) 286-5801

To: Joe Herring, TMDL Staff
Watershed Improvement Section
Department of Natural Resources
via email: joe.herring@dnr.state.ia.us

Date: May 21, 2007
Project #: 43-07-002
Re: Proposed McLoud Run TMDL

ENCLOSED

ORIGINAL	DATE	DESCRIPTION
1	5/21/07	City of Cedar Rapids TMDL response

COMMENTS

Joe –

Enclosed is the City of Cedar Rapids comment on the proposed TMDL for thermal shock in McLoud Run.

SIGNED: ______________________________
Ken Bickner
Stormwater Management Project Engineer

Encl.

cc: Steve Hershner
Dave Elgin, PE & LS, City Engineer

4307002/MCLOUD RUN TMDL/TRM KDB IDNR(1)

(Written comment #2 page 1 of 6)

RESPONSE TO "WATER QUALITY IMPROVEMENT PLAN FOR MCLOUD RUN"

THE CITY OF CEDAR RAPIDS

MAY 21, 2007

By Ken Bickner,
Stormwater Management Project Engineer

I. QUESTIONING THE APPLICABILITY OF THE "TEMPERATURE CHANGE" CRITERION OF CHAPTER 61.

The City of Cedar Rapids questions and resists the application of IAC [567] 61.3(3) *b.*, which states in part:

> "(5) Temperature.
>
> 1. No heat shall be added to interior streams…that would cause an increase of more than 3°C. The rate of temperature change shall not exceed 1°C per hour."

We maintain that this standard was only intended to address anthropogenic point sources, such as cooling water discharges. The standard as currently written implies application of heat at a single point. If the standard was meant to be applied meaningfully to ambient non-point solar sources of heat, it would specify the length of the stream segment in which the specified temperature rise could occur. The standard is exceedingly vague and is not meaningful if the stream segment length is not specified. For instance, the Des Moines River probably experiences a rise of 3°C as it traverses the entire state, and likely did before the advent of European settlers.

We concede that 61.2(1) states "This policy shall apply to all point and nonpoint sources of pollution", but we maintain that when 61.3(3) *b.* was written, it was not envisioned that it would be applied to ambient solar sources of heat. As it is written, the length of stream over which the temperature change can occur is implicitly a single point. If the Cedar Rapids Municipal Storm Sewer System is to be regulated as a nonpoint source, the criterion is not adequate to use as a regulatory justification. If the Cedar Rapids Municipal Storm Sewer System is to be regulated as a collection of point sources, the criterion is probably already met at any one outfall.

II. THE UNENFORCEABILITY OF A STANDARD THAT IS COMMONLY VIOLATED.

If applied to ambient solar sources of heat, the standard would probably result in violations in every small stream within any developed area and probably many others as well. We are concerned that by application of a numerical criterion, the Department opens itself, and this and other jurisdictions, to a lawsuit for nonenforcement of the law. It is entirely imaginable that a citizen group would sue the state under 455B.111 of the Iowa Code to enforce the same standard in every class B water in the state. The State and the various jurisdictions would not be able to meet such a standard, and the standard would be excessive in most cases.

The question of unenforceability is not an imaginary issue. An actual case of this occurred with the previous standard for total dissolved solids in the same chapter. That standard limited Total Dissolved Solids (TDS) in discharges to 750 mg/L. Various jurisdictions would have been entirely incapable of meeting that standard, since their source water contained TDS in excess of 750 mg/L. A jurisdiction that was subjected to enforcement of this action could reasonably claim unequal treatment when other jurisdictions were being allowed such discharges, simply for lack of scrutiny. IDNR recognized this, and the standard was changed in 2004 to read "Acceptable levels of total dissolved solids (TDS)…will be established on a site-specific basis."

(Written comment #2 page 2 of 6)

III. THE EXCESSIVENESS OF THE STANDARD.

Furthermore, the application of a numerical criterion derived from IAC [567] 61.3(3) *b*., in addition to being of questionable legality, is excessive. The one known incident of a fish kill resulted from a rainfall the raised the water temperature 19°F (10.6°C) in 1 hour and 15 minutes. This incident is estimated to have killed only 10 percent of the trout in McLoud Run. Three incidents in 2003, reported in the Draft TMDL under consideration here, are not thought to have caused any fish death. The most extreme, on August 11, showed a rise of about 8°C in about one hour.

(Ignoring for now that comparison of the two results is confounded by the installation of bank hides between the 2001 and 2003 incidents), it is rational to conclude that the lowest rate of temperature rise that results in trout mortality is somewhere between 8°C per hour and 10.6°C in 1.25 hours.

IV. QUESTIONING THE APPLICABILITY OF THE ANTIDEGRADATION POLICY IN THIS INSTANCE.

Further, the City of Cedar Rapids questions and resists the unlimited application of the antidegradation policy as a basis for a thermal shock TMDL in McLoud Run. The antidegradation policy, as stated in IAC [567] 61.2(2) *a*., states:

> "Existing surface water uses and the level of water quality necessary to protect the existing uses will be maintained and protected."

It is questionable whether a trout fishery is an existing use under this clause, for the trout in McLoud Run exist only by action of the State. It is not established that trout ever existed naturally in the stream. By absurd extension, the State could stock trout in any stream in Iowa, then impose a TMDL to protect that existing use.

Section 316 of the Federal Water Pollution Control Act states:

> "(a) With respect to any point source otherwise subject to the provisions of section 301 or section 306 of this Act, whenever the owner or operator of any such source, after opportunity for public hearing, can demonstrate to the satisfaction of the Administrator (or, if appropriate, the State) that any effluent limitation proposed for the control of the thermal component of any discharge from such source will require effluent limitations more stringent than necessary to assure the projection and propagation of a balanced, **indigenous** population of shellfish, fish, and wildlife in and on the body of water into which the discharge is to be made, the Administrator (or, if appropriate, the State) may impose an effluent limitation under such sections for such plant, with respect to the thermal component of such discharge (taking into account the interaction of such thermal component with other pollutants), that will assure the projection and propagation of a balanced, indigenous population of shellfish, fish, and wildlife in and on that body of water." [EMPHASIS ADDED]

Three aspects of the current proposed TMDL are addressed by this section:

1. The proposed limitations are significantly more stringent than necessary.
2. The Clean Water Act is intended to protected indigenous species.
3. The State may adopt a lesser standard that will nonetheless protect the species (assuming that the objection under 2. does not hold.)

(Written comment #2 page 3 of 6)

V. LIMITATIONS ON THE POWER OF THE ENVIRONMENTAL COMMISSION TO ENACT REGULATIONS SIGNIFICANTLY MORE STRINGENT THAN THE CLEAN WATER ACT.

Furthermore, Section 303 (d) of the Clean Water Act is the ostensible enabling legislation for this regulation. It states:

> "(d)(1)(A) Each State shall identify those waters within its boundaries for which the effluent limitations required by section 301(b)(1)(A) and section 301(b)(1)(B) are not stringent enough to implement any water quality standard applicable to such waters. The State shall establish a priority ranking for such waters, taking into account the severity of the pollution and the uses to be made of such waters.
>
> (B) Each State shall identify those waters or parts thereof within its boundaries for which controls on thermal discharges under section 301 are not stringent enough to assure protection and propagation of a balanced **indigenous** population of shellfish, fish, and wildlife.
>
> (C) …
>
> (D) Each State shall estimate for the waters identified in paragraph (1)(D) of this subsection the total maximum daily thermal load required to assure protection and propagation of a balanced, **indigenous** population of shellfish, fish and wildlife. Such estimates shall take into account the normal water temperatures, flow rates, seasonal variations, existing sources of heat input, and the dissipative capacity of the identified waters or parts thereof. Such estimates shall include a calculation of the maximum heat input that can be made into each such part and shall include a margin of safety which takes into account any lack of knowledge concerning the development of thermal water quality criteria for such protection and propagation in the identified waters or parts thereof.
>
> (2) …
>
> (3) For the specific purpose of developing information, each State shall identify all waters within its boundaries which it has not identified under paragraph (1)(A) and (1)(B) of this subsection and estimate for such waters the total maximum daily load with seasonal variations and margins of safety, for those pollutants which the Administrator identifies under section 304(a)(2) as suitable for such calculation and for thermal discharges, at a level that would assure protection and propagation of a balanced **indigenous** population of fish, shellfish and wildlife."[ELISIONS AND EMPHASES ADDED]

Application of the Clean Water Act to introduced species is more stringent than the federal regulations. Iowa Code 455B, which enables environmental regulation by the IDNR, states at 455B.105:

> "3. …When the commission proposes or adopts rules to implement a specific federal environmental program and the rules impose requirements more restrictive than the federal program being implemented requires, the commission shall identify in its notice of intended action or adopted rule preamble each rule that is more restrictive than the federal program requires and shall state the reasons for proposing or adopting the more restrictive requirement. In addition, the commission shall include with its reasoning a financial impact statement detailing the general impact upon the affected parties."

We question whether the Notice of Intended Action for Chapter 61 included identification of the intent to use 303.d. to protect introduced species. We further question whether a financial impact statement was included in the deliberation over this question.

(Written comment #2 page 4 of 6)

VI. AN APPROACH TO MAINTENANCE OF A TROUT FISHERY IN MCLOUD RUN THAT IS NOT DEPENDENT ON REGULATION

The desire of the Iowa Department of Natural Resources Water Quality Bureau to protect and promote the development of McLoud Run as a fishery is understandable and commendable. However, in this case a top-down regulatory approach is not based on good legal ground.

The local jurisdictions in the McLoud basin are also interested in the success of McLoud Run. Removing the question from the realm of regulatory fiat frees the jurisdictions to pursue the protection of McLoud Run in a creative and practical way.

Before the jurisdictions can adopt reasonable and useful regulations to lessen thermal shock in McLoud Run, the following need to be established:

- What is the lethal rate of temperature increase for trout in McLoud Run? The question is site specific, since the role of bank hides and fish behavior cannot be extrapolated from general information about trout.
- What is the likelihood of a lethal incident occurring in a given year? We have attempted to establish this from existing climatological records, but have been frustrated by the fact that the IDOT pavement thermometers were not in operation during the 2001 incident.

The process of adopting development regulations could involve the following steps:

1. Using weather data (especially microdata specific to the basin), the jurisdictions and IDNR fisheries could work together to establish a criterion for thermal shock based on actual data about the response of trout in the stream.
2. The local jurisdictions, using weather data analysis, would determine the likelihood of an event meeting that criterion within any given year.
3. The State and the local jurisdictions would conduct the following economic analysis:
    a. Establish the statistical frequency of a lethal event.
    b. Establish the cost of restocking as necessary to compensate for fish lost during a lethal event.
    c. Establish the cost for measures that would eliminate or lessen the frequency of lethal events. These measures are likely to include or at least consider:
        i. Shading of impervious surfaces.
        ii. Detention of stormwater pipe flows.
        iii. Other means of cooling stormwater pipe flows (e.g. metal pipe contact cooling.)
        iv. Infiltration of surface runoff.
        v. Control of impervious surface heat transfer through regulation or alteration of impervious surface albedo and heat capacity.
        vi. Measures to improve trout habitat throughout the watershed.
    d. The cost of control could be compared to the cost of restocking and the least cost alternativec be selected.

(Written comment #2 page 5 of 6)

VII. CONCLUSION

The City of Cedar Rapids is committed to maintaining McLoud Run as a trout stream but does not believe that imposition of a TMDL using the justification of IAC [567] 61.3(3) *b* or the antidegradation policy is warranted or justified.

(Written comment #2 page 6 of 6)

Iowa DNR Responses to City of Cedar Rapids:

I. CITY OF CEDAR RAPIDS COMMENT #1: QUESTIONING THE APPLICABILITY OF THE "TEPMPERATURE CHANGE" CRITERION OF CHAPTER 61.

Iowa DNR Response:

We agree that this standard (IAC [567] 61.3(3) *b. (5)*) was likely written to only address anthropogenic point sources of heat, not ambient/solar sources of chronic heat. Indeed, this is implied on Page 16 of the draft TMDL under the section entitled *Applicable water quality standards*:

> *"These criteria are based on acute changes in water temperature resulting from direct, anthropogenic additions of heat to the stream. They do not apply to chronic heating of the stream from natural solar inputs (background sources) or nonpoint source inputs."*

Discharge of pollutants from an NPDES-permitted Municipal Separate Stormwater System (MS4) is considered point source pollution. Thus, application of the numerical standard (IAC [567] 61.3(3) *b. (5)*) to the MS4 is deemed necessary. The draft TMDL for heat in McLoud Run does not apply to chronic heating of the stream by solar energy; it only applies to acute thermal enrichment at discrete points from permitted stormwater discharges.

In the future, it may be possible to incorporate alternative criteria for assessing the stream's aquatic life uses other than just a numeric standard. For instance, the state's 2004 bioassessment methodology (IDNR, 2004)[**] is regularly used to determine biological impairments in wadeable Class B streams throughout the state and for 305(b) assessments. If biological monitoring showed that fish and benthic communities in McLoud Run are consistently healthy and viable, yet the numerical temperature criteria were still being violated, it would provide evidence that the numeric standards may be wrong. However, it should be noted that there are a number of unresolved issues to overcome before bioassessment scores from McLoud Run can be compared to an appropriate reference stream. If the city has an interest in pursuing this option, the Iowa DNR is pleased to cooperate.

[**] Iowa Department of Natural Resources (IDNR), 2004. Biological Assessment of Iowa's Wadeable Streams. Environmental Services Division. Iowa Department of Natural Resources. Available online at: http://wqm.igsb.uiowa.edu/wqa/streambio/index.html.

II. CITY OF CEDAR RAPIDS COMMENT #2: THE UNENFORCEABILITY OF A STANDARD THAT IS COMMONLY VIOLATED.

Iowa DNR Response:

This comment is based on the false premise that the TMDL applies to ambient solar sources of heat. As stated in Section I above, the numeric criteria of IAC [567] 61.3(3) *b.* (5) are interpreted in the TMDL to only apply to acute thermal discharges from point sources.

III. CITY OF CEDAR RAPIDS COMMENT #3: THE EXCESSIVENESS OF THE STANDARD.

Iowa DNR Response:

In developing TMDLs, the Iowa DNR does not have the ability to lessen (weaken) applicable state water quality standards. While a discussion of whether or not the state water quality standard for temperature (IAC [567] 61.3(3) *b.(5)*) is excessive may be warranted, it is an entirely different issue and is not appropriate for it to be addressed by the draft TMDL.

Furthermore, linking violations of the numeric criteria to only the presence or absence of trout death is not an adequate indication of the overall health of the ecosystem. Not only does it allow for the possibility of Type II errors (i.e., a "false negative," that not finding dead fish must mean that no fish were killed), more importantly it does not account for stress incurred by the fish and benthic community. Biological monitoring of aquatic macroinvertebrate communities in the past has indeed shown poor health and diversity in the stream, possibly due to a number of stressors attributed to the urban watershed (Fisher, 2006)[††]. Practically speaking, the numeric temperature criterion is one of the few quantifiable means we have for addressing an impairment in an urban stream plagued by a complexity of stressors.

[††] Fisher, 2006. Biomonitoring organochlorine and cholinesterase inhibiting insecticide in eastern Iowa streams. Master's thesis. University of Northern Iowa. Library Call #LD2585.F5345.

IV. CITY OF CEDAR RAPIDS COMMENT #4: QUESTIONING THE APPLICABILITY OF THE ANTIDEGRADATION POLICY IN THIS INSTANCE.

Iowa DNR Response:

The antidegradation policy is not the basis of the thermal TMDL in McLoud Run. Fish kills occurring regularly in the stream provided the impetus to list McLoud Run as a 303(d) waterbody, in accordance with Iowa's Section 303(d) and 305(b) assessment methodology (narrative criteria protect all streams against acutely toxic conditions). The requirement for a TMDL is founded upon violation of the clear violations of state water quality standards for rapid temperature change in the stream. The temperature violations were based on the stream's designation as an aquatic life resource, independently of the presence of trout in the stream, and would apply to any Class B stream in the state caused by point source thermal discharges. In McLoud Run, the maximum hourly increase of 1°C standard applies irrespective of its status as either a coldwater or warmwater stream and with or without the DNR's trout stocking program in place.

V. CITY OF CEDAR RAPIDS COMMENT #5: LIMITATIONS ON THE POWER OF THE ENVIRONMENTAL COMMISSION TO ENACT REGULATIONS SIGNIFICANTLY MORE STRINGENT THAN THE CLEAN WATER ACT.

Iowa DNR Response:

As implied in Section 4, the presence of stocked trout in the stream does not provide the sole rationale for Clean Water Act enforcement in McLoud Run. While fish kills may have flagged McLoud Run during the 305(b) process, it was secondary investigation into the matter and monitoring data which show clear violations of Class B aquatic life criteria that warrant the need for a TMDL.

VI. CITY OF CEDAR RAPIDS COMMENT #6: AN APPROACH TO MAINTENANCE OF A TROUT FISHERY IN MCLOUD RUN THAT IS NOT DEPENDENT ON REGULATION.

Iowa DNR Response:

We agree; the Iowa DNR Watershed Improvement Section also believes that a top-down approach is not the most efficient means of improving water quality in the state of Iowa. Grassroots activism by citizens and businesses in the watershed have the most potential for successful management of the stream. Page 8 of the draft TMDL states that:

> *"Improvements to the stream will happen most quickly if local interest spurs voluntary action among people living and working in the watershed."*

For these reasons, the IDNR Watershed Improvement Section distributes up to $2-3 million dollars of federal funding for incentive-based, non-regulatory water quality improvements across the state each year (319 Nonpoint Source Program). Additional funding is made available to local jurisdictions through the Watershed Improvement Review Board (WIRB), Lakes Restoration program, and Watershed Protection Funds via other government agencies. Although regulatory in nature, we see the TMDL as a useful resource for setting quantifiable water quality targets, identifying pollutant sources, and outlining possible solutions to assist local groups in solving water quality problems; thus, the TMDL goes hand-in-hand to help guide efforts made by recipients of water quality grants. The implementation plan included in the McLoud Run TMDL was written to provide local government and citizens with an opportunity to seek out their own solutions for meeting the water quality goals of the report.

Secondly, McLoud Run was a recipient of 319 funding from 2001-2007, with a total award of $679,500. While some progress was made in the watershed, over 25% of the grant money was unspent to date and the water quality impacts have yet to be proven, save for the absence of additional documented fish kills. While you state that *"Removing the question from the realm of regulatory fiat frees the jurisdictions to pursue the protection of McLoud Run in a creative and practical way*," we contend that this approach has already been tried in McLoud Run; indeed, additional monitoring of the stream may in fact show that it was successful. Until that can be demonstrated, the TMDL is not only required but should be accepted by local jurisdictions as it will help sustain interest in the resource, help with future funding opportunities, and assist with better targeting of resources for the thermal impairment.

VII. CONCLUSION

A TMDL for McLoud Run is made necessary by the following chain of reason:

1. Numerical criteria for temperature apply to McLoud Run as a Class B (aquatic life) waterbody.
2. Discharges from MS4 stormwater outfalls owned and operated by the Cities of Cedar Rapids and Hiawatha are legally considered point sources.
3. Violations of the numeric criteria for temperature that are the result of point source stormwater discharge are not exempt from IAC [567] 61.3(3) *b.(5).*

The Iowa DNR is obligated to uphold the requirements of the federal Clean Water Act, but at the same time strives to work cooperatively with local jurisdictions to achieve water quality improvements with practical solutions. With sufficient evidence of improved water quality and/or a demonstration that designated uses are being met, the de-listing of McLoud Run as an impaired waterbody can occur; however, that evidence does not exist at this time. Biological sampling in the stream and continuous temperature monitoring may demonstrate that Class B uses are being met, but until such time this TMDL is justified and required.