Water Quality Improvement Plan
for

Des Moines River, Iowa

Total Maximum Daily Load for Nitrate

Prepared by

Keith E. Schilling and Calvin F. Wolter

Iowa Department of Natural Resources, Geological and Water Survey
109 Trowbridge Hall, Iowa City, IA 52242-1319

Iowa Department of Natural Resources
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TABLE OF CONTENTS

List of Figures

List of Tables

EXECUTIVE SUMMARY

The Federal Clean Water Act requires the Iowa Department of Natural Resources (IDNR) to develop a Water Quality Improvement Plan, also known as a Total Maximum Daily Load (TMDL), for waters that have been identified on the state's 303(d) list as impaired by a pollutant. The 2004 305(b) assessment reported that the designated drinking water use of the Des Moines River from Center Street dam in Des Moines to Interstate 80 bridge (segment 04-UDM-0010_2) was impaired due to nitrate-nitrogen (nitrate) concentrations. For the impaired segment, the Class C (drinking water) uses were assessed as "not supporting" due to the level of nitrate that exceeds state water quality standards and USEPA maximum contaminant level (MCL). The applicable water quality standard for nitrate is 10 milligrams per liter (mg/l). A Water Quality Improvement Plan has been developed to calculate the maximum allowable nitrate load for the impaired segments of the Des Moines River that will ensure compliance with water quality standards.

The Des Moines (DSM) River at 2nd Avenue in Des Moines drains a watershed of 6,245 square miles (mi^2) flowing from its headwaters in Minnesota through north-central Iowa. The watershed is located within the Des Moines Lobe landform region of Iowa dominated by low relief and poor surface drainage. Land cover in the DSM River watershed is predominantly agricultural, consisting of 78.5 percent row crops, 14.3 percent grass, 2.7 percent forest, 2.5 percent urban, and 1.9 percent water and wetlands. The average annual precipitation total for the watershed for the 1995 to 2006 period ranged from 30.9 at Algona to 31.9 inches at Ft Dodge and Ankeny. Total streamflow and baseflow in the DSM River at 2nd Avenue averaged 7.34 and 5.23 inches, respectively.

Surface water from the DSM River is used by the City of Des Moines for drinking water. During the 1995 to 2006 period, nitrate concentrations in the river ranged from 0.5 to 14.5 mg/l and averaged 6.3 mg/l. Concentrations exceeded 10 mg/l approximately 16.4 percent of the time from 1995 to 2006 (719 out of 4382 values). Nitrate concentrations exhibit clear seasonality, with higher concentrations occurring during April, May and June as well as November and December. Nitrate concentrations measured in various large subbasins in the DSM River watershed from 1999 to 2006 indicated substantial variation. Nitrate concentrations exceeded the MCL in over 30 percent of the measured values in four basins, whereas nitrate concentrations in the West Fork of the DSM River exceeded the MCL only 6.6 percent of the time. Upstream of Saylorville Reservoir, nitrate concentrations exceeded 10 mg/l about 26 percent of the time but downstream of the reservoir, nitrate exceeded 10 mg/l only 16.6 percent of the time.

The sources of nitrate can be divided into two major categories, point sources and nonpoint sources. The point sources include activities such as municipal, industrial, and semi-public wastewater treatment systems, urban stormwater (MS4 permits), permitted animal feeding operations, and water treatment plants. There are a total of seventy-four (74) entities in the DSM River watershed with National Pollution Discharge Elimination System (NPDES) permits. There are three cities in the Des Moines River watershed with Municipal Separate Storm Sewer Systems (MS4s) permits: Des Moines, Grimes and Johnston. Eight water treatment plants have applied for an NPDES permit. Nonpoint sources of nitrate to the DSM River include contributions from agricultural land, developed land (urban and residential areas), and natural sources. Potential nonpoint sources from agricultural sources include fertilizer, soil mineralization, legume fixation, and manure. Potential nonpoint sources from developed land sources include septic systems and turf grass fertilizer. Potential natural sources include atmospheric deposition and wildlife. Soil mineralization and nitrogen fertilizer are the largest nonpoint sources of nitrogen in the Des Moines River watershed, contributing approximately 60 percent of the total nitrogen input.

Legume fixation accounted for 15 percent of the total nitrogen in the Des Moines River watershed. Nitrogen from animal manure from all sources accounted for nearly 11 percent of the total nitrogen inputs in the watershed.

The load duration curve (LDC) modeling approach was used in this TMDL to compare measured pollutant concentrations and daily flow data to the water quality standard at a range of flow conditions. A nitrate TMDL target of 9.5 mg/l was adopted that allows for a margin of safety (MOS) of 0.5 mg/l. A maximum nitrate reduction of 34.4 percent at the watershed outlet was needed for all days to be less than the TMDL target of 9.5 mg/l. The percentage of days that exceeded the TMDL decreased with decreasing flow percentile, from 77.9 percent in the 90-100 percent range to 0.9 percent in the 30-40 percent range (only 4 of 439 samples exceeded the TMDL target in this flow range). Overall for the entire flow range, 19.3 percent of the days exceeded the TMDL target. During the 12-year monitoring period evaluated, a nitrate impairment did not occur when DSM River streamflow was less than 953 cubic feet per second (cfs).

Point sources associated with WWTPs do not contribute substantially to the nitrate impairment for the Des Moines River at 2nd Avenue. There were no nitrate exceedances at lower flows in the river (i.e., lowest 30% of flows, or flows less than 742 cfs), which would be the time when impacts from WWTP's would be evident if they were to occur. To ensure that low flows in the river are adequately protected from potential point source impacts, a two-tiered system of wasteload allocations is established. Tier I wasteloads are assigned to WWTPs when streamflow in the Des Moines River at 2nd Avenue is greater than 742 cfs and Tier II wasteloads are applied when flows are less than 742 cfs. The total wasteload allocated to WWTP sources in the Des Moines River above the City of Des Moines at 2nd avenue is set to their existing maximum nitrate load when flows are greater than 742 cfs (Tier I = 17,906.6 lbs/day), and is set to their existing average nitrate load when flows are less than 742 cfs (Tier II = 5,757.7 lbs/day).

Additional wasteload capacity was allocated for MS4 cities (379 lbs/day), water treatment plants (2,326.5 lbs/day) and unsewered communities (239.8 lbs/day). The total wasteload allocated to the DSM river above 2nd Avenue was 20,851.9 lbs/day (Tier I conditions) and 8,703.0 lbs/day (Tier II conditions). The load allocation (LA) for nonpoint sources varies by flow and was set to be the difference between the TMDL target of 9.5 mg/l and the sum of the wasteload allocation (WLA) and the MOS.

The Soil and Water Assessment Tool (SWAT) model was used to evaluate streamflow and pollutant loading patterns in the DSM River watershed. The model inputs included climate, topography, land use, soils, feedlots and confinements, manure application areas, WWTPs and census data. The streamflow and nitrate calibration process was completed by varying several SWAT calibration parameters within their acceptable ranges. There were a total of 173 subbasins included in the model. Nitrate loss rates in subbasins varied from less than 5 kilograms per hectare (kg/ha) (0.45 pounds per acre, lb/ac) to more than 20 kg/ha (18 lb/ac) in the Des Moines River watershed. Eight subbasins had nitrate losses greater than 20 kg/ha (18 lb/ac), with four of these subbasins located in the eastern half of the Boone River watershed (Upper White Fox Creek, Buck Creek, Lyon's Creek and Drainage Ditch 206). Elevated nitrate loading rates were also associated with the Beaver Creek watershed located in the southern extent of the Des Moines River basin. Lowest nonpoint source loading rates in subbasins were mainly located in the central core of the watershed containing the Des Moines River floodplain corridor. Point sources contribute to 6.4 percent of the total nitrate load and nonpoint sources contribute 93.6 percent of the total nitrate load in the watershed. A total of 67 of the 173 subbasins (38.7 percent) had total nitrate losses greater than 15 kg/ha (13 lb/ac)when point sources were included in the model.

Best management practices (BMPs) implemented in the Des Moines River watershed can be used to reduce nitrate loads. Watershed scale nitrate load reductions were evaluated using the calibrated SWAT model. For the Des Moines River TMDL, three global-scale nitrate load reduction scenarios were evaluated: 1) Reduce the rate of ammonia fertilizer application in the watershed from 170 kg/ha (152 lb/ac) to 100 kg/ha (89 lb/ac) and 50 kg/ha (45 lbs/ac); 2) Remove all manure generated from permitted or registered CAFOs and feedlots; and 3) Remove all human waste from the watershed. In addition to the global assessments, four spatial configurations of potential load reductions in various subbasins were evaluated to improve our understanding of targeting strategies: 1) target major nitrate load reductions in all subbasins with annual average losses greater than 15 kg/ha (13 lb/ac) (55 subbasins out of 173); 2) target major nitrate load reductions in all subbasins of the Boone River watershed; 3) target major nitrate load reductions in subbasins located closest to the DMWW intake at 2nd Avenue; and 4) target major nitrate load reductions in subbasins located furthest away from the DMWW intake at 2nd Avenue (Minnesota subbasins).

Nitrate load reductions from the global-scale changes ranged from 4.8 to 38.0 percent, with the greatest potential load reduction associated with reducing fertilizer inputs from 170 to 50 kg/ha (152 to 45 lb/ac). SWAT model results suggest that the reduction in fertilizer applications to 50 kg/ha (45 lb/ac) would be sufficient to achieve the 34.4 percent reduction in nitrate loads required in this TMDL. Eliminating manure inputs to the Des Moines River watershed (from permitted or registered CAFOs and feedlots) resulted in a nitrate load reduction of 7.25 percent at the watershed outlet, whereas eliminating all human waste in the watershed achieved a nitrate reduction of 4.8 percent. Spatially, targeting subbasins near the watershed outlet for major reductions in fertilizer applications was more efficient than the other three strategies for reducing watershed nitrate loads. Compared to area of land treated, targeting the 55 highest subbasins was most effective, with a 14.1 percent reduction in nitrate loads achieved by reducing applications on 30.3 percent of the land area

Results suggest that global scale reductions in fertilizer applications (everyone reducing at a similar rate) achieved greater nitrate load reductions than specific targeting strategies. The nitrate load reduction achieved by targeting 55 subbasins for fertilizer applications of 50 kg/ha (45 lb/ac) was 14.4 percent, substantially less than the 25 percent load reduction achieved by everyone applying 100 kg/ha (89 lb/ac). If targeting for load reductions is a preferred strategy, the most efficient load reductions occurred when fertilizer applications were reduced in subbasins nearest the watershed outlet. Local scale efforts to reduce nitrate loads involve improved nutrient use, better in-field management and off-site management techniques. A variety of actions to control nonpoint urban sources include both structural and non-structural practices.

Existing monitoring programs provide large-scale estimates of water loss and pollutant export from various major subbasins. A three step monitoring paradigm is suggested that would shift the focus of monitoring to smaller basins with the objective of detecting water quality changes. The first step would be to identify basins contributing the highest concentrations and loads. Once a basin has been selected for monitoring, the second step is developing a monitoring program that includes the following elements: 1) monitoring objectives; 2) monitoring design; 3) sampling locations; 4) sample parameters; and 5) sample frequency and duration. After an appropriate period of time, step three of the monitoring program would include a reevaluation to assess whether or not the program is meeting the monitoring objectives.

1.0 INTRODUCTION

The Federal Clean Water Act requires the Iowa Department of Natural Resources (IDNR) to develop a Water Quality Improvement Plan, also known as a Total Maximum Daily Load (TMDL), for waters that have been identified on the state's 303(d) list as impaired by a pollutant. One segment of the Des Moines River has been identified as impaired by nitrate-nitrogen (nitrate) (Figure 1-1). A Water Quality Improvement Plan has been developed for the impaired segment. The purpose of this Water Quality Improvement Plan is to calculate the maximum allowable nitrate load for the impaired segment of the Des Moines River that will ensure compliance with water quality standards.

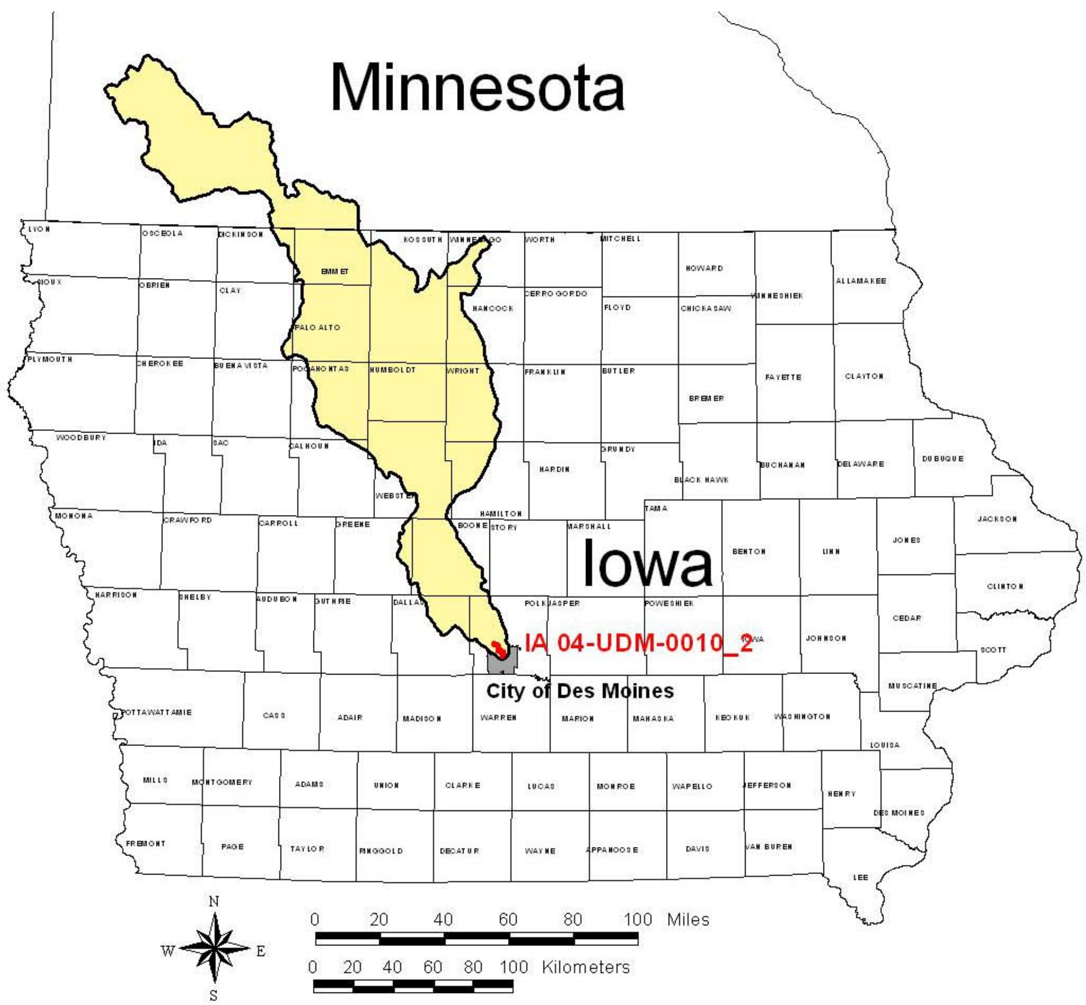

Figure 1-1. Location of Des Moines River watershed and impaired segment.

The Water Quality Improvement Plan presented in this report outlines a phased approach to TMDL development and implementation. A phased approach is helpful when the origin, interaction, and quantification of pollutants contributing to water quality problems are complex and difficult to fully understand and predict. Based on available information,, the waterbody load capacity, existing pollutant load in excess of this capacity, and the source load allocations are estimated based. A monitoring plan will be used to determine if prescribed load reductions result in attainment of water quality standards and whether the target values are sufficient to meet designated uses. Monitoring activities may include routine sampling and analysis, and watershed and/or watershed modeling. Monitoring is essential to a Water Quality Improvement Plan in order to:

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

Additional data will be used to determine if the implemented TMDL and watershed management plan have been, or are, effective in addressing the identified water quality impairment. The data and information can also be used to determine if the TMDL has accurately identified the required components (i.e. loading/assimilative capacity, load allocations, in-stream response to pollutant loads, etc.) and if revisions are appropriate.

This TMDL has been prepared in compliance with the current regulations for TMDL development that were promulgated in 1992 as 40 CFR Part 130.7 in compliance with the Clean Water Act. These regulations and consequent TMDL development are summarized below:

1. Name and geographic location of the impaired or threatened waterbody for which the TMDL is being established:

The 2004 305(b) assessment reports that the 6.5 mile segment of the Des Moines River from Center Street dam in Des Moines to Interstate 80/35 bridge in Section 17, T79N, R24W in Polk County (segment 04-UDM-0010_2) has designated uses of aquatic life, fish consumption, primary contact (recreation) and drinking water. The designated use classes are Class B(WW-1), Class HH, Class A1, and Class C, respectively. The 2004 305(b) assessment determined that the drinking water use (Class C) of the Des Moines River from Center Street dam in Des Moines to Interstate 80 bridge (segment 04-UDM-0010_2) was impaired due to nitrate.

2. Identification of the pollutant and applicable water quality standards:

The pollutant causing the water quality impairment is nitrate. For the impaired segment, the Class C (drinking water) uses were assessed as “not supporting” due to levels of nitrate that exceeds state water quality standards and USEPA maximum contaminant level (MCL). The applicable water quality standard for nitrate is 10 mg/l.

3. Quantification of the pollutant load that may be present in the waterbody and still allow attainment and maintenance of water quality standards:

The acceptable load of nitrate that may be present in the river is the product of the allowable nitrate concentration (10 mg/l) multiplied by the flow rate. Maintaining this level as the maximum allowable nitrate load would ensure that designated uses of the Des Moines River for drinking water supply are maintained at all times.

4. Quantification of the amount or degree by which the current pollutant load in the waterbody, including the pollutant from upstream sources that is being accounted for as background loading, deviates from the pollutant load needed to attain and maintain water quality standards:

A load duration curve approach was used in this TMDL to compare measured pollutant concentrations and daily flow data to the water quality standard at a range of flow conditions. Based on this method, the required maximum reduction of daily nitrate loads was 34.4 percent.

5. Identification of pollution source categories:

Nonpoint sources of nitrate have been identified as the main cause of the drinking water impairment in the Des Moines River at Des Moines. Point sources, such as wastewater treatment plants, urban runoff, and water treatment plants, are also likely contributors to the nitrate loads, but these sources play a less significant role.

6. Wasteload allocations for pollutants from point sources:

The wasteload allocations (WLA) for nitrate from point sources to the Des Moines River include nitrate loads from wastewater treatment plants (WWTPs), stormwater runoff from three communities with MS4 permits, water treatment plants and future nitrate loads from unsewered communities. A two-tiered system of wasteload allocations is established for WWTPs. Tier I wasteloads are assigned to WWTPs when streamflow in the Des Moines River at 2nd Avenue is greater than 742 cfs and Tier II wasteloads are applied when flows are less than 742 cfs. The total wasteload allocated to WWTP sources in the Des Moines River above the City of Des Moines at 2nd avenue is set to their existing maximum nitrate load when flows are greater than 742 cfs (Tier I = 17,906.6 lbs/day), and is set to their existing average nitrate load when flows are less than 742 cfs (Tier II = 5,757.7 lbs/day). Additional wasteload capacity was allocated for MS4 cities (379 lbs/day), water treatment plants (2,326.5 lbs/day) and unsewered communities (77.1 lbs/day). The total wasteload allocated to the DSM river above 2nd Avenue was 20,689.2 lbs/day (Tier I conditions) and 8,540.3 lbs/day (Tier II conditions).

7. Load allocations for pollutants from nonpoint sources:

The load allocations (LA) assigned to nonpoint sources of pollution for this TMDL is based upon the applicable water quality standards for the stream’s designated use. For nitrate, the LA was set to be the difference between the maximum allowable pollutant load and the WLA plus the margin of safety (see below).

8. A margin of safety:

This TMDL contains both an explicit and implicit margin of safety (MOS). The MOS for nitrate was explicitly set to be 0.5 mg/l.. An implicit margin of safety was set by using very conservative assumptions in the derivation of numeric targets for the WLA and LA.

9. Consideration of seasonal variation:

Seasonal variation in nitrate loads was evaluated using the load duration curve that accounted for seasonal and annual variations in streamflow. Nitrate loads were evaluated by month.

10. Allowance for reasonably foreseeable increases in pollutant loads:

For point sources, allowance for future growth was included in this TMDL by considering the possibility that currently unsewered communities may construct a wastewater treatment plant in the future. These communities may request an NPDES permit to discharge nitrogen into the Des Moines River watershed. To accommodate potential nitrogen discharge from future WWTPs, additional wasteload capacity was reserved in this TMDL. For nonpoint sources, no allowances for future growth were included in the TMDL because current watershed land uses are predominantly agricultural and the addition/deletion of animal feeding operations (which could increase or decrease nitrate loading) cannot be predicted or quantified at this time.

11. Implementation plan:

An implementation plan is outlined in Section 5 of this TMDL. The reduction of nitrate loads will be carried out through a combination of non-regulatory activities and monitoring for results. Nonpoint source pollution will be addressed using available programs, technical advice, information and education, and financial incentives.

12. Reasonable Assurance:

Reasonable assurance for the reduction of nonpoint source loading is given by the availability of technical and financial assistance for conservation practices and watershed improvement grants. Funding made available to local stakeholder groups on an annual basis provides an opportunity for local citizens and landowners to seek their own solutions with technical guidance from state and local government agencies.

2.0 DESCRIPTION AND HISTORY OF THE DES MOINES RIVER AT 2^ND^ AVENUE IN DES MOINES

The Des Moines (DSM) River at 2nd Avenue in Des Moines drains a watershed of 6,245 mi^2 flowing from its headwaters in Minnesota through north-central Iowa (Figure 2-1). The watershed receives water from portions of 18 Iowa counties and flows southward more than 220 miles from its origin in Lake Shetek in Murray County Minnesota. The DSM River (West Fork) and East Fork DSM River form major tributary branches that merge within Humboldt County. The Boone River joins the DSM River in southern Webster County and the DSM River flows southward where it is impounded to create Saylorville Lake reservoir in Polk County. Downstream of the reservoir, Beaver Creek is the only major tributary that joins the DSM River before the 2nd Avenue gage location (Figure 2-2).

2.1 Geology and Soils

The watershed of the DSM River is located within the Des Moines Lobe landform region of Iowa (Figure 2-1). The Des Moines Lobe landform region is a region dominated by low relief and poor surface drainage that was recently glaciated (<12,000 years old) (Prior, 1991). The geology of the Des Moines Lobe region consists largely of pebbly glacial drift (unsorted mixture of sand, silt and clay) in flat till plains, clay and peat in depressions or prairie pothole areas, and sand and gravel deposits in floodplains of larger streams and rivers. The average thickness of Quaternary deposits in the DSM River watershed (Iowa portion only) is 145 feet, although this is variable (s.d.= 126 feet). A region where Quaternary thicknesses are less than 50 feet is located within portions of Humboldt, Webster, Kossuth and Pocahontas counties. Overall, the thickness of Quaternary deposits suggests little interaction of surface water with bedrock aquifers in the watershed region.

The major soil associations found within the DSM River watershed is the Clarion-Nicollet-Webster association which comprises 15.2, 13.9 and 11.3 percent of the watershed within the Iowa portion of the basin, respectively. Canesteo soils are also found with the dominant association and comprise another 16.9 percent of the watershed. The Clarion-Nicollet-Webster association soils formed in Wisconsin glacial till and sediments under native grass vegetation. Clarion soils are well drained and are in higher, steeper areas, Nicollet soils are somewhat poorly drained on lower parts of gentle slopes, and Webster soils are found in poorly drained low areas. Canisteo soils are similar to Webster soils and are found in swales occurring on a gently undulating till plain.

Okoboji, Harps and Kossuth soils are minor soil mapping units found in the basin comprising 3.9, 2.9 and 1.7 percent of the watershed within the Iowa portion of the basin, respectively. Okoboji soils are very poorly drained, moderately slowly permeable soils formed in upland depressions. Harps soils are poorly drained, moderately permeable soils formed on rims of depressions on broad upland flats, whereas Kossuth soils are poorly drained, moderately slowly permeable soils formed on level to slightly concave slopes on uplands.

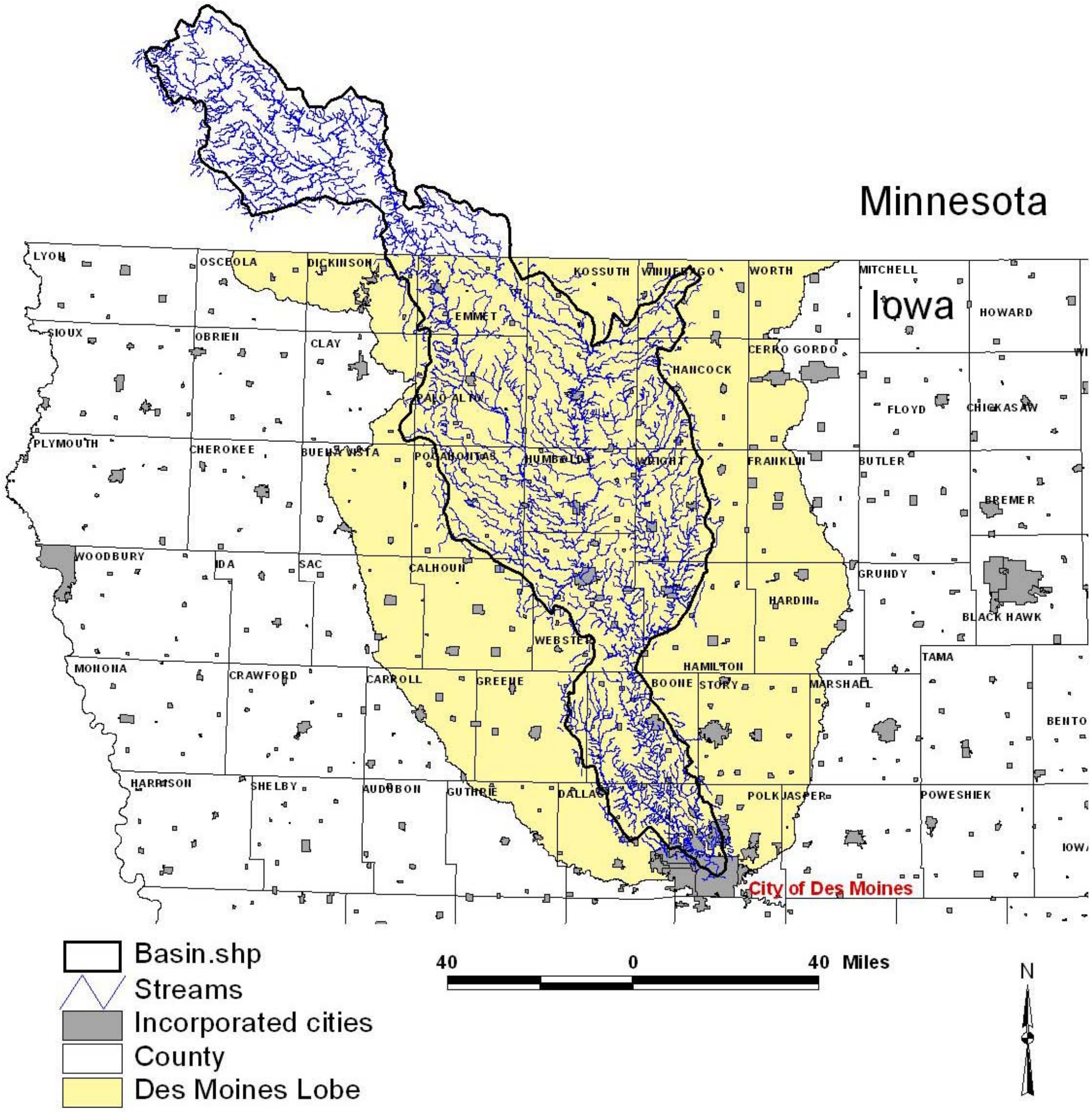

Figure 2-1. Location of DSM River watershed in Iowa and Minnesota.

2.2 Stream Network and Watershed Delineations

Although the DSM River (i.e. formerly known as the "West Fork"), East Fork and Boone Rivers form the major tributary rivers in the watershed, other major tributary streams can be delineated (Figure 2-2). Major tributary branches include Lizard, Pilot, Beaver, Jack and Black Cat creeks in the western portion of the basin and Buffalo, Lindsey, Plum, Prairie, Eagle, and White Fox creeks in the east (Figure 2-2). In the southern portion of the watershed, Beaver Creek is the only substantial tributary.

Subwatersheds within the DSM River basin are delineated based on their size or Hydrologic Unit Code (HUC). There are five HUC8 (390-1953 mi^2) basins in the DSM River watershed above 2^{nd} Avenue. Within this size designation there are 36 HUC10 basins (62.5 to 390 mi^2) and 143

HUC12 basins (15.6 to 62.5 mi^2) within the Iowa portion of the basin. For much of this TMDL, primary consideration will be given to assessing loads from HUC12 size watersheds wherever practicable.

The stream network is monitored by nine U.S.G.S. stream gages in the watershed (Figure 2-2). There is a stream gage on the DSM River at 2nd Avenue where nitrate concentrations are monitored by the DMWW. Two gages located near the outlet of the basin are associated with Saylorville Reservoir (sites 2 and 4; Figure 2-2). The location at site 5 is the DSM River gage near Stratford and this gage is closest to the upstream limits of Saylorville Reservoir. The major tributaries of the Boone River and East Fork DSM River are monitored by USGS gages at sites 6 and 9, respectively, whereas streamflow from the upper DSM River is monitored near Humboldt (site 8).

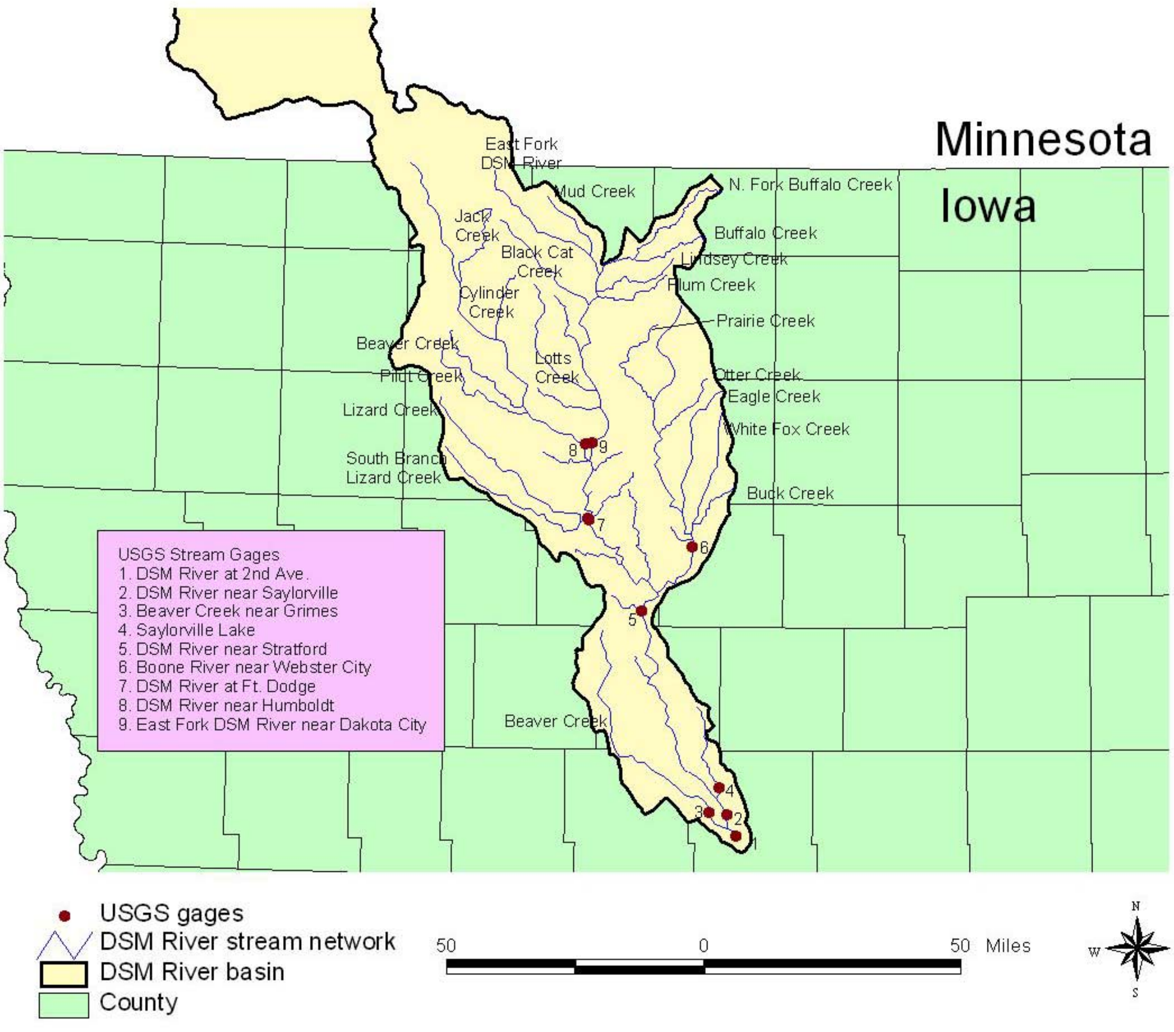

Figure 2-2. Location of DSM River watershed in Iowa, including stream network and USGS stream gages.

2.3 Land Cover

Land cover summarized from the 2002 statewide land cover map (Figure 2-3) indicates that land cover in the DSM River watershed is predominantly agricultural, consisting of 78.5 percent row crops, 14.3 percent grass, 2.7 percent forest, 2.5 percent urban, and 1.9 percent water and wetlands. Figure 2-4 shows the percentage of land under row crop production in HUC12 basins within the Iowa portion of the DSM River watershed. Most HUC12 basins have row crop land cover over more than 75 percent of their area. Only one basin in the Des Moines area including Saylorville Reservoir has row crop land cover less than 25 percent.

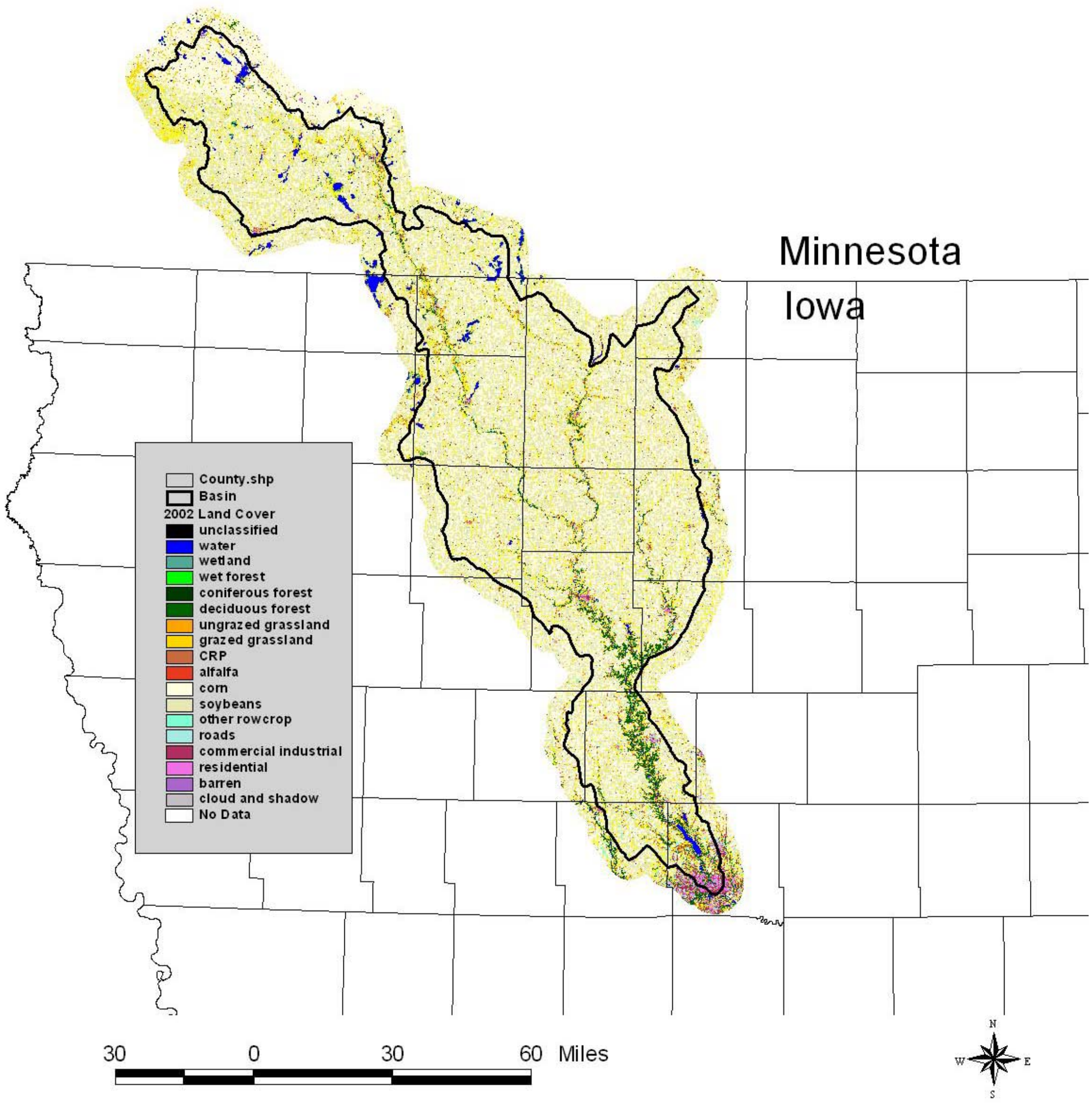

Figure 2-3. Land cover in DSM river watershed from 2002.

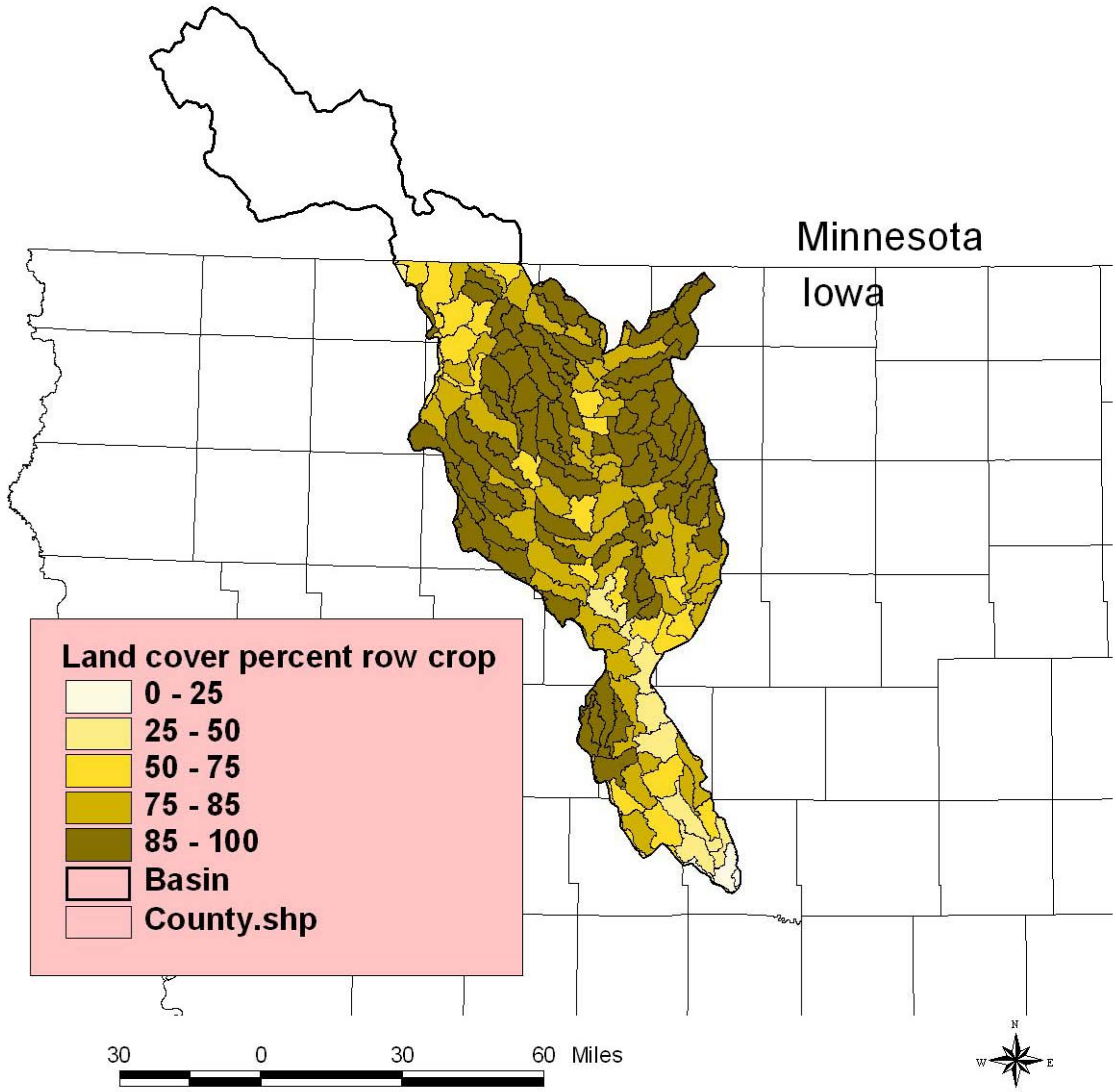

Figure 2-4. Percentage of land cover in row crop land use in HUC12 subbasins of the DSM River watershed (Iowa portion only).

2.4 Climate

Climatic conditions in the Des Moines River watershed were assessed for a 12 year period from 1995 to 2006. Daily precipitation was downloaded from the Iowa Environmental Mesonet (http://mesonet.agron.iastate.edu/ index.phtml) for representative locations within the watershed. Table 2-1 includes a summary of annual precipitation for three representative sites within the DSM River watershed from the north to south.

The average annual precipitation total for the watershed for the 1995 to 2006 period ranged from 30.9 at Algona to 31.9 inches at Ft Dodge and Ankeny. Precipitation varied substantially year-by-year, with the highest annual precipitation occurring in Ankeny in 1998 (41.5 in) and Algona in 2005 (40.2 in), and lowest annual precipitation occurring in Ft Dodge in 1997 (21.9 in). Overall, while the average annual values were similar across the three sites, substantial variations occurred across the watershed on an annual basis.

Table 2-1. Summary of annual precipitation at three weather stations in the Des Moines River watershed.

	Total Annual Precipitation (in)		
Year	**Algona**	**Ft. Dodge**	**Ankeny**
1995	33.52	32.12	32.81
1996	28.68	36.64	31.21
1997	24.39	21.90	26.54
1998	34.52	33.68	41.49
1999	31.03	32.32	33.41
2000	31.01	29.88	26.60
2001	31.68	36.46	31.43
2002	26.96	29.30	25.47
2003	23.45	31.14	32.66
2004	33.08	36.00	36.84
2005	40.22	34.63	33.16
2006	32.32	28.66	31.94
Avg.	30.91	31.90	31.96

2.5 Hydrology

Daily streamflow records from six USGS gaging stations located in the DSM River watershed were evaluated in this TMDL (Table 2-2). Locations of the gaging stations are shown on Figure 2-2. The hydrograph of streamflow was separated into baseflow and stormflow components using the USGS program PART (Rutledge, 1998). Baseflow is the portion of streamflow derived from groundwater discharge to stream channels.

The 1995 to 2006 period of streamflow record was evaluated and the results indicate variability in average annual discharge (Figure 2-5). Average annual discharge was greatest in the Boone River (9.07 in) whereas the other five watershed areas had average annual discharge within a relatively narrow range (7.0 to 7.4 in; Table 2-2). Baseflow was more consistent than total discharge, ranging between 4.8 to 5.8 inches, or alternatively, between 69 to 80 percent of total discharge. Downstream of Saylorville Reservoir at the DMWW 2nd Avenue intake, total discharge and baseflow were 7.34 and 5.23 inches, respectively.

Annual discharge varied from 1.3 inches in Beaver Creek in 2000 to 14.5 inches in the Boone River in 2001. Lower annual discharge occurred mainly during 2000 and 2002 and was associated with below normal precipitation. Greatest annual discharge generally occurred in 2001 when discharge and baseflow exceeded 11 inches and 8 inches, respectively.

Table 2-2. Summary of annual discharge, baseflow and baseflow percentage at major USGS gaging sites in the DSM River watershed.

			Mean Values 1995 to 2006		
Station Location	**USGS Station**	**Drainage Area (mi^2)**	**Discharge (in)**	**Baseflow (in)**	**Percentage of Discharge as Baseflow**
East Fork DSM River at Dakota City	05479000	1,308	7.43	5.68	75.8%
DSM River at Ft. Dodge	05480500	4,190	6.90	5.59	79.9%
Boone River at Webster City	05481000	844	9.07	5.78	63.5%
DSM River near Stratford	05481300	5,452	7.43	5.44	72.6%
Beaver Creek near Grimes	05481950	358	7.05	4.75	68.6%
DSM River at 2nd Ave.	05482000	6,245	7.34	5.23	69.3%

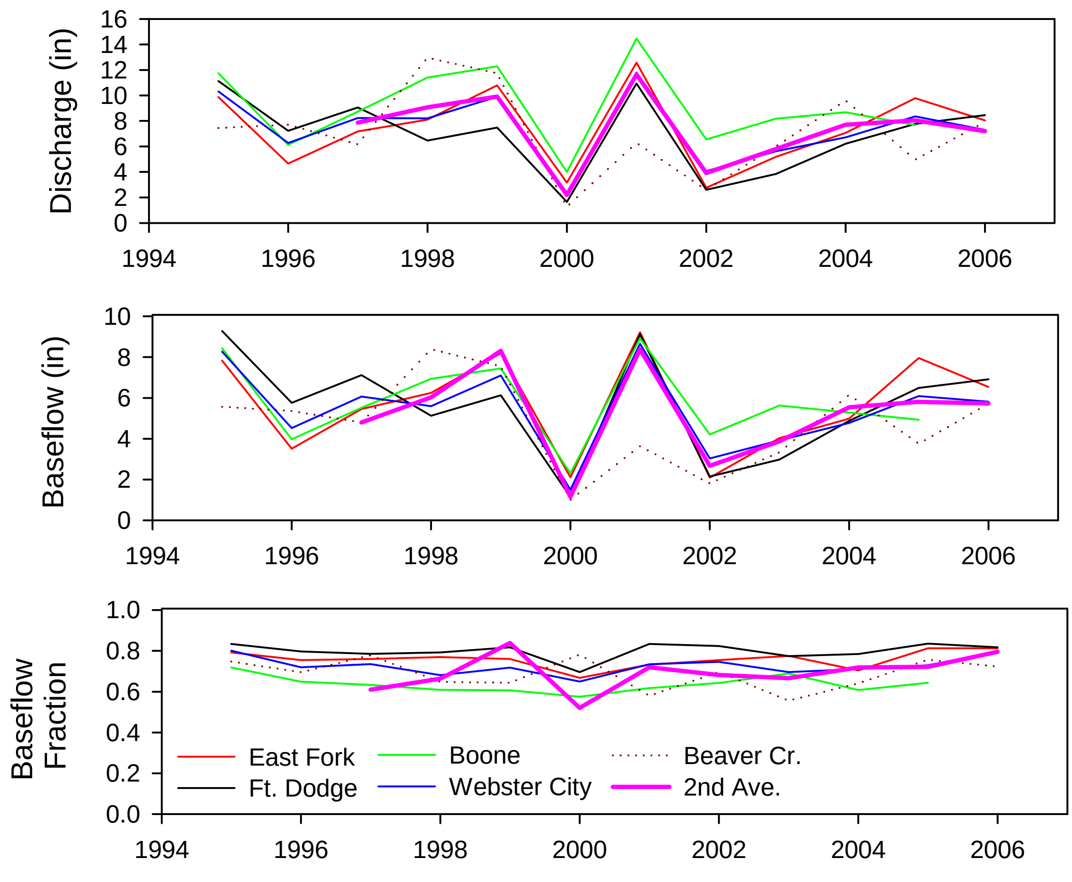

Figure 2-5. Summary of discharge, baseflow and baseflow fraction at six major stream gaging sites in the DSM River watershed.

Seasonally, greatest discharge tended to occur in April through June when average discharge exceeded 1.5 inches in the DSM River at Stratford and at 2nd Avenue (Figure 2-6). Data from both DSM River gages are reported to highlight the effects of Saylorville Reservoir on DSM River flow. Flow at Stratford is proportional to incoming flow to the reservoir, whereas flow at 2nd Avenue is proportional to flow export from the reservoir. The monthly average discharge and baseflow at both gage sites are similar for most months, but export flows from Saylorville are greater than incoming flows during July. Reservoir effects are more apparent with baseflow fraction (Figure 2-6). Baseflow in the DSM River at 2nd Avenue is less than baseflow above the reservoir at Stratford during the late winter and fall periods, but higher during May and June. This suggests that the reservoir strongly affects streamflow and in particular baseflow. It should be noted that evaluating streamflow and baseflow downstream from a reservoir includes the effects of Bureau of Land Management (BLM) management of Saylorville Lake on discharge patterns. Results from this section are used mainly to highlight the fact that the reservoir affects streamflow patterns in the DSM River.

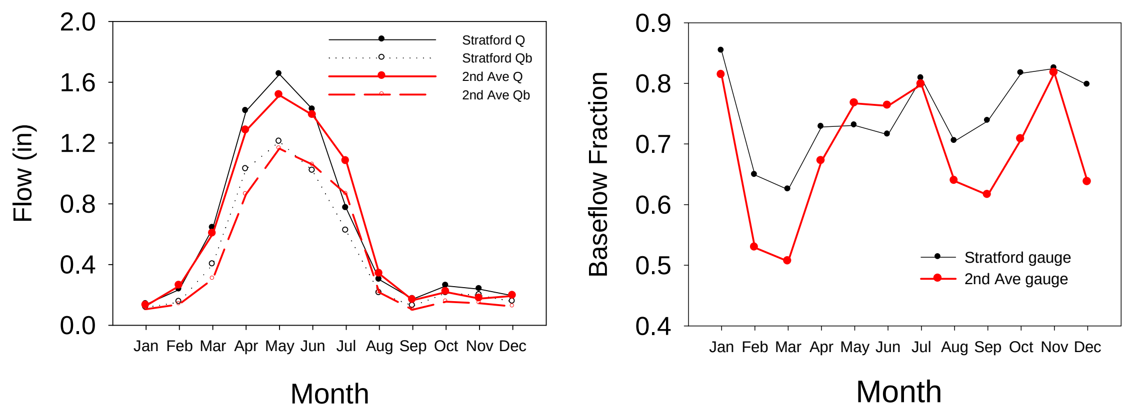

Figure 2-6. Summary of monthly streamflow (Q), baseflow (Qb) and baseflow fraction in the DSM River at Stratford and at 2nd Avenue, 1995 to 2006.

3.0 TOTAL MAXIMUM DAILY LOAD (TMDL) FOR NITRATE IMPAIRMENT

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

3.1 Problem Identification

Surface water from the Des Moines River is used by the City of Des Moines for drinking water. Because of the water use for drinking water supply, the Class C water quality standard applies to the river at the surface water intake. The definition of Class "C" waters (IAC Chapter 61) states:

> "Class "C" waters. Water which are designated as Class "C" are to be protected as a raw water source of potable water supply."

The applicable water quality standard for nitrate for Class "C" designated use is the USEPA maximum contaminant level (MCL) of 10 mg/l.

The 2004 305(b) assessment reports that the Class "C" designated use of the Des Moines River at the 2nd Avenue drinking intake was impaired due to levels of nitrate that exceed the MCL. The specific impairments of Class "C" designated use at the City of Des Moines are described in the 2004 305(b) assessment:

> "The Class C (drinking water) uses are assessed (monitored) as "partially supporting" due to high levels of nitrate in the Des Moines River. Results of monitoring by the Des Moines Water Works in this river segment that show that over 27% of the samples collected during the 2000-2002 assessment period (104 of 405) contained nitrate above the 10 mg/l MCL (mean = 7.6 mg/l; median = 8.0 mg/l; maximum = 13.2 mg/l). According to IDNR's assessment methodology, if more than 25% of the samples exceed the state water quality standard for nitrate (=the MCL of 10 mg/l), the Class C (drinking water) uses should be assessed as "not supported." Due, however, to over-sampling by water supply utilities during times of year when nitrate levels tend to be high, the use of a simple percentage of samples in violation of the MCL likely overestimates the percentage of time that nitrate levels actually exceed the MCL. Thus, to correct for this bias, IDNR staff summarized the Des Moines River nitrate data from the Des Moines Water Works as weekly averages and compared these averages to the water quality standard. Nineteen of the 145 weekly average nitrate levels (13%) for the period 2000-2002 exceeded the standard (weekly mean=5.9 mg/l; weekly median=6.0 mg/l; maximum weekly average=12.8 mg/l). According to IDNR's assessment guidelines, if between 10% and 25% of the samples exceed the MCL for nitrate, the Class C uses are assessed as "partially supported." Thus, according to IDNR's assessment guidelines, the DMWW data—whether summarized as individual samples or as weekly averages--suggest that the Class C drinking water uses are "partially supported." In addition, the continued periodic use of a nitrate removal system by the Des Moines Water Works also suggests an impairment to drinking water uses due to high levels of nitrate in the Des Moines River. According to U.S. EPA's Section 305(b) guidelines (page 3-44 of U.S. EPA 1997b), the use of the nitrate removal system by the DMWW constitutes "more than conventional treatment" and thus indicates that the designated drinking water uses are not fully supported (=impaired)."

Although the 2004 305(b) assessment considered a 2000-2002 assessment period, a longer 12-year assessment period is evaluated in this TMDL. Water quality data were obtained from the Des Moines Water Works (DMWW) for the 1996 to 2005 period to evaluate the degree of nitrate impairment at their raw water intake at 2nd Avenue.

Surface water samples collected from the DSM River by the DMWW on a daily to weekly basis from 1995 to 2006 were analyzed for nitrate using EPA Method 300.0. A daily nitrate record for this assessment period was generated by the DMWW using linear interpolation between measured values to estimate nitrate concentrations for days when no water samples were collected. Using a daily nitrate concentration record calculated in this manner is appropriate for this TMDL for the following reasons: 1) nitrate concentrations do not vary significantly during baseflow periods between storm events, and during wet periods, more frequent samples were collected by the DMWW; 2) daily nitrate concentrations were measured by the DMWW when concentrations approached the MCL (thus measured data accurately reflects more vulnerable high-nitrate periods); and 3) a daily record does not have a sampling bias that reflects more sample collection occurring during high nitrate periods (thus weighted toward higher than average values and not indicative of the daily concentrations over the long term). In the 2004 305(b) assessment, the effects of sampling bias were acknowledged. While 27 percent of the total samples collected during the reporting period had nitrate greater than 10 mg/l, when assessed on a weekly basis, the percentage of weekly mean samples that exceeded the standard decreased to 13 percent. This issue was addressed in this TMDL by using a daily record made up of measured values and interpolated daily values.

A daily record of nitrate concentrations and discharge in the DSM River at 2nd Avenue is shown in Figure 3-1. During the 1995 to 2006 period, nitrate concentrations ranged from 0.5 to 14.5 mg/l and averaged 6.3 mg/l. Concentrations exceeded 10 mg/l approximately 16.4 percent of the time from 1995 to 2006 (719 out of 4382 values).

Examining the specific 2000 to 2002 assessment period of the 2004 305(b) report using the daily DMWW data from 2nd Avenue indicates that nitrate concentrations exceeded the 10 mg/l MCL approximately 16.4 percent of the time (180 out of 1096 daily values). The percentage of exceedance using daily values in this TMDL is less than the value cited in the 305(b) report (27 percent), because the TMDL assessment includes estimated values for days when samples were not collected. When summarized on a weekly basis for the 2000-2002 305(b) period (thereby eliminating the sampling bias), 19 of 45 weeks (13 percent) indicated average nitrate concentrations exceeding the MCL, a percentage similar to this TMDL report. The percentage of time nitrate concentrations exceeded 10 mg/l was the same for both the entire DMWW record (1995 to 2006) and the 2000 to 2002 305(b) reporting period.

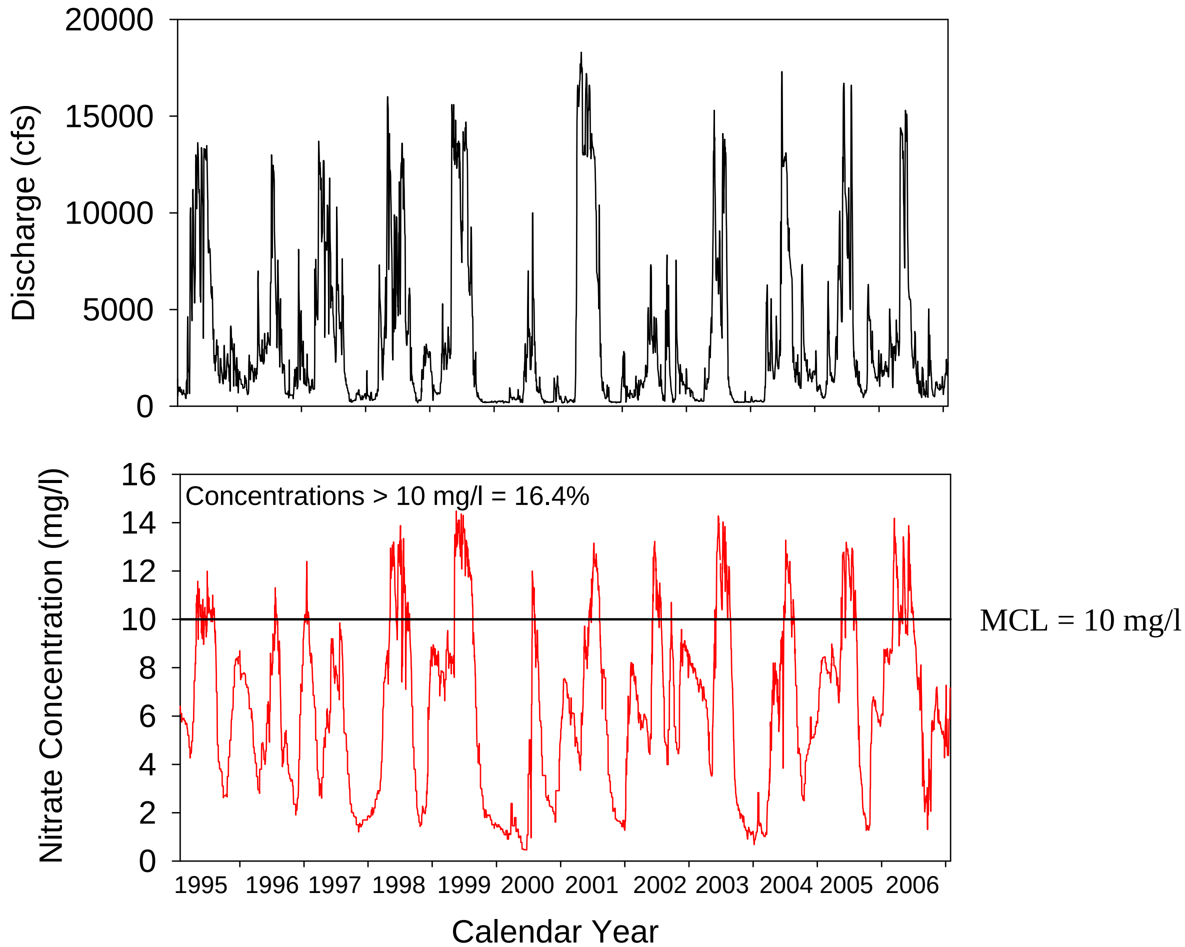

Figure 3-1. Daily streamflow and nitrate concentrations measured in the Des Moines River at 2nd Avenue.

3.2 Temporal and Spatial Patterns in Nitrate Concentrations

3.2.1 Temporal Patterns

Monthly mean nitrate concentrations in the DSM River at 2nd Avenue exhibited clear seasonality, with higher concentrations occurring during May, June and July when median nitrate concentrations approached or exceeded 10 mg/l (Figure 3-2). Concentrations tended to decrease in late summer and fall, but increase again in November and December. All months except September, October and November had at least one sample during the month exceeding 10 mg/l.

The relation of nitrate concentrations to discharge in the DSM River was evaluated based on the flow regime in the river during the sampling period. Discharge measured at the time of sampling was divided into quartiles to determine whether nitrate concentrations related better to high or low flows in the river. Major differences were noted in nitrate concentrations in the upper half of the flow range compared to lower half (Figure 3-3). Median nitrate concentrations decreased from 10.2 mg/l in the 75-100% quartile range to 2.0 mg/l in the lowest 25%, whereas mean concentrations decreased from 9.6±2.9 mg/l in the 75-100% quartile range, to 7.0±2.5 mg/l in the 75-50% range, 5.6±2.3 mg/l to 3.0±2.0 mg/l in the lowest quartile range.

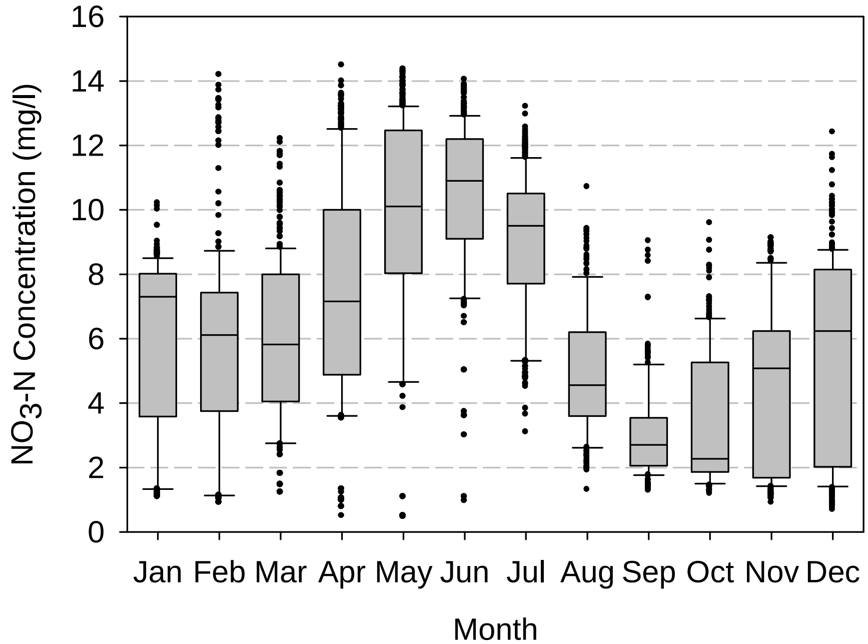

Figure 3-2. Variations in monthly nitrate concentrations in the DSM River at 2nd Avenue. Box plots illustrate the 25th, 50th and 75th percentiles; the whiskers indicate the 10th and 90th percentiles; and the circles represent data outliers.

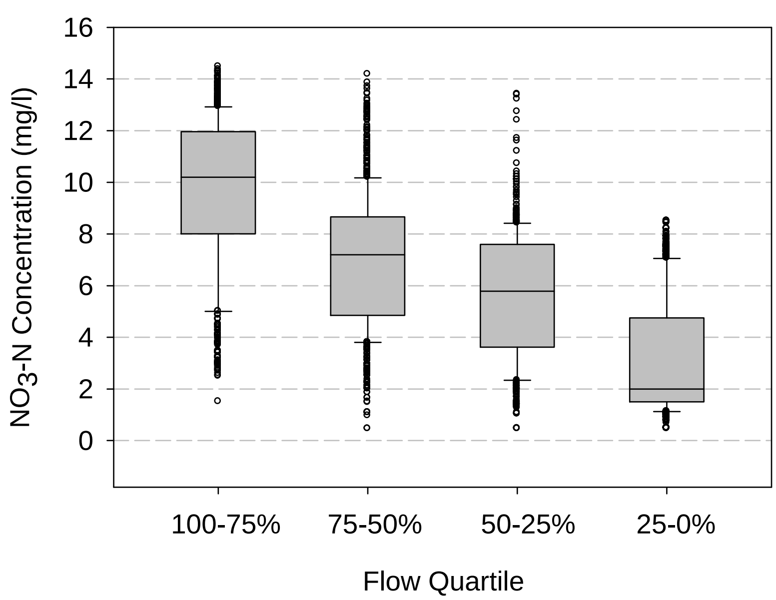

Figure 3-3. Variations in nitrate concentration with discharge in the DSM River.

3.2.2 Spatial Variations

A variety of data sources were used to evaluate spatial patterns of nitrate concentrations in the Des Moines River watershed. Nitrate concentration data are available from the IDNR/UHL ambient water monitoring network at sites located at the West Fork of the DSM River at Humboldt, East Fork of the DSM River at Dakota City, Boone River near Webster City, and Beaver Creek near Grimes (Table 3-1). Another IDNR/UHL ambient water monitoring site is located downstream of Saylorville Reservoir, upstream of the City of Des Moines. This site is part of the water monitoring network responsible for assessing impacts of cities on surface waters of the state. A final monitoring site is associated with the ISU/ACOE Des Moines River Water Quality Monitoring Network. The site is located upstream of Saylorville Reservoir near Stratford in Boone County. Nitrate concentration data from these monitoring sites provide indications of nitrate concentration hot spots in the DSM River watershed. Comparison data are for the 1999 to 2005 period because ambient monitoring began in 1999.

Table 3-1. Comparison of nitrate concentrations measured at various monitoring sites in the DSM River watershed from 1999 to 2006.

Watershed	Agency	Storet ID	Sample Freq.	Comparison of Nitrate Concentrations 1999 to 2006			
				n	Avg. (mg/l)	%>10 mg/l	Max (mg/l)
West Fork at Humboldt	IDNR/ UHL	10460001	Month	90	4.6	6.6	11
East Fork at Dakota City	IDNR/ UHL	10550001	Month	96	7.0	33.3	18
Boone River near Webster City	IDNR/ UHL	10400001	Month	87	8.0	41.4	28
Des Moines River at Stratford	ISU/ ACOE	17080001	Month[1]	96	6.3	31.8	18
Beaver Creek near Grimes	IDNR/ UHL	10070001	Month	87	7.4	32.2	18
Des Moines River below dam	ISU/ ACOE	17080002	Month[1]	96	6.2	16.6	14
Des Moines River upstream of DSM	IDNR/ UHL	10770002	Month	77	6.3	15.6	13

[1]Monthly mean values evaluated to provide comparison with other sites sampled monthly

Nitrate concentrations measured in various large subbasins in the DSM River watershed from 1999 to 2006 indicated substantial variation (Figure 3-4). Nitrate concentrations exceeded the MCL over 30 percent of the measured values in four basins, with the Boone River showing an exceedance rate over 41 percent. In contrast, nitrate concentrations in the West Fork of the DSM River exceeded the MCL only 6.6 percent of the time. Upstream of Saylorville Reservoir, nitrate concentrations at Stratford exceeded 10 mg/l about 32 percent of the time based on monthly mean values. Downstream of the reservoir, nitrate exceeded 10 mg/l 16.6 percent of the time. The exceedance rate downstream of the reservoir measured at the “upstream” City of Des Moines site was similar to the exceedance rate measured at 2nd Avenue (15.6 vs. 16.6 percent, respectively) despite the influence of Beaver Creek discharging into the DSM River between these two locations.

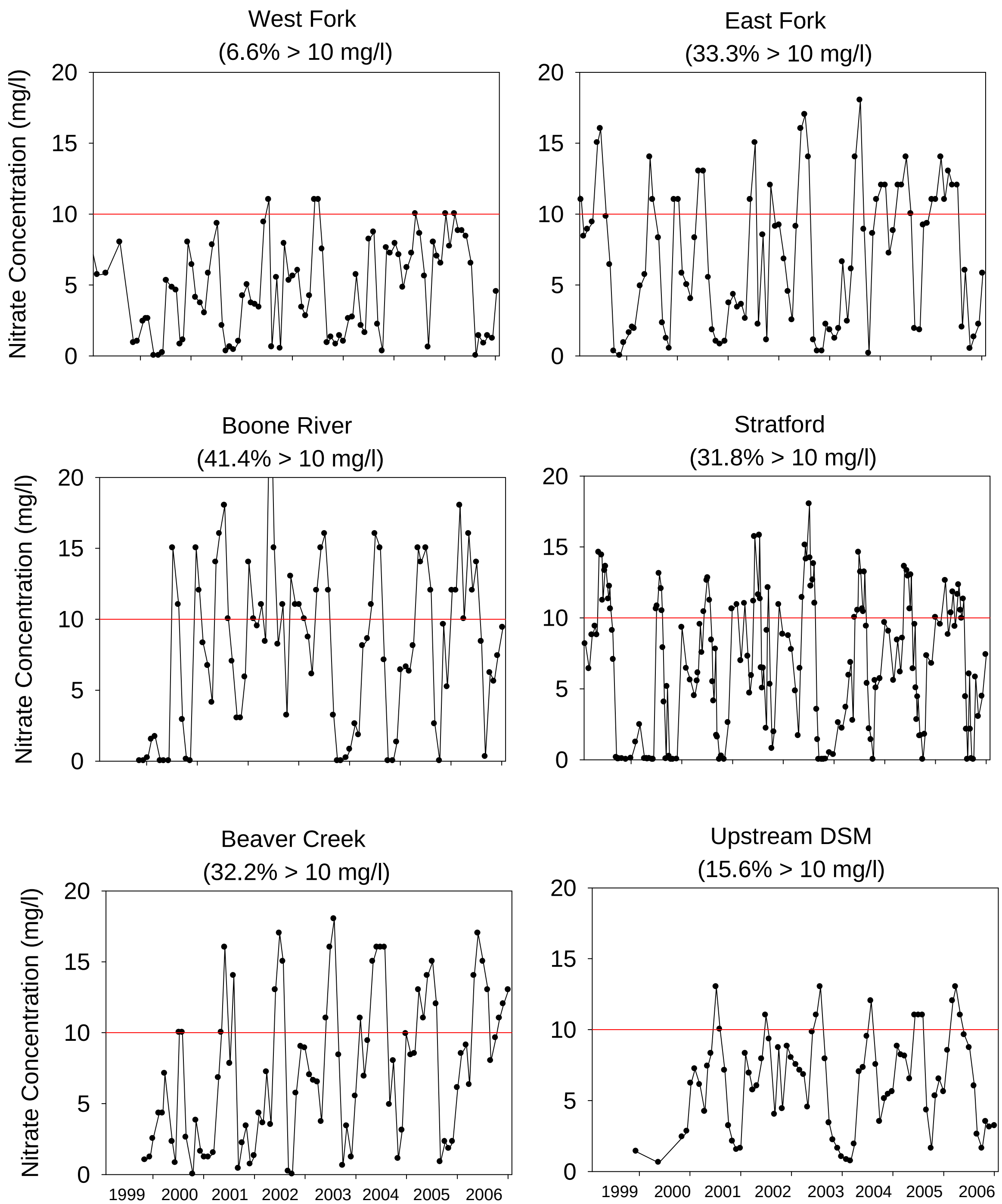

Figure 3-4. Nitrate concentrations measured at major subbasin monitoring sites in the DSM River watershed.

3.2.3 Effects of Saylorville Reservoir on DSM River Nitrate

Nitrate concentrations and mass balances were evaluated for the reservoir for a 30-year period from 1977 to 2006. Incoming water flux, nitrate concentrations and estimated nitrate loads to Saylorville reservoir were obtained from the USGS stream gaging station (05481300) and ISU/ACOE monitoring site at Stratford (ISU/ACOE Site 1; labeled site 5 in Figure 2-2). Downstream of the reservoir, nitrate concentrations were obtained from the ISU/ACOE monitoring site downstream of the Saylorville dam (ISU/ACOE Site 5; labeled site 2 in Figure 2-2). Streamflow downstream of the dam was obtained from the USGS stream gaging station near Saylorville (05481650),

Nitrate concentrations upstream and downstream of Saylorville Reservoir were similar (Figure 3-5). Over a 30-year (360-month) period, nitrate concentrations followed similar patterns, with deviations mainly occurring during high and low flow periods. This is shown more clearly when the nitrate concentration data are plotted as percentiles (Figure 3-6). Upstream of Saylorville, monthly mean nitrate concentrations exceed the MCL of 10 mg/l about 18.2 percent of the time, but downstream of the dam, nitrate concentrations exceeded the MCL only 12.6 percent of the time, suggesting that the reservoir reduces the amount of MCL violations by about 5.6 percent. At low concentration percentiles, nitrate levels remain higher downstream of the reservoir compared to incoming nitrate concentration inputs (Figure 3-6). Overall, Saylorville Reservoir appears to attenuate variation in nitrate concentration so that the downstream nitrate is smoother and less variable (lower high values and higher low values) than upstream nitrate concentrations. This effect is likely due to mixing and storage within the reservoir and nitrogen transformations.

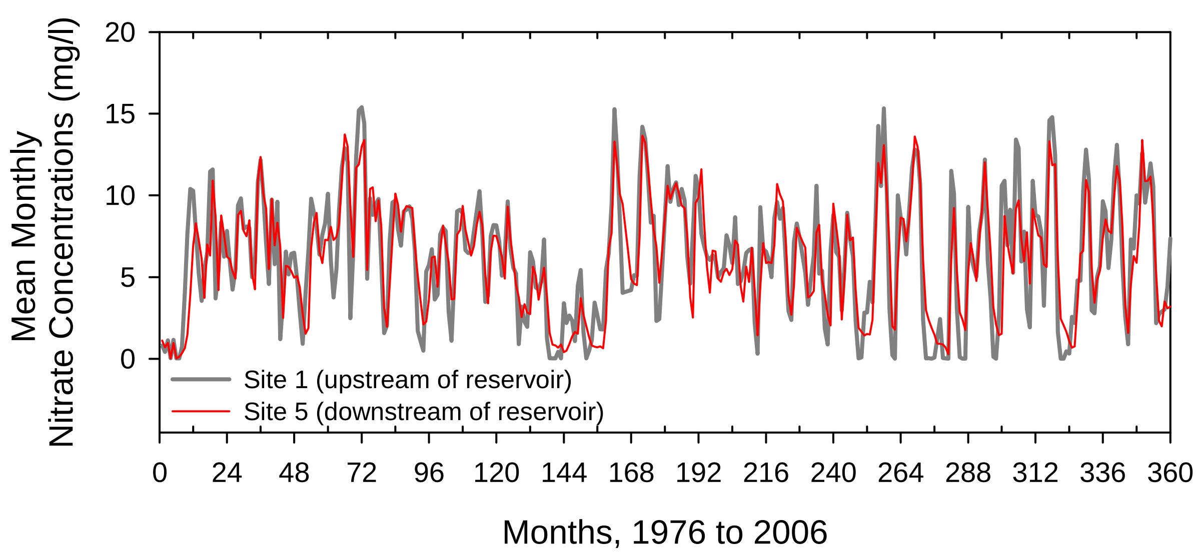

Figure 3-5. Comparison of nitrate concentrations upstream and downstream of Saylorville Reservoir.

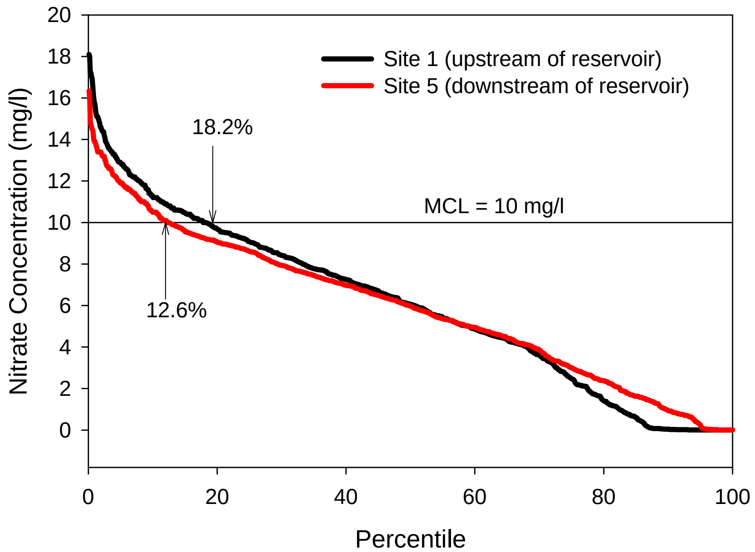

Figure 3-6. Nitrate concentrations upstream and downstream of Saylorville Reservoir shown as a percentile of exceedance.

In terms of nitrate loads, the ability to compare upstream versus downstream loads becomes problematic since the upstream gaging station is located about two counties north of the reservoir. Therefore, incoming flows to the reservoir must be adjusted to reflect a greater watershed area contributing to water flux into the reservoir. Comparing the watershed area at Stratford (5452 mi^2) to Saylorville (5841 mi^2) suggests that the downstream area is 6.6 percent greater than the upstream area. However, downstream flow, on average, is about 8 percent greater than upstream flow. Thus, approximately 6.6 percent more watershed area results in about 8 percent more streamflow into the reservoir, possibly due to drier conditions to the north. To estimate nitrate loading rates, streamflow at Stratford was increased by 8 percent to estimate flow into Saylorville. Using the adjusted Stratford flow with measured nitrate concentrations at ISU/ACOE Site 1 (gage site 5; Figure 2-2), the incoming nitrate load to the reservoir was estimated. Downstream nitrate loads were more easily estimated since nitrate concentrations and streamflow were measured downstream of the dam.

Results suggest that nitrate loads vary little between upstream and downstream of the reservoir (Figure 3-7). An overall nitrate load reduction of approximately 5.6 percent was estimated over a 32-year record (Stenback and Crumpton, personal communication). Load reductions varied year-by-year, with individual years varying considerably from the average. Five years showed slightly more nitrate leaving than entering Saylorville. As expected, dry years generally showed more loss than wet years. However, the load estimates ignore nitrate concentration sources between Boone and Stratford, as well as nitrate inputs directly to the lake. Further, the load reduction estimates did not consider nitrogen transformations than may occur in the reservoir. In terms of the water budget, the estimates assumed precipitation inputs to the lake and evaporation from the lake were in balance (and thus negligible), and that groundwater inputs/outputs were also negligible. Overall, the 5.6 percent decrease in nitrate loads was similar to the magnitude of concentration decrease, suggesting that Saylorville Reservoir does not significantly affect stream nitrate concentrations and loads.

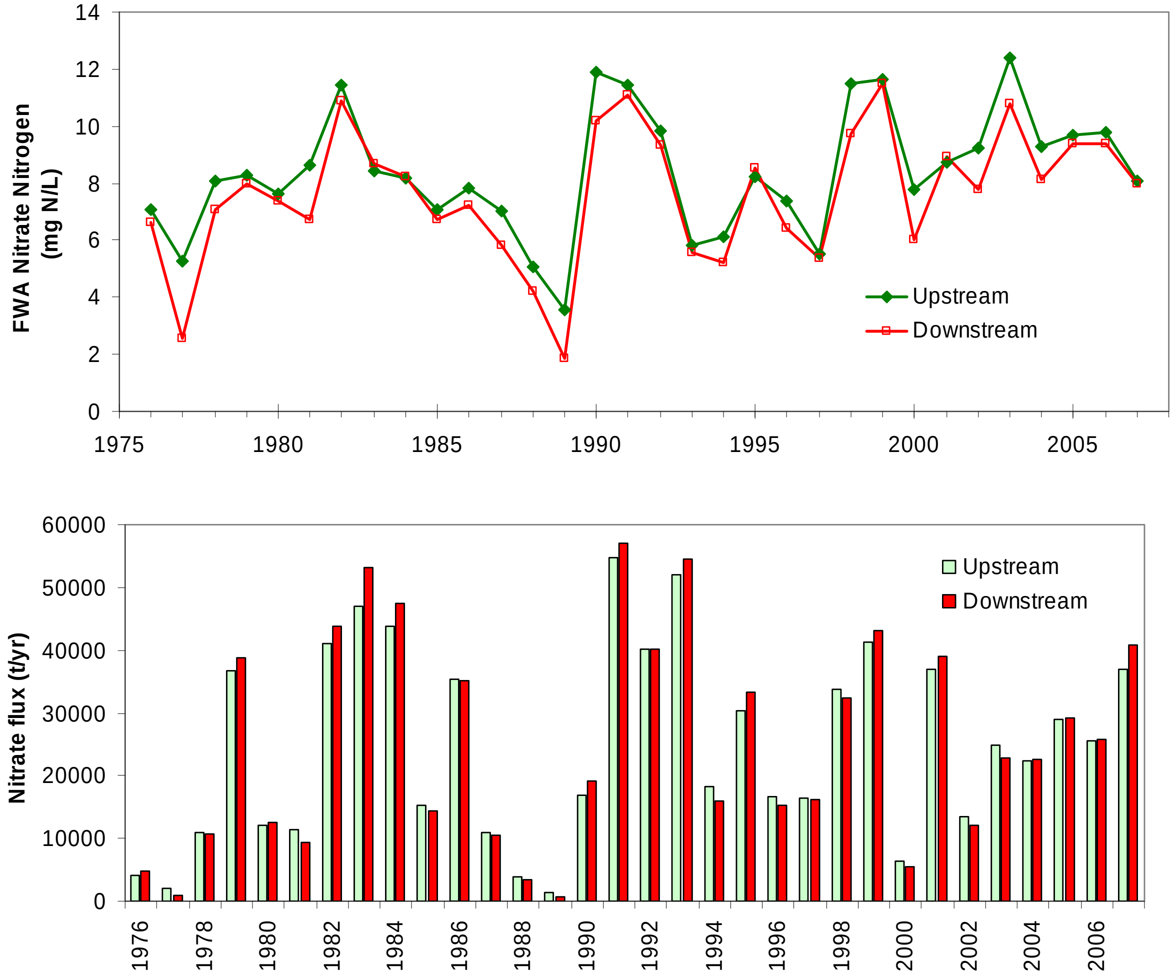

Figure 3-7. Annual flow-weighted average (FWA) nitrate concentration and flux (metric tons per year) near the Saylorville Reservoir upstream and downstream locations for the period 1976-2007. (Graphic provided courtesy of W.G. Crumpton and G.A. Stenback, Iowa State University).

3.2.4 ACWA Monitoring

The Agriculture's Clean Water Alliance (ACWA) is a group comprised of fertilizer dealers in the Raccoon and Des Moines River watersheds who have partnered with the DMWW, Iowa State University, the National Soil Tilth Laboratory and Iowa Department of Agriculture and Land Stewardship (IDALS) to sponsor a water monitoring program. The ACWA monitoring program is currently developing a comprehensive monitoring program in the Des Moines River watershed. In 2007, 30 sites were monitored in the Boone River watershed (Table 3-2). Samples are analyzed at the DMWW water quality laboratory.

Table 3-2. Summary of selected 2007 nitrate monitoring results (in mg/l) for the Boone River watershed.

		Sampling Dates (selected dates in 2007)				2007 Avg.
Site ID	**Site Name**	**12-Apr-07**	**7-Jun-07**	**5-Jul-07**	**2-Aug-07**	**(n=~15)**
BR01	Boone River	12.69	17.44	13.06	0.10	10.18
BR02	Prairie Creek	14.25	18.75	10.18	3.12	11.01
BR03	Boone River	13.94	18.25	13.84	0.45	10.39
BR04	Brewers Creek	17.72	22.96	14.84	0.41	12.85
BR05	Boone River	14.71	17.05	18.4	4.82	12.96
BR05A	Boone River	4.6	N/A	N/A	N/A	4.60
BR06	Lyons Creek	17.23	19.8	22.18	1.74	13.15
BR07	Boone River	13.57	17.91	12.48	0.15	10.41
BR08	Boone River	17.9	21.4	18.28	2.62	13.03
BR09	Boone River	15.48	22.3	19.53	0.07	13.87
BR10	Eagle Creek	15.95	19.53	14.88	0.22	11.39
BR11	Boone River	13.23	17.36	11.7	0.15	10.17
BR12	White Fox Creek	18.91	22.08	20.4	2.97	14.60
BR13	Boone River	17.1	19.11	6.95	N/A	N/A
BR14	Boone River	13.65	17.15	11.5	0.15	10.42
BR15	Boone River	16.17	17.93	5.72	0.17	10.50
BR16	Boone River	13.98	17.04	11.44	0.27	10.38
BR17	Eagle Creek	16.43	19.79	16.64	1.02	12.90
BR18	Little Eagle Creek	16.28	19.91	15.71	3.17	15.62
BR19	Otter Creek	15.07	18.72	14.01	0.61	11.72
BR20	Boone River	12.01	16.6	10.17	0.23	9.90
BR21	Boone River	12.02	16.38	9.6	0.29	9.83
BR22	West Otter Creek	14.61	17.2	12.43	0.12	11.26
BR23	Otter Creek	16.78	20.51	16.99	1.49	13.68
BR24	Prairie Creek	12.28	16.25	8.74	0.20	10.36
BR25	Boone River	12.08	14.72	5.2	0.38	8.88
BR26	Prairie Creek	10.63	13.56	5.91	0.13	8.37
BR27	Boone River	10.51	14.66	4.95	0.51	8.43
BR28	Boone River	11.27	15.46	7.7	0.76	N/A
BR29	Middle Branch Boone River	11.93	16.45	6.75	0.77	10.15
BR30	East Branch Boone River	13.62	18.36	10.51	0.06	10.76

A map of mean nitrate concentrations from 2007 (n=11) indicates spatial variations in stream nitrate concentrations in the Boone River subbasins (Figure 3-8). Highest concentrations were observed in Lyon's Creek, Little Eagle Creek and Otter Creek where average concentrations exceeded 14 mg/l. Overall, monitoring data from the ACWA provide greater spatial resolution of the nitrate concentration patterns within the Boone River watershed.

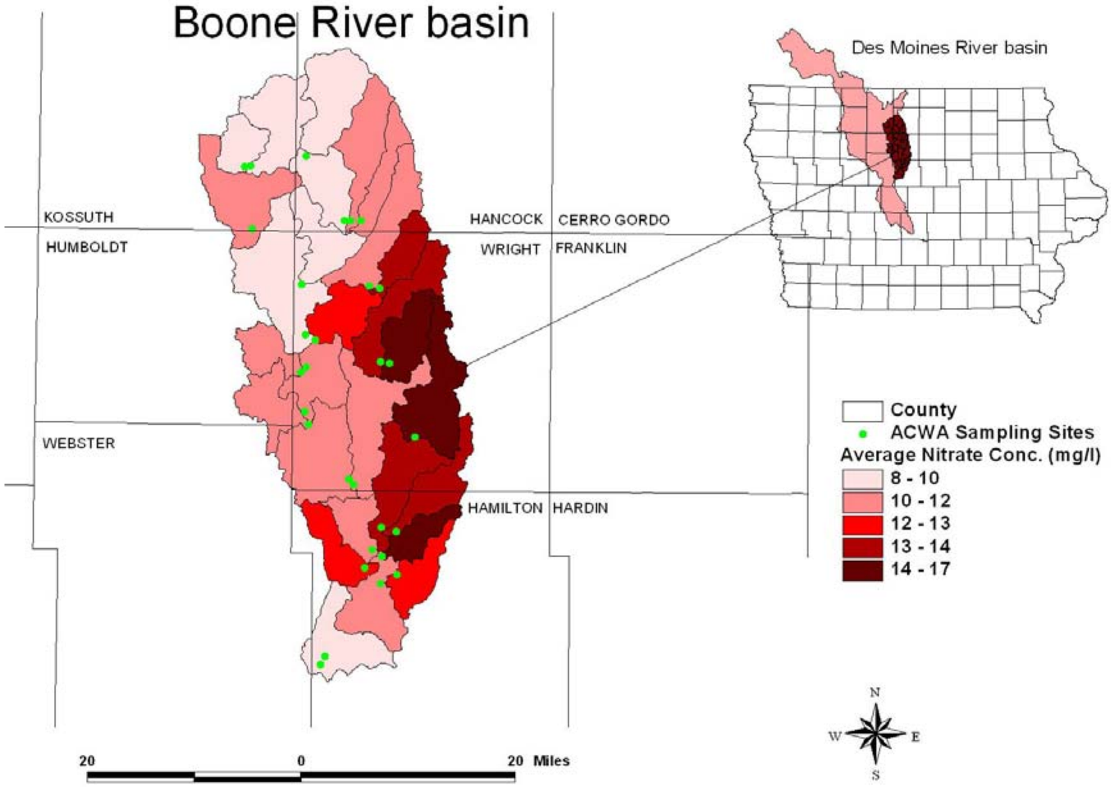

Figure 3-8. Nitrate concentration patterns in Boone River subbasins.

3.2.5 Beaver Creek Watershed Monitoring

In 2006, water quality monitoring by the DMWW was implemented at more than 30 sites in Beaver Creek watershed (Figure 3-9). Water samples are collected on a monthly to weekly basis through the year and analyzed by the DMWW laboratory. Selected results from a few sites in 2007 indicated that nitrate concentrations regularly exceeded 10 mg/l at many Beaver Creek monitoring sites (Table 3-3).

Table 3-3. Nitrate concentrations (in mg/l) measured at selected Beaver Creek sites in 2007.

Date	BC04	BC10	BC10A	BC10B	BC11	BC11A	BC11B	BC11C	BC12
Apr 25	4.8	9.4	10.5	8.4	N/A	8.5	10.1	7.3	7.3
May22	14.3	15.4	15.8	20.9	N/A	14.0	15.6	14.5	13.6
Jun 5	14.6	16.1	17.0	21.2	15.9	15.1	15.9	15.2	13.6
Jun 26	12.1	14.3	14.4	17.9	14.4	12.7	15.4	13.7	N/A
Jul 23	4.0	4.6	7.1	7.3	3.9	4.7	5.8	2.1	1.6

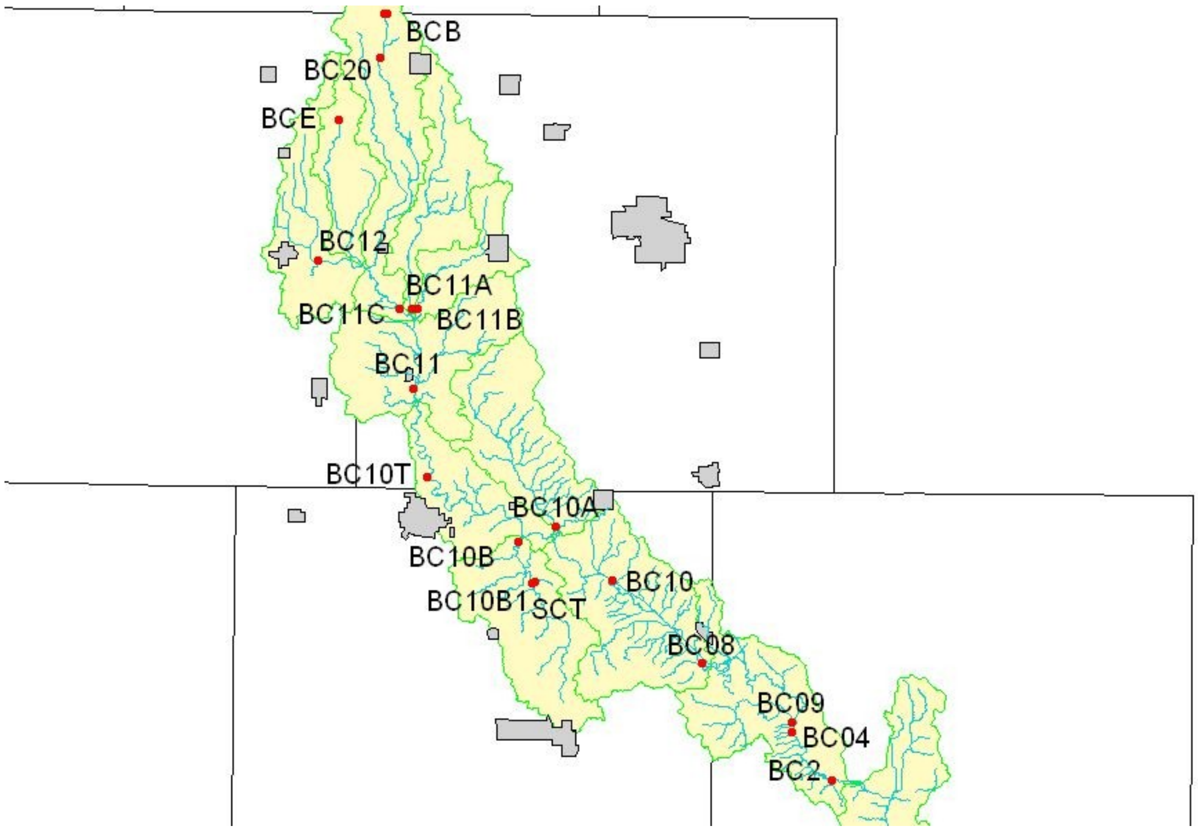

Figure 3-9. Location of monitoring sites in Beaver Creek watershed (graphic provided courtesy of DMWW).

3.3 Pollution Source Assessment

The sources of nitrate can be divided into two major categories, point sources and nonpoint sources. Point sources are facilities whose discharge is covered by an NPDES permit that discharge pollutants directly into a stream, such as pipe effluent from a wastewater treatment plant. Nonpoint sources of pollutants are located diffusely across the landscape and discharge to streams with overland surface water runoff or groundwater discharge as baseflow or tile drainage. Waste loads from point sources are easier to assess because concentration and flow are assessed at the end of a pipe, whereas determining load allocations from nonpoint sources or point sources addressing stormwater and animal feeding operations requires understanding of the concentration and rate of discharge of pollutants over large geographical areas (Schilling and Wolter, 2001). In this section, potential pollution sources are assessed from point and nonpoint sources.

3.3.1 Point Sources

There are a total of seventy-four (74) entities in the Iowa portion of the Des Moines River watershed with National Pollution Discharge Elimination System (NPDES) permits. Further, there are seventeen (17) entities in the Minnesota portion of the watershed. Most of the NPDES facilities are municipal sewage treatment plants, but there are several industrial contributors, animal feeding operations (AFOs), urban areas covered by Municipal Separate Storm Sewer Systems (MS4s), and water treatment plants. Load estimates were calculated for WWTPs with Discharge Monitoring Records (DMRs) that discharge measurable quantities of effluent to surface waters. Load estimates were also calculated for water treatment systems with NPDES applications on file.

Very few wastewater treatment plants monitor for nitrate or total nitrogen in effluent. Therefore, estimates of the quantity of nitrate/total nitrogen are limited to generic, conservative assumptions based on type of treatment, quantity and quality of influent wastewater, and per capita pollutant generation. Since the cycling of nitrogen in the environment occurs rapidly and often unpredictably, and because what little monitoring in WWTPs exists as Total Kjeldahl Nitrogen (TKN), load estimates in this assessment were estimated using TKN as a surrogate for nitrate. The nitrogen load to a wastewater treatment plant is always measured as TKN since very little of it is ever anything other than organic nitrogen (proteins and their degradation products -amino acids and polypeptides) and the breakdown of the organic nitrogen degradation products to urea and then ammonia. The Kjeldahl analytical procedure is the total of all of these. In the wastewater treatment process the influent TKN is converted to ammonia and then oxidized to nitrate (nitrification). If the treatment process stops at nitrification then most of the nitrogen is discharged in the effluent as nitrate and ammonia. There are also nitrogen fractions that leave the system as:

- sludge from primary solids settling,
- sludge from cell synthesis in the aeration unit,
- the small refractory part of the influent organic nitrogen that passes through the plant unchanged,
- the fraction of nitrogen lost to the atmosphere through denitrification.

With the exception of a plant designed for denitrification, most of the nitrogen coming into the plant is leaving the plant. Therefore, in this assessment, total influent TKN is assumed to equal total effluent nitrate. This assumption is reasonable, though conservative, and provides a margin of safety between the nitrate WLA and the mass of nitrate actually discharged to a stream.

An estimate of the average daily nitrate load discharged into the Des Moines River stream network above the Class C impairment at 2nd Avenue in Des Moines was obtained using one of three methods described below. The average daily nitrate load was then scaled up to estimate the maximum daily load using the procedure described in EPA's Technical Support Document for Water Quality-Based Toxics Control (EPA, 1991). Briefly, maximum daily nitrate load was estimated using a multiplier value to convert the average load to maximum values. The multiplier is dependent on factors such as effluent variability, number of samples collected per month, and the targeted percentile of occurrence probability. For this estimate, the multiplier was based on the 99th percentile occurrence probability. The effluent variability, expressed as the coefficient of variability (CV), was assumed to be the default value of 0.6 based on collection of four samples per month. Using these assumptions, the multiplier is 3.11, so that the maximum daily nitrate load was estimated by multiplying the average daily nitrate load by 3.11.

TYPE 1 ESTIMATES: If a facility has design influent TKN (from a construction permit), then it was assumed that influent TKN = effluent nitrate.

The premise of this assumption is to take a conservative approach, assuming that all nitrogen coming into a plant is conserved through the treatment process and discharged in effluent. This is one of several conservative assumptions used as the basis for the implicit margin of safety (MOS).

TYPE 2 ESTIMATES: For facilities with no design TKN in their permit, and in the absence of other data, the generic assumption of 0.027 lbs TKN/person/day was used to estimate influent loads to WWTPs. This value is based on the EPA's Nitrogen Control Manual (EPA, 1993). The most recent U.S. Census (2000) was used to estimate population, and in the absence of population data (e.g. for semi-public facilities) the facility's population equivalent was used.

The Type 2 estimate assumes that influent TKN loads are equivalent to 0.027 lbs per person per day, and 100 percent of influent TKN is converted to nitrate in the treatment process. As with the Type 1 estimate, this is a conservative approach that assumes no removal of nitrate by the wastewater treatment process.

Example from City of Boone:

2000 U.S. Census population = 12,803

Daily TKN in effluent = 12,803 * 0.027 = 345.7 lbs nitrate/day

Many of these facilities are controlled discharge lagoons, meaning that they discharge intermittently to surface waters. Discharge monitoring records (DMRs) provide flow data for the day and quantity of discharge, allowing loads to be calculated. For these facilities, a controlled discharge calculation worksheet in Excel was used to calculate intermittent loadings. The worksheet uses DMR data and the assumption of 0.027 lbs TKN/person/day and allows TKN to accumulate in the lagoon until discharge (for a maximum of 180 days).

For semi-public facilities or sanitary districts where a census population was unavailable, the long term average flow was obtained from the facility's DMR reports and the population equivalent was based on a typical residential flow contribution of 100 gallons per capita per day. For the facilities where no flow data was available, the population equivalent was based on the construction permit design loading.

TYPE 3 ESTIMATES: For industrial permits, or facilities accepting waste from significant industrial contributors, permits were evaluated individually to estimate combined loads from industrial contributors and municipal sewage.

Where nitrogen loads from industrial contributors were felt to be significant, influent TKN/max NH_3 monitoring values or daily TKN design loads (obtained from the construction permit) were simply added to municipal sewage loads (estimated using same assumptions as the Type 2 Estimate) to get a combined nitrate load estimate.

Example from Estherville Foods plant:

In Estherville, the Estherville Foods plant monitors TKN at the outfall to the city sewer system as part of their discharge permit. The long term average daily TKN value was found to be 438.2 lbs/day. This value was added to the type 2 TKN estimate based on the 2000 census population of 6,656 for the City of Estherville. The total daily nitrate load is calculated as follows:

TKN load from Estherville Foods, Inc. coming into city WWTP = *438.2 lbs/day*

Effluent from city WWTP = 6,656 * 0.027 lbs/person/day = *179.7 lbs/day*

Combined Nitrate Load = 438.2 lbs/day + 179.7 lbs/day = 617.9 lbs nitrate/day.

The Koch Nitrogen facility in Ft. Dodge includes two wastewater outfalls to Brushy Creek. Outfall 001 discharges process wastewater, cooling water and stormwater and outfall 002 discharges domestic wastewater from employees. The Koch fertilizer plant monitors discharge of flow from outfall 001 for ammonia, organic nitrogen, and nitrate and values are reported as a 30 day average. Because some portion of the organic nitrogen and ammonia may be converted to nitrate, the sum of the nitrogen sources were added together to obtain a nitrate load estimate for the facility.

22.46 lbs ammonia + 13.14 lbs organic N + 39.22 lb nitrate = 74.81 lbs/day nitrate

For outfall 2, the facility employs 41 people, so nitrate loads from outfall 2 were estimated as follows:

41 people * 0.027 lbs/person/day = 1.11 lbs/day

Combining the two outfalls yields the total daily average nitrate load for Koch Nitrogen:

Combined Nitrate Load = 74.81 lbs/day + 1.11 lbs/day = 75.92 lbs nitrate/day

A summary of facilities assessed, permit type, discharge frequency, estimate type and average daily and maximum daily nitrate load for Iowa facilities is provided in Table 3-4. A summary of average daily nitrate loads is provided for Minnesota facilities in Table 3-5. It should be noted that data provided for Minnesota facilities are presented in this TMDL for information and modeling purposes only. The point source loads from Minnesota facilities are assumed to be part of the background river quality as the Des Moines River enters the State of Iowa. The locations of NPDES facilities in Iowa and Minnesota are shown in Figure 3-10.

Table 3-4. Assessed facilities in Iowa portion of the Des Moines River watershed.

Site Name	EPA ID Number	Permit type	Discharge Frequency	Estimate Type	Average Daily Nitrate Load (lbs/day)	Maximum Daily Nitrate Load (lbs/day)
Algona, City of	IA0022055	Municipal	Continuous	3	229	712.19
Armstrong, City of	IA0028517	Municipal	Continuous	1	33	102.63
Ayrshire, City of	IA0079077	Municipal	Controlled	2	5.45	16.95
Badger, City of	IA0029041	Municipal	Controlled	2	16.47	51.22
Bancroft, City of	IA0057762	Municipal	Controlled	2	21.82	67.86
Barnum, City of	IA0041246	Municipal	Controlled	2	5.27	16.39
Bode, City of	IA0047805	Municipal	Controlled	2	8.83	27.46
Boone, City of	IA0058076	Municipal	Continuous	2	345.68	1075.06
Boxholm, City of	IA0058491	Municipal	Controlled	2	5.81	18.07
Brit, City of	IA0023582	Municipal	Continuous	2	55.40	172.29

Brushy Creek State Park North Campground, DNR	IA0074543	Semi Public	Controlled	2	1.40	4.35
Burt, City of	IA0027405	Municipal	Controlled	2	15.01	46.68
Camp Hantesa	IA0073806	Semi Public	Continuous	2	0.59	1.83
Camp Dodge	IA0063215	Semi Public	Continuous	2	25.11	78.09
Clare, City of	IA0062936	Municipal	Controlled	2	5.13	15.95
Clarion, City of	IA0030945	Municipal	Continuous	1	89	276.79
Coats Utilities	IA0062421	Semi Public	Controlled	2	3.92	12.19
Corwith, City of	IA0021351	Municipal	Continuous	1	17	52.87
Cylinder, City of	IA0064823	Municipal	Controlled	2	2.97	9.24
Dakota City, City of	IA0048003	Municipal	Continuous	2	97	301.67
Dayton, City of	IA0023558	Municipal	Controlled	2	23.87	74.24
Duncombe, City of	IA0027413	Municipal	Controlled	2	12.80	39.81
Eagle Grove, City of	IA0034380	Municipal	Continuous	3	180	559.80
Easter Seal Camp Sunnyside	IA0071226	Semi Public	Controlled	2	0.84	2.61
Emmetsburg, City of	IA0021580	Municipal	Continuous	3	210	653.10
Estherville, City of	IA0023744	Municipal	Continuous	3	617.9	1921.67
Fort Dodge, City of	IA0044849	Municipal	Continuous	1	2000	6220.00
Gilmore City, City of	IA0031194	Municipal	Controlled	2	15.01	46.68
Goldfield, City of	IA0036137	Municipal	Controlled	2	18.36	57.10
Graettinger, City of	IA0027821	Municipal	Controlled	2	24.30	75.57
Grand Junction, City of	IA0041891	Municipal	Controlled	2	26.03	80.95
Granger, City of	IA0041912	Municipal	Continuous	1	35	108.85
Grimes, City of	IA0035939	Municipal	Continuous	1	303	942.33
Gruver, City of	IA0077488	Municipal	Controlled	2	2.86	8.89
Humboldt, City of	IA0047791	Municipal	Continuous	3	142	441.62
Jester Park 1, Polk County Conservation	IA0064106	Semi Public	Continuous	2	5.40	16.79
Jester Park 2, Polk County Conservation	IA0071803	Semi Public	Continuous	2	5.42	16.86
Kanawha, City of	IA0026000	Municipal	Controlled	2	19.95	62.04
Koch Nitrogen Plant	IA0000302	Industrial	Continuous	3	75.92	236.11
Lake Cornelia Sanitation District	IA0066401	Municipal	Controlled	2	6.26	19.47
Lehigh, City of	IA0021296	Municipal	Controlled	2	13.42	41.74
Livermore, City of	IA0023566	Municipal	Controlled	2	11.64	36.20
Madrid, City of	IA0028207	Municipal	Continuous	1	97	301.67
Mallard, City of	IA0023370	Municipal	Controlled	2	8.05	25.04
Oak Lake Maintenance, Inc.	IA0065242	Semi Public	Continuous	2	8.32	25.88
Ogden, City of	IA0041904	Municipal	Continuous	1	94	292.34
Otho, City of	IA0032948	Municipal	Controlled	2	15.42	47.96
Pilot Mound, City of	IA0058530	Municipal	Controlled	2	0	0.00
Pocahontas, City of	IA0035173	Municipal	Continuous	1	92	286.12
Polk City, City of	IA0041939	Municipal	Continuous	2	63.29	196.83
Renwick, City of	IA0032760	Municipal	Controlled	2	8.26	25.69

Ringsted, City of	IA0057436	Municipal	Controlled	2	11.77	36.60
Rolfe, City of	IA0032310	Municipal	Continuous	1	17.30	53.80
Rutland, City of	IA0061239	Municipal	Controlled	2	3.92	12.19
Savage Sanitation District, Fort Dodge	IA0059200	Municipal	Continuous	2	26.92	83.72
Saylorville Bob Shelter	IA0065528	Semi Public	Controlled	2	2.59	8.05
Scenic Valley Conference Center and Camp, Inc.	IA0067202	Semi Public	Controlled	2	2.59	8.05
Southdale Addition, Algona	IA0068284	Semi Public	Continuous	2	0.68	2.11
South Oak Estates, Algona	IA0065269	Semi Public	Continuous	2	1.00	3.11
Stratford , City of	IA0035980	Municipal	Controlled	2	20.14	62.64
Swea City, City of	IA0047813	Municipal	Controlled	2	17.33	53.90
Thor, City of	IA0058581	Municipal	Controlled	2	4.70	14.62
Titonka, City of	IA0033375	Municipal	Controlled	2	15.77	49.04
US gypsum	IA0066796	Industrial	Continuous	3	2.40	7.46
Van Diest Industry	IA0070033	Industrial	Continuous	3	3.40	10.57
Vincent, City of	IA0032930	Municipal	Controlled	2	4.27	13.28
Wallingford, City of	IA0062812	Municipal	Controlled	2	5.67	17.63
Webster City, City of	IA0036625	Municipal	Continuous	3	400	1244.00
Wesley, City of	IA0033472	Municipal	Controlled	2	12.61	39.22
West Bend, City of	IA0036994	Municipal	Controlled	2	22.52	70.04
Whittemore, City of	IA0033430	Municipal	Controlled	2	14.31	44.50
Woodward, City of	IA0057517	Municipal	Continuous	1	71	220.81
Woodward Resource Center	IA0063916	Semi Public	Continuous	2	13.18	40.99
Woolstock, City of	IA0061310	Municipal	Controlled	2	5.50	17.11
YMCA Boone	IA0070874	Semi Public	Continuous	2	1.86	5.78
TOTAL					**5,757.74**	**17,906.57**

Table 3-5. Assessed facilities in Minnesota portion of Des Moines River Watershed

Site Name	**EPA ID Number**	**Permit type**	**Discharge Frequency**	**Estimate Type**	**Average Daily Nitrate Load (lbs/day)**
Avoca & Iona WWTP	MN0022004	Municipal	Controlled	2	8.61
Brewster WWTP	MN0021750	Municipal	Controlled	2	13.55
Ceylon WWTP	MNG580006	Municipal	Controlled	2	11.15
Currie WWTP	MN0025682	Municipal	Controlled	2	6.08
Dunnell WWTP	MN0056103	Municipal	Continuous	2	5.32

Fulda WWTP	MN0023507	Municipal	Controlled	2	34.64
Heron Lake WWTP	MN0023655	Municipal	Controlled	2	20.74
Jackson WWTP	MNG580063	Municipal	Controlled	2	94.53
Lake Wilson WWTP	MNG580061	Municipal	Controlled	2	7.29
Lakefield WWTP	MNG550011	Municipal	Continuous	2	46.47
Okabena WWTP	MN0050288	Municipal	Controlled	2	5.00
Sherburn WWTP	MN0024872	Municipal	Continuous	2	29.21
Slayton WWTP	MN0024911	Municipal	Controlled	2	55.94
Windom WWTP	MN0022217	Municipal	Continuous	2	121.23
Worthington Industrial WWTP, Swift and Company	MN0031178	Municipal	Continuous	3	3800
Worthington WWTP	MN0031186	Municipal	Continuous	2	304.64

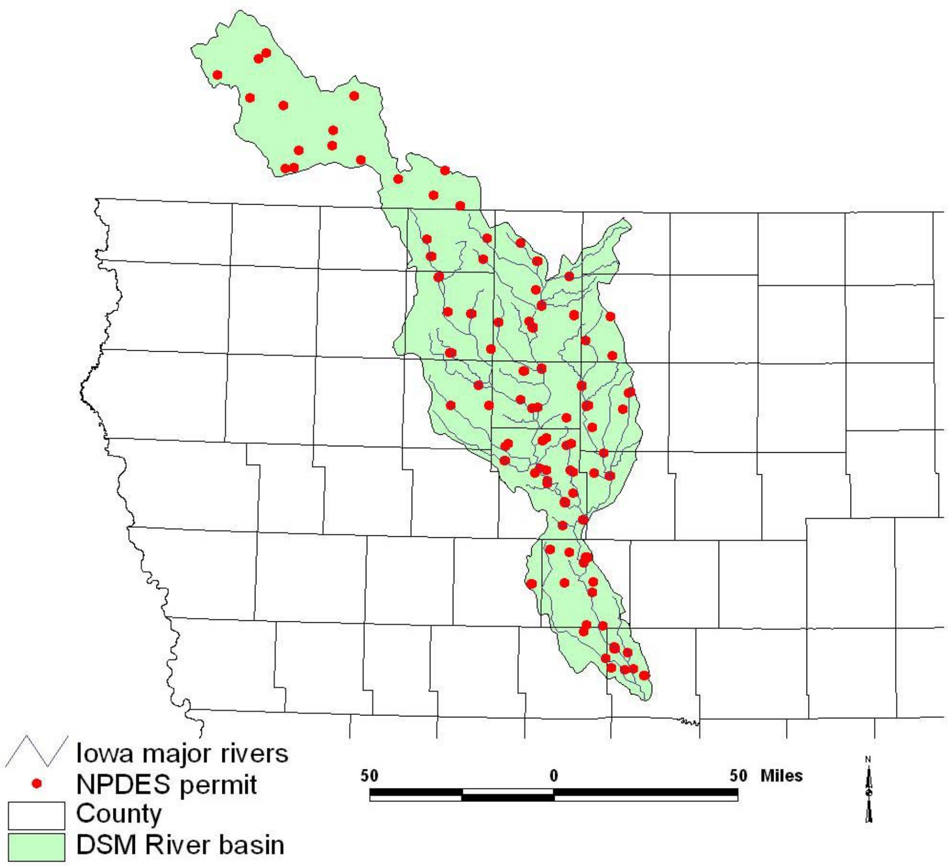

Figure 3-10. Location of NPDES facilities in the Des Moines River watershed.

Some animal feeding operations may be considered a point source because facilities larger than 1000 animal units are required to have an NPDES permit. However, by state law, discharge of pollutants from livestock operations is set at zero tons per year (IAC – Chapter 65). Any nitrate discharged from these facilities occurs from either manure application or episodic events such as spills. For open feedlots, facilities larger than 1000 animal units are considered NPDES facilities and their permits require retention and application of manure on cropped fields. There are four feedlots in the Des Moines River watershed with NPDES permits (Table 3-6). Of the smaller open lots, it is required that facilities settle solids before runoff enters a stream. The list of point sources does not include permitted facilities that do not treat an organic waste stream, such as quarry operations.

Table 3-6. Animal feeding operations (feedlots) with NPDES permits in the Des Moines River watershed.

Name	County	NPDES#	EPA ID	Animal Type	Head	Daily N Load (lbs/day)
Ulrich, Jerry	Emmet	3200010	IA0078573	Cattle	2,500	0
Greig & CO., Inc. Feedlot	Emmet	3200001	IA0077623	Cattle	2,000	0
Brenton Brothers, INC.	Dallas	2500001	IA0038911	Cattle	9,640	0
Hoiz Brothers, INC	Greene	3756814	IA0080837	Cattle	Unknown	0

There are three cities in the Des Moines River watershed that have Municipal Separate Storm Sewer Systems (MS4s) permits: Des Moines (EPA ID IA0075540), Grimes (EPA ID IA0078882) and Johnston (EPA ID IA00778212). The existing TKN load discharged to the Des Moines River from these communities is unknown. In Section 3.5.4, a numeric standard for the MS4 permits is provided based on the water quality standard.

Water treatment plants are required to have an NPDES permit to discharge water (e.g., filter backflush, wash water, etc.) to storm sewers or to surface water bodies. In the Des Moines River watershed (Iowa portion), eight facilities have applied for an NPDES permit (Table 3-7). Discharge limits for nitrogen were not specified in the permit applications. For the eight facilities with NPDES applications, the average amount of water discharged from water treatment plants ranged from 0.02 to 2.3 million gallons per day (MGD), or 1.5 to 18.5 percent of the raw water flow (Table 3-7). In terms of maximum flow, the percentage of raw water discharged ranged from 0.03 to 3.6 MGD, or 1.7 to 29.0 percent of raw water flow. Nitrate concentrations from the water treatment plants discharged from the facilities were reported in their permit applications. Nitrate loads discharge from water treatment facilities were estimated from their maximum discharge flow (average values were used if maximum values were not reported) multiplied by the TMDL target concentration for nitrate (9.5 mg/l) (see Section 3.4 for explanation of target concentration). For Saylorville and outfall #2 for the Iowa Lakes Regional Water Osgood Plant near Graettinger, the estimated discharge concentration from reverse osmosis water treatment was used.

Since the Saylorville plant was not yet constructed or operating at the time the permit application was submitted, the DMWW provided estimates of pollutant concentrations and loads. According to the DMWW, estimated effluent values varied for two different operating scenarios. For normal operation when all wastewater is discharged, the nitrate concentrations were 40 mg/l (nitrate load of 767 lbs/day) average and 50 mg/l (1,460 lbs/day) maximum. Average and maximum discharge flows for this scenario are listed as 2.3 and 3.5 million gallons per day, respectively. In the second scenario only reverse osmosis concentrate is discharged and the estimate nitrate values were 50 mg/l (542 lbs/day) average and 70 mg/l (934 lbs/day) maximum. Average and maximum discharge flows are listed as 1.3 and 1.6 million gallons per day, respectively. For purposes of this TMDL, the maximum nitrate loads during normal operation were assumed. The NPDES permit for the Saylorville plant did not specify discharge concentration limits for nitrate. Since the outfall from the plant was not located within the impaired segment for the Des Moines River, Class C water quality standards were not applied to the discharge.

Furthermore, the DMWW noted in their permit applications that "…raw water quality will change over the first few years of operation. Once the radial collector wells (our raw water source) are installed along the Des Moines River, it will take awhile before we start to see the influence of the river water in our wells. Initially we will be pumping mostly groundwater until we can induce flow from the river into the wells. Once the wells get established, we anticipate over half the water will be from the river and the other half from the groundwater. For this permit application, we have assumed our raw water will be mainly groundwater, a worst case water quality situation. It may make sense to reassess water quality in one to two years as outfall water quality may change." Thus, it is anticipated that the nitrate load from the Saylorville water treatment plant will change during operation.

Overall, the maximum daily nitrate load from the eight water treatment plants with NPDES applications is estimated to be 2205.8 lbs/day.

Table 3-7. Water treatment plants with NPDES permit applications in the Des Moines River watershed. Daily nitrate-N load determined from maximum discharge flow rate (average value used if maximum not available) multiplied by discharge nitrate concentration.

Facility	**Raw water flow (MGD)**	**Discharge Flow Avg. (MGD)**	**Fraction of raw water flow**	**Discharge Flow Max (MGD)**	**Fraction of raw water flow**	**Raw Water Nitrate Conc. (mg/L)**	**Nitrate Conc. in Discharge Water (mg/L)**	**TMDL Target Nitrate Conc. (mg/l)**	**Max. Daily N Load (lbs/day) (Flow max * 9.5)**
Boone Water Treatment Plant	2.0	0.0423	2.12%			NA	3.9	9.5	3.35
Clay Regional Water (Spencer)	1.1	0.0252	2.29%	0.288	26.18%	NA	0.23	9.5	22.83
Humboldt Water Treatment Plant	1.85	0.027	1.46%	0.031	1.68%		5	9.5	2.46
ILRW Osgood Plant (Graettinger) Outfall #1	7.7	0.3	3.90%	0.66	8.57%	2.0	4.0	9.5	23.78

Facility	Raw water flow (MGD)	Discharge Flow Avg. (MGD)	Fraction of raw water flow	Discharge Flow Max (MGD)	Fraction of raw water flow	Raw Water Nitrate Conc. (mg/L)	Nitrate Conc. in Discharge Water (mg/L)	TMDL Target Nitrate Conc. (mg/l)	Max. Daily N Load (lbs/day) (Flow max * 9.5)
ILRW Osgood Plant (Graettinger) Outfall #2 (RO reject)	7.7	1.4	18.18%				15		584.11
John W. Pray Water Facility (Ft. Dodge)	3.7	0.1	2.70%			NA	0.02	9.5	7.93
Mason City Water Treatment Plant	12.5	0.66	5.28%	1.09	8.72%	NA	0.02	9.5	86.41
Saylorville Water Treament Plant (Des Moines Water Works)	12.4	2.3	18.55%	3.5	28.23%	NA	50*		1460.27
Xenia North Water Treatment Plant (Dayton)	1.12	0.0179	1.60%	0.185	16.52%	9.0	5.0	9.5	14.67
TOTAL									2205.8

3.3.2 Nonpoint Sources

Nonpoint sources of nitrate to the Des Moines River include contributions from agricultural, developed land (urban and residential areas), and natural sources. Potential nonpoint sources from agricultural sources include commercial fertilizer, soil mineralization, legume fixation, and manure. Potential nonpoint sources from developed land sources include septic systems and turf grass fertilizer. Naturally occurring nonpoint sources include atmospheric deposition and wildlife contributions. These potential sources are briefly discussed in the following section. Potential sources of nitrate were estimated as total nitrogen inputs to the landscape with the understanding that all forms of nitrogen on the landscape have the potential to be mineralized and delivered to streams as nitrate.

The nonpoint sources of nitrogen (nitrate) in the Des Moines River watershed were evaluated using data and procedures developed for the statewide nutrient budget (Libra et al., 2004). Although the nutrient budget addressed only the 1997-2002 time period, assumptions developed for the report remain valid and budget results are useful to assess the relative contribution from the various nonpoint sources of nitrogen to the basin. Specific details and assumptions used to develop the nitrogen input estimates were presented in the nutrient budget report (Libra et al., 2004). Table 3-8 summarizes the nonpoint source inputs of nitrogen and their relative proportions in the Des Moines River watershed above the DMWW intake at 2nd Avenue.

Table 3-8. Nitrogen inputs from nonpoint sources in the Des Moines River watershed. Inputs summarized using procedures reported in Libra et al. (2004).

Source Category	Nitrogen Inputs	Des Moines River at 2nd Avenue (N in tons per year)	Percentage of Total N inputs
Agricultural	Fertilizer	117,787	22.98%
	Soil mineralization	189,942	37.05%
	Legume fixation	76,821	14.99%
	Manure		
	Hogs	38,294	7.47%
	Cattle	7,618	1.49%
	Chicken	5,750	1.12%
	Turkey	3,515	0.69%
Developed	Septic systems	239	0.05%
	Turf grass	7,231	1.41%
Natural	Atmospheric deposition	65,016	12.68%
	Wildlife (deer)	140	0.03%
	Wildlife (deer x 2)	279	0.05%
	TOTAL	512,631	

Results suggest that soil mineralization and nitrogen fertilizer are the largest nonpoint sources of nitrogen in the Des Moines River watershed, contributing approximately 60 percent of the total nitrogen input. Assuming that 20 pounds of nitrogen per row crop acre are mineralized for every one percent organic matter in the soil (Libra et al., 2004), it is clear that tilling Iowa's organic rich soils (2-5 percent organic matter) has potential to release a substantial amount of nitrate to streams without additional fertilizer inputs. However, the source of organic matter in soils includes not just background levels of naturally-occurring organic matter, but fertilizer and manure added to cropped fields to increase soil fertility. The combined source of organic matter from this total nitrogen (N) pool is available for mineralization. Thus a major source of nitrogen to the Des Moines River is leaching of soil nitrogen derived from organic matter, manure and fertilizer in row crop fields.

Fertilizer N applied to row crop fields was estimated to account for 23 percent of the total nitrogen inputs in the watershed. However, it should be noted that estimations of fertilizer use in Iowa are poorly documented. In the state nutrient budget, estimated fertilizer N input were derived from county fertilizer sales statistics and then apportioned to corn acres in a watershed (Libra et al., 2004). The proportion of fertilizer sales in each county was applied to the statewide amount of N and phosphorus (P) to generate the amount of N and P used in each county. Unit prices were also held constant across the state. Thus, while fertilizer use is a major source of N in the watershed, its actual amount remains an estimate only.

Legume fixation by crops such as soybeans, alfalfa and other hay and pasture may be a significant source of nitrogen in agricultural watersheds. Legume fixation is the process by which symbiotic bacteria around the roots of the plant convert elemental nitrogen gas (N_2) to inorganic nitrogen. The rate of nitrogen fixation varies by crop, with soybean N fixation estimated to be 2 pounds of nitrogen per bushel (lbs N/bu), alfalfa at 50 lbs N/ton and other hay and pasture at 90 lbs N/acre (Libra et al., 2004). Legume fixation accounted for 15 percent of the total nitrogen in the Des Moines River watershed. Nitrogen from animal manure from all sources accounted for nearly 11 percent of the total nitrogen inputs in the watershed (Table 3-8). Most of the manure N was associated with hogs (7.5 percent), whereas cattle and poultry accounted for less than 1.5 percent.

Nitrogen sources from developed lands (urban and residential areas) considered N contributions from septic systems and turf grass. Rural septic systems can be a significant source of total nitrogen to groundwater that may eventually discharge to surface water. The failure rate of septic systems varies considerably across counties in Iowa. For example, county sanitarians in the Raccoon River watershed who responded to requests for septic system information indicated that, in some counties, 70 to 90 percent of the systems would be considered failing due to lack of maintenance, failure to meet existing codes or are simply out of date (non-permitted). In regions where permitting regulations have been enforced, septic systems are monitored regularly and failure rates are much lower. For this TMDL, in order to build in a margin of safety, it was assumed that all septic systems have failed in the Des Moines River watershed.

While information regarding the specific number and status of septic systems in the watershed is not available, it can be reasonably assumed that rural populations rely nearly exclusively on septic systems for waste disposal. Using the 2000 U.S. Census estimate of rural population in the watershed and an estimated rate of 9.9 lbs N/person per year (Libra et al., 2004), the amount of N from septic systems in the Des Moines River watershed above 2^{nd} Avenue was estimated to be 239 tons N per year (Table 3-8). In terms of the other N inputs in the watershed, septic systems were found to contribute about 0.05 percent of the total N.

Nitrogen inputs from turf grass considered commercial N applied to urban lawns, golf courses and other grasslands in incorporated areas. Turf grass fertilizer use was estimated from sales data by county and applied equally to all grasslands within incorporated areas. Estimated turf grass N in the Des Moines River watershed area was estimated to 7,231 tons/year, or approximately 1.4 percent of the total N inputs (Table 3-8).

Natural sources of N are considered to consist of contributions from atmospheric deposition and wildlife, with atmospheric N inputs comprising an estimated 12.7 percent of the total N input to the watershed (Table 3-8). This percentage was similar to the contribution of manure N to the watershed. Atmospheric deposition was evaluated as the sum of wet and dry nitrogen dissolved in rain, attached to wind-blown particles, or existing as aerosols as estimated from rainfall monitoring records and other reports (Libra et al., 2004). While rainfall sources of N can be considered “natural”, the concentrations of nitrogen in precipitation are likely influenced by agricultural activities, including N volatilization from fertilizer, manure storage, and crop senescence, as well as wind-blown erosion of soil N during crop planting and harvesting. Monitoring near Iowa State University in Ames has indicated approximately 2.5 mg/l of nitrogen in Iowa rainfall (Libra et al., 2004).

Contributions of N from wildlife in Iowa are difficult to assess due to lack of estimates of animal species densities. The closest approximation of wildlife density in Iowa is developed from deer populations tracked by the Iowa DNR. Deer populations are estimated annually for each county in Iowa for hunting and licensing purposes. With an estimated 0.05 lbs N generated per deer/day, it was estimated that deer contribute 140 tons of N per year in the Des Moines River watershed. Because data are not available for wildlife densities for other animals, it was estimated that total wildlife N in the watershed could be approximated by multiplying the deer N contribution by a factor of two. Hence, total wildlife N was estimated to be 279 tons per year or 0.05 percent of the total N in the watershed (Table 3-8).

3.4 TMDL Approach and Target

As previously discussed in Section 3.1, a TMDL is required for the Des Moines River for nitrate. For nitrate, the TMDL was calculated using a duration curve analysis to assess the relation of measured daily loads to the water quality benchmark across a range of flow conditions. This approach was deemed appropriate because nitrate concentrations often varied by flow, tending to increase in concentration as streamflow discharge increased. In this Section, a general discussion of the TMDL calculation is initially presented, followed by a discussion of the duration curve modeling approach.

3.4.1 Waterbody Pollutant Loading Capacity

A TMDL is a calculation of the maximum amount of pollutant that a water body can receive and still meet water quality standards and/or designated uses. It is the sum of the loads of the selected pollutant from all contributing point and nonpoint sources, as well as a margin of safety to account for uncertainty. The TMDL is developed according to the following equation:

$$TMDL = \Sigma WLA + \Sigma LA + MOS$$

where:

TMDL = Total Maximum Daily Load
ΣWLA = Sum of wasteload allocations (point sources)
ΣLA = Sum of load allocations (nonpoint sources)
MOS = Margin of safety (may be implicit or explicit)

The WLA includes contributions from point sources in the DSM River watershed, including discharge from municipal and industrial sewage treatment plants, MS4 permits, large animal feeding operations and water treatment facilities (see Tables 3-4 to 3-7). The LA includes contributions from all nonpoint sources (agriculture, developed land and natural sources) as well as animal feeding operations and feedlots not covered in the point source inventory. The MOS is the part of the allocation that accounts for uncertainty that the allocations will result in attainment of water quality standards.

The three TMDL components (WLA, LA, MOS) were all calculated as maximum daily loads. For nitrate, the maximum daily load was calculated in metric tons of nitrate per day (Mg). Metric tons are very similar to standard U.S. tons and can be converted by multiplying by a factor of 1.1. When metric tons are reported, the equivalent value in U.S. tons is also provided in parentheses.

3.4.2 Modeling Approach

The load duration curve (LDC) modeling approach was used in this TMDL to compare measured pollutant concentrations and daily flow data to the water quality standard at a range of flow conditions. The LDC method involves developing a flow duration curve or a representation of the percentage of days in a year when a given instream flow occurs. A lower percentile rank of flow indicates periods when flow rarely occur and typically represents high flow periods (storm events), whereas a low percentile rank of flow indicates periods when flow is exceeded most of the time (low flow periods). The allowable pollutant load curve is calculated using the flow duration curve by multiplying the flow values to the applicable TMDL target. The observed pollutant loads in the river are plotted on the developed curve. Points that fall above the allowable load curve indicate exceedances, while points that fall below the curve indicate acceptable loads.

Monitoring data that exceeds the water quality standard at high flows (low percentile) indicates pollutant sources that are problems during major precipitation and runoff events. Examples might include nitrogen or manure runoff from cropped fields after a heavy rainfall. Observed water quality violations at low flows (high percentiles) are often from continuous direct discharges, such as wastewater treatment plants, cattle in streams or failed septic systems. The load duration curve analysis can often separate the impact of point and nonpoint sources on stream water quality.

3.4.3 TMDL Target

The TMDL target for nitrate is 10 mg/l at the DMWW surface water intake on the Des Moines River at 2nd Avenue.

3.4.4 Margin of Safety

The TMDL target requires that stream nitrate concentrations do not exceed the target level for the entire range of streamflow. However, the TMDL target above does not include a margin of safety (MOS). The TMDL equation can be rearranged to reflect the MOS in the TMDL target as follows:

TMDL – MOS = WLA + LA

A MOS can be either explicit or implicit in the TMDL. For the Des Moines River, both MOS categories were used for nitrate. An explicit MOS of 5% (0.5 mg/l) was used for the 10 mg/l TMDL target. Thus a nitrate TMDL target that includes a MOS is 9.5 mg/l (10 mg/l TMDL – 0.5 mg/l MOS).

The explicit MOS is reinforced for nitrate through conservative assumptions implicit in the representation and modeling of point and nonpoint sources. In particular, the point source contributions were calculated using many conservative assumptions that overestimated the point source contributions. For example, point source loads were based on TKN concentrations, not nitrate, and thus overestimated pollutant discharge concentrations. When measured point source data were not available, estimates were based on population estimates. Comparing population-estimated data with measured data, it is apparent that the estimated data greatly overestimated nitrate discharge loads. Estimates based on population do not consider denitrification losses that occur during the treatment process and thus overestimate point source loads.

3.5 TMDL for Nitrate at City of Des Moines

3.5.1 Existing Load

The existing load for nitrate measured at the 2nd Avenue intake is shown on the load duration curve (Figure 3-11). Based on 12 years of daily nitrate concentration and flow data (1995 to 2006), the daily nitrate load was plotted against the percentile of streamflow. Results indicate that a wide range of nitrate loads was measured during the 10-year period and that nitrate loads varied with streamflow. Also shown in Figure 3-11 is the TMDL. As noted above, this line was derived from multiplying the TMDL target concentration (9.5 mg/l) by the daily flow, thus delineating the acceptable range of nitrate load for the range of flow conditions encountered during the 12-year period. Comparing the measured nitrate load (points) to the TMDL indicates that many days had daily nitrate loads above the TMDL. Overall, no exceedances occurred at low flow conditions above about the 64th percentile. The range of flow conditions accounted for seasonal and annual variations during the assessment period.

3.5.2 Departure from Load Capacity

Figure 3-11 indicates that daily nitrate loads exceeded the TMDL target during higher flows (flow percentiles greater than 35.7 percent). The difference between the current existing load and the TMDL target (9.5 mg/l) was evaluated by deciles of flow (10 percent flow ranges) (Table 3-9). The maximum daily nitrate reduction required to meet the required TMDL target in each flow range was identified. This value represents the maximum amount of nitrate reduction needed for all measured loads in a flow range to be reduced below the TMDL target. Also shown in Table 3-9, is the percentage of days in each flow range that exceeded the TMDL.

Nitrate loads exceeded the TMDL target (9.5 mg/l) at flow ranges above the 30th percentile. The lowest flow measured in the DSM River at 2nd Avenue with a nitrate load above the TMDL target was 953 cubic feet per second (cfs). In other words, during the 12-year monitoring period, at no time did a nitrate impairment occur when DSM River streamflow was less than 953 cfs. For the entire record, a maximum nitrate reduction of 34.4 percent was needed for all days to be less than the TMDL target of 9.5 mg/l. Overall, when a reduction was needed in a decile range, the amount of nitrate reduction required varied within a relatively narrow range between 29.0 to 34.4 percent. However, the percentage of days in each flow decile that exceeded the TMDL target decreased with decreasing flow percentile, from 77.9 percent in the 90-100 range to 0.9 percent in the 30-40 percent range (only 4 of 439 samples exceeded the TMDL target in this flow range). Overall for the entire flow range, 19.3 percent of the days exceeded the TMDL target.

3.5.3 Seasonal Variation

Seasonal variation in nitrate loads in the Des Moines River at 2nd Avenue was evaluated by analyzing the daily nitrate load data by month (Table 3-10). Months requiring significant nitrate load reductions primarily included the period between February and July when load reductions ranged from 22.1 to 34.4 percent. The months of December and August also required nitrate load reductions greater than 10 percent. During the period between April and July, more than 31 percent of the days exceeded the TMDL. The month of June had nitrate exceedances occur on nearly 70 percent of the days. In contrast the period of August to November rarely had nitrate exceedances occur, with no exceedances in September and November and less than 0.5 percent of the days with exceedances in August and October.

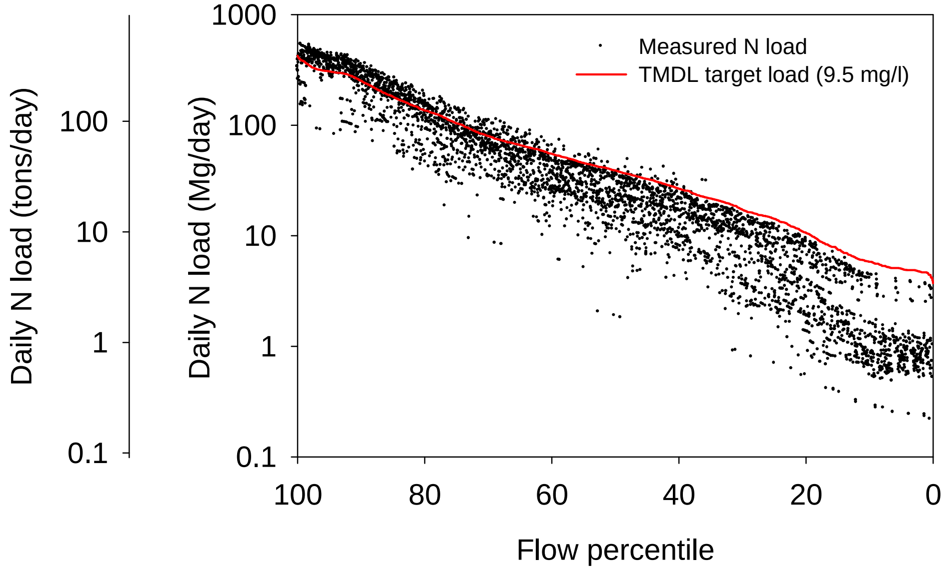

Figure 3-11. Load duration curve for daily Des Moines River nitrate loads at 2nd Avenue from 1996 to 2006. Solid red line is the TMDL target (see text for further explanation).

Table 3-9. Summary of nitrate load reductions needed and days requiring nitrate load reductions in the Des Moines River at 2nd Avenue. Load reductions summarized for each flow range decile of streamflow.

Flow Range (%)	Minimum Flow in Range (cfs)	Maximum Flow in Range (cfs)	Maximum Reduction Needed (%)	% of Days Needing Reduction within Flow Range
100-90	10890	18300	34.4%	77.6%
90-80	5870	10800	33.6%	57.8%
80-70	3438	5853	31.5%	27.6%
70-60	2370	3436	33.0%	18.5%
60-50	1680	2370	29.2%	5.7%
50-40	1150	1680	29.2%	4.6%
40-30	744	1150	29.0%	0.9%
30-20	460	742	-	-
20-10	250	459	-	-
10-00	160	250	-	-
All data				
100-0	160	18300	34.4%	19.3%

Table 3-10. Summary of nitrate reductions needed by month in Des Moines River at 2nd Avenue.

Month	Minimum Flow in Month (cfs)	Maximum Flow in Month (cfs)	Maximum Reduction Needed (%)	% of Days Needing Reduction
Jan	170	3,060	6.9%	0.8%
Feb	190	7,600	33.0%	6.8%
Mar	190	16,600	22.1%	7.8%
Apr	324	18,300	34.4%	30.8%
May	190	17,300	33.8%	57.0%
Jun	1,260	17,000	32.3%	69.4%
Jul	306	16,100	28.0%	50.0%
Aug	262	7,820	11.2%	0.3%
Sep	160	7,330	-	-
Oct	180	7,560	0.8%	0.5%
Nov	180	8,103	-	-
Dec	170	4,940	23.4%	7.0%

3.5.4 Pollutant Allocation

The pollutant allocation is the amount of daily nitrate load allocated to point sources (wasteload allocation), nonpoint sources (load allocation) and a margin of safety. Appendix B provides a listing of all wasteload allocations provided in this TMDL.

Wasteload allocation. Point sources associated with WWTPs do not contribute substantially to the nitrate impairment for the Des Moines River at 2nd Avenue. There were no nitrate exceedances at lower flows in the river (i.e., lowest 30% of flows), which would be the time when impacts from WWTP's would be evident if they were to occur. According to the streamflow record of the Des Moines River at 2nd Avenue evaluated in this TMDL (1996 to 2006), streamflow less than 742 cfs represents the cutoff for the lowest 30 percent of flows (Table 3-9). During lower flows in the Des Moines River baseflow conditions also dominate river hydrology, although storm events can cause streamflow to increase during any flow period. To ensure that low flows in the river are adequately protected from potential point source impacts, a two-tiered system of wasteload allocations is established. Tier I wasteloads are assigned to WWTPs when streamflow in the Des Moines River at 2nd Avenue is greater than 742 cfs and Tier II wasteloads are applied when flows are less than 742 cfs.

For Tier I, when Des Moines River streamflow is greater than 742 cfs, the WWTP wasteload allocation is set to the maximum daily nitrate load (Appendix B). When Tier II conditions are applicable, the WWTP wasteload allocation is set to the average daily nitrate load. The tiered approach to WWTP wasteloads is appropriate for several reasons. The wasteload estimates developed for WWTPs were conservative and represented a "worst-case" condition of daily nitrate loads from these point sources. Recall that the wasteload estimates for WWTPs assumed that all TKN nitrogen entering the plant was leaving the plant as nitrate and no facility or in-stream losses of nitrate were considered. In the highly improbable event that all WWTPs discharge their maximum allowable limit of nitrate on the same day, when streamflow in the Des Moines River is greater than 742 cfs (Tier I), there would not be a nitrate exceedance at the 2nd Avenue intake. During low flows less than 742 cfs, allowing maximum daily nitrate loads to be discharged to the Des Moines River would not be prudent because it would threaten the TMDL when streamflows are most vulnerable to point source impact. Even though nitrate exceedances have not occurred below this threshold, establishing the Tier II wasteload provides reasonable assurance for future compliance. Thus, the Tier II wasteload enables WWTPs to discharge their average daily nitrate load, just not their maximum loads, and still remain well below the TMDL.

In practice, WWTP operators would check the daily streamflow at the USGS stream gage on the Des Moines River at 2nd Avenue (http://waterdata.usgs.gov/nwis/uv?05482000) to determine whether streamflow is greater or less than 742 cfs. If streamflow is greater than 742 cfs, their wasteload is set to the maximum daily nitrate load. If the stream gage is reporting streamflow less than 742, the WWTP would be allowed to discharge no more than their average daily nitrate load established in this TMDL.

The total wasteload allocated to WWTP sources in the Des Moines River above the City of Des Moines at 2nd avenue is set to their existing maximum nitrate load (Tier I = 17,906.6 lbs/day or 8.121 Mg/day) when flows are greater than 742 cfs, and is set to their existing average nitrate load (Tier II = 5,757.7 lbs/day or 2.611 Mg/day) when flows are less than 742 cfs.

Wasteload allocations are also needed for other point sources in the Des Moines River watershed above 2nd Avenue, including 1) permitted livestock animal feeding operations, 2) MS4 cities, and 3) water treatment plants. In addition, future wasteload allocations for nitrogen were reserved for communities that are currently unsewered but that may install wastewater treatment plants in the future that will discharge nitrogen to the Des Moines River. The wasteload allocation for each of these additional point sources is provided below.

Animal Feeding Operations. The total wasteload allocated for NPDES permitted livestock animal feeding operations in the Des Moines River watershed is zero in accordance with IAC Chapter 65.

MS4 Permits. Numeric standards have not been provided for urban storm water sources through the NPDES MS4 permit program in the Des Moines River watershed. As noted in Section 3.3.1, three communities in the Des Moines River watershed above 2nd Avenue (Des Moines, Grimes and Johnston) have MS4 permits. The wasteload for these cities was determined using output from a watershed-based hydrologic model, the area of the city within a modeled subbasin, and the TMDL target concentration. The watershed model predicted how much surface runoff was generated in a subbasin, and this annual amount was then multiplied by the fraction of the subbasin containing the MS4 city. In the case of Johnston, the city extent occupied portions of two subbasins and these areas were combined into a single amount. The annual volume of runoff from each city was multiplied by the TMDL target concentration of 9.5 mg/l to yield the total load of nitrate allocated to city runoff. The annual loads in kilograms were converted to lbs/day for reporting. The spreadsheet used for estimating the wasteload allocated for the MS4 cities is provided in Appendix A. The MS4 nitrogen wasteload allocated to Grimes, Johnston and Des Moines is 24, 100, and 255 lbs/day, respectively. Together, the sum of the wasteload allocations for MS4s is 379 lbs/day or 0.172 Mg/day.

Water Treatment Plants. Although water treatment plants are required to have an NPDES permit to discharge water (e.g., filter backflush, wash water, etc.) to storm sewers or to surface water bodies, in the Des Moines River watershed (Iowa portion), only eight facilities have or have applied for an NPDES permit (Table 3-7). Thus, in addition to assigning a WLA for each of the eight facilities, additional wasteload must be allocated for all other water treatment facilities in the watershed to provide capacity when these systems apply for their NPDES permits. Available records indicate 55 additional municipal water systems in the Iowa portion of the Des Moines River watershed (Appendix B). Of the eight water treatment plants with permits, their permit applications do not specify a nitrogen discharge limit. Therefore, the wasteload allocation for nitrogen discharge is required for all water treatment plants in the Des Moines River watershed. The nitrogen wasteload for water treatment facilities in the Des Moines River watershed is allocated as the total capacity for all combined facilities in the basin.

The total wasteload allocated to water treatment plants was estimated using the amount of water waste generated by a facility multiplied by the nitrate target concentration of 9.5 mg/l. For the eight facilities with existing NPDES permits, if provided, the maximum discharge rate multiplied by 9.5 mg/l was used for their wasteload allocation (Table 3-7). An average discharge rate was used if a maximum discharge rate was unavailable. For the DMWW Saylorville plant, the maximum discharge rate was multiplied by the DMWW's estimate of maximum nitrate concentration discharge. Since the NPDES permit for the facility has been issued, the existing load is allocated in this TMDL.

For the remaining facilities that have not submitted NPDES permits, the wasteloads for these facilities must be estimated. The amount of water discharged from unpermitted water treatment plants was estimated to be 10% of the total volume of water pumped. The 10% value was provided as a general rule-of-thumb by staff in the Water Supply Section of IDNR (S. Grapp, personal communication, September 4, 2008) and supported by staff in the NPDES section (L. Wagner, personal communication, September 8, 2008). The 10% estimate exceeds the average discharge flow from seven facilities with existing NPDES applications and exceeds the maximum ratio from three facilities (Table 3-7). However, the 10% estimate is less than the maximum discharge ratio from the Saylorville Water Treatment Plant, Clay Regional Water system and Xenia North Water Treatment plant, and is likely less than the amount of water discharged from plants that use reverse-osmosis water treatment (waste may comprise up to 40% of annual pumped volume). However, the 10% water discharge rate is considerably higher than normal for the majority of systems in the watershed. Thus, this value was considered reasonable to estimate the total wasteload for all water treatment systems in the Des Moines River

The total volume of water used by 55 municipal water systems in the Iowa portion of the Des Moines River watershed is 5,556 million gallons per year, or 15.2 million gallons per day (MGD) (Appendix B). It is estimated that 10% of the water used by these systems is discharged to the Des Moines River system (1.52 MGD). This value is multiplied by the TMDL target concentration for nitrate (9.5 mg/l with MOS). The total wasteload allocation for water treatment plants in the Iowa portion of the Des Moines River watershed that do not currently have NPDES permits or permits pending is 120.7 lbs/day or 0.055 Mg/day. It should be noted that no wasteloads from water treatment plants were allocated for the Minnesota portion of the Des Moines River watershed. Nitrate contributions from Minnesota water treatment plant sources are considered background river quality as it enters the State of Iowa.

Together with the eight facilities with permits, the total wasteload allocated to water treatment plants is 2326.5 lbs/day (2205.8 lbs/day from eight permitted facilities + 120.7 lbs/day from 55 unpermitted facilities), or 1.055 Mg/day.

Unsewered Communities. Unsewered communities are considered a nonpoint source in this TMDL and as such, their N loads have been allocated in the load allocation (see next section). However, in the future, these communities may wish to build their own wastewater treatment facility, in which case, the communities may request an NPDES permit to discharge nitrogen into the Des Moines River watershed. To accommodate potential nitrogen discharge from future WWTPs, additional wasteload capacity is reserved. There are currently 22 unsewered communities in the Des Moines River watershed (Iowa portion only) with a total population of 2,856 (2000 census). A listing of the known unsewered communities in the Des Moines River watershed (Iowa portion) and their respective populations is provided in Appendix B. Using the generic assumption of 0.027 lbs TKN/person/day developed in Section 3.3.1 (Type 2 estimate), the average daily nitrate load in effluent that could be discharged from future WWTPs built by unsewered communities is 2,856 * 0.027 = 77.1 lbs nitrate/day (0.035 Mg/day). To convert this average estimate to a maximum daily nitrate load, a multiplier of 3.11 was used (see section 3.3.1). Thus, the maximum daily nitrate load discharged from future WWTPs built by unsewered communities is 77.1 * 3.11 = 239.8 lbs nitrate/day (0.109 Mg/day). This value is thus considered a reserve capacity of additional wasteload in the Des Moines River watershed available for currently unsewered communities to draw from when requesting an NPDES permit to construct a new WWTP in the basin. The 77.1 lbs nitrate/day amount is added to the current wasteload to account for future nitrogen discharge.

The wasteload allocation for the Des Moines River above 2nd Avenue is the sum of the current wasteload from WWTPs (Tier I and Tier II), MS4 communities, water treatment plants and future wasteload from potential WWTPs to be built by currently unsewered communities. A listing of wasteload allocations for these entities is provided in Appendix B. The total wasteload allocated to these sources in the Des Moines River watershed above 2nd Avenue is as follows

Tier I conditions for WWTPs (streamflow > 742 cfs at USGS gage at 2nd Aveune):

WLA (in Mg/day) = WWTPs (8.121 Mg/day) + AFO (0 Mg/day) + MS4 (0.172 Mg/day) + WTP (1.055 Mg) + Unsewered communities (0.109 Mg/day) = **9.457 Mg/day**

WLA (in lbs/day) = WWTPs (17,906.6 lbs/day) + AFO (0 lbs/day) + MS4 (379 lbs/day) + WTP (2326.5 lbs/day) + Unsewered communities (239.8 lbs/day) = **20,851.9 lbs/day**

Tier II conditions for WWTPs (streamflow < 742 cfs at USGS gage at 2nd Aveune)

WLA (in Mg/day) = WWTPs (2.611 Mg/day) + AFO (0 Mg/day) + MS4 (0.172 Mg/day) + WTP (1.055 Mg) + Unsewered communities (0.109 Mg/day) = **3.947 Mg/day**

WLA (in lbs/day) = WWTPs (5,757.7 lbs/day) + AFO (0 lbs/day) + MS4 (379 lbs/day) + WTP (2326.5 lbs/day) + Unsewered communities (239.8 lbs/day) = **8,703.0 lbs/day**

Load allocation. Nonpoint sources are contributing to the majority of the nitrate impairment in the Des Moines River measured at 2nd Avenue. Because the daily nitrate load varies by flow, the load allocation will also vary by flow. The load allocation is set using the following equations for Tier I and Tier II conditions:

Tier I conditions for WWTPs (streamflow > 742 cfs at USGS gage at 2nd Avenue):

LA = TMDL (10 mg/l x Flow) – WLA (9.457 Mg/day) – MOS (0.5 mg/l x Flow)

Tier II conditions for WWTPs (streamflow < 742 cfs at USGS gage at 2nd Aveune)

LA = TMDL (10 mg/l x Flow) – WLA (3.947 Mg/day) – MOS (0.5 mg/l x Flow)

The load allocation is set to be the difference between the TMDL target of 10 mg/l and the sum of the WLA and the MOS. Based on the maximum nitrate reduction needed for the 12-year record at the 2nd Avenue intake, nonpoint source nitrate loads require a reduction of 34.4 percent for all daily nitrate loads to be less than the TMDL target (9.5 mg/l). Reducing all daily nonpoint sources by this amount would ensure that all daily nitrate loads would be less than the LA. The specific nitrate load reduction needed in decile flow ranges is shown in Table 3-9. If daily flows are placed in a specific decile range, the amount of nitrate load reduction associated with each flow decile is known. Table 3-11 presents the load allocation by flow range. The load allocation was derived by subtracting the WLA and MOS from the TMDL as described above.

Table 3-11. Load allocation for nitrate in the Des Moines River at 2nd Avene.

Flow Range (%)	Maximum Flow in Range (cfs)	TMDL (Mg)	MOS (Mg)	WLA Tier I (Mg)	WLA Tier II (Mg)	LA (Mg)
100-90	18300	447.773	22.389	9.457	--	415.928
90-80	10800	264.260	13.213	9.457	--	241.590
80-70	5853	143.214	7.161	9.457	--	126.596
70-60	3436	84.074	4.204	9.457	--	70.413
60-50	2370	57.990	2.900	9.457	--	45.634
50-40	1680	41.107	2.055	9.457	--	29.595
40-30	1150	28.139	1.407	9.457	--	17.275
30-20	742	18.156	0.908	--	3.947	13.301
20-10	459	11.231	0.562	--	3.947	6.722
0-10	250	6.117	0.306	--	3.947	1.864

-- = not applicable

Margin of Safety. The MOS is set explicitly to be 0.5 mg/l multiplied by the daily flow. Because it is flow dependent, the actual daily nitrate MOS will vary. During all flows, establishing a MOS of 0.5 mg/l will ensure that nitrate concentrations in the Des Moines River remain less than 10 mg/l. In addition, a number of conservative assumptions were made implicitly to account for uncertainty and variability in the development of the TMDL.

4.0 DES MOINES RIVER WATERSHED MODEL

4.1 SWAT Model Setup and Description

The Soil and Water Assessment Tool (SWAT) is a hydrologic and water quality model developed by the U.S. Department of Agriculture (USDA) Agricultural Research Service (ARS) (Arnold et al., 1998 Arnold and Fohrer, 2005; Gassman et al., 2007). It is a long-term, continuous, watershed-scale, simulation model that operates on a daily time step and is designed to assess the impact of land use and different land management practices on water, nutrient and bacteria yields. The model is physically based and includes major components of weather, hydrology, soil temperature, crop growth, nutrients, bacteria and land management.

In SWAT, a watershed is divided into multiple subwatersheds, which are further subdivided into unique soil/land use characteristics called hydrologic response units (HRUs). For the Des Moines River watershed, the subbasins were selected to match the 12-digit Hydrologic Unit Code (HUC) watershed boundaries plus additional sub-basins at gage station locations within the watershed. The process of creating the subbasin boundaries and HRUs was performed within the ArcView SWAT (AVSWAT) interface. Initially, the 30-meter Digital Elevation Model (DEM) was loaded into the model and the 1:100,000 scale National Hydrography Dataset (NHD) was used to burn the stream network into the DEM. This was done to ensure that watershed boundaries were properly delineated in the northern portion of the watershed typified by low relief of the Des Moines Lobe landscape region. There were a total of 173 subbasins included in the model (Figure 4-1). Basin names and areas are provided on Table 4-1.

The HRUs were created within AVSWAT by loading the Soil Survey Geographic (SSURGO) data and the 2002 landcover grid as a polygon coverage. The HRUs were determined using thresholds of 10% landcover and 5% soil. All together, a total of 2,516 HRUs were created in the SWAT model. The hydrology and water quality components are computed at the HRU level and the loads are summed together at the subbasin level and routed downstream through main channels.

Daily weather data were obtained from the National Weather Service COOP monitoring sites available through Iowa Environmental Mesonet (http://mesonet.agron.iastate.edu). AVSWAT assigned the appropriate weather station information to each subbasin based on the proximity of the station to the centroid of the subwatershed. A total of 19 weather stations were used to provide the temperature and precipitation data for the 13-year time frame.

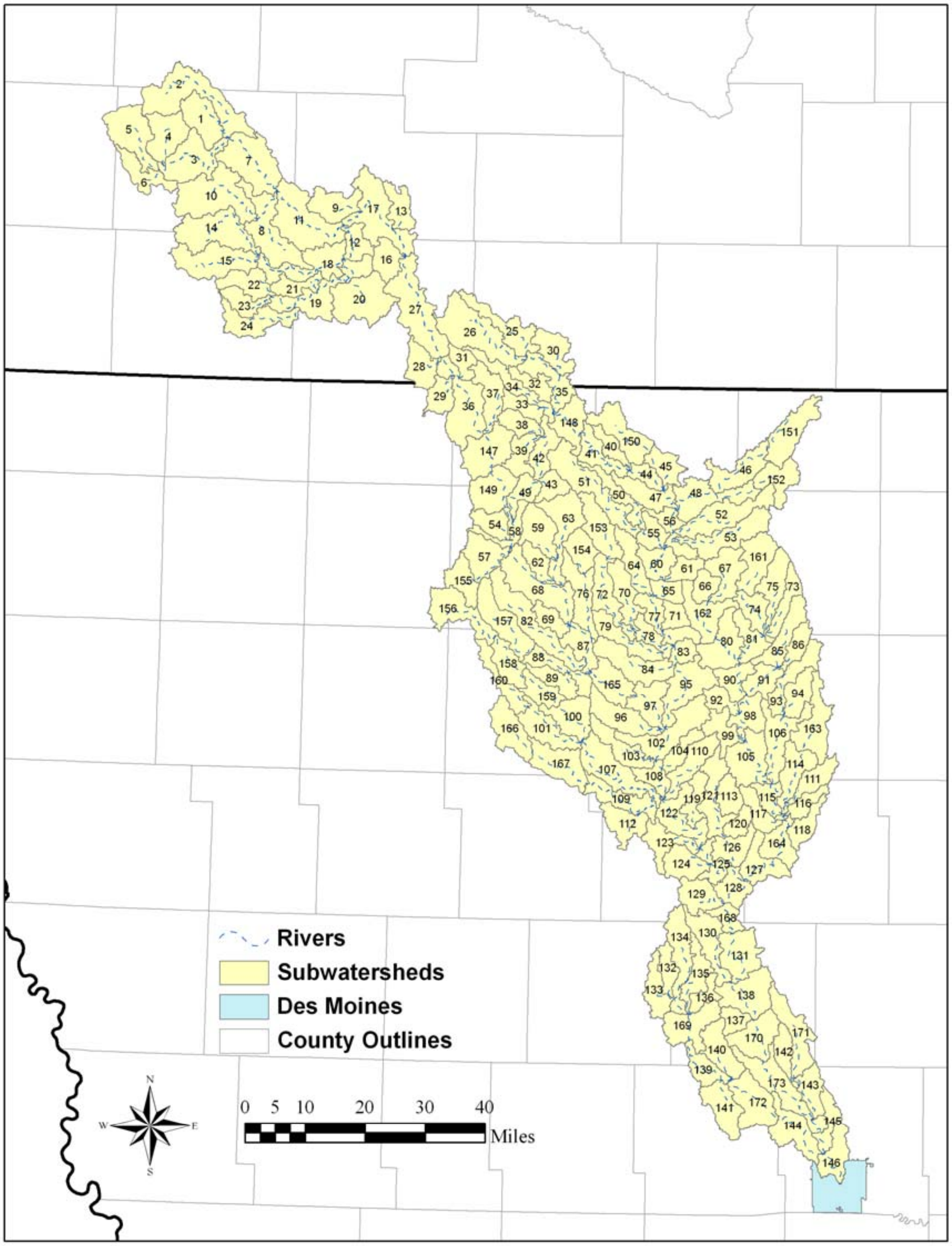

Figure 4-1. Location of 173 subbasins included in the Des Moines River SWAT model. Numbers correspond to basin names on Table 4-1.

Table 4-1. Basin names and basin areas of subbasins used in SWAT model. Basins with no name are located in Minnesota.

Basin No.	Basin Name	Area (acres)	Row Crop Percentage	Basin No.	Basin Name	Area (acres)	Row Crop Percentage
1	1	25580	n/a	87	Des Moines River-Drainage Ditch 17	17489	75.7
2	2	55175	n/a	88	Lower Pilot Creek	18279	80.4
3	3	35463	n/a	89	Crooked Creek-Pilot Creek	15129	90.3
4	4	26879	n/a	90	Boone River-Joint Drainage Ditch 3, 47	16157	84.4
5	5	35181	n/a	91	Otter Creek-Boone River	16565	88.7
6	6	18695	n/a	92	Drainage Ditch 9	11568	89.4
7	7	44008	n/a	93	Upper Eagle Creek	21950	85.7
8	8	41842	n/a	94	Little Eagle Creek	18194	87.9
9	9	22835	n/a	95	East Fork Des Moines River-Drainage Ditch 4	34162	78.2
10	10	51654	n/a	96	Indian Creek-Des Moines River	27710	86.1
11	11	50222	n/a	97	Des Moines River-Drainage Ditch 35	22940	70.1
12	12	14336	n/a	98	Boone River-Drainage Ditch 9	18422	77.5
13	13	16798	n/a	99	Drainage Ditch 3-Boone River	16850	87.6
14	14	42571	n/a	100	Lower North Branch Lizard Creek	24865	83.0
15	15	38640	n/a	101	Middle Lizard Creek	26093	85.6
16	16	16815	n/a	102	Des Moines River-Bass Creek	37298	82.0
17	17	46248	n/a	103	Deer Creek-Des Moines River	21310	86.9
18	18	33952	n/a	104	Badger Creek-Des Moines River	13171	85.6
19	19	38352	n/a	105	Boone River-Drainage Ditch 46	32328	78.7
20	20	41998	n/a	106	Lower Eagle Creek	30667	81.1
21	21	13059	n/a	107	Lower Lizard Creek	38218	75.0
22	22	19167	n/a	108	Des Moines River-Bradys Creek	12816	58.8
23	23	14359	n/a	109	Lower South Branch Lizard Creek	23832	76.0
24	24	27135	n/a	110	Soldier Creek-Des Moines River	23062	81.7
25	25	26499	n/a	111	Buck Creek-White Fox Creek	16431	86.1
26	26	50227	87.6	112	Spring Creek-South Branch Lizard Creek	21167	85.4
27	27	51363	n/a	113	Lateral 1	14390	89.2
28	28	19696	89.5	114	Lower White Fox Creek	23654	84.3
29	Drainage Ditch 23	15117	69.6	115	Boone River-Drainage Ditch 68	12110	67.3
30	30	20239	76.9	116	Lyons Creek	11279	83.2
31	31	10843	86.5	117	Brewers Creek	14841	80.5
32	32	12385	80.4	118	Drainage Ditch 206	14917	83.4
33	Drainage Ditch 40	12287	91.9	119	Holliday Creek	13862	72.2
34	Soldier Creek-East Fork Des Moines River	19880	86.2	120	Drainage Ditch 11-Brushy Creek	10134	86.3
35	East Fork Des Moines River	23357	70.7	121	Upper Brushy Creek-Des Moines River	27658	87.4
36	Des Moines River-School Creek	42824	59.3	122	Des Moines River-Gypsum Creek	27161	44.3
37	Brown Creek	22053	86.1	123	Prairie Creek-Drainage Ditch 96	21039	84.2
38	Drainage Ditch 7-Jack Creek	13758	89.9	124	Crooked Creek-Des Moines River	19883	84.8
39	Upper Jack Creek	16588	62.3	125	Des Moines River-Crooked Creek	13115	47.1
40	Prairie Creek-East Fork Des Moines River	10999	91.3	126	Lower Brushy Creek-Des Moines River	18418	67.7
41	East Fork Des Moines River-Crooked Run	19817	75.8	127	Boone River-Prairie Creek	22414	60.6
42	Middle Jack Creek	17496	88.1	128	Des Moines River-Allen Creek	16941	47.9
43	Drainage Ditch 21-Jack Creek	12271	93.0	129	Skillet Creek	20461	77.3
44	East Fork Des Moines River-Prairie Creek	10249	78.9	130	Bluff Creek-Middle Des Moines River	26976	78.2
45	Mud Creek-East Fork Des Moines River	16367	86.8	131	Des Moines River-Elkhorn Creek	29662	43.2
46	Lower Little Buffalo Creek	26379	89.9	132	Little Beaver Creek-West Beaver Creek	12699	91.4
47	East Fork Des Moines River-Drainage Ditch 63	21483	85.1	133	West Beaver Creek	18549	86.9
48	Buffalo Creek-Drainage Ditch 175	32888	80.3	134	Beaver Creek-West Beaver Creek	30361	88.2
49	Lower Jack Creek	13773	76.3	135	Middle Beaver Creek	19010	88.8
50	Calamus Creek-Black Cat Creek	16526	88.9	136	East Beaver Creek	10383	79.0
51	Middle Black Cat Creek	42758	89.5	137	Bear Creek-Shady Branch	10478	74.4
52	Lindsey Creek-East Fork Des Moines River	35478	88.2	138	Des Moines River-Honey Creek	32686	38.4
53	Plum Creek-East Fork Des Moines River	32818	89.2	139	Beaver Creek-Slough Creek	16524	66.2
54	Drainage Ditch 132	14580	82.5	140	Little Beaver Creek-Beaver Creek	23721	82.2
55	Lower Black Cat Creek	13531	78.9	141	Slough Creek	25067	83.7
56	East Fork Des Moines River-Lindsey Creek	17407	76.1	142	Little Creek	13843	76.5
57	Silver Creek-Drainage Ditch 23	24206	82.4	143	Lower Big Creek-Des Moines River	17085	54.7
58	Des Moines River-Drainage Ditch 132	13814	63.7	144	Beaver Creek-Middle Des Moines River	28638	34.6
59	Drainage Ditch 80-Cylinder Creek	24528	85.5	145	Des Moines River-Rock Creek	14301	44.1
60	East Fork Des Moines River-Drainage Ditch 51	17454	56.0	146	Des Moines River-Saylor Creek	20110	11.9
61	Purcell Creek	11919	83.1	147	Des Moines River-Drainage Ditch 151	32987	69.7
62	Dry Ditch	12582	86.9	148	East Fork Des Moines River-Drainage Ditch 3	21668	82.8
63	Cylinder Creek	32799	89.2	149	Des Moines River-Drainage Ditch 49	28017	66.0
64	Fourmile Creek-East Fork Des Moines River	19974	86.4	150	Mud Creek-Drainage Ditch 4	30256	90.0
65	East Fork Des Moines River-Purcell Creek	11169	69.8	151	Upper Little Buffalo Creek	30028	89.0
66	Drainage Ditch 177	11815	89.1	152	Buffalo Creek-Drainage Ditch 39	21434	88.2
67	Prairie Creek-Eddy Creek	25463	88.6	153	Upper Lotts Creek-East Fork Des Moines Rive	26624	89.8
68	Des Moines River-Drainage Ditch 41	41117	74.2	154	Prairie Creek-Drainage Ditch 167	17149	89.3
69	Drainage Ditch 48	12346	91.7	155	Silver Creek-Drainage Ditch 62	17980	81.3
70	Hine Creek	21442	90.2	156	North Branch Lizard Creek Headwaters	31430	86.2
71	Drainage Ditch 182	10708	87.8	157	Upper Pilot Creek	31880	89.8
72	Middle Lotts Creek-East Fork Des Moines River	25200	86.8	158	Upper North Branch Lizard Creek	19064	89.5
73	East Branch Boone River	15988	90.4	159	Middle North Branch Lizard Creek	15857	90.4
74	Boone River-Drainage Ditch 44	16109	87.8	160	Upper Lizard Creek	18053	86.4
75	Middle Branch Boone River	23999	89.3	161	Boone River-Drainage Ditch 97	27255	88.8
76	Prairie Creek-Lateral A	27217	87.2	162	Prairie Creek-Drainage Ditch 116	26726	89.1
77	East Fork Des Moines River-Drainage Ditch 94	22161	76.1	163	Upper White Fox Creek	31009	86.3
78	Lower Lotts Creek-East Fork Des Moines River	12297	80.3	164	Boone River-Drainage Ditch 206	20421	64.4
79	Trulner Creek	21896	88.0	165	Des Moines River-Drainage Ditch 7	23269	79.0
80	Prairie Creek-Drainage Ditch 18	29733	88.9	166	Upper South Branch Lizard Creek	26618	90.5
81	Boone River-Middle Branch Boone River	17057	87.9	167	Middle South Branch Lizard Creek	30169	85.6
82	Beaver Creek-Upper Des Moines River	42240	85.5	168	Des Moines River-Allen Creek	10850	43.9
83	East Fork Des Moines River-Lotts Creek	9574	79.8	169	Beaver Creek-Beaver Branch	28553	88.4
84	Bloody Run-East Fork Des Moines River	32733	89.3	170	Des Moines River-Richardson Branch	27573	52.2
85	West Otter Creek-Boone River	23486	89.4	171	Upper Big Creek-Des Moines River	29091	83.2
86	Otter Creek-Drainage Ditch 107	12864	88.3	172	Beaver Creek-Royer Creek	31782	66.2
				173	Des Moines River-Murphy Branch	38468	36.1

Overall, the following data sources were used to set up the basic SWAT model for the Des Moines River watershed:

- 30-meter DEM, USGS (http://seamless.usgs.gov)
- 1:100,000 scale NHD, USGS
- 2002 landcover grid, 15-meter, Iowa DNR
- 12-digit HUC boundaries, NRCS
- Climate data, Iowa Environmental Mesonet, National Weather Service COOP
- Soil Survey Geographic (SSURGO) soil data, NRCS
- Iowa Soil Properties and Interpretations Database (ISPAID), Iowa Cooperative Soil Survey
- Animal Feeding Operations database, Iowa DNR
- 2002 Iowa agriculture statistics, USDA-NASS
- 2000 US Census data, US Census Bureau
- WWTP data, Iowa DNR

The SWAT model was run on a daily time step for the 1994 to 2006 period for an 11-year simulation period (the first two years were associated with a model start-up period). Flow and nitrate loads were calibrated to the daily flow and nitrate concentration record available from the DMWW at 2nd Avenue in Des Moines.

4.2 Data Inputs and Model Assumptions

The following section describes data inputs unique to the Des Moines River watershed SWAT model, data sources for these inputs, and assumptions incorporated into the model. In many cases, model input and parameterization was completed using a SWAT model input program called iSWAT developed by Iowa State University Center for Agriculture and Rural Development.

Tile Drainage: Tile drainage is known to be an important component to the hydrology and nutrient loss from poorly drained lands typical of the Des Moines Lobe landscape region. Two methods were used to estimate the amount of land with subsurface tile drainage in the watershed. Both methods were based on identifying soil types that would require tile drainage in order for farming to occur. The first method developed by the U.S.D.A. National Soil Tilth Lab (D. James, NSTL, personal communication) identifies soils that have a low slope range value (2% or less), a drainage class of poor to very poor and a hydrologic group code with the "D" determination. The second method developed at Iowa State University (J. Miller, ISU, personal communication) considers a low slope range value (5% or less), a drainage class code greater than 40 and a subsoil group of 1 or 2. The variables for both methods are found in the ISPAID (Iowa Soil Properties and Interpretations Database) table. Soils that met either of these criteria were combined with the 2002 landcover information to identify row crop ground with probable tile drainage (Figure 4-2). Extent of tile drainage was not estimated for the Minnesota portion of the Des Moines River watershed. As noted in Figure 4-2, except for major river valleys, much of the watershed is likely underlain by tile drainage.

When tiles were placed in selected soil mapping units, they were assigned at a depth of 1.2 m below the ground surface. The combination of row crop ground with the specific soil mapping units was selected in the AVSWAT management files and the tile information was entered for those HRUs.

Fertilizer Application: Nitrogen and phosphorus fertilizer were applied to row-crop lands at rates and times consistent with available information. In the Raccoon River TMDL, fertilizer information provided by the ACWA indicated that on average 142 lbs/ac of N (NH_3, urea, UAN) was applied to 95 percent of the corn ground and an average of 76 lbs/ac of P (DAP) was applied to 60 percent of the crop ground in the watershed (Schilling et al., 2008). In the DSM River SWAT model, these conditions were retained. N fertilizer was applied to 100 percent of the corn ground, di-ammonium phosphate fertilizer was applied to soybean ground before planting, and anhydrous ammonia was applied in the fall after soybeans are harvested. The rates and timing are consistent with data provided by the ACWA.

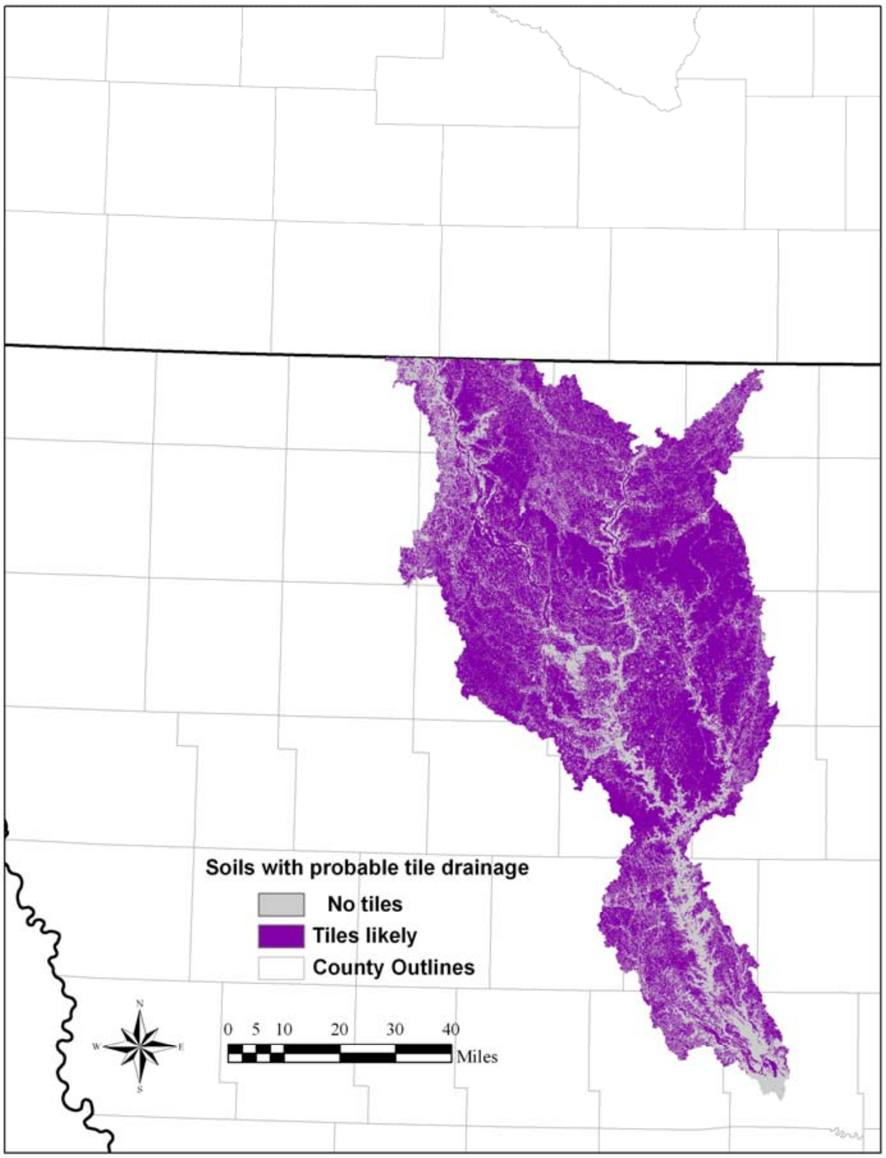

Figure 4-2. Soils with probable tile drainage in theIowa portion of the Des Moines River watershed.

Manure Application: Nitrogen losses from manure applications in the Des Moines River watershed are derived from two main sources: manure from feedlots (cattle manure) and manure from confined animal feeding operations (CAFOs) (Figure 4-3). The amount of manure in the watershed was distributed according to existing GIS coverages of cattle feedlots and CAFOs. The locations of cattle feedlots were used to estimate the amount of nitrogen from manure land applied by each feedlot. Manure was distributed on ground to be planted with corn (half applied in the spring and half applied in the fall).

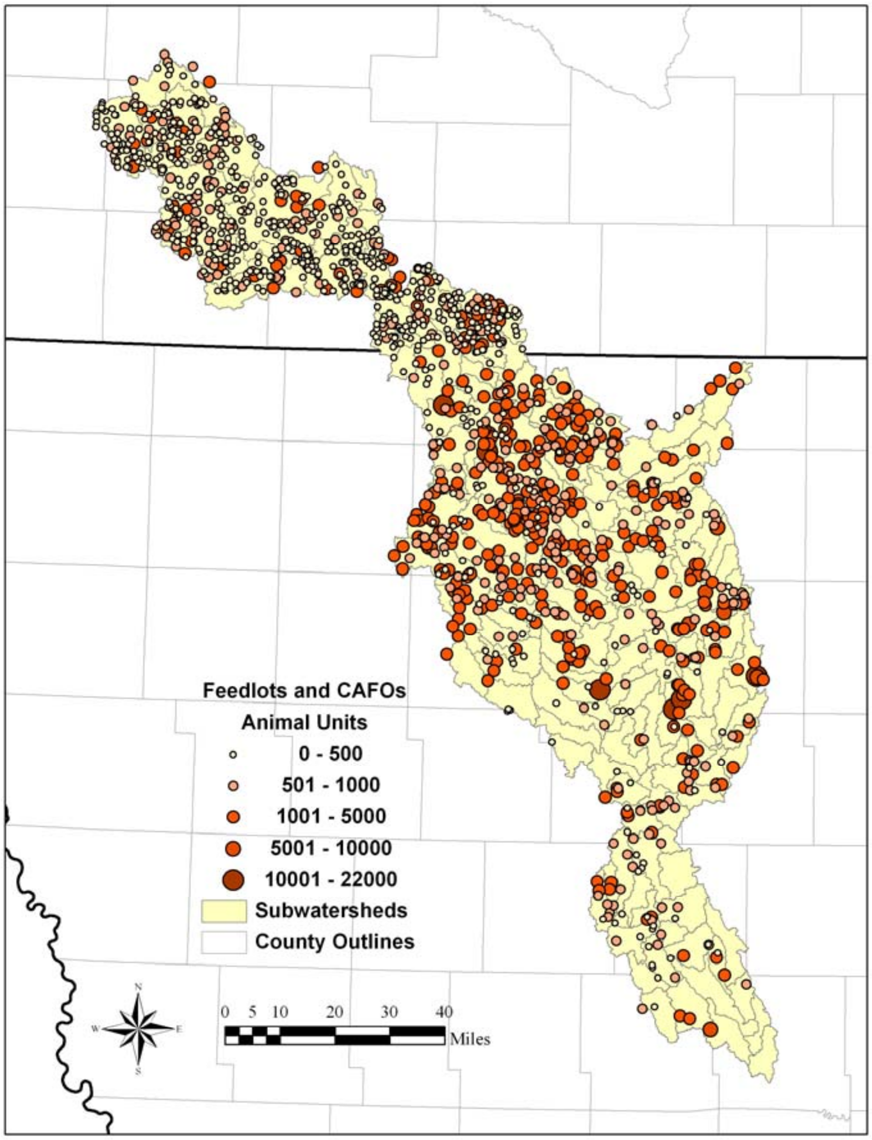

Figure 4-3. Distribution of feedlots and CAFOs in the Des Moines River watershed.

Wildlife Input: Deer grazing was added to the forest management file at the rate of 100 deer/square mile of forest.

Point Source Inputs: In the Des Moines River SWAT model, point source contributions to streams included inputs from human sources consisting of septic discharge and WWTP discharge.

The amount of human nitrogen discharged from septic systems into streams was estimated for each subbasin by summing the rural population from the 2000 census block coverage and multiplying the population by the average amount of nitrate generated by an individual. For nitrate it was assumed that 9.9 pounds of nitrogen was generated per person per year. All nitrogen values were assumed to be as nitrate.

For waste water treatment plants three methods were used to determine the amount of nitrogen discharged to streams. If a facility had a design limit for nitrogen, this limit was used at all times. If a facility had no design limits, a constant nitrogen value was assumed that was derived from the population estimate (or population equivalent). If the WWTP was a controlled discharge, a worksheet was used to determine how much nitrogen was stored until discharge using the rate constant.

For the model, loads from WWTPs were input in monthly time steps. Because the model was set up to run and initiate calibration in 1994, average monthly WWTP loads were needed that extended back in time for 13 years. Hence, monthly discharge rates for nitrogen were estimated by averaging the months of data that were available and applying these averages back in time. For the WWTPs with controlled discharge, the months that discharge occurred were examined to see which months discharge occurred most often. Average WWTP loads for those months were estimated from the available data and the same pattern of monthly and annual loads was then applied back in time to extend the data record to 1994.

4.3 Model Calibration and Validation

Measured data collected in the Des Moines River watershed were used for calibration of flow, and nitrate loads. The measured data used for model calibration were primarily collected from the stream gage and DMWW sampling site on the Des Moines River at 2nd Avenue.

SWAT was executed for a total simulation period of 13 years. Model calibration was performed manually by adjusting hydrologic and nitrate transport parameters (described below) and then comparing model output with measured data. The calibration process was initiated by first calibrating the stream hydrology and then calibrating for nitrate loads. This approach recognizes the importance of "following the water" as the carrier of pollutant loads.

The model predictions were evaluated for both the calibration and validation periods using graphical comparisons and two statistical measures: the coefficient of determination (R^2) and the Nash Sutcliffe simulation efficiency (E) developed by Nash and Sutcliffe (1970). The R^2 value is an indicator of the strength of relationship between measured and simulated values, whereas the E value measures how well the simulated values agree with the measured value. Both values typically range from zero to one, with value of one considered a perfect match.

4.3.1 Streamflow Calibration

The streamflow calibration process was completed by varying several SWAT hydrologic calibration parameters within their acceptable ranges to match predicted annual and monthly streamflow time series with their corresponding measured values. Calibration was achieved by adjusting several hydrologic parameters, including the curve number, soil available water capacity, evaporation compensation coefficient, and groundwater delay within their acceptable ranges (Table 4-2).

Table 4-2. Summary of SWAT calibration parameters adjusted and their final calibrated value.

Component	SWAT Calibration Parameter	Final Calibrated Value
Streamflow	Curve number	
	Corn	67
	Soybeans	68
	Grass	59
	Alfalfa	59
	Urban	66
	Forest	66
	Surface Runoff Lag (SURLAG)	4 days
	Soil evaporation compensation coefficient (ESCO)	0.95
	Groundwater delay (GW_Delay)	30 days
	Alpha baseflow factor (Alpha_BF)	0.048 days
	Hargreaves ET method	
Nitrate	Ammonia fertilizer rate	170 kg/ha (152 lbs/ac)
	Di-ammonium phosphate fertilizer rate	175 kg/ha (156 lbs/ac)
	Nitrogen percolation coefficient (NPERCO)	0.8

The hydrologic effects of Saylorville Reservoir were assessed using the reservoir routine in the SWAT model. Table 4-3 shows the required elements in the SWAT model for reservoir water and nutrient routing and the calibration values utilized in the Des Moines River model. Reservoir parameters were provided by the U.S. Army Corps of Engineers.

Table 4-3. Summary of SWAT calibration parameters required for reservoir routing and their final calibrated value.

SWAT Parameter	Units	Value
Surface area of reservoir when filled to emergency spillway	ha	6515
Volume of reservoir when filled to emergency spillway	104 m^3	79,066
Surface area of reservoir when filled to principal spillway	ha	5,868
Volume of reservoir when filled to principal spillway	104 m^3	67,817
Initial volume at beginning of model (January 1, 1994)	104 m^3	9,530
Initial sediment concentration in reservoir	mg/l	10
Equilibrium sediment concentration	mg/l	10
Median particle diameter of sediment	µm	10.1
Hydraulic conductivity of reservoir bottom	mm/hr	0.5

The Des Moines River SWAT model was calibrated and validated by comparing the simulated hydrology at the 2nd Avenue gage with measured values at annual and monthly time steps (Figure 4-4). The graphical results indicate that SWAT accurately tracked the annual and monthly streamflow trends across the model period. Over the entire simulation period, the modeled average annual average streamflow at 2nd Avenue (7.51 in) was very close to the measured value (7.34 in). The modeled average monthly streamflow (0.61 in) closely matched the measured monthly average (0.63 in) over the 120 month simulation period. Model calibration was confirmed by the statistical measures. The r^2 and E statistics for monthly comparisons were 0.80 and 0.79, respectively.

With the SWAT model successfully calibrated for water flux, the average annual water balance components for the Des Moines River can be evaluated (Table 4-4). Baseflow was assessed in the SWAT model by combining tile flow and groundwater flow and was estimated to be 4.8 in for the 10-year modeling period. This value was slightly lower than the value of 5.2 in estimated with the hydrograph separation program. The baseflow fraction was modeled to be 63 percent using SWAT and 69 percent using the baseflow separation program. Discharge and baseflow were estimated to represent approximately 24.4 and 15.4 percent of annual precipitation, respectively. The amount of evapotranspiration (ET) predicted by the model (23.0 in) was similar to the estimate of 24.3 in estimated for the Raccoon River (Schilling and Wolter, 2008). The watershed hydrology simulated with the SWAT model was consistent with available information and previous studies.

Table 4-4. Average annual water balance components for Des Moines River estimated by SWAT model.

Water Balance Components	Depth (mm)	Depth (in)
Precipitation	782.58	30.81
Surface Runoff	71.48	2.81
Baseflow	120.68	4.75
Tile Flow	62.02	2.44
Evapotranspiration	585.32	23.0
Total Streamflow	190.83	7.51

4.3.2 Nitrate Model Calibration

The nitrate calibration process was completed by varying several SWAT nitrogen calibration parameters within their acceptable ranges to match model predicted annual and monthly nitrate loads with their corresponding measured values. With the hydrology calibration completed successfully, nitrate calibration was achieved by adjusting only a few factors (Table 4-2). The ammonia fertilizer rate was lowered from 190 kg/ha (170 lb/ac) to 170 kg/ha (152 lb/ac) during the calibration process and some in-stream factors were adjusted.

SWAT model results at annual and monthly time steps were compared to measured data collected by the DMWW at the 2nd Avenue water intake (Figure 4-5). The modeled average annual nitrate load at 2nd Avenue (18.0 kg/ha or 16.1 lb/ac) was very close the measured annual average load (17.5 kg/ha, or 15.6 lb/ac) for an eight-year period from 1999 to 2006. On a monthly basis, modeled nitrate loads tracked closely with the measured values at 2nd Avenue (Figure 4-5). The average modeled monthly nitrate load for 96-months was 1.50 kg/ha (1.33 lb/ac), which compared very well with the measured value of 1.46 kg/ha (1.30 lb/ac). The r^2 and E statistics for the monthly nitrate loads were 0.77 and 0.74, respectively.

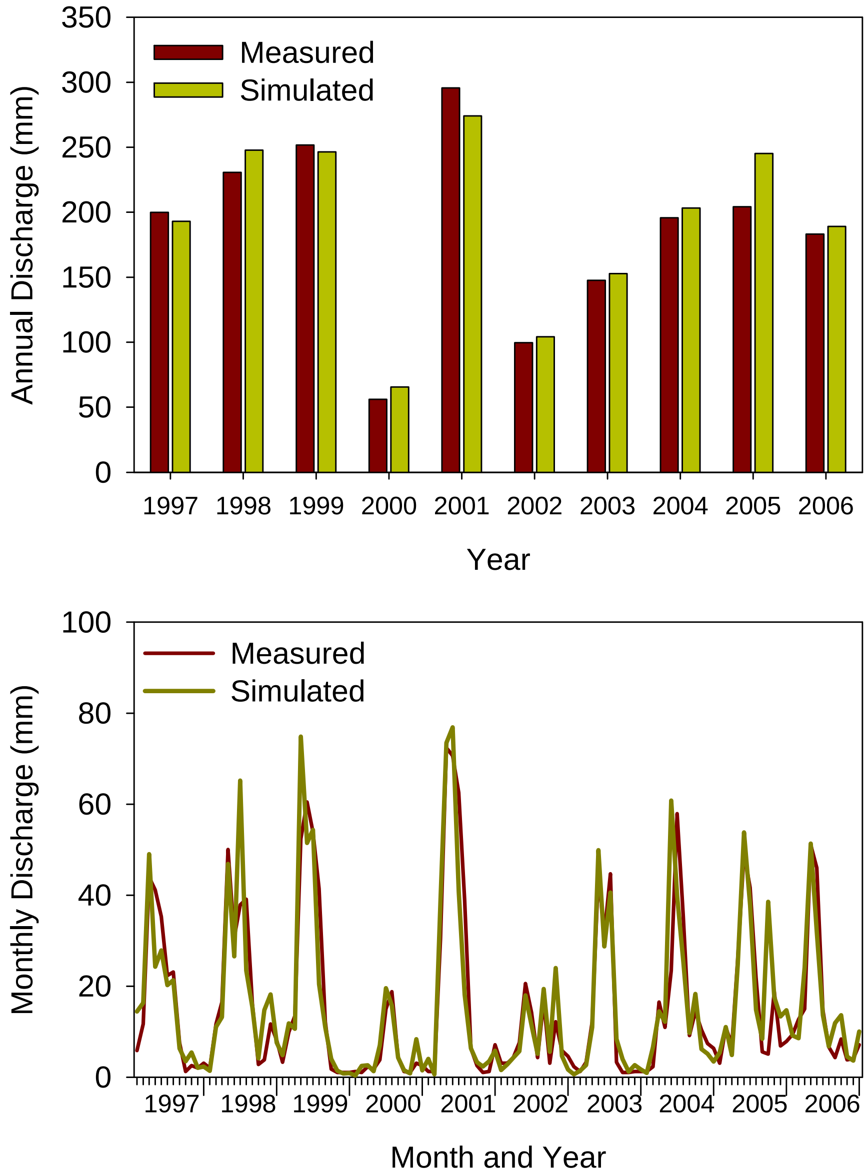

Figure 4-4. Annual and monthly flow calibration for the Des Moines River at 2nd Avenue.

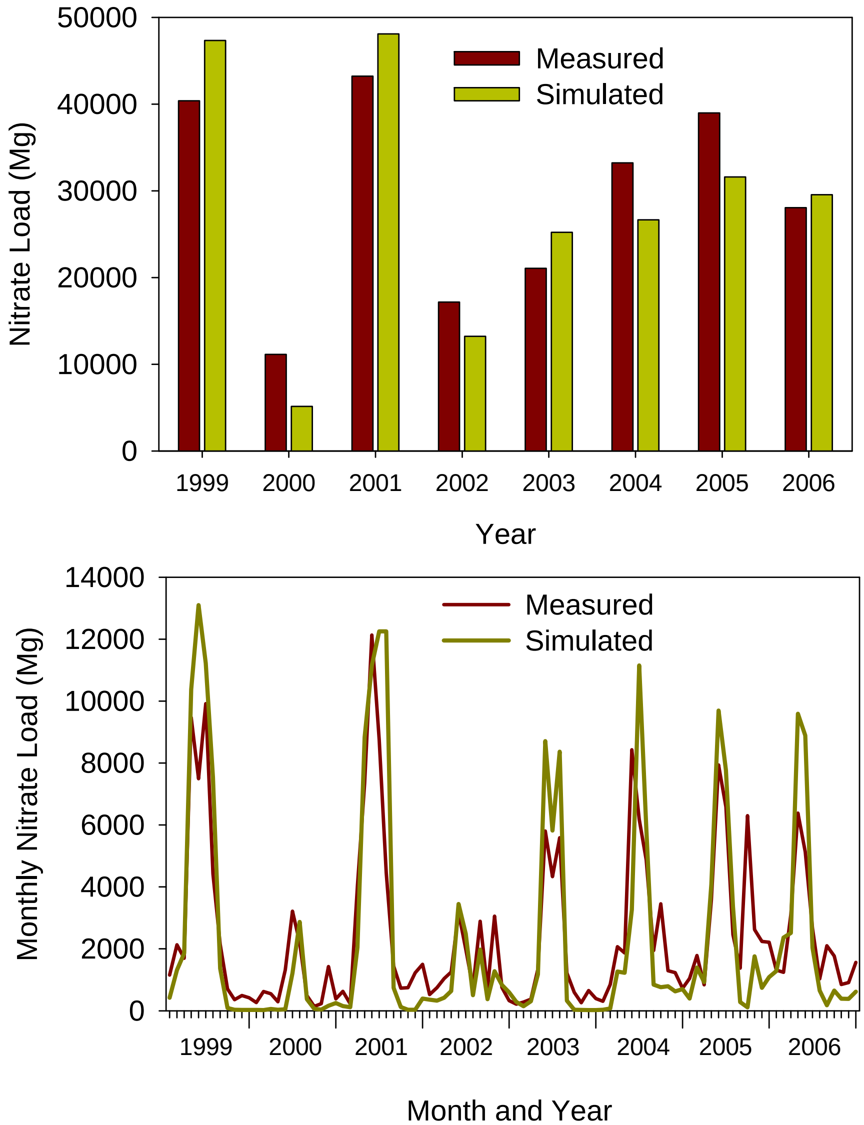

Figure 4-5. Annual and monthly nitrate load calibration for the Des Moines River at 2nd Avenue.

4.3.3 Nitrate Loading Patterns

The calibrated SWAT model for nitrate was used to assess the spatial patterns of nitrate loads in the Des Moines River watershed. The SWAT model provides output in several forms with which to evaluate loading patterns at the HUC12 subbasin level. In this report, nitrate loads were evaluated as average annual nitrate loading rates generated per unit area in each subbasin. Since the model was run in metric units, model output is reported in kg/ha with units in lbs/acre notation provided in parentheses. To evaluate the total nitrate loss from a subbasin, point source loads from WWTPs and septic systems in each subbasin were added to the nonpoint source nitrate loads. The total mass of nitrate generated from point and nonpoint source loads by subbasin can be compared by multiplying their loading rates by the watershed area.

Nonpoint Source Nitrate Loading Rates. Figure 4-6 shows the average annual total nitrate loss from subbasins in the Des Moines River watershed (nonpoint sources only). Nitrate loss rates varied from less than 5 kg/ha (4.5 lb/ac) to more than 20 kg/ha (17.9 lb/ac) in the Des Moines River watershed. Eight subbasins had nitrate losses greater than 20 kg/ha (17.9 lb/ac), with four of these subbasins located in the eastern half of the Boone River watershed (Upper White Fox Creek, Buck Creek, Lyon's Creek and Drainage Ditch 206). Much of the Boone River watershed had nonpoint source nitrate losses greater than 15 kg/ha (13.4 lb/ac) (Figure 4-6), including Upper White Fox Creek with the greatest nitrate loss rate of the 173 subbasins (28.6 kg/ha or 25.5 lb/ac). Elevated nitrate loading rates were also associated with the Beaver Creek watershed located in the southern extent of the Des Moines River basin. Nine of the eleven subbasins in the Beaver Creek watershed had nitrate losses greater than 15 kg/ha (13.4 lb/ac), including Little Beaver Creek with an average annual loss of near 21 kg/ha (18.8 lb/ac). Lowest nonpoint source loading rates in subbasins were mainly located in the central core of the watershed containing the Des Moines River floodplain corridor. Among all subbasins, the subbasin with the lowest nitrate loss rate was Saylor Creek located north of the Des Moines metropolitan area with a nonpoint source loss rate of 1.43 kg/ha (1.28lb/ac). A ranked summary (highest to lowest) of the nonpoint source loading rates in the Des Moines River watershed is provided in Table 4-5.

Point vs. Nonpoint Loads. The contribution of point sources and nonpoint sources to total nitrate loads was evaluated by considering the total amount of nitrate mass produced (in kilograms) in each subbasin. Since the point source loads were added to the subbasin export as the water exited a subbasin, these loads were easily separated from the total so that point sources and nonpoint sources could be evaluated. The mass of nitrate generated from point and nonpoint sources in Des Moines River subbasins is shown on Figure 4-7 and 4-8, respectively. It should be noted that the scales on the two maps were kept the same to better show comparisons between the two sources. A summary of subbasin point and nonpoint source loads (in kg) in the Des Moines River watershed is provided in Table 4-6. The loads in Table 4-6 were ranked by point source load from highest to lowest to provide clear indication of subbasin with greater point source contribution. The percent contribution of point source loads to overall nitrate loads from a subbasin is provided, as well as the overall average total nitrate loss by area (kg/ha) (Table 4-6). Figure 4-9 shows the total average annual nitrate load from point and nonpoint sources from 173 Des Moines River subbasins.

Greater point source nitrate loads were associated with subbasins containing wastewater treatment plants (Figure 4-7). The greatest point source load was associated with Subbasin 24 in Minnesota, a subbasin that contains the City of Worthington. On average, it is estimated that point sources from this subbasin export over 516,000 kg (1,137,780 lbs) of nitrate per year and contribute nearly 78 percent of the total nitrate loss from the basin (Table 4-6). The total nitrate loading rate from Subbasin 24, including point and nonpoint sources, was nearly 61 kg/ha (54 lb/ac). Of subbasins located in Iowa, point sources from four subbasins contribute more than 67,000 kg (147,735 lbs) of nitrate per year. In Gypsum Creek basin containing the City of Ft. Dodge, nitrate loads from point sources (345,822 kg/yr or 765,538 lbs/yr) comprise 78 percent of the total nitrate export, whereas in Drainage Ditch 151 and Drainage Ditch 206, point source loads of 105,287 kg (232,158 lbs) and 67,586 kg (149,027 lbs) comprise about 39 percent of the total annual nitrate load (Table 4-6). Most of the point source loads in Des Moines River subbasins comprise less than 10 percent of the total nitrate load. Summing the total point source loads (1,695,526 kg or 3,738,635 lbs) and nonpoint sources loads (24,757,349 kg or 54,589,955 lbs) reveals that point sources contribute to 6.4 percent of the total nitrate load and nonpoint sources contribute 93.6 percent of the total nitrate load in the watershed. Thus, while point sources may contribute to nitrate loads in a few subbasins, nitrate export in the Des Moines River appears to be predominantly a nonpoint source issue.

Total annual nitrate loss from subbasins ranged from 3.6 to nearly 61 kg/ha (3.2 to 54.5 lb/ac respectively) and averaged 15.6 kg/ha (13.9 lb/ac) (Table 4-6). When point source contributions were added to the nonpoint source loads, the same subbasins highlighted in Figure 4-8 remain in the high range (greater than 20 kg/ha or 17.9 lb/ac) and several subbasins containing elevated point source contributions were added (Figure 4-9). Two of the 14 subbasins with annual losses greater than 20 kg/ha (17.9 lb/ac) occurred in the Minnesota portion of the Des Moines River watershed. A total of 67 of the 173 subbasins (38.7 percent) had total nitrate losses greater than 15 kg/ha (13.4 lb/ac) (point sources included), whereas 55 of 173 (31.8 percent) had nonpoint source losses greater than 15 kg/ha (13.4 lb/ac). Overall, of the major tributary watersheds of the Des Moines River, nitrate losses from subbasins of the Boone River and Beaver Creek were generally highest.

Table 4-5. Ranked summary of average annual nonpoint source nitrate loss rates in Des Moines River subbasins. Basin numbers correspond to those shown on Figure 4-1. Minnesota subbasins do not have a name provided.

Basin No.	Basin Name	Average Nitrate Load (kg/ha)	Average Nitrate Load (lbs/ac)	Basin No.	Basin Name	Average Nitrate Load (kg/ha)	Average Nitrate Load (lbs/ac)
163	Upper White Fox Creek	28.64	25.56	72	Middle Lotts Creek-East Fork Des Moines River	13.90	12.41
118	Drainage Ditch 206	23.23	20.74	57	Silver Creek-Drainage Ditch 23	13.88	12.39
116	Lyons Creek	22.83	20.38	139	Beaver Creek-Slough Creek	13.86	12.37
108	Des Moines River-Bradys Creek	21.92	19.57	80	Prairie Creek-Drainage Ditch 18	13.84	12.35
111	Buck Creek-White Fox Creek	21.51	19.20	76	Prairie Creek-Lateral A	13.77	12.30
132	Little Beaver Creek-West Beaver Creek	20.89	18.65	24	24	13.76	12.29
151	Upper Little Buffalo Creek	20.88	18.64	29	Drainage Ditch 23	13.75	12.28
96	Indian Creek-Des Moines River	20.55	18.35	68	Des Moines River-Drainage Ditch 41	13.75	12.27
168	Des Moines River-Allen Creek	19.74	17.62	35	East Fork Des Moines River	13.72	12.25
135	Middle Beaver Creek	19.70	17.58	47	East Fork Des Moines River-Drainage Ditch 63	13.72	12.25
134	Beaver Creek-West Beaver Creek	19.64	17.54	83	East Fork Des Moines River-Lotts Creek	13.70	12.23
114	Lower White Fox Creek	18.99	16.96	5	5	13.61	12.16
136	East Beaver Creek	18.64	16.65	90	Boone River-Joint Drainage Ditch 3, 47	13.58	12.13
153	Upper Lotts Creek-East Fork Des Moines River	18.50	16.52	74	Boone River-Drainage Ditch 44	13.47	12.03
104	Badger Creek-Des Moines River	18.47	16.49	70	Hine Creek	13.40	11.96
154	Prairie Creek-Drainage Ditch 167	18.11	16.17	110	Soldier Creek-Des Moines River	13.39	11.96
133	West Beaver Creek	17.95	16.02	32	32	13.32	11.89
4	4	17.75	15.85	14	14	13.27	11.85
30	30	17.63	15.74	117	Brewers Creek	13.19	11.78
3	3	17.35	15.49	89	Crooked Creek-Pilot Creek	13.12	11.71
103	Deer Creek-Des Moines River	17.26	15.41	92	Drainage Ditch 9	13.07	11.67
105	Boone River-Drainage Ditch 46	17.17	15.33	71	Drainage Ditch 182	13.04	11.64
23	23	17.13	15.30	88	Lower Pilot Creek	13.03	11.63
130	Bluff Creek-Middle Des Moines River	16.83	15.03	85	West Otter Creek-Boone River	12.95	11.57
155	Silver Creek-Drainage Ditch 62	16.77	14.97	164	Boone River-Drainage Ditch 206	12.95	11.56
20	20	16.72	14.93	45	Mud Creek-East Fork Des Moines River	12.93	11.54
169	Beaver Creek-Beaver Branch	16.69	14.90	63	Cylinder Creek	12.92	11.54
86	Otter Creek-Drainage Ditch 107	16.69	14.90	101	Middle Lizard Creek	12.87	11.49
91	Otter Creek-Boone River	16.60	14.82	7	7	12.85	11.47
11	11	16.53	14.76	33	Drainage Ditch 40	12.78	11.41
140	Little Beaver Creek-Beaver Creek	16.47	14.70	69	Drainage Ditch 48	12.71	11.35
6	6	16.46	14.69	34	Soldier Creek-East Fork Des Moines River	12.70	11.34
152	Buffalo Creek-Drainage Ditch 39	16.37	14.62	19	19	12.66	11.30
53	Plum Creek-East Fork Des Moines River	16.33	14.58	17	17	12.65	11.30
16	16	16.24	14.50	106	Lower Eagle Creek	12.65	11.30
93	Upper Eagle Creek	16.21	14.48	119	Holliday Creek	12.63	11.28
54	Drainage Ditch 132	16.17	14.44	36	Des Moines River-School Creek	12.59	11.24
141	Slough Creek	16.07	14.35	170	Des Moines River-Richardson Branch	12.58	11.23
94	Little Eagle Creek	16.05	14.33	97	Des Moines River-Drainage Ditch 35	12.47	11.14
113	Lateral 1	16.02	14.30	156	North Branch Lizard Creek Headwaters	12.46	11.12
172	Beaver Creek-Royer Creek	15.99	14.28	59	Drainage Ditch 80-Cylinder Creek	12.44	11.11
50	Calamus Creek-Black Cat Creek	15.96	14.25	99	Drainage Ditch 3-Boone River	12.43	11.10
12	12	15.69	14.01	51	Middle Black Cat Creek	12.38	11.05
171	Upper Big Creek-Des Moines River	15.64	13.96	127	Boone River-Prairie Creek	12.35	11.03
22	22	15.52	13.86	58	Des Moines River-Drainage Ditch 132	12.35	11.02
75	Middle Branch Boone River	15.40	13.75	143	Lower Big Creek-Des Moines River	12.32	11.00
21	21	15.36	13.71	64	Fourmile Creek-East Fork Des Moines River	12.31	10.99
1	1	15.35	13.70	100	Lower North Branch Lizard Creek	12.28	10.96
109	Lower South Branch Lizard Creek	15.31	13.67	166	Upper South Branch Lizard Creek	12.25	10.94
123	Prairie Creek-Drainage Ditch 96	15.23	13.60	37	Brown Creek	12.23	10.92
67	Prairie Creek-Eddy Creek	15.20	13.57	66	Drainage Ditch 177	12.22	10.91
98	Boone River-Drainage Ditch 9	15.16	13.54	147	Des Moines River-Drainage Ditch 151	12.18	10.88
73	East Branch Boone River	15.16	13.54	144	Beaver Creek-Middle Des Moines River	12.17	10.87
28	28	15.08	13.46	65	East Fork Des Moines River-Purcell Creek	12.07	10.77
82	Beaver Creek-Upper Des Moines River	15.06	13.44	159	Middle North Branch Lizard Creek	12.01	10.72
9	9	14.95	13.35	25	25	11.97	10.68
121	Upper Brushy Creek-Des Moines River	14.95	13.35	148	East Fork Des Moines River-Drainage Ditch 35	11.91	10.63
124	Crooked Creek-Des Moines River	14.94	13.34	31	31	11.91	10.63
160	Upper Lizard Creek	14.79	13.21	95	East Fork Des Moines River-Drainage Ditch 4	11.87	10.60
120	Drainage Ditch 11-Brushy Creek	14.78	13.19	27	27	11.83	10.56
40	Prairie Creek-East Fork Des Moines River	14.77	13.19	167	Middle South Branch Lizard Creek	11.69	10.43
81	Boone River-Middle Branch Boone River	14.77	13.19	115	Boone River-Drainage Ditch 68	11.63	10.39
161	Boone River-Drainage Ditch 97	14.77	13.19	131	Des Moines River-Elkhorn Creek	11.57	10.33
158	Upper North Branch Lizard Creek	14.72	13.14	41	East Fork Des Moines River-Crooked Run	11.51	10.27
52	Lindsey Creek-East Fork Des Moines River	14.71	13.14	162	Prairie Creek-Drainage Ditch 116	11.46	10.23
46	Lower Little Buffalo Creek	14.71	13.13	56	East Fork Des Moines River-Lindsey Creek	11.45	10.22
150	Mud Creek-Drainage Ditch 4	14.68	13.10	55	Lower Black Cat Creek	11.44	10.21
157	Upper Pilot Creek	14.67	13.10	43	Drainage Ditch 21-Jack Creek	11.37	10.15
18	18	14.66	13.09	78	Lower Lotts Creek-East Fork Des Moines River	11.31	10.09
44	East Fork Des Moines River-Prairie Creek	14.62	13.05	79	Trulner Creek	11.02	9.84
142	Little Creek	14.61	13.05	149	Des Moines River-Drainage Ditch 49	10.95	9.78
102	Des Moines River-Bass Creek	14.56	13.00	77	East Fork Des Moines River-Drainage Ditch 94	10.88	9.72
62	Dry Ditch	14.50	12.94	48	Buffalo Creek-Drainage Ditch 175	10.81	9.66
15	15	14.37	12.83	26	26	10.81	9.65
13	13	14.31	12.78	126	Lower Brushy Creek-Des Moines River	10.71	9.56
137	Bear Creek-Shady Branch	14.31	12.78	49	Lower Jack Creek	10.57	9.43
8	8	14.28	12.75	61	Purcell Creek	10.36	9.25
10	10	14.14	12.63	138	Des Moines River-Honey Creek	9.81	8.76
42	Middle Jack Creek	14.13	12.62	128	Des Moines River-Allen Creek	9.69	8.65
2	2	14.04	12.53	39	Upper Jack Creek	9.38	8.37
84	Bloody Run-East Fork Des Moines River	14.00	12.50	60	East Fork Des Moines River-Drainage Ditch 51	9.25	8.26
107	Lower Lizard Creek	14.00	12.50	145	Des Moines River-Rock Creek	8.71	7.78
165	Des Moines River-Drainage Ditch 7	13.99	12.49	122	Des Moines River-Gypsum Creek	8.69	7.76
112	Spring Creek-South Branch Lizard Creek	13.96	12.47	125	Des Moines River-Crooked Creek	7.08	6.32
129	Skillet Creek	13.95	12.45	173	Des Moines River-Murphy Branch	6.65	5.94
38	Drainage Ditch 7-Jack Creek	13.93	12.44	146	Des Moines River-Saylor Creek	1.43	1.28
87	Des Moines River-Drainage Ditch 17	13.92	12.43				

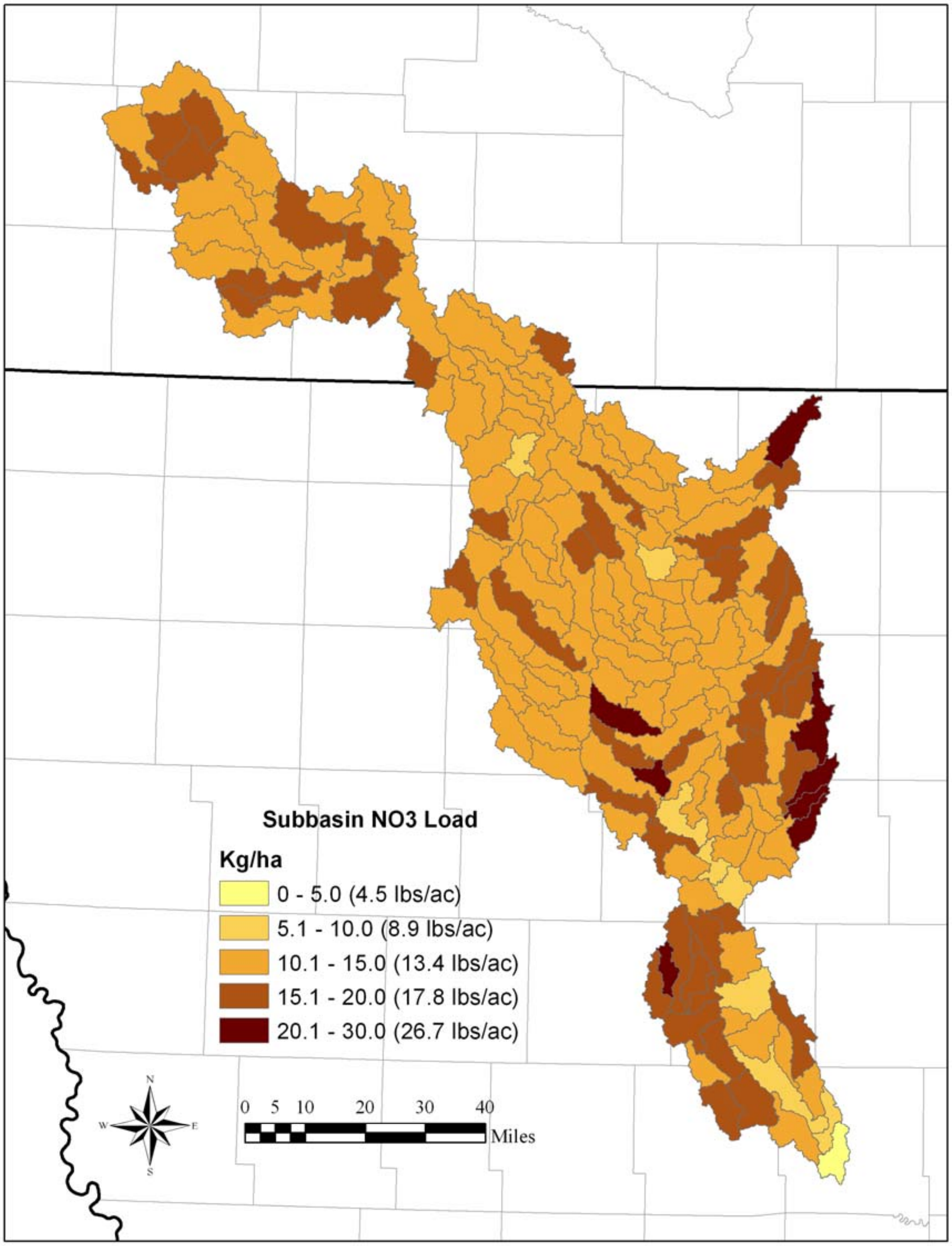

Figure 4-6. Total annual nonpoint source nitrate loss from subbasins.

Table 4-6. Ranked summary of total point loads by subbasin. The percentage of the total load from point sources, and the total annual nitrate loss rate by subbasin (point and nonpoint sources) are also provided. Basin numbers correspond to those shown on Figure 4-1. Minnesota subbasins do not have a name provided.

Basin No.	Basin Name	Point Source Load (kg)	Total Nitrate Load (kg)	Percent Point Source	Total Nitrate Load (kg/ha)	Total Nitrate Load (lb/ac)
24	24	516288	667388	77.36%	60.78	54.26
122	Des Moines River-Gypsum Creek	345822	441360	78.35%	40.15	35.85
147	Des Moines River-Drainage Ditch 151	105287	267884	39.30%	20.07	17.92
164	Boone River-Drainage Ditch 206	67586	174582	38.71%	21.13	18.86
144	Beaver Creek-Middle Des Moines River	60356	201435	29.96%	17.38	15.52
60	East Fork Des Moines River-Drainage Ditch 51	42406	107740	39.36%	15.25	13.62
4	4	37948	231022	16.43%	21.24	18.96
68	Des Moines River-Drainage Ditch 41	35961	264672	13.59%	15.91	14.20
105	Boone River-Drainage Ditch 46	31258	255890	12.22%	19.56	17.46
97	Des Moines River-Drainage Ditch 35	26363	142163	18.54%	15.31	13.67
17	17	23190	259981	8.92%	13.89	12.40
146	Des Moines River-Saylor Creek	18014	29660	60.74%	3.64	3.25
106	Lower Eagle Creek	16907	173922	9.72%	14.01	12.51
136	East Beaver Creek	16207	94543	17.14%	22.50	20.09
160	Upper Lizard Creek	15940	123993	12.86%	16.97	15.15
173	Des Moines River-Murphy Branch	12615	116108	10.86%	7.46	6.66
143	Lower Big Creek-Des Moines River	11932	97080	12.29%	14.04	12.54
20	20	10514	294636	3.57%	17.34	15.48
75	Middle Branch Boone River	10089	159694	6.32%	16.44	14.68
138	Des Moines River-Honey Creek	7776	137485	5.66%	10.39	9.28
27	27	7359	253299	2.91%	12.19	10.88
25	25	6617	134948	4.90%	12.58	11.24
41	East Fork Des Moines River-Crooked Run	6409	98684	6.49%	12.31	10.99
95	East Fork Des Moines River-Drainage Ditch 4	6198	170339	3.64%	12.32	11.00
10	10	5252	300874	1.75%	14.39	12.85
149	Des Moines River-Drainage Ditch 49	5204	129403	4.02%	11.41	10.19
56	East Fork Des Moines River-Lindsey Creek	5029	85695	5.87%	12.16	10.86
145	Des Moines River-Rock Creek	4964	55366	8.97%	9.57	8.54
133	West Beaver Creek	4801	139503	3.44%	18.58	16.59
129	Skillet Creek	4397	119883	3.67%	14.48	12.93
45	Mud Creek-East Fork Des Moines River	4268	89912	4.75%	13.57	12.12
48	Buffalo Creek-Drainage Ditch 175	4177	148103	2.82%	11.13	9.94
172	Beaver Creek-Royer Creek	4074	209771	1.94%	16.31	14.56
85	West Otter Creek-Boone River	4065	127184	3.20%	13.38	11.95
109	Lower South Branch Lizard Creek	3971	151598	2.62%	15.72	14.03
108	Des Moines River-Bradys Creek	3930	117634	3.34%	22.68	20.25
128	Des Moines River-Allen Creek	3892	70312	5.54%	10.26	9.16
104	Badger Creek-Des Moines River	3869	102339	3.78%	19.20	17.14
2	2	3866	317293	1.22%	14.21	12.69
150	Mud Creek-Drainage Ditch 4	3834	183519	2.09%	14.99	13.38
76	Prairie Creek-Lateral A	3804	155481	2.45%	14.12	12.60
72	Middle Lotts Creek-East Fork Des Moines River	3802	145596	2.61%	14.28	12.75
98	Boone River-Drainage Ditch 9	3766	116817	3.22%	15.67	13.99
51	Middle Black Cat Creek	3564	217694	1.64%	12.58	11.23
107	Lower Lizard Creek	3529	220026	1.60%	14.23	12.70
100	Lower North Branch Lizard Creek	3399	126935	2.68%	12.61	11.26
26	26	3366	223032	1.51%	10.97	9.80
11	11	3365	339304	0.99%	16.69	14.91
131	Des Moines River-Elkhorn Creek	3326	142150	2.34%	11.84	10.57
170	Des Moines River-Richardson Branch	3189	143593	2.22%	12.87	11.49
163	Upper White Fox Creek	3168	362556	0.87%	28.89	25.80
7	7	2949	231726	1.27%	13.01	11.62
67	Prairie Creek-Eddy Creek	2931	159571	1.84%	15.49	13.83
77	East Fork Des Moines River-Drainage Ditch 94	2922	100525	2.91%	11.21	10.01
82	Beaver Creek-Upper Des Moines River	2898	260247	1.11%	15.22	13.59
36	Des Moines River-School Creek	2871	220991	1.30%	12.75	11.39
125	Des Moines River-Crooked Creek	2861	40417	7.08%	7.62	6.80
14	14	2855	231416	1.23%	13.43	11.99
18	18	2849	204302	1.39%	14.87	13.28
8	8	2807	244543	1.15%	14.44	12.89
19	19	2776	199232	1.39%	12.84	11.46
113	Lateral 1	2663	95959	2.77%	16.48	14.71
5	5	2659	196486	1.35%	13.80	12.32
15	15	2589	227308	1.14%	14.54	12.98
102	Des Moines River-Bass Creek	2518	222288	1.13%	14.73	13.15
79	Trulner Creek	2508	100121	2.50%	11.30	10.09
171	Upper Big Creek-Des Moines River	2379	186492	1.28%	15.84	14.14
3	3	2376	251358	0.95%	17.51	15.64
34	Soldier Creek-East Fork Des Moines River	2215	104358	2.12%	12.97	11.58
90	Boone River-Joint Drainage Ditch 3, 47	2164	90974	2.38%	13.91	12.42
139	Beaver Creek-Slough Creek	2144	94799	2.26%	14.18	12.66
121	Upper Brushy Creek-Des Moines River	1911	169243	1.13%	15.12	13.50
1	1	1787	160635	1.11%	15.52	13.86
140	Little Beaver Creek-Beaver Creek	1698	159762	1.06%	16.64	14.86
141	Slough Creek	1651	164636	1.00%	16.23	14.49
124	Crooked Creek-Des Moines River	1625	121870	1.33%	15.15	13.52
21	21	1624	82782	1.96%	15.66	13.99
123	Prairie Creek-Drainage Ditch 96	1609	131294	1.23%	15.42	13.77
63	Cylinder Creek	1567	173110	0.91%	13.04	11.64
35	East Fork Des Moines River	1566	131212	1.19%	13.88	12.39
99	Drainage Ditch 3-Boone River	1558	86309	1.81%	12.66	11.30
52	Lindsey Creek-East Fork Des Moines River	1553	212809	0.73%	14.82	13.23
9	9	1530	139718	1.09%	15.12	13.50
96	Indian Creek-Des Moines River	1492	231931	0.64%	20.68	18.47
37	Brown Creek	1478	110614	1.34%	12.39	11.07
32	32	1447	68206	2.12%	13.61	12.15
130	Bluff Creek-Middle Des Moines River	1409	185114	0.76%	16.96	15.14

Table 4-6. Continued.

Basin No.	Basin Name	Point Source Load (kg)	Total Nitrate Load (kg)	Percent Point Source	Total Nitrate Load (kg/ha)	Total Nitrate Load (lb/ac)
142	Little Creek	1400	83267	1.68%	14.86	13.27
84	Bloody Run-East Fork Des Moines River	1377	186816	0.74%	14.10	12.59
46	Lower Little Buffalo Creek	1359	158400	0.86%	14.84	13.25
134	Beaver Creek-West Beaver Creek	1358	242708	0.56%	19.75	17.64
30	30	1356	145744	0.93%	17.79	15.89
167	Middle South Branch Lizard Creek	1352	144026	0.94%	11.80	10.53
119	Holliday Creek	1325	72173	1.84%	12.87	11.49
28	28	1319	121510	1.09%	15.24	13.61
112	Spring Creek-South Branch Lizard Creek	1296	120892	1.07%	14.11	12.60
153	Upper Lotts Creek-East Fork Des Moines River	1290	200627	0.64%	18.62	16.63
22	22	1285	121698	1.06%	15.69	14.01
117	Brewers Creek	1281	80522	1.59%	13.41	11.97
110	Soldier Creek-Des Moines River	1262	126259	1.00%	13.53	12.08
53	Plum Creek-East Fork Des Moines River	1261	218181	0.58%	16.43	14.67
6	6	1252	125769	1.00%	16.62	14.84
157	Upper Pilot Creek	1218	190441	0.64%	14.76	13.18
127	Boone River-Prairie Creek	1176	113188	1.04%	12.48	11.14
166	Upper South Branch Lizard Creek	1153	133120	0.87%	12.36	11.03
103	Deer Creek-Des Moines River	1146	150001	0.76%	17.39	15.53
114	Lower White Fox Creek	1139	182919	0.62%	19.11	17.06
16	16	1128	111664	1.01%	16.41	14.65
13	13	1126	98390	1.14%	14.47	12.92
161	Boone River-Drainage Ditch 97	1117	164004	0.68%	14.87	13.28
101	Middle Lizard Creek	1115	137005	0.81%	12.97	11.58
169	Beaver Creek-Beaver Branch	1111	193985	0.57%	16.79	14.99
59	Drainage Ditch 80-Cylinder Creek	1040	124503	0.83%	12.54	11.20
64	Fourmile Creek-East Fork Des Moines River	1025	100496	1.02%	12.43	11.10
57	Silver Creek-Drainage Ditch 23	1021	136940	0.75%	13.98	12.48
39	Upper Jack Creek	1020	63960	1.59%	9.53	8.51
80	Prairie Creek-Drainage Ditch 18	1015	167486	0.61%	13.92	12.43
29	Drainage Ditch 23	1013	85122	1.19%	13.91	12.42
47	East Fork Des Moines River-Drainage Ditch 63	997	120235	0.83%	13.83	12.35
23	23	964	100514	0.96%	17.30	15.44
12	12	962	92009	1.05%	15.86	14.16
151	Upper Little Buffalo Creek	918	254587	0.36%	20.95	18.71
115	Boone River-Drainage Ditch 68	914	57919	1.58%	11.82	10.55
93	Upper Eagle Creek	848	144868	0.59%	16.31	14.56
162	Prairie Creek-Drainage Ditch 116	837	124750	0.67%	11.53	10.30
33	Drainage Ditch 40	823	64365	1.28%	12.94	11.56
137	Bear Creek-Shady Branch	820	61492	1.33%	14.50	12.95
126	Lower Brushy Creek-Des Moines River	813	80655	1.01%	10.82	9.66
165	Des Moines River-Drainage Ditch 7	811	132539	0.61%	14.08	12.57
88	Lower Pilot Creek	741	97121	0.76%	13.13	11.72
50	Calamus Creek-Black Cat Creek	740	107483	0.69%	16.07	14.35
158	Upper North Branch Lizard Creek	736	114306	0.64%	14.82	13.23
148	East Fork Des Moines River-Drainage Ditch 35	730	105154	0.69%	11.99	10.71
31	31	726	52966	1.37%	12.07	10.78
65	East Fork Des Moines River-Purcell Creek	719	55259	1.30%	12.23	10.92
135	Middle Beaver Creek	690	152208	0.45%	19.78	17.66
70	Hine Creek	681	116954	0.58%	13.48	12.03
155	Silver Creek-Drainage Ditch 62	681	122683	0.56%	16.86	15.05
152	Buffalo Creek-Drainage Ditch 39	673	142681	0.47%	16.45	14.69
94	Little Eagle Creek	669	118848	0.56%	16.14	14.41
156	North Branch Lizard Creek Headwaters	627	159045	0.39%	12.50	11.16
61	Purcell Creek	623	50568	1.23%	10.48	9.36
111	Buck Creek-White Fox Creek	604	143609	0.42%	21.60	19.28
81	Boone River-Middle Branch Boone River	593	102552	0.58%	14.86	13.27
78	Lower Lotts Creek-East Fork Des Moines River	590	56847	1.04%	11.42	10.20
38	Drainage Ditch 7-Jack Creek	589	78154	0.75%	14.04	12.53
159	Middle North Branch Lizard Creek	587	77649	0.76%	12.10	10.80
73	East Branch Boone River	581	98683	0.59%	15.25	13.62
54	Drainage Ditch 132	573	96006	0.60%	16.27	14.53
66	Drainage Ditch 177	573	59018	0.97%	12.34	11.02
42	Middle Jack Creek	569	100637	0.57%	14.21	12.69
55	Lower Black Cat Creek	567	63190	0.90%	11.54	10.30
71	Drainage Ditch 182	562	57064	0.99%	13.17	11.76
154	Prairie Creek-Drainage Ditch 167	548	126226	0.43%	18.19	16.24
118	Drainage Ditch 206	524	140745	0.37%	23.32	20.82
74	Boone River-Drainage Ditch 44	513	88316	0.58%	13.55	12.10
58	Des Moines River-Drainage Ditch 132	511	69537	0.74%	12.44	11.11
87	Des Moines River-Drainage Ditch 17	490	99017	0.49%	13.99	12.49
91	Otter Creek-Boone River	489	111768	0.44%	16.67	14.89
120	Drainage Ditch 11-Brushy Creek	481	61080	0.79%	14.89	13.30
168	Des Moines River-Allen Creek	477	87145	0.55%	19.85	17.72
89	Crooked Creek-Pilot Creek	459	80756	0.57%	13.19	11.78
40	Prairie Creek-East Fork Des Moines River	455	66206	0.69%	14.87	13.28
86	Otter Creek-Drainage Ditch 107	454	87320	0.52%	16.77	14.98
49	Lower Jack Creek	446	59336	0.75%	10.65	9.51
44	East Fork Des Moines River-Prairie Creek	423	61061	0.69%	14.72	13.14
92	Drainage Ditch 9	415	61610	0.67%	13.16	11.75
116	Lyons Creek	414	104611	0.40%	22.92	20.46
69	Drainage Ditch 48	382	63867	0.60%	12.78	11.41
132	Little Beaver Creek-West Beaver Creek	379	107712	0.35%	20.96	18.71
62	Dry Ditch	330	74146	0.44%	14.56	13.00
83	East Fork Des Moines River-Lotts Creek	290	53349	0.54%	13.77	12.29
43	Drainage Ditch 21-Jack Creek	229	56671	0.40%	11.41	10.19

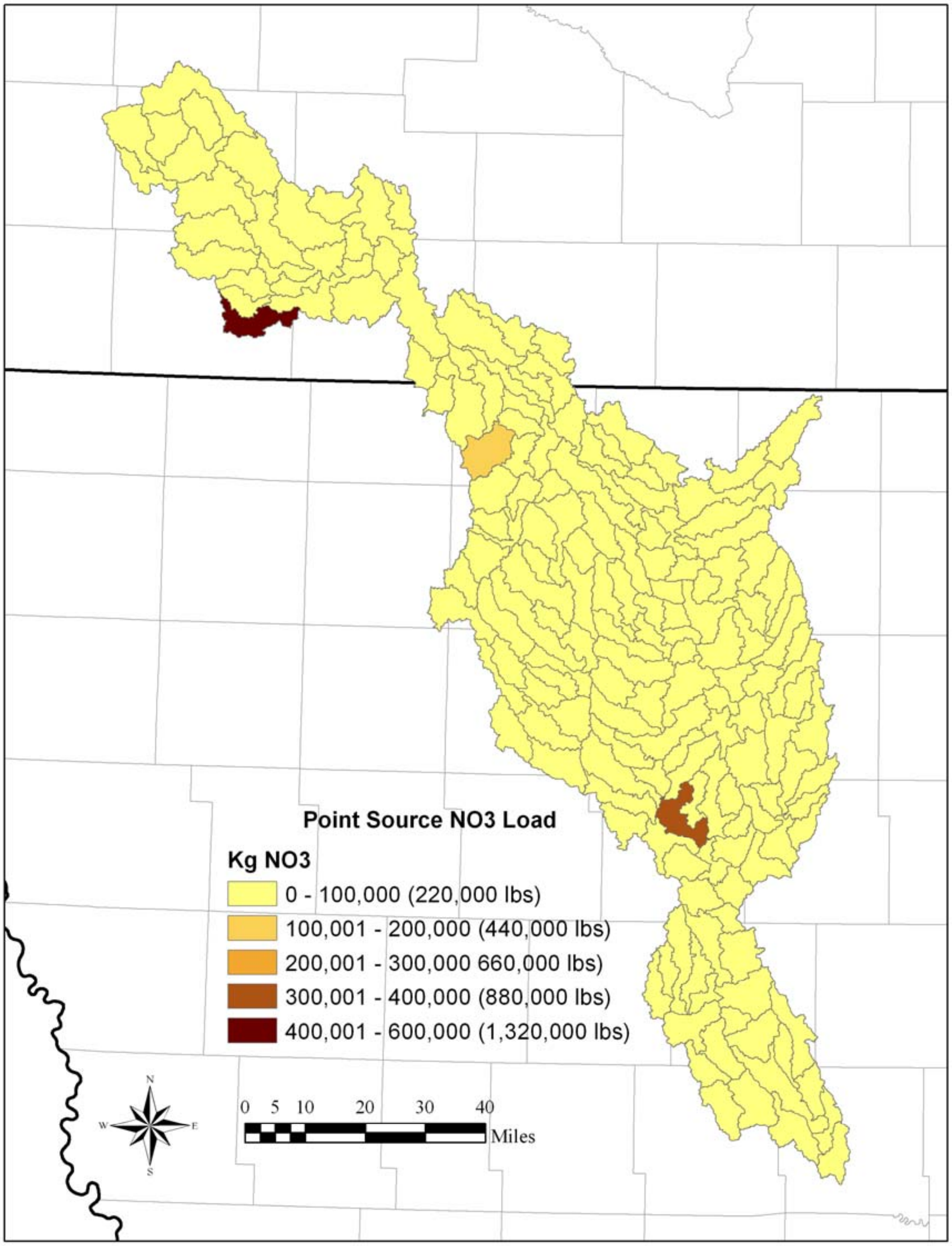

Figure 4-7. Total annual mass of nitrate exported from subbasins from point sources (kg per year).

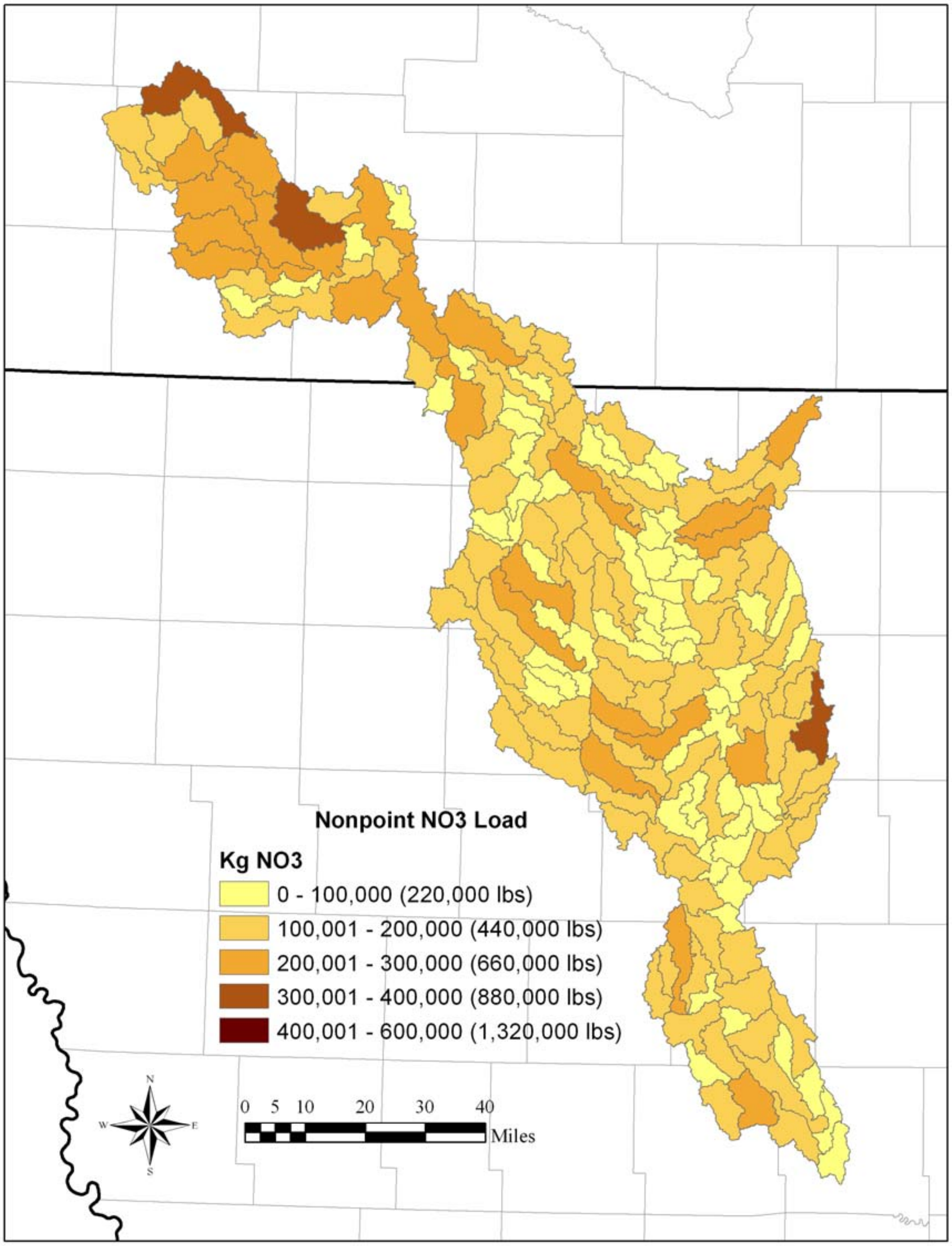

Figure 4-8. Total annual mass of nitrate exported from subbasins from nonpoint sources (kg per year).

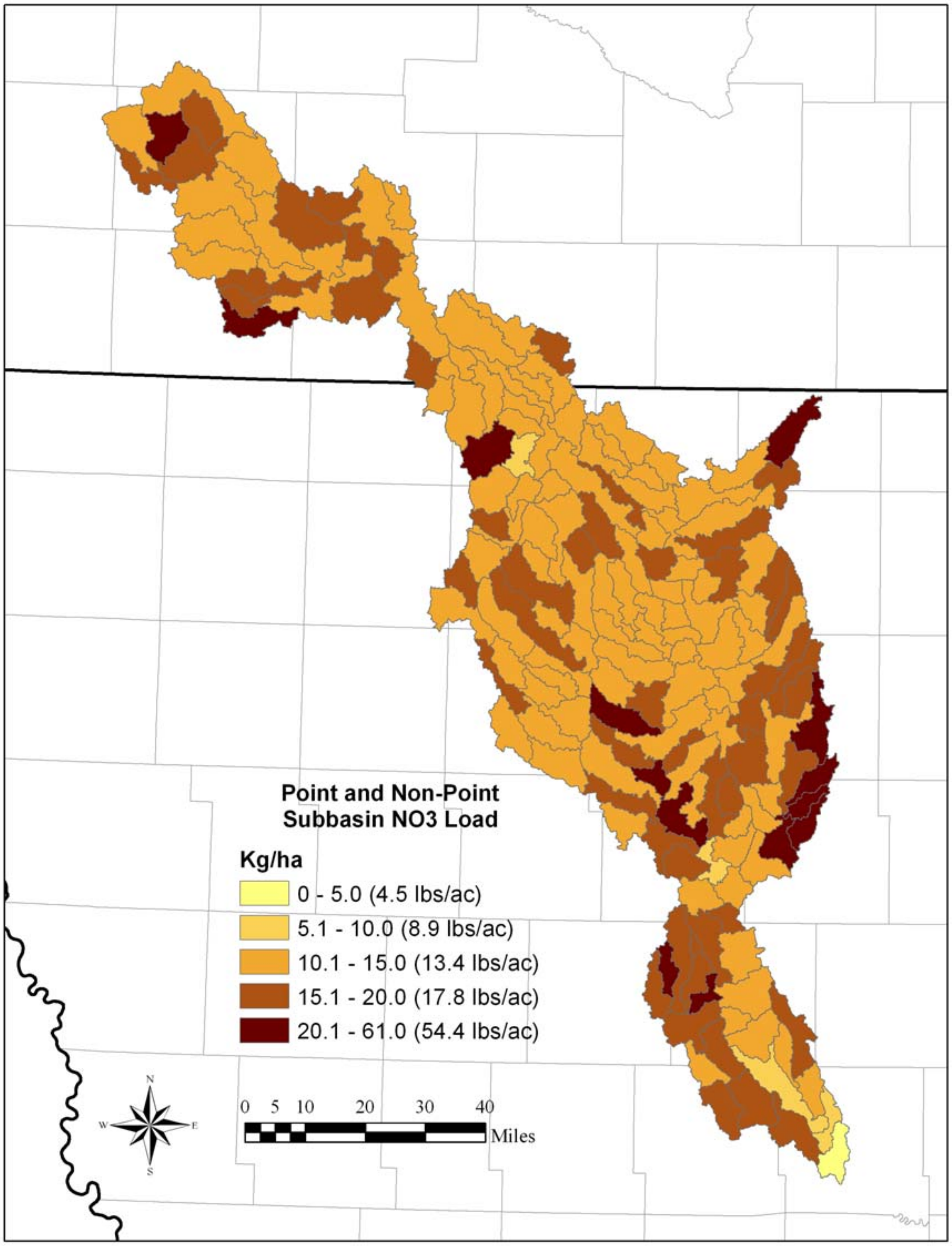

Figure 4-9. Total annual loading of nitrate exported from subbasins from point and nonpoint sources (kg/ha).

5.0 IMPLEMENTATION PLAN

This section describes how best management practices (BMPs) implemented in the Des Moines River watershed can be used to reduce nitrate loads in the river. An implementation plan is not a required component of a Total Maximum Daily Load but can provide department staff, partners and watershed stakeholders with a strategy for improving Des Moines River water quality.

This section is divided into two main parts based on two different scales of BMP implementation. In Section 5.1, the SWAT watershed model was used to evaluate the effectiveness of BMPs implemented on a global scale (i.e., uniformly across the entire watershed) or in various spatial patterns to reduce nitrate loads at the watershed outlet. The benefit of this approach is that several load reduction alternatives can be evaluated to see what load reductions are possible if everyone in the watershed or subbasin changed their management practice accordingly. The global assessment provides a best-case set of conditions to compare results from one practice against that of another. However, the problem with this scale of assessment is that the results are unrealistic. For example, it is fully understood that it is impossible for humans to be removed from the watershed. Thus, the objective of Section 5.1 is to provide a large-scale view of load reduction strategies, in essence, a view from 30,000 feet above the watershed.

In Section 5.2, various field-scale or local BMPs are presented to reduce nitrate losses from smaller parcels of land. This view is essentially "out the back door" and the discussion considers a wide range of BMP alternatives that may or may not be appropriate for any one landowner. A list of BMP options for nonpoint source loads is presented and the degree of BMP effectiveness to reduce pollutant loads is assessed. Options available to reduce the impacts from human nonpoint and point sources are presented in the context of local BMP implementation.

5.1 Watershed Scale Load Reduction Scenarios

Watershed scale nitrate load reductions were evaluated using the calibrated SWAT model described in Section 4. Appropriate load reduction scenarios were identified and the model parameters and inputs were adjusted to incorporate the new management strategy into the model. Model results were then compared to the calibrated "baseline" condition to measure the degree of load reduction achieved. Reductions in nitrate loads are expressed in terms of the percent reduction from the baseline condition. The assessment considered changes in the average annual export of nitrate for an 11-year model simulation period.

5.1.1 Selection of Scenarios

Many options exist to reduce nitrate loads from a watershed (see Section 5.2). For the Des Moines River TMDL, three global-scale nitrate load reduction scenarios were evaluated:

1. Reduce the rate of ammonia fertilizer application in the watershed to 100 kg/ha and 50 kg/ha (89 and 45 lbs/ac, respectively).
2. Remove all manure generated from permitted or registered CAFOs and feedlots.
3. Remove all human waste from the watershed.

The first set of scenarios focused on reducing the application rate of nitrogen fertilizer in the watershed from the baseline condition of 170 kg/ha (152 lb/ac) to 100 kg/ha (89 lb/ac) and 50 kg/ha (45 lb/ac). This scenario did not affect manure applications as a source of nutrients, only fertilizer rates. The objective of this scenario was to evaluate the degree by which water quality could be improved if nitrogen fertilizer rates were reduced by everyone equally in the Des Moines River watershed.

The second scenario was performed to assess the effect of removing all manure from the watershed. Manure sources removed included animals in permitted or registered feedlots and CAFOs (cattle, swine, poultry). The manure sources were removed from the watershed and existing fertilizer applications were unchanged.

The third scenario addressed the impact of human waste in the watershed from septic systems and wastewater treatment plants. Contributions from both types of point sources were assumed to be zero. The purpose of this scenario was to distinguish between human and nonhuman impacts to the Des Moines River.

In addition to the global assessments, spatial configurations of potential load reductions in various subbasins were evaluated to improve our understanding of targeting strategies. The spatial configurations represented four possible strategies available for targeting load reductions in the basin (Figure 5-1):

1. Target major nitrate load reductions in all subbasins with annual average losses greater than 15 kg/ha (13.4 lb/ac) (55 subbasins out of 173).
2. Target major nitrate load reductions in all subbasins of the Boone River watershed.
3. Target major nitrate load reductions in subbasins located closest to the DMWW intake at 2nd Avenue.
4. Target major nitrate load reductions in subbasins located furthest away from the DMWW intake at 2nd Avenue (Minnesota subbasins).

For all of the targeting strategies, major nitrate reductions in subbasins were simulated by reducing ammonia-nitrogen applications to 50 kg/ha (45 lb/ac). The reduction in fertilizer application rates served as a surrogate for possible wholesale nitrate reductions that might occur in the subbasin from many possible BMP's. In essence, the combined effects of many BMP's was considered to be equivalent to reducing fertilizer applications to 50 kg/ha (45 lb/ac).

Results from the targeting scenarios were evaluated using three approaches. First, nitrate load reductions at 2nd Avenue from the targeting scenarios were compared to the baseline condition. Secondly, load reductions were compared to the amount of land area treated under the various targeting scenarios to assess whether there was proportionality between treated area and load reduction. Finally, the effectiveness of the load reduction strategy was evaluated by comparing the percentage reduction in total fertilizer N in each strategy (combined ammonia-N, nitrate-N and organic-N) with the total load reduction percentage achieved at 2nd Avenue. The ratio of the percentages indicated the effectiveness of the load reduction strategy. Ratios closer to one were more effective, indicating a closer correspondence of fertilizer N reductions and watershed-scale load reductions in the Des Moines River at 2nd Avenue.

In targeting strategy 1, the objective was to substantially reduce nitrate losses in 55 subbasins contributing the greatest loads to evaluate whether targeting load reductions in these subbasins would achieve proportionally greater nitrate load reduction at the basin outlet. In targeting strategy 2, the Boone River watershed was singled out for major nitrate load reductions so the effects of targeting in a large basin could be assessed. The Boone River watershed was selected because many HUC12 subbasins in the watershed had nitrate losses greater than 15-20 kg/ha (13.4 to17.9 lb/ac).

Because of the unique shape of the Des Moines River watershed with a narrowing of the perimeter at the upper and lower sections of the basin, targeting strategies 3 and 4 were focused on evaluating the effects of load reductions occurring at the upper and lower ends of the watershed. The lower end of the watershed consisted of the Beaver Creek basin and several subbasins near the City of Des Moines. The upper end of the basin was delineated to comprise a similar land area as the lower end.

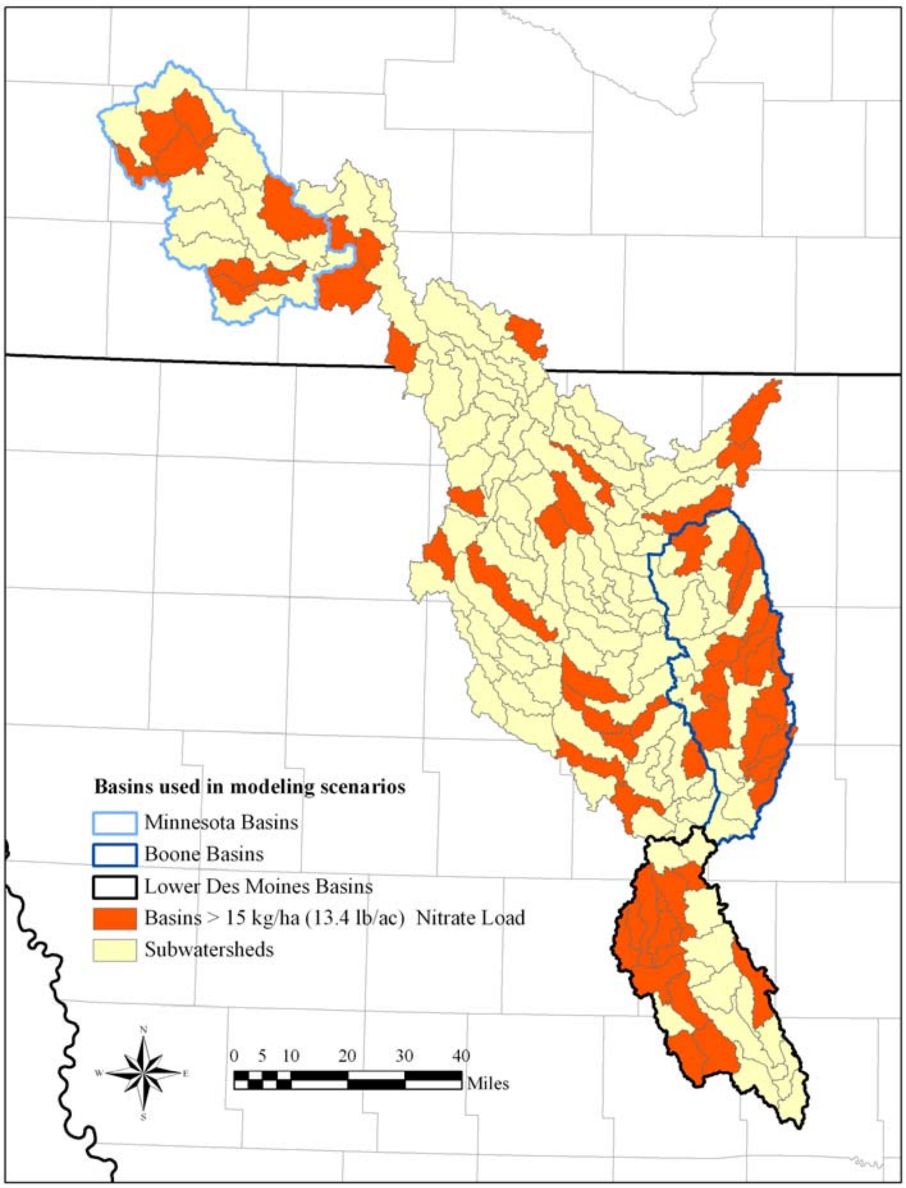

Figure 5-1. Spatial configurations of potential load reduction strategies in various subbasins of the Des Moines River watershed.

5.1.2 SWAT Model Scenario Results

Results from three global load reduction scenarios for nitrate are shown in Table 5-1. Nitrate load reductions ranged from 4.8 to 38.0 percent, with the greatest potential load reduction associated with reducing fertilizer inputs from 170 to 50 kg/ha (152 to 45 lbs/ac). Reducing fertilizer inputs to 100 kg/ha achieved a 25.2 percent reduction. SWAT model results suggest that the reduction in fertilizer applications to 50 kg/ha (45 lb/ac) would be sufficient to achieve the 34.4 percent reduction in nitrate loads required in this TMDL. When viewed from an efficiency standpoint, that is, relating the reduction in nitrate loads at the watershed outlet to reductions in fertilizer applications, reducing applications to 100 kg/ha (89 lb/ac) was more efficient than reducing applications to 50 kg/ha (45 lb/ac) (Table 5-1). A 25.2 percent reduction in watershed nitrate load was achieved with a 29.5 percent reduction in nitrogen fertilizer inputs (efficiency of 85.3 percent), whereas the efficiency ratio was 75.1 percent for the reduction to 50 kg/ha (45 lb/ac).

Eliminating manure inputs to the Des Moines River watershed resulted in a nitrate load reduction of 7.25 percent at the watershed outlet. This suggests that nitrogen derived from manure sources contributes a little over 7 percent of the total stream nitrate load at Des Moines. Removing manure nitrogen from the watershed was less efficient than reducing fertilizer applications. By removing all manure from the basin, organic N contributions were entirely removed and ammonia-N contributions were reduced somewhat. Thus, the efficiency was approximately 60 percent, with a 12.1 percent reduction in fertilizer N inputs resulting in a watershed load reduction of 7.25 percent.

Eliminating all human waste in the watershed achieved a nitrate reduction of 4.8 percent, which suggests that human waste sources contribute about 5 percent of the nitrate export. The percentage includes contributions from septic systems and WWTPs. Thus, nitrate loads from human sources contribute relatively little to the total nitrate loads at the watershed outlet, and if they could be removed entirely from the hydrologic system, a reduction of 4.8 percent could be achieved. There was no efficiency determined with this scenario since fertilizer applications were unchanged.

Table 5-1. Nitrate load reductions from global-scale changes compared to the baseline condition assessed at 2nd Avenue.

	Baseline (170 kg/ha ammonia fertilizer, manure, humans)	**100 kg/ha ammonia fertilizer, manure, humans**	**50 kg/ha ammonia fertilizer, manure, humans**	**No manure**	**No human waste**
Total kg NO_3-N Load	28,950,000	21,660,000	17,950,000	26,850,000	27,550,000
Reduction (kg NO_3-N)		7,290,000	11,000,000	2,100,000	1,400,000
Percent Load Reduction (%)		**25.18%**	**38.00%**	**7.25%**	**4.84%**
Ammonia in Fertilizer kg/ha	64.728	40.156	22.605	59.675	64.728
Ammonia N reduction		24.572	42.123	5.053	0
Percent Reduction (%)		37.96%	65.08%	7.81%	
NO_3 in Fertilizer (kg/ha)	13.536	13.536	13.536	13.485	13.536
Organic N in Fertilizer (kg/ha)	5.004	5.004	5.004	0	5.004
Total N in Fertilizer (kg/ha)	83.268	58.696	41.145	73.16	83.268
Percent Reduction N in Fertilizer (%)		**29.51%**	**50.59%**	**12.14%**	
Reduction Ratio		**85.33%**	**75.11%**	**59.76%**	

Results from four targeting scenarios are provided in Table 5-2. The greatest load reduction was achieved by targeting the top 55 subbasins for fertilizer reduction (14.1%) whereas the spatial targeting of subbasins in the Boone River watershed and subbasins in lower Des Moines and Minnesota were comparable (5.4 to 6.0 percent).

In terms of efficiency, targeting subbasins near the watershed outlet for major reductions in fertilizer applications was more efficient than the other three strategies for reducing watershed nitrate loads (Table 5-2). Targeting lower Des Moines River watersheds resulted in an efficiency of nearly 1 (95.1 percent), suggesting that reducing fertilizer applications near the basin outlet would result in greater proportional reduction in watershed nitrate loads. Targeting the 55 subbasins had an efficiency of 87.1 percent, whereas targeting the upper Des Moines River subbasins and the Boone River watershed for major nitrate load reductions resulted in efficiencies of 79.3 and 73.6 percent, respectively.

Table 5-2. Nitrate load reductions from targeted reductions in fertilizer rates compared to the baseline condition assessed at 2nd Avenue.

	Baseline (170 kg/ha ammonia fertilizer, manure, humans)	**Top 55 subbasins reduced to 50kg/ha, manure, humans)**	**Boone River watershed reduced to 50 kg/ha, manure, humans)**	**Minnesota subbasins reduced to 50 kg/ha, manure, humans)**	**Lower DSM subbasins reduced to 50 kg/ha, manure, humans)**
Total kg NO_3-N Load	28,950,000	24,880,000	27,370,000	27,200,000	27,390,000
Reduction (kg NO_3-N)		4,070,000	1,580,000	1,750,000	1,560,000
Percent Reduction (%)		**14.06%**	**5.46%**	**6.04%**	**5.39%**
Ammonia in Fertilizer kg/ha	64.728	51.291	58.55	58.378	60.01
Ammonia N reduction		13.437	6.178	6.35	4.718
Percent Reduction (%)		20.76%	9.54%	9.81%	7.29%
NO_3 in Fert (kg/ha)	13.536	13.536	13.536	13.536	13.536
Organic N in Fertilizer (kg/ha)	5.004	5.004	5.004	5.004	5.004
Total N in Fertilizer (kg/ha)	83.268	69.831	77.09	76.918	78.55
Reduced N in Fertilizer (%)		**16.14%**	**7.42%**	**7.63%**	**5.67%**
Reduction ratio based on N applications		**87.12%**	**73.56%**	**79.27%**	**95.10%**
Area of watershed affected (ac)	4,030,035	1,220,258	580,270	611,933	553,811
Percentage of DSM River watershed		**30.28%**	**14.40%**	**15.18%**	**13.74%**
Reduction ratio based on land area		**46.43%**	**37.92%**	**39.79%**	**39.23%**

Compared to area of land treated, targeting the 55 highest subbasins was more effective, considering that a 14.1 percent reduction in nitrate loads could be achieved by reducing applications on 30.3 percent of the land area (efficiency of 46.4 percent). The other three targeting strategies had a similar proportional land area treated (13.7 to 15.2 percent) and a similar nitrate load reduction (5.4 to 6.0 percent), and thus a similar efficiency 37.9 to 39.8 percent). Interestingly, reducing applications in the Minnesota subbasins was marginally more effective in reducing watershed nitrate loads than reducing applications in either the Boone River watershed or subbasins near the outlet.

Overall, the results from the SWAT modeling of three global and four targeting scenarios indicates that only a global reduction in fertilizer applications to 50 kg/ha (45 lb/ac) would achieve the 34 percent nitrate load reduction required by this TMDL. A global fertilizer reduction to 100 kg/ha (89 lb/ac) achieved a 25 percent reduction in loads, suggesting that global nitrogen applications need to be in the range between 100 and 50 kg/ha (89 to 45 lb/ac) (albeit closer to 50 kg/ha). Results also suggest that global scale reductions in fertilizer applications (that is, everyone reducing at a similar rate) achieved greater nitrate load reductions than specific targeting strategies. The nitrate load reduction achieved by targeting 55 subbasins for 50 kg/ha (45 lb/ac) nitrogen fertilizer applications was 14.4 percent, substantially less than the 25 percent load reduction achieved by everyone applying 100 kg/ha (89 lb/ac) of fertilizer. If targeting for load reductions is a preferred strategy, the most efficient load reductions occurred when fertilizer applications were reduced in subbasins nearest the watershed outlet. In the Des Moines River watershed, these subbasins mainly included contributions from areas within the Beaver Creek basin. The second most efficient load reduction strategy was associated with targeting the 55 subbasins with highest nitrate loads. However, it should be emphasized that none of the targeting strategies resulted in load reductions sufficient to meet the TMDL objective.

The efficiency of reducing fertilizer applications to 100 kg/ha (89 lb/ac) by everyone (85.3%) was similar to the efficiency of reducing applications to 50 kg/ha (45 lb/ac) in the 55 targeted subbasins (87.1%). In contrast, the efficiency of reducing fertilizer applications to 50 kg/ha (45 lb/ac) by everyone (75.1%) had a similar efficiency to the targeting options of subbasins in Minnesota and the Boone river watershed (73 to 79%). Thus, while the global reduction to 50 kg/ha (45 lb/ac) may achieve the desired result in reducing watershed loads to meet the TMDL, the option was not necessarily the most efficient. Eliminating all manure from the watershed was least efficient compared to the other global and targeting options.

5.2 Local BMP Implementation

5.2.1 NPS Load Reductions from Agricultural Sources

At the scale of an individual landowner, there are many options available for implementing BMPs that will help reduce loads of nitrate in streams. For example, Dinnes et al. (2002) provides a useful summary of strategies to reduce nitrate leaching in tile-drained landscapes. Table 5-3 lists the conservation practices and identifies the effectiveness of the practices to reduce pollutant loads. Load reductions are evaluated in terms of reducing loads from surface water runoff or reducing groundwater loads as either baseflow or tile drainage. Practices that provide the greatest potential for load reductions are highlighted in the table and discussed below.

Improving nutrient use efficiencies by changing the timing and rate of nitrogen applications are considered among the best practices that an individual landowner could adopt that reduce losses of nitrate to streams with subsurface flow (Table 5-3). Changing the fertilizer application methods to injection methods that minimize surface application and volatilization may reduce runoff losses of nitrogen.

Table 5-3. List of conservation practices available to reduce nonpoint source loads of nitrate and their potential effectiveness.

		Nitrate Load Reduction Effectiveness[1]	
Conservation Practice	**Description**	**Surface Runoff**	**Baseflow or Tile drainage**
Improve Nutrient Use			
Spring application of fertilizers	Change fertilizer application from the fall to spring to reduce N loss and increase fertilizer use efficiency. The closer the application is timed to crop needs, the less N is lost to streams.	+	++
Reduce fertilizer application rate	Reduce the rate of fertilizer applications below currently applied rate. A variable rate or site-specific fertilizer program could reduce applications on individual fields. Improved methodologies are needed to reliably assess site-specific N recommendations.	+	++
Change fertilizer application method	Change from conventional anhydrous NH3 application to innovative subsurface injection methods to minimize volatilization and reduce leaching.	++	- to +
Use nitrification inhibitors	Use of controlled or slow-release N fertilizers to slow conversion of fall-applied fertilizer to nitrate.	+	+
Manure management	Manage the application of manure to cropped fields according to the nutrient application rates of nitrogen or phosphorus. Manure should not be applied at rates that exceed the soil infiltration rate or during wet periods of runoff.	+	+
Adopt comprehensive farm nutrient management plan	Follow the guidance of NRCS Conservation Practice Standard 590 to manage the amount, source, placement, form and timing of the application of plant nutrients and soil amendments.	+	+
In-field Management			
Adopt conservation tillage	Utilize no-till or mulch-till practices on crop ground.	+	-
Contour planting and terracing	Plant crops in rows parallel to land surface topographic contours or install terraces to shorten the slope lengths of hillsides in order to reduce overland runoff.	+	-
Use cover crops	Plant cover crops of legumes, cereals, or grasses in fields during non-crop periods to reduce nitrate leaching during vulnerable fall and spring periods.	+	++
Diversification of cropping systems and rotations	Include perennial legume or nonlegume crops in rotation with corn and soybeans to decrease water yield due to longer growing season. Perennial crops receive less fertilizer and tillage than annual cropping systems.	+	++
Retire lands through CRP	Convert vulnerable crop lands to perennial grass through Conservation Reserve Program.	++	++

[1]Ranking criteria: ++ = very effective, + = effective, ± = no effect, - = negative effect

		Nitrate Load Reduction Effectiveness[1]	
Conservation Practice	**Description**	**Surface Runoff**	**Baseflow or Tile drainage**
Exclude livestock from streams	Manage pastures to exclude livestock access to streams. Install alternative watering systems if needed.	+	±
Establish rotational grazing systems	Establish fenced paddock system and rotate livestock grazing around pasture to reduce pasture degradation and manure buildup.	+	±
Incorporate manure into subsoil	Use techniques to incorporate manure into subsoil rather than spreading or applying manure to land surface.	+	± or -
Control feedlot runoff	Utilize run-on control (divert clean water away) and install berms, detention basins or other control structures to capture runoff and settle solids from feedlot runoff events.	+	± or -
Manage manure storage	Manage manure storage or modify manure storage structures to safely contain the manure until conditions are appropriate for field applications.	+	±
Use alternative tile drainage system design and management	Decrease drainage intensity using shallower tile depth or wider spacing to reduce subsurface flow and nitrate loss. Use controlled drainage when site conditions permit.	±	++
Install denitrification bioreactors	Use organic materials (corn stalks, wood chips, sawdust, etc.) as organic amendments to encourage denitrification during treatment of tile drain effluent or interception of subsurface drainage through a wall or trench.	±	++
Utilize in-field conservation buffers	Install conservation buffers, including field borders, filter strips, contour buffer strips, grass waterways, windbreaks hedgerows and other practices, to reduce surface water runoff and sediment erosion.	+	±
Off-site Management			
Plant riparian buffers	Riparian buffers of forest and herbaceous cover planted along stream corridors reduce pollutant transport to streams with surface runoff through combined processes of deposition, infiltration and dilution. Stream buffers may reduce groundwater nitrate concentrations but flows from tile drainage may bypass the buffer.	++	+ or ±
Install wetlands	Strategically site wetlands in the landscape to capture and remove nitrate from surface and subsurface water sources. For greatest reductions, wetlands should be placed in locations with highest nitrate concentrations. Utilize USDA programs (CREP) to install wetlands that intercept flows from large tile drainage systems.	+	++

[1]Ranking criteria: ++ = very effective, + = effective, ± = no effect, - = negative effect

In terms of improving in-field management of conservation practices, surface and subsurface nitrate losses could be reduced by incorporating perennial or cover vegetation into farming systems. Diversifying cropping systems, retiring lands to the CRP, or using cover crops during non-crop periods operate similarly by reducing annual water yield and nitrate losses during vulnerable spring and fall periods. Subsurface nitrate losses could also be reduced in heavily drained areas by using alternative tile drainage designs that decrease drainage density or enhance subsurface denitrification.

Off-site measures could be adopted that reduce nitrate losses from surface runoff and subsurface delivery (Table 5-3). Riparian buffers planted along stream corridors would decrease nitrate loads from surface runoff, whereas installing wetlands to intercept tile flows offers promise for reducing nitrate loads from larger geographic areas. Iowa State University studies of CREP (Conservation Reserve Enhancement Program) wetlands demonstrate that relatively small areas of wetlands intercepting tile drainage can remove up to 70% of the nitrate loads. Off-site actions may be facilitated or installed by individual landowners or by groups of individuals that seek to make landscape-wide changes that affect many landowners directly or indirectly.

5.2.2 Point Source Reductions from Human Sources

Pollutant losses from human sources includes urban stormwater runoff and discharge from WWTPs and septic systems. While these sources do not contribute significantly to nitrate impairment in the Des Moines River, actions may be justified to improve local water quality.

Urban runoff comes from a variety of sources, including impervious surfaces like roads, rooftops and parking lots, as well as pervious surfaces like lawns. Urban runoff can be an important source of pollutants at a local scale. There are a variety of actions to control nonpoint urban sources, including both structural and non-structural practices. Many of these practices are described in detail in an USEPA guidance document (USEPA, 2005). Structural practices include those engineered to manage or alter the flow, velocity, duration and other characteristics of runoff by physical means. These practices are designed to control storm water volume and peak discharge to improve water quality, reduce downstream erosion, provide flood control and promote groundwater recharge, in some cases. Nonstructural practices prevent or reduce urban runoff by reducing potential pollutants or manage runoff at the source. These practices may take the form of regulatory controls (e.g., codes, ordinances, regulations, standards, or rules) or voluntary pollution prevention practices. Nonstructural practices can be further divided into land use practices and source control practices. Land use practices are designed to prevent or reduce impacts from new development or in sensitive areas of the watershed. Source control practices are aimed at preventing or reducing potential pollutants at their source before they come in contact with runoff. This may involve educating citizens about proper disposal of pet waste and application of lawn fertilizers and pesticides.

Permitted point source discharges include sewage treatment plants, water treatment plants and industrial sources. Although they do not represent a dominant source of nitrogen, they may account for a measurable portion of pollutant loads especially at lower streamflows. Existing technology may be used to reduce nitrogen loads delivered to stream from point sources. In some areas, nutrient reductions from WWTPs have proven to be cost-effective and more certain than estimated reductions from agricultural BMPs. Use of Biologic Nutrient Removal and Enhanced Nutrient Removal technologies have been implemented to reduce N concentrations by 50 to 80 percent. Industrial WWTPs should be evaluated for opportunities to reduce nitrogen discharges through pollution prevention, process modification or treatment.

Loads from failing septic systems do not significantly contribute to stream impairments, but they may be the easiest to address with readily available technology. Inspections of septic systems should be used to identify failing or outdated septic systems and these systems should be upgraded accordingly. While these upgrades may not substantially affect pollutant loadings in the Des Moines River, they may improve local water quality noticeably.

6.0 MONITORING PLAN

This section describes the existing water quality monitoring being conducted in the Des Moines River watershed and presents suggestions for improving monitoring actions for detection of water quality improvements from TMDL implementation.

6.1 Existing Water Quality Monitoring

In a watershed the size of the Des Moines River, there are several entities conducting water flow and quality monitoring at various locations for multiple purposes. Major ongoing monitoring programs in the watershed are associated with (1) USGS stream gaging, (2) Des Moines Water Works monitoring at 2nd Avneue, (3) ambient water quality monitoring conducted by the Iowa Department of Natural Resources, (4) river monitoring by the Army Corps of Engineers through Iowa State University and (5) ambient water quality monitoring conducted by the ACWA. Each of these major water monitoring programs are discussed briefly below.

6.1.1 USGS Stream Gaging

The U.S. Geological Survey operates nine gaging stations and six crest stage stations in the Des Moines River watershed. Eight of the nine gaging stations measure water stage at stream locations and one station measures stage at Saylorville Lake. Locations of the nine continuous stream gaging sites in the watershed are shown in Figure 6.1. The period of record varies among the stations. Three stations began in the 1940's (East Fork, Boone, Ft. Dodge), four stations began in the 1960's (Humboldt, Stratford, Saylorville and Beaver Creek), and the gage at 2nd Avenue began in 1996. Discharge measurements are collected every 15-minutes and reported as daily averages. Current and historical discharge information is provided by the U.S. Geological Survey at http://waterdata.usgs.gov/ia/nwis/rt.

The stream gaging stations are critical for monitoring the routing and delivery of water in the basin. Since water is the pollutant carrier through the landscape, any assessment of loads should first "follow the water". Daily flow measurements collected at stream gage stations are useful for developing an understanding of the timing and magnitude of water export from basins and can be paired with water sample collection to measure pollutant loads. When water quality samples are spaced apart in time, continuously monitored discharge can be used to estimate daily loads using regression-based load estimating programs like ESTIMATOR, LOADEST or AUTOBEALE. Often, the first step in developing a hydrologic model for a watershed is calibrating the model for streamflow, and data from stream gages provide much needed information for model calibration.

At a minimum it is recommended that the existing stream gaging be continued in the Des Moines River watershed for the foreseeable future. Maintaining stream gaging records across decadal timeframes is critical to discern trends in streamflow and pollutant loading patterns. In addition, installing additional stream gages should be considered in targeted smaller basins. Evaluating hydrologic conditions at the HUC12 level, as modeled in this TMDL, would necessitate installing stream gages in watersheds less than about 60 mi^2. While cost prohibitive at all HUC12 basins, targeting several HUC12 basins throughout the watershed for additional stream gaging would allow for improved hydrologic assessment and load estimation modeling. Stream gages could be installed in subbasins targeted for BMP implementation for better tracking of pollutant loads.

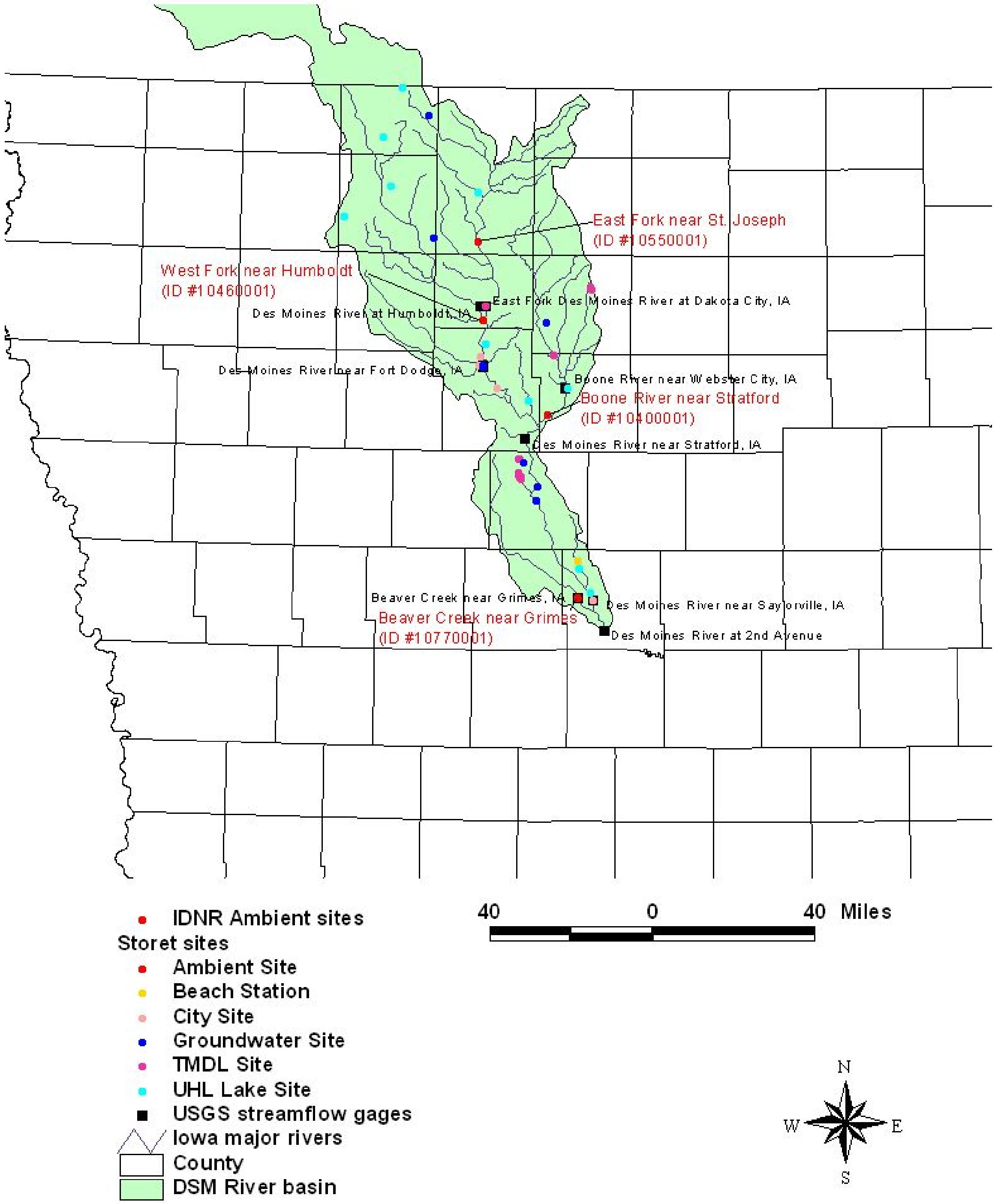

Figure 6-1. Locations of stream gages and monitoring sites in Des Moines River watershed. Unmarked IDNR ambient monitoring sites are associated with various short-term water quality monitoring projects in the basin.

6.1.2 Water Supply Monitoring

The DMWW monitors surface water quality for nitrate in the Des Moines River on a daily or near daily basis at their intake on 2nd Avenue. The water supply is strongly encouraged to continue this monitoring activity at a similar frequency to document whether stream nitrate concentrations respond to watershed BMP implementation. The DMWW's intake at 2nd Avenue represents the "point of compliance" for drinking water, inasmuch as the best measure of success for achieving nitrate load reductions is reduced exceedances at the drinking water intakes. The high-resolution data record of pollutant concentrations in the Des Moines River measured by the DMWW at 2nd Avenue is also needed to serve as the best estimate available of the export load of nitrate from the watershed. This true "measured" load is rarely available in watersheds and serves as an important check on the ability of analytical and numerical models to reliably predict export loads.

6.1.3 IDNR Ambient Monitoring Program

The IDNR conducts ambient water quality monitoring at four sites in the Des Moines River watershed, one site on the Des Moines near Humboldt, a second site on the East Fork of the Des Moines river near St. Joseph, a third site on the Boone River near Stratford, and a fourth site on Beaver Creek near Grimes (Figure 6-1). These monitoring sites are sampled monthly for many constituents, including nitrate. Because the sites are located near USGS stream gages, the sampling data can be used with continuous discharge data to provide estimates of daily, seasonal and annual nitrate loads.

In addition, two additional sampling sites are located in the basin associated with city monitoring. One site is located upstream of the City of Ft. Dodge, and a second is located upstream of the City of Des Moines (Figure 6-1). The purpose of these sites is to document water quality conditions upstream of the city's wastewater treatment plant and other forms of urban discharge.

It is important for evaluating TMDL implementation that the ambient water quality network in the watershed to be maintained. Because the sites are located on major tributary branches of the river, results provide assessment of differences in pollutant loading patterns throughout the basin. Data from various locations in the basin also prove extremely valuable for calibrating watershed-scale models, particularly for nitrate. Continuation of ambient monitoring in the watershed would enable long-term trends to be better assessed in the future.

6.1.4 The Des Moines River Water Quality Network (DMRWQN)

The DMRWQN is a surface water quality project sponsored by the US Army Corps of Engineers that collects water samples at locations along the Des Moines and Raccoon rivers and Saylorville and Red Rock reservoirs. The program maintains three sites on the Des Moines River above the DMWW intake on 2nd Avenue. One site is located upstream of Saylorville Reservoir (Site 1), a second site is located 0.15 miles upstream of Saylorville dam (Site 4), and a third site is located downstream from Saylorville Reservoir and upstream from the City of Des Moines (Site 5). Surface water samples are collected approximately 22 times per year for 50 parameters. An important benefit of this monitoring program to the TMDL program is its longevity that extends back nearly 40 years. The long-term record provides an important link to historical water quality patterns in the basin and enables characterization of normal year-to-year variability and detection of water quality trends. The DMRWQN is thus an important component for evaluating the success of BMP implementation in the Des Moines River watershed.

6.1.5 ACWA Monitoring

The ACWA has initiated collection and analysis of surface water samples from locations throughout the Des Moines River watershed. In 2007, 30 sites were monitored in the Boone River watershed. Samples were collected on a bi-weekly basis from April to August by trained staff and volunteers and analyzed for a variety of parameters by the DMWW water quality laboratory. In 2008, additional monitoring sites were added throughout the Des Moines River watershed (Figure 6-2). Concentration data collected at these sites provides valuable information on spatial patterns of many pollutant concentrations, including nitrate. Several of the ACWA sites correspond to subbasins analyzed in this TMDL using the SWAT model. Results from the ACWA monitoring are providing valuable information for assessing temporal and spatial patterns and targeting problem areas in the basin. Monitoring activities should be continued and possibly expanded to the extent practicable.

6.1.6 IOWATER Network

The DNR Monitoring and Assessment section administers a volunteer-based monitoring program called IOWATER. A dedicated IOWATER volunteer network has collected extensive data on the Des Moines River. Their efforts have high social significance and provide valuable information on the river now and into the future. The data collected by IOWATER was not used in development of this TMDL because of the specific data needs the models require; however, the data provides anecdotal evidence to water quality professionals and helps connect water quality results to watershed stakeholders.

6.1.7 Strengths and Weaknesses of Existing Monitoring Network

The five major components of the existing water monitoring network in the Des Moines River watershed address important needs for TMDL implementation monitoring but also have limitations. The strengths of the existing monitoring program lie in providing large-scale estimates of water loss and nitrate export from various major subbasins. Combined with stream gaging, water quality monitoring conducted by the DMWW at 2nd Avenue accurately captures the total nitrate export from the basin, whereas nitrate monitoring conducted for the IDNR ambient program and DMRWQN provide quality estimates of nitrate export from major subbasins. These total load estimates are needed to assess trends in nitrate concentrations and loads and enable watershed models to be better calibrated and validated.

A weakness applies to the scale of the monitoring sites. Although the large-scale monitoring enables export loads from major subbasins to be estimated in a cost-effective manner, the size of the monitored basins will limit the detectability of improvements from TMDL implementation. Unless basin-wide, wholesale changes in practices or land use are implemented, the chances of seeing improvements in nitrate loads at major watershed outlets are slim. Schilling and Thompson (2000) noted that "…monitoring NPS water quality improvements is not an easy task. Pollution results from runoff across a landscape which has varied land management practices, with the resulting impacts measured in perennial streams typically a mix of effects from many different parcels of land, many different components of management, integrated over many time scales." This concept is particularly true in a watershed the size of the Des Moines River. Monitoring for the detection of water quality improvement in nitrate loads will require a shift in thinking from large-scale global assessments to smaller and more focused watershed assessments.

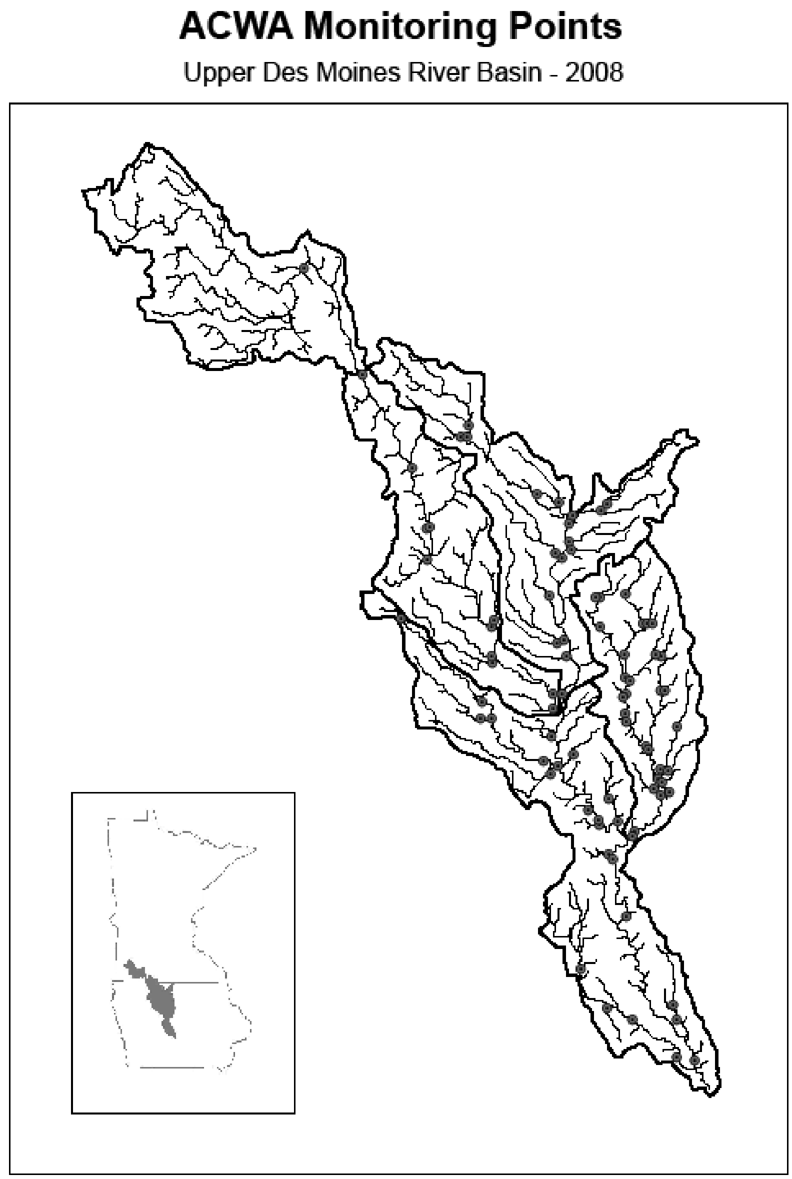

Figure 6-2. Location of monitoring sites in the Upper Des Moines River watershed in 2008.

6.2 Proposed Monitoring Plan

This section provides guidance for establishing a new watershed monitoring program for detection of water quality improvements following BMP implementation. The existing monitoring network would continue to operate as described above, but a new monitoring paradigm would shift the focus of monitoring to smaller basins with the objective of detecting water quality changes. Steps needed to establish a new monitoring program are outlined below.

Step 1. Target a Basin. The first step towards implementing a new monitoring program is deciding where to monitor. Identifying an appropriate basin to invest time, money and effort to monitor will allow limited resources to be used most effectively. Implementation of BMPs to reduce nitrate loads in the watershed should be targeted in those basins contributing the highest concentrations and loads. Reducing loads from these basins would have a proportionally larger effect on the overall export of nitrate loads than load reductions occurring in less affected areas.

The results from the SWAT model generated for this TMDL may provide the best tool for targeting subbasins for BMP implementation. Model results identified subbasins that contributed highest nitrate loads to surface water. These identified subbasins should be targeted for BMP implementation because they contribute proportionally greater loads than other subbasins. Furthermore, the SWAT modeling suggested that targeting subbasins in Beaver Creek watershed might be more efficient for impacting nitrate loads at the DMWW at 2nd Avenue.

A second issue to address when targeting basins for load reductions is selecting an appropriate watershed size to monitor. The size of the targeted watershed will affect the ability of monitoring to detect whether water quality improvements occur since it is easier to detect changes in smaller watersheds than larger watersheds. Detecting improvements in Des Moines River water quality at the DMWW will be infinitely more difficult than detecting changes in a HUC12 watershed like Lyon's Creek. The SWAT model for the Des Moines River evaluated loads emanating from HUC12 basins that ranged in size from 300 to more than 10,000 ha (about 750 to 25,000 acres). This size of watershed may be appropriate for targeting BMP implementation and detecting water quality improvements in a reasonable timeframe. In a general sense, the smaller the watershed, the greater probability there is of detecting water quality improvements resulting from BMP implementation.

As an example, results from the Walnut Creek Monitoring Project provide some context for this discussion. In the HUC12 sized Walnut Creek watershed (20 mi^2) located in Jasper County, nitrate concentrations decreased approximately 1.2 mg/l over 10 years in response to 23.5 percent of watershed planted in reconstructed prairie (Schilling et al., 2006). In smaller subbasins less than 2000 acres in size, substantially greater nitrate concentration reductions were observed (up to 3.4 mg/l in 10 years). Considering that Walnut Creek watershed is a rather small HUC12 basin, project results suggest that even in small watersheds, the ability to detect water quality improvements was best associated with subbasins within the HUC12 watershed. Since subbasins comprise larger and larger watershed areas, it is recommended that monitoring stream water quality should focus on small subbasins where changes are detectable in reasonable time frames. Results from subbasin monitoring efforts that document water quality improvements can then be used as the basis to promote similar practices in other subbasins and eventually lead to watershed-wide adoption of BMPs.

Step 2. Developing a Monitoring Program. Once a basin has been selected for monitoring, the second step is developing a monitoring program that includes the following elements: 1) monitoring objectives; 2) monitoring design; 3) sampling locations; 4) sample parameters; and 5) sample frequency and duration. Each of these elements is discussed briefly below.

1. Monitoring Objectives. It is critical that before beginning a monitoring program, consideration is given to what the overall goals and objectives of the program will be. Is the monitoring objective aimed at measuring the true pollutant export load from a watershed, or is it simply to gather enough data to develop an analytical or numerical model? Is the objective to measure the water quality response from a given conservation practice or measure the cumulative response from a set of practices? Given an objective or series of objectives, a monitoring program can be designed to meet them. Monitoring objectives can be general or very specific, but it is important that objectives be given serious consideration before implementing a program. Tools are available to assist with this process (IDNR, 2007).

It is important that the public realize that although a project may be funded today, the time needed to effectively plan and implement a project may take some time. Time is needed to identify pollution sources and critical areas, design management measures, engage landowner participation and integrate new practices into cropping and management cycles (Meals and Dressing, 2006). It usually takes time for a water body to become impaired, and it will take time to accomplish the clean-up.

2. Monitoring Design. Monitoring design refers to how a monitoring program is set up to meet specific monitoring objectives. Depending on what your objectives are, a monitoring scheme can be designed to gather the information needed to answer the questions posed. Three monitoring designs common to water quality studies are before/after, upstream/downstream and paired watershed (Spooner et al., 1987). A before/after design incorporates water quality monitoring from a downstream station for a period of time before and after BMP implementation. An upstream/downstream design requires a calibration and treatment period (before/after design) with sampling locations positioned upstream and downstream of the treatment area. During a calibration period, the goal is to establish conditions before treatment and the treatment period refers to monitoring conditions after treatment occurs to see if conditions have changed. A paired watershed design comprises two watersheds of similar location and land use (control and treatment) and two time periods of study (calibration and treatment). Typically one sampling station is positioned at the outlet of each watershed. The goal is to first establish a relationship between the two watersheds during a calibration period, then implement BMPs, and finally monitor during a treatment period to see if the relationship between the two watersheds has changed.

With the three common designs, they each require that pre-BMP monitoring be conducted to establish background conditions before land treatment is conducted. Unfortunately, in practice, it is often difficult to convince stakeholders that monitoring is needed before BMPs are implemented. Probably the most common monitoring design is conducting a monitoring program while practices are being implemented and testing for a gradual change in pollutant concentrations at the watershed outlet. The problem with this common approach is that it is often difficult to distinguish the effects of treatment on downstream water quality from effects of climate variability or other factors unrelated to treatment. Year-to-year climate variability can often obscure and overshadow any reductions in pollutant loads due to treatment. Caution is thus needed with this gradual change design to attribute incremental improvements in water quality to treatment without first considering climate effects or other unrelated causes.

3. Sampling Locations. Sampling locations in a watershed are often related to the type of sampling design implemented. Most often, the primary sampling location in a watershed project is the watershed outlet. The outlet captures drainage and pollutant export from the watershed and is thus a "bottom-line" measure for how well BMP implementation is improving watershed water quality. However, water quality effects initially occur at or near the location where practices are being implemented, so expectations that effects would appear promptly at the watershed outlet, perhaps miles downstream, are misguided. Monitoring can be best focused in smaller watersheds closer to pollution sources. Monitoring several subbasins within a watershed would allow comparisons of the differential effectiveness of BMPs over time and for analyzing their incremental contributions to the overall basin response. Upstream sampling locations allow an evaluation of upper basin effects on water quality, upstream of the treatment area. Upstream sampling is clearly needed when implementing an upstream/downstream sampling design.

Particularly in the Des Moines watershed, tile drainage is an important source of water and nitrate loads to streams. Identifying sampling locations at major drainage tile outlets may be an important component to monitoring projects in heavily tiled areas. Drainage district maps may be used to assist identification of potential sampling points in a tile drainage network.

In larger watersheds, conducting periodic synoptic surveys over the course of a project may identify changes as they occur.

4. Sampling Parameters. Sampling parameters include discharge monitoring, chemical concentrations and other related parameters. It is recommended that discharge monitoring accompany chemical monitoring in a targeted watershed to accurately measure the streamflow portion of the total load. Measuring the water flux will provide valuable information on how precipitation is routed through the basin-wide hydrologic cycle, for example, whether discharge occurs mainly with storm runoff or baseflow, or how much runoff occurs with a given rainfall event. Continuous discharge measurements at the watershed outlet will also enable more accurate estimation of pollutant loads. It may also be prudent to measure discharge from certain drainage tile outlets to account for these water sources in the watershed water balance. Discharge monitoring may involve establishing a new USGS stream gage on a stream, or simply monitoring stream stage with a water level recorder. The stream stage data may be converted to water discharge with development of a rating curve.

Consideration should be given to designing a monitoring program to measure nitrate concentrations and loads effectively in the Des Moines River watershed. A dissolved pollutant like nitrate is leached from soils and moves with shallow groundwater before being discharged to streams with groundwater seepage (baseflow) or, more rapidly, with tile drainage. Nitrate concentrations in streams do not typically exhibit wide fluctuations over short time intervals (i.e., days) and they generally follow a near-normal statistical distribution in a given year. Because of this, water quality sampling for nitrate may be conducted on a fixed interval basis where samples are collected at regularly scheduled times. Since nitrate is primarily delivered with baseflow and baseflow comprises a majority of total streamflow, a fixed sampling program will be biased toward collecting baseflow water samples when nitrate is delivered to streams. However, it may take many years for practices that reduce nitrate leaching to have an impact on surface water quality when groundwater travel times are considered.

Sampling parameters may also include constituents that help explain the observed pollutant concentration and loading patterns in streams. These parameters may involve measurement of temperature, dissolved oxygen, specific conductance or other field parameters, or measurement of additional laboratory constituents that follow similar temporal or spatial patterns (e.g., major ions, ammonia or organic nitrogen, fecal coliform). Collection of additional analytical information may help resolve the sources and timing of pollutant delivery to streams. The continuous real-time nitrate monitoring installed at the Van Meter gage on the Des Moines River is a promising new technology for evaluating nitrate concentration patterns and loads in streams. Installing similar monitoring equipment at other locations within the Des Moines watershed may expand the understanding of temporal variations in nitrate concentrations over short time scales.

5. Sampling Frequency and Duration. The question of how long should a monitoring program be implemented is a function of the design of the sampling program. It is possible for water quality improvements to occur without anybody noticing unless the response is measurable and a suitable program is in place. The design of the program determines the ability to detect a water quality change against the background of natural variability. Sampling frequency is a key determinant of how long it will take to document change. Meals and Dressing (2006) stated "In a given system, taking n samples per year, a certain statistical power exists to detect a trend. If the number of samples per year is reduced, statistical power is reduced, and it may take longer to document a significant trend or to state with confidence that a concentration has dropped below a water quality standard." Simply stated, fewer samples collected will result in a longer period of monitoring needed to detect water quality improvements. At a minimum the sampling duration should be three to five years, not including a recommended pre-BMP monitoring program. For example, in the Walnut Creek watershed where large tracts of row crop lands are being replaced with native prairie at the Neal Smith National Wildlife Refuge, a minimum of three years of water quality monitoring was needed before the first statistically significant change was detected in stream nitrate concentrations (Schilling et al., 2006).

Monitoring is also conducted to reliably estimate pollutant loads. In this case, sufficient number of samples should be collected to pair with discharge data to provide data for standard regression models (e.g., ESTIMATOR, LOADEST). Although these models will run with monthly data, the model estimates would be greatly improved with higher resolution sampling data. Moreover, if sufficient numbers of samples are collected, as demonstrated by the DMWW dataset, pollutant loads may, in essence, become "known" and not estimated values. Monitoring should carefully consider whether to stratify the number of samples collected by month, that is, change the number of samples based on the season (e.g., greater number of samples in May and June). While this method may enable better estimation of total annual loads, the number of samples collected per month will need to be addressed when attempting to compare results by month.

For nitrate monitoring, bi-monthly sampling (one sample every two weeks) may be an appropriate balance between weekly sampling that may contain redundant information and monthly sampling that may miss important seasonal or flow correlations. Periodic event monitoring may be appropriate to account for short term fluctuations in concentrations to accurately capture the magnitude and patterns of nitrate losses from storm events. Ultimately, deciding on an appropriate sampling frequency is likely to be on a case-by-case basis based on cost-benefit considerations.

Step 3. Data Assessment and Reevaluation. By Step 3, the appropriate basin has been targeted for BMPs and a monitoring program has been designed and implemented. Sampling and analytical data should be archived regularly, and data should be evaluated annually to assess the water quality status and trends. Pollutant loads should be calculated if stream discharge data were collected at monitoring sites. Results from existing monitoring programs should be included in the data evaluation and incorporated into an overall watershed picture.

After an appropriate period of time, the monitoring program should be reevaluated to assess whether or not the program is meeting the monitoring objectives. Sampling parameters and frequency can be adjusted to better reflect monitoring objectives or any changes in the program focus. This is an important step to build into a monitoring program because it commits project leaders and stakeholders to assessing the ongoing benefits and costs of monitoring. If monitoring is not meeting its stated objectives, the program should be reevaluated and changed if necessary.

7.0 PUBLIC PARTICIPATION

Public involvement is important in the Total Maximum Daily Load (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 the Des Moines River.

7.1 Public Meetings

In the early stages of TMDL development, an agency stakeholder meeting was conducted on December 13, 2006 at the Des Moines Botanical Center from 6-8 pm regarding the TMDL process and the schedule for the Des Moines River TMDL. Once the document was complete, a public meeting was held on June 24, 2009 at the Johnston City Center from 6-8 pm. Representatives from several groups were represented including; IDNR, City of Johnston, Sierra Club, Iowa Farm Bureau, HR Green Co., and local citizens.

IDNR staff provided information regarding the TMDL program, monitoring activities in the river and the models used for the TMDL and the implementation section of the document. Additionally, IDNR personnel explained the next steps required to improve water quality in the Des Moines River including the type of funding available.

7.2 Written Comments

IDNR received six official comments on the draft version of the TMDL for the Des Moines River. The comments and IDNR responses are included in Appendix C of this document.

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APPENDIX A. CALCULATION OF WASTELOAD CAPACITY FOR MS4 CITIES IN THE DES MOINES RIVER WATERSHED

MS4 City	Sub-basin [a]	Subbasin Area (ac)	Surface Runoff in Subbasin (mm/yr) [b]	City Area in Subbasin (ac) [c]	Total Surface Runoff (m3/yr) [d]	NO3-N Target Conc. (mg/l)	Nitrogen WLA (kg/yr)	Nitrogen Load (lbs/day)
Grimes	144	28,638	46.895	2175	412,737	9.5	3921	24
Johnston	144	28,638	50.889	7131	1,353,244			
	145	14,327		1878	386,820			
(total)					1,740,064	9.5	16531	100
Des Moines	146	20,109	128.929	8522	4,446,180	9.5	42239	255

[a] number of subbasin refers to subbasin ID used in SWAT model (see Figure 4-1 and Table 4-1)

[b] amount of average annual surface runoff predicted by SWAT model for subbasin

[c] area of subbasin with an MS4 city within the subbasin boundary

[d] fraction of subbasin surface runoff apportioned to MS4 city

Method of Calculation of MS4 Capacity: Results from the calibrated SWAT model (see Section 4) were used to determine the annual MS4 wasteload from Grimes, Johnston and Des Moines. The average annual runoff from the subbasin containing the MS4 city was calculated by the SWAT model. The watershed model predicted how much surface runoff was generated in a subbasin, and this annual amount was then multiplied by the fraction of the subbasin containing the MS4 city. In the case of Johnston, the city extent occupied portions of two subbasins and these areas were combined into a single amount. The annual average volume of runoff from each city was multiplied by the TMDL target concentration of 9.5 mg/l to yield the total load of nitrate allocated to city runoff. The annual loads were divided by 365 to derive a daily load and converted to lbs/day for reporting.

APPENDIX B. SUMMARY OF WASTELOAD ALLOCATIONS FOR POINT SOURCES IN THE DES MOINES RIVER WATERSHED

B1. Wasteload allocations for NPDES facilities evaluated in the TMDL.

Site Name	EPA ID Number	Permit type	Discharge Frequency	**Tier I** Maximum Daily Nitrate Load (lbs/day)	**Tier II** Average Daily Nitrate Load (lbs/day)
Algona, City of	IA0022055	Municipal	Continuous	712.19	229
Armstrong, City of	IA0028517	Municipal	Continuous	102.63	33
Ayrshire, City of	IA0079077	Municipal	Controlled	16.95	5.45
Badger, City of	IA0029041	Municipal	Controlled	51.22	16.47
Bancroft, City of	IA0057762	Municipal	Controlled	67.86	21.82
Barnum, City of	IA0041246	Municipal	Controlled	16.39	5.27
Bode, City of	IA0047805	Municipal	Controlled	27.46	8.83
Boone, City of	IA0058076	Municipal	Continuous	1075.06	345.68
Boxholm, City of	IA0058491	Municipal	Controlled	18.07	5.81
Brit, City of	IA0023582	Municipal	Continuous	172.29	55.40
Brushy Creek State Park North Campground, DNR	IA0074543	Semi Public	Controlled	4.35	1.40
Burt, City of	IA0027405	Municipal	Controlled	46.68	15.01
Camp Hantesa	IA0073806	Semi Public	Continuous	1.83	0.59
Camp Dodge	IA0063215	Semi Public	Continuous	78.09	25.11
Clare, City of	IA0062936	Municipal	Controlled	15.95	5.13
Clarion, City of	IA0030945	Municipal	Continuous	276.79	89
Coats Utilities	IA0062421	Semi Public	Controlled	12.19	3.92
Corwith, City of	IA0021351	Municipal	Continuous	52.87	17
Cylinder, City of	IA0064823	Municipal	Controlled	9.24	2.97
Dakota City, City of	IA0048003	Municipal	Continuous	301.67	97
Dayton, City of	IA0023558	Municipal	Controlled	74.24	23.87
Duncombe, City of	IA0027413	Municipal	Controlled	39.81	12.80
Eagle Grove, City of	IA0034380	Municipal	Continuous	559.80	180
Easter Seal Camp Sunnyside	IA0071226	Semi Public	Controlled	2.61	0.84
Emmetsburg, City of	IA0021580	Municipal	Continuous	653.10	210
Estherville, City of	IA0023744	Municipal	Continuous	1921.67	617.9
Fort Dodge, City of	IA0044849	Municipal	Continuous	6220.00	2000
Gilmore City, City of	IA0031194	Municipal	Controlled	46.68	15.01
Goldfield, City of	IA0036137	Municipal	Controlled	57.10	18.36
Graettinger, City of	IA0027821	Municipal	Controlled	75.57	24.30
Grand Junction, City of	IA0041891	Municipal	Controlled	80.95	26.03
Granger, City of	IA0041912	Municipal	Continuous	108.85	35
Grimes, City of	IA0035939	Municipal	Continuous	942.33	303
Gruver, City of	IA0077488	Municipal	Controlled	8.89	2.86
Humboldt, City of	IA0047791	Municipal	Continuous	441.62	142
Jester Park 1, Polk County Conservation	IA0064106	Semi Public	Continuous	16.79	5.40
Jester Park 2, Polk County Conservation	IA0071803	Semi Public	Continuous	16.86	5.42
Kanawha, City of	IA0026000	Municipal	Controlled	62.04	19.95
Koch Nitrogen Plant	IA0000302	Industrial	Continuous	236.11	75.92

Site Name	EPA ID Number	Permit type	Discharge Frequency	**Tier I** Maximum Daily Nitrate Load (lbs/day)	**Tier II** Average Daily Nitrate Load (lbs/day)
Lake Cornelia Sanitation District	IA0066401	Municipal	Controlled	19.47	6.26
Lehigh, City of	IA0021296	Municipal	Controlled	41.74	13.42
Livermore, City of	IA0023566	Municipal	Controlled	36.20	11.64
Madrid, City of	IA0028207	Municipal	Continuous	301.67	97
Mallard, City of	IA0023370	Municipal	Controlled	25.04	8.05
Oak Lake Maintenance, Inc.	IA0065242	Semi Public	Continuous	25.88	8.32
Ogden, City of	IA0041904	Municipal	Continuous	292.34	94
Otho, City of	IA0032948	Municipal	Controlled	47.96	15.42
Pilot Mound, City of	IA0058530	Municipal	Controlled	0.00	0
Pocahontas, City of	IA0035173	Municipal	Continuous	286.12	92
Polk City, City of	IA0041939	Municipal	Continuous	196.83	63.29
Renwick, City of	IA0032760	Municipal	Controlled	25.69	8.26
Ringsted, City of	IA0057436	Municipal	Controlled	36.60	11.77
Rolfe, City of	IA0032310	Municipal	Continuous	53.80	17.30
Rutland, City of	IA0061239	Municipal	Controlled	12.19	3.92
Savage Sanitation District, Fort Dodge	IA0059200	Municipal	Continuous	83.72	26.92
Saylorville Bob Shelter	IA0065528	Semi Public	Controlled	8.05	2.59
Scenic Valley Conference Center and Camp, Inc.	IA0067202	Semi Public	Controlled	8.05	2.59
Southdale Addition, Algona	IA0068284	Semi Public	Continuous	2.11	0.68
South Oak Estates, Algona	IA0065269	Semi Public	Continuous	3.11	1.00
Stratford , City of	IA0035980	Municipal	Controlled	62.64	20.14
Swea City, City of	IA0047813	Municipal	Controlled	53.90	17.33
Thor, City of	IA0058581	Municipal	Controlled	14.62	4.70
Titonka, City of	IA0033375	Municipal	Controlled	49.04	15.77
US gypsum	IA0066796	Industrial	Continuous	7.46	2.40
Van Diest Industry	IA0070033	Industrial	Continuous	10.57	3.40
Vincent, City of	IA0032930	Municipal	Controlled	13.28	4.27
Wallingford, City of	IA0062812	Municipal	Controlled	17.63	5.67
Webster City, City of	IA0036625	Municipal	Continuous	1244.00	400
Wesley, City of	IA0033472	Municipal	Controlled	39.22	12.61
West Bend, City of	IA0036994	Municipal	Controlled	70.04	22.52
Whittemore, City of	IA0033430	Municipal	Controlled	44.50	14.31
Woodward, City of	IA0057517	Municipal	Continuous	220.81	71
Woodward Resource Center	IA0063916	Semi Public	Continuous	40.99	13.18
Woolstock, City of	IA0061310	Municipal	Controlled	17.11	5.50
YMCA Boone	IA0070874	Semi Public	Continuous	5.78	1.86
TOTAL (lbs/day)				**17,906.6**	**5,757.7**
TOTAL (Mg/day)				**8.121**	**2.611**

B2. Wasteload allocation for water treatment plants considered in this TMDL (permitted)

Water Treatment System Name	County	Discharge Flow Avg. (MGD)	Discharge Flow Max (MGD)	Nitrate Conc. in Discharge Water (mg/L)	TMDL Target Nitrate Conc. [1] (mg/l)	Wasteload Allocation (9.5 mg/l x Flow[2]) (lbs/day)	Wasteload Allocation (Mg/day)
Boone Water Treatment Plant	Boone	0.0423		3.9	9.5	3.35	0.0015
Clay Regional Water (Spencer)	Clay	0.0252	0.288	0.23	9.5	22.83	0.0104
Humboldt Water Treatment Plant	Hum-boldt	0.027	0.031	5	9.5	2.46	0.0011
ILRW Osgood Plant (Graettinger) Outfall #1 (sand filter)	Palo Alto	0.3	0.66	4	9.5	23.78	0.0108
ILRW Osgood Plant (Graettinger) Outfall #2 (RO reject)		1.4		15*		584.11	0.2649
John W. Pray Water Facility (Ft. Dodge)	Webster	0.1		0.02	9.5	7.93	0.0036
Mason City Water Treatment Plant	Cerro Gordo	0.66	1.09	0.02	9.5	86.41	0.0392
Saylorville Water Treatment Plant (Des Moines Water Works)	Polk	2.3	3.5	50*		1460.27	0.6623
Xenia North Water Treatment Plant (Dayton)	Webster	0.0179	0.185	5	9.5	14.67	0.0067
TOTAL						**2205.81**	**1.0004**

[1]TMDL target concentration was used to allocate wasteload unless nitrate concentration was higher for permitted facility

[2]Maximum discharge was considered in wasteload allocation if provided. Average discharge was used if maximum flow was not available.

B3. Wasteload allocation reserved for water treatment plants considered in this TMDL (unpermitted).

Water Treatment System Name	County	Total Pumped Volume (MGY)	Volume Discharged to DSM River (10% of total volume) (GPD)		
Algona Municipal Utilities	Kossuth	435.0	119178.1		
Ankeny, City Of	Polk	800.0	219178.1		
Armstrong, City Of	Emmet	60.0	16438.4		
Ayrshire, City Of	Palo Alto	10.0	2739.7		
Badger, City Of	Webster	22.0	6027.4		
Bancroft Municipal Utilities	Kossuth	44.1	12082.2		
City Of Barnum	Webster	10.0	2739.7		
Bode, City Of	Humboldt	15.0	4109.6		
Boxholm, City Of	Boone	10.0	2739.7		
Burt, City Of	Kossuth	27.5	7534.2		
Clare, City Of	Webster	10.0	2739.7		
Clarion, City Of	Wright	145.0	39726.0		
Corwith, City Of	Hancock	20.0	5479.5		
Dakota City, City Of	Humboldt	44.0	12054.8		
Dayton, City Of	Webster	35.0	9589.0		
Duncombe, City Of	Webster	26.0	7123.3		
Eagle Grove, City Of	Wright	250.0	68493.2		
Emmetsburg Municipal Water Dept.	Palo Alto	210.0	57534.2		
Estherville, City Of	Emmet	850.0	232876.7		
Fenton, City Of	Kossuth	11.0	3013.7		
Gilmore City, City Of	Humboldt	31.1	8520.5		
Goldfield, City Of	Wright	28.0	7671.2		
Graettinger, City Of	Palo Alto	50.0	13698.6		
Grand Junction Municipal Light & Water	Greene	55.0	15068.5		
Granger, City Of	Dallas	25.0	6849.3		
Grimes, City Of	Polk	250.0	68493.2		
Gruver, City Of	Emmet	5.1	1397.3		
Havelock, City Of	Pocahontas	10.0	2739.7		
Kanawha, City Of	Hancock	34.0	9315.1		
Lehigh, City Of	Webster	30.0	8219.2		
Livermore, City Of	Humboldt	25.0	6849.3		
Lone Rock, City Of	Kossuth	9.0	2465.8		
Lu Verne, City Of	Humboldt	12.0	3287.7		
Madrid, City Of	Boone	146.0	40000.0		
Mallard, City Of	Palo Alto	25.5	6986.3		

Water Treatment System Name	County	Total Pumped Volume (MGY)	Volume Discharged to DSM River (10% of total volume) (GPD)		
Ogden Municipal Utilities	Boone	125.0	34246.6		
Otho, City Of	Webster	36.8	10082.2		
Palmer, City Of	Pocahontas	16.0	4383.6		
Pocahontas, City Of	Pocahontas	115.0	31506.8		
Polk City, City Of	Polk	88.0	24109.6		
Renwick, City Of	Humboldt	20.0	5479.5		
Ringsted, City Of	Emmet	17.6	4821.9		
Rolfe, City Of	Pocahontas	45.0	12328.8		
Rutland, City Of	Humboldt	10.0	2739.7		
Superior, City Of	Dickinson	7.3	2000.0		
Swea City, City Of	Kossuth	27.5	7534.2		
Thor, City Of	Humboldt	6.0	1643.8		
Titonka, City Of	Kossuth	35.0	9589.0		
Vincent, City Of	Webster	9.0	2465.8		
Webster City, City Of	Hamilton	1095.0	300000.0		
Wesley, City Of	Kossuth	19.0	5205.5		
West Bend, City Of	Palo Alto	52.0	14246.6		
Whittemore, City Of	Kossuth	27.0	7397.3		
Woden Water Supply	Hancock	24.0	6575.3		
Woolstock, City Of	Wright	10.0	2739.7		
		Total Pumped Volume from water treatment plants (unpermitted) (MGY)	**Total Volume Discharged to DSM River (10% of total volume) (GPD)**	**Wasteload Allocation (9.5 mg/l x discharge volume) (lbs/day)**	**Wasteload Allocation (9.5 mg/l * discharge volume) (Mg)**
TOTAL		**5556**	**1522054.8**	**120.68**	**0.0547**

B4. Wasteload allocations for animal feeding operations (feedlots) with NPDES permits evaluated in this TMDL.

Name	County	NPDES#	EPA ID	Animal Type	Head	Wasteload Allocation (lbs/day)
Ulrich, Jerry	Emmet	3200010	IA0078573	Cattle	2,500	0
Greig & CO., Inc. Feedlot	Emmet	3200001	IA0077623	Cattle	2,000	0
Brenton Brothers, INC.	Dallas	2500001	IA0038911	Cattle	9,640	0
Hoiz Brothers, INC	Greene	3756814	IA0080837	Cattle	Unknown	0

B5. Wasteload allocations reserved for unsewered communities evaluated in the TMDL

Community Name	County	Population (2000 census)		
Fenton	Kossuth	317		
Lu Verne	Kossuth	299		
Woden	Hancock	243		
Ayrshire	Palo Alto	202		
Moorland	Webster	197		
Havelock	Pocahontas	177		
Luther	Boone	158		
Lone Rock	Kossuth	157		
Superior	Dickinson	142		
Fraser	Boone	137		
Bouton	Dallas	136		
Bradgate	Humboldt	101		
Plover	Pocahontas	95		
Dana	Greene	84		
Dolliver	Emmet	77		
Curlew	Palo Alto	62		
Ottosen	Humboldt	61		
Hardy	Humboldt	57		
Rodman	Palo Alto	56		
Beaver	Boone	53		
Berkley	Boone	24		
Pioneer	Humboldt	21		
		Total Population of Unsewered Communities	**Average Daily Nitrate Load (Pop. X 0.027 lbs nitrate/day) (lbs/day)**	**Maximum Daily Nitrate Load (avg. X 3.11) (lbs/day)**
TOTAL		**2856**	**77.1**	**239.8**

B6. Wasteload allocations for MS4 communities evaluated in the TMDL. Details of MS4 calculation presented in Appendix A.

MS4 City	Wasteload Allocation (lbs/day)	Wasteload Allocation (Mg/day)
Grimes	24	0.0109
Johnston	100	0.0454
Des Moines	255	0.1156
TOTAL	**379**	**0.172**

APPENDIX C. PUBLIC COMMENTS

Berckes, Jeff [DNR]

From: Steven Witmer [switmer@ci.johnston.ia.us]
Sent: Monday, June 22, 2009 5:00 PM
To: Berckes, Jeff [DNR]
Subject: Des Moines River TMDL
Follow Up Flag: Follow up
Flag Status: Completed

Hi Jeff,

I'm sure I'll see you and Keith at the meeting later this week, but I was wondering if you could clear up a question for me on the draft plan. In the section on existing monitoring, I see various monitoring efforts mentioned including USGS stream gaging, DNR ambient monitoring, water supply monitoring, and ACWA monitoring, but I notice that IOWATER monitoring, even the snapshot events, are completely absent. I guess I find that more than a little frustrating having personally organized eight snapshot events for Beaver Creek since 2004. Beaver Creek is noted in the plan as the last major tributary to enter the river before the impaired segment. There is also data from the Polk County snapshots that ought to be relevant as well.

I brought up the same question with regard to the bacteria TMDL last year and the response I received questioned whether the snapshot data was "Credible Data", after which I confirmed that there has been a QAPP in place for the snapshot events and they *are* considered credible data per the Iowa Credible Data Law. The IOWATER staff sped up their efforts last year to get the snapshot data available on STORET to make it more readily available and the data for Beaver Creek was some of the first to be added and has been available since last November.

I don't expect that the data collected would radically change the TMDL information and I know that two datasets annually is not as substantial as the monthly monitoring done by the DNR, for example, but nonetheless for some of the tributaries that snapshot data is the *only* data available. For example, Slough Creek, a tributary of Beaver Creek, has consistently shown itself to have by far the highest nitrate levels anywhere in the Beaver Creek watershed (for example, in 6 out of 7 sets of data collected since April 2005 when we added Slough Creek to the snapshot, Slough Creek sites have the highest nitrate concentrations – this is according to laboratory analysis done by the UHL laboratories in accordance with the QAPP). The data from the snapshots was sufficient to get DMWW to add Slough Creek as a monitoring site for some of their own monitoring efforts, and had the snapshot data not been available that may not have happened. The Dallas County Soil & Water Commission also applied (unsuccessfully, unfortunately) for a Watershed Development and Planning Grant for Slough Creek based upon this data.

These snapshot events – not just the Beaver Creek one, but all of them that occur around the state – represent a significant investment of time and effort on the part of the both the event organizers (who are usually volunteers), and the people who volunteer for them. The volunteers offer their time, often giving up several hours or more for each event, sometimes in beautiful weather when they could be doing something else, sometimes in horrible weather (during the snapshots, I've monitored in near 100 degree heat, and also while snow flurries were falling), and using their own vehicles and fuel, sometimes driving a hundred miles round trip during an event to visit their assigned sites. I know in one of the eastern Iowa events the organizer broke his ankle during an event. So I hope you can understand my frustration when I find that while I'm asking my volunteers to sacrifice their personal time and resources to obtain this data, and while I've been told that this data is considered "credible data" on multiple occasions, that this data doesn't even receive passing mention in the TMDL plan. If the IOWATER data, and the snapshot data at the very least, do not qualify as “existing monitoring”, I would certainly be interested in having an explanation of why not.

Please do not take this as a criticism of the TMDL as a whole. I know a lot of effort has gone into writing this plan and apart from this single issue I’m wholly supportive of it. I just think that by neglecting to mention these snapshot events you unfairly deprive them of credibility, unfairly deny the hard work of dozens of dedicated volunteers, and deprive those who would work to implement this TMDL plan who may not be aware of these events of a potential tool that could be at their disposal.

Thank you,

Steven Witmer
Coordinator, Beaver & Walnut Creek Snapshot events, 2004-2008
Coordinator, Raccoon River Snapshot events, 2006-2007
Chair, Water Quality Committee, Raccoon River Watershed Association

Fields of Opportunities

STATE OF IOWA

CHESTER J. CULVER, GOVERNOR
PATTY JUDGE, LT. GOVERNOR

DEPARTMENT OF NATURAL RESOURCES
RICHARD A. LEOPOLD, DIRECTOR

July 7, 2009

Steve Witmer
City of Johnston
6221 Merle Hay Road
Johnston, IA 50131
515-727-7763

Dear Mr. Witmer:

Thank you for taking the time to comment on the Des Moines River Water Quality Improvement Plan (WQIP) for nitrate. We value your interest in affecting positive change in the Des Moines River watershed and look forward to working with you in the future.

The following is a response to your comments delivered via e-mail on June 22, 2009:

Thank you for calling our attention to IOWATER data collected by you and your colleagues in the Des Moines River. We appreciate and support the IOWATER program and encourage local watershed groups to collect data through the program. The data collected by the IOWATER program can be useful to grow support and "ownership" of a waterbody for local groups. However, developing an integrated model, such as the model used in the Des Moines River TMDL, requires a significant level of continuous monitoring data.

Additionally, the model for this TMDL was developed before the IOWATER data you mention was available on ADBnet and therefore was not used in the development of the TMDL. As you mention in your letter, the WQIP mirrors your expected results, which is a testament to your sampling results.

The WQIP now includes language speaking to the IOWATER efforts in the watershed and encourages further community participation in the program. Thanks again for all your help in setting up the public meeting in Johnston and for all of your hard work in the Des Moines and Raccoon River watersheds. If you have further questions I can be reached at 515-281-4791.

Sincerely,

Jeff Berckes, TMDL Program Coordinator
Watershed Improvement Section

WALLACE STATE OFFICE BUILDING / 502 EAST 9th STREET / DES MOINES, IOWA 50319-0034
515-281-5918 TDD 515-242-5967 FAX 515-281-6794 www.iowadnr.gov

Berckes, Jeff [DNR]

From: Virginia Soelberg [soelbergv@dwx.com]
Sent: Sunday, June 28, 2009 8:41 PM
To: Berckes, Jeff [DNR]
Subject: TMDL

Follow Up Flag: Follow up
Flag Status: Completed

Comments to the DNR regarding the Des Moines River TMDL report given June 24, 2009. Pollutant: Nitrates

Thanks to the DNR for their work in identifying the nitrate problems.
We as consumers of water from the Des Moines Water Works pay a considerable amount of money to remove these excess nitrate levels from our drinking water. In response to my question, I was told that 95% of the pollution source is non-point. To address this problem realistically, the issue of fertilizer on row crops must be addressed!

I see several important considerations. Incentives and grants alone will not, in my estimation, result in significant improvements. There must be regulation and oversight. The issues need to be dealt with through a watershed approach, rather than piece-meal efforts.
However, expecting a watershed group to "attract" all stakeholders to participate is naive. Best management practices can't be just "suggested." They need to be expected. And taxpayers can't always be expected to pay farmers for doing the right thing. For instance, wetland mitigation should be a part of the cost of doing business, and riparian buffers of perhaps 100' should be a requirement, not an option.

We know what needs to be done; let's start doing it!

Thank you.

Virginia H. Soelberg
5979 Dogwood Circle
Johnston, Iowa 50131

Fields of Opportunities

STATE OF IOWA

CHESTER J. CULVER, GOVERNOR
PATTY JUDGE, LT. GOVERNOR

DEPARTMENT OF NATURAL RESOURCES
RICHARD A. LEOPOLD, DIRECTOR

July 7, 2009

Virginia Soelberg
5979 Dogwood Circle
Johnston, IA 50131

Dear Ms. Soelberg:

Thank you for taking the time to comment on the Des Moines River Water Quality Improvement Plan for nitrate. We value your interest in affecting positive change in the Des Moines River watershed and look forward to working with you in the future.

The following is a response to your comments delivered via e-mail on June 28, 2009:

The Water Quality Improvement Plan for the Des Moines River serves two purposes. First, it satisfies a requirement of the Clean Water Act to develop a TMDL for the nitrate impairment. Second, it is a document that can be used by local stakeholders as a guide to improve water quality. Nonpoint source pollution, such as runoff from fertilizer application on row crops, is not regulated at this time.

As discussed in the meeting, a small watershed approach is preferred for improving water quality. Active community groups have been effective across the state in engaging citizens and landowners throughout their watershed to adopt pollutant reducing practices, both residential and agricultural. Communities can use the Water Quality Improvement Plan to identify watersheds that are the most problematic for nitrate contributions and start their efforts there. By targeting the most problematic watersheds first, the Des Moines River should theoretically benefit from reductions in nitrate. Once progress is made in the first watershed, a community can move on to the next most problematic watershed, and begin restoration efforts there.

Your comments regarding best management practices, including wetlands and riparian buffers, are part of the suite of options suggested in the implementation plan. I hope the Water Quality Improvement Plan proves helpful in any watershed work you are involved with. If you have further questions, I can be reached at 515-281-4791.

Sincerely,

Jeff Berckes, TMDL Program Coordinator
Watershed Improvement Section

Johnston

City Hall
6221 Merle Hay Road
P.O. Box 410
Johnston, IA 50131
515-278-2344
Fax 515-278-2033

Police Department
6221 Merle Hay Road
P.O. Box 410
Johnston, IA 50131
515-278-2345

Public Works
6400 NW Beaver Dr.
P.O. Box 410
Johnston, IA 50131
515-278-0822
Fax 515-727-8092

Crown Point
Community Center
6300 Pioneer Parkway
P.O. Box 410
Johnston, IA 50131
515-251-3707

Public Library
6700 Merle Hay Road
P.O. Box 327
Johnston, IA 50131
515-278-5233
Fax 515-278-4975

June 25, 2009

Jeff Berckes
Iowa Department of Natural Resources
Watershed Improvement
Sent via email: jeff.berckes@dnr.iowa.gov

SUBJECT: Iowa Department of Natural Resources (Iowa DNR); Draft Des Moines River Water Quality Improvement Plan

Jeff:

As part of the public comment period for the Iowa DNR draft plan, thank you for coming to Johnston on Wednesday evening, June 24, 2009. We appreciated the opportunity to meet you and other Iowa DNR staff. The draft plan represents many months of effort by talented professionals.

Thank you for recognizing the efforts of the IOWATER program and its volunteers too.

The City of Johnston is beginning our sixth year as an "MS4 permitted city". With the help of Greg Pierce, Nilles Associates, we completed the field work for our city's comprehensive watershed assessment in 2008. Greg is currently working with us on a draft Stormwater Management Plan document for Johnston. The timing is good for an emphasis and greater understanding of nitrate, the pollutant of concern in the Des Moines River.

As the Iowa DNR moves forward to encourage implementation of the Des Moines River Water Quality Plan, we offer the following:

1. Permits for "MS4 cities" define municipal boundaries that do not correspond to watershed boundaries.

2. Johnston will continue to work on public education specifically related to stormwater, Best Management Practices and to identify projects based on the priorities established in our Stormwater Management Plan.

3. With the understanding that approximately 78% of the Des Moines River watershed is in row crop land use, we encourage Iowa DNR to look beyond the cities (and the jurisdiction of our municipal boundaries) to implementation and cooperation in the 16 Iowa county areas that are outside cities and also a part of the watershed.

4. Consider revisiting this Plan in 5 – 10 years, to review water quality data and determine if efforts in the Des Moines River watershed are making a positive difference. The Total Maximum Daily Load (TMDL) goal proposed in the Plan, including a margin of safety is 9.5 mg/L.

5. It is our understanding that the public meeting in Johnston is the only event planned by Iowa DNR prior to closure of the public comment period on July 6th. We are concerned that the public outside the Des Moines metro area will not be informed and public education efforts to improve water quality will not be served.

Once again, thank you for your efforts.

Sincerely,

Deb Schiel-Larson

Deb Schiel-Larson, AICP
Planner II/ Landscape Architect
Tele.: 515/727-7763
Email: dlarson@ci.johnston.ia.us

Copy: David Wilwerding, City of Johnston;
Greg Pierce, Nilles Associates

July 7, 2009

Deb Schiel-Larson
City of Johnston
6221 Merle Hay Road
Johnston, IA 50131
515-727-7763

Dear Ms. Schiel-Larson:

Thank you for taking the time to comment on the Des Moines River Water Quality Improvement Plan (WQIP) for nitrate. We value your interest in affecting positive change in the Des Moines River watershed and look forward to working with you in the future.

The following is a response to your comment letter dated June 25, 2009:

Point 1: *Permits for "MS4 cities" define municipal boundaries that do not correspond to watershed boundaries*.
Unfortunately, political boundaries usually do not correspond to watershed boundaries. Your comment was relayed to Joe Griffin. The wasteload allocation in the WQIP for the City of Johnston's MS4 permit is intended to apply only to that portion of the city that drains into the Des Moines River Watershed.

Point 2: *Johnston will continue to work on public education specifically related to stormwater, Best Management Practices and to identify projects based on the priorities established in our Stormwater Management Plan*.
The DNR appreciates the work that the City of Johnston has done and we look forward to working with you to improve education and awareness to improve water quality. The City of Johnston continues to show a willingness to work in the watershed that will prove beneficial to Johnston residents.

Point 3: *With the understanding that approximately 78% of the Des Moines River watershed is in row crop land use, we encourage Iowa DNR to look beyond the cities (and the jurisdiction of our municipal boundaries) to implementation and cooperation in the 16 Iowa county areas that are outside cities and also a part of the watershed.*
The WQIP speaks to the land use and relative contributions of nitrate to the Des Moines River. Local watershed groups are encouraged to engage all stakeholders in the watershed, including agricultural landowners and producers. For the TMDL to be reached, the implementation plan of the WQIP cites fertilizer application as a major source of nitrate loads in the watershed.

Point 4: *Consider revisiting this Plan in 5 – 10 years, to review water quality data and determine if efforts in the Des Moines River watershed are making a positive difference. The Total*

Maximum Daily Load (TMDL) goal proposed in the Plan, including a margin of safety is 9.5 mg/L.
The impaired waters list for Iowa contains hundreds of waterbodies throughout the state. The Clean Water Act requires the State of Iowa to develop a TMDL for all impaired waters listed on the 303(d) list. With limited resources, the TMDL program has the capacity to complete 10-12 WQIPs annually. Given the workload for the program, and the current resources, a revision of the Des Moines Nitrate TMDL is not currently planned.

Point 5: *It is our understanding that the public meeting in Johnston is the only event planned by Iowa DNR prior to closure of the public comment period on July 6th. We are concerned that the public outside the Des Moines metro area will not be informed and public education efforts to improve water quality will not be served.*
The meeting on June 24, 2009 was the only public meeting held to deliver the WQIP for the Des Moines River Nitrate TMDL. A public meeting for a WQIP is a standard operating procedure the DNR Watershed Improvement Section developed to encourage stakeholder involvement and increase the visibility and transparency of the process. Given demands on our resources and the interest in the watershed, it was determined to have one public meeting in the City of Johnston. If a local group shows interest in working in the Des Moines River watershed, the Watershed Improvement Section staff is dedicated to empowering that community to revitalize the water quality by fostering community partnerships and by providing technical guidance.

Thank you again for your support and your letter. If you have further questions, I can be reached at 515-281-4791.

Sincerely,

Jeff Berckes, TMDL Program Coordinator
Watershed Improvement Section

July 6, 2009

Jeff Berckes
Environmental Specialist
TMDL & Water Quality Assessment Section
Iowa Department of Natural Resources
Des Moines, IA 50319

The members of the Palo Alto County Farm Bureau appreciate the opportunity to comment on the draft Total Maximum Daily Load for the Des Moines River watershed. We support the use of continued voluntary best management practices and the coordinated use of information and education programs to inform all citizens in the watershed about these important issues.

The Des Moines River draft TMDL says that a 30 percent reduction in fertilizer application rates in the watershed may be necessary to achieve a required 34 percent nitrate load reduction. This is not supported by university fertilizer recommendations. If this is true, this is unacceptable from and agronomic standpoint. Iowa agriculture must be able to follow university recommendations. It would be unsustainable for farmers to grown corn at fertilizer rates that low for extended periods of time. Also, at some point, soil organic mater would suffer and more erosion may follow, worsening sediment delivery to the river.

On our farm, we fertilize according to soil samples and leaf tissue samples. We never apply more than the crop requires, and sometimes we do apply less if we can get by because of soil type or fertilizer cost. A 30 percent reduction is just not an acceptable alternative. As stewards of the land for the next generations, we are already doing everything we can to keep the water clean and costs down.

One other point of interest is a study going on in our area. The Natural Resources Conservation Service, in cooperation with the Iowa Soybean Association, is doing a study on the Silver Lake Watershed. The NRCS is looking at nitrate levels and sediment levels in Silver Lake, near Ayrshire. With the study, a water sample is taken in the spring and in the fall, and every two weeks during the growing season. Farmers have voluntarily changed tillage and fertility practices, as well as replace above ground intakes with rock intakes. We all want the same thing in clean water, we just need obtainable goals and guidelines

Thank you for the opportunity to comment.

Sincerely,

Dan Chism
Palo Alto County Farm Bureau President

Fields of Opportunities

STATE OF IOWA

CHESTER J. CULVER, GOVERNOR
PATTY JUDGE, LT. GOVERNOR

DEPARTMENT OF NATURAL RESOURCES
RICHARD A. LEOPOLD, DIRECTOR

July 15, 2009

Dan Chism
Palo Alto County Farm Bureau
712-852-4443

Dear Mr. Chism:

Thank you for taking the time to comment on the Des Moines River Water Quality Improvement Plan (WQIP) for nitrate. The following is a response to your comment letter dated July 6, 2009:

The second paragraph cites a discussion in the WQIP regarding a 30 percent reduction in fertilizer application rates in the watershed for a corresponding 34 percent nitrate load reductions to the river. The TMDL actually uses a 70 percent reduction in fertilizer application to reach a 34 percent nitrate load reduction in the watershed in one of the three hypothetical scenarios. This analysis and discussion is located within the Implementation Plan section of the document. As stated in the first paragraph of the section, "*An implementation plan is not a required component of a Total Maximum Daily Load but can provide department staff, partners and watershed stakeholders with a strategy for improving Des Moines River water quality*". The Implementation Plan includes three scenarios using the modeling outlined in the document and their effectiveness in reaching the TMDL for the river. The purpose of these scenarios is to provide a starting point for scenario analysis for local stakeholders wanting to work in the watershed.

The DNR recognizes and appreciates the dedication to conservation and the stewardship efforts of a number of progressive farmers throughout the state. The efforts you and your colleagues have made in conservation and stewardship represent the type of changes to traditional farming practices that are necessary to improve land conservation and water quality. We look forward to working with more farmers in more communities to increase awareness of water quality issues and conservation farming practices. We also look forward to finding more ways to cost effectively improve water quality across the state.

If you have further questions, I can be reached at 515-281-4791.

Sincerely,

Jeff Berckes, TMDL Program Coordinator
Watershed Improvement Section

July 6, 2009

Jeff Berckes
Environmental Specialist
TMDL & Water Quality Assessment Section
Iowa Department of Natural Resources
Des Moines, IA 50319

The members of the Wright County Farm Bureau appreciate the opportunity to comment on the draft Total Maximum Daily Load for the Des Moines River watershed. We support the use of continued voluntary best management practices and the coordinated use of information and education programs to inform all citizens in the watershed about these important issues.

The Des Moines River draft TMDL says that a 30 percent reduction in fertilizer application rates in the watershed may be necessary to achieve a required 34 percent nitrate load reduction. This is not supported by university fertilizer recommendations. If this is true, this is unacceptable from an agronomic standpoint. Iowa agriculture must be able to follow university recommendations. It would be unsustainable for farmers to grown corn at fertilizer rates that low for extended periods of time. Also, at some point, soil organic mater would suffer and more erosion may follow, worsening sediment delivery to the river.

The efforts of farmers to help protect the watershed is not going unnoticed. Farmers are using buffer strips along rivers and creeks, using strip till and no till in areas also as examples of farmers taking the initiative. Farmers are also doing a better job of using split applications of nitrogen and fertilizers by applying them at different stages in the growing season they reduce the chances of the nitrates being diluted in times of heavy spring rains. The potential risk of not being able to use University recommended rates will decrease our ability to create bushels which in turn reduces our ability to create income or to meet demand. I believe as a farming community that cities, towns, and counties can not withstand these loses of income potential.

As we look deeper into this issue it will not only affect farmers but also municipalities and city business' that apply nitrates, etc. to lawns. Farmers are obviously not the only supposed "violators" or "victims" of this proposed watershed legislation. Farmers are continuing to improve their waterways/buffer strips by doing better conservation tillage practices. They will continue to do what they can and will look at all options to control these affects but in turn these practices need to be cost effective in order for them to work and work well.

Please consider all the ways that the farmers are doing to help with this issue without taking or limiting the amount of food our crops need to grow and survive in order to support the growing population.

Thank you for the opportunity to comment.

Sincerely,

Troy Watne
Wright County Farm Bureau President

Fields of Opportunities

STATE OF IOWA

CHESTER J. CULVER, GOVERNOR
PATTY JUDGE, LT. GOVERNOR

DEPARTMENT OF NATURAL RESOURCES
RICHARD A. LEOPOLD, DIRECTOR

July 15, 2009

Troy Watne
Wright County Farm Bureau
515-532-3280

Dear Mr. Watne:

Thank you for taking the time to comment on the Des Moines River Water Quality Improvement Plan (WQIP) for nitrate. The following is a response to your comment letter dated July 6, 2009:

The second paragraph cites a discussion in the WQIP regarding a 30 percent reduction in fertilizer application rates in the watershed for a corresponding 34 percent nitrate load reductions to the river. The TMDL actually uses a 70 percent reduction in fertilizer application to reach a 34 percent nitrate load reduction in the watershed in one of the three hypothetical scenarios. This analysis and discussion is located within the Implementation Plan section of the document. As stated in the first paragraph of the section, "*An implementation plan is not a required component of a Total Maximum Daily Load but can provide department staff, partners and watershed stakeholders with a strategy for improving Des Moines River water quality*". The Implementation Plan includes three scenarios using the modeling outlined in the document and their effectiveness in reaching the TMDL for the river. The purpose of these scenarios is to provide a starting point for scenario analysis for local stakeholders wanting to work in the watershed.

The DNR recognizes and appreciates the dedication to conservation and the stewardship efforts of a number of progressive farmers throughout the state. We look forward to working with more farmers in more communities to increase awareness of water quality issues and conservation farming practices. We also look forward to finding more ways to cost effectively improve water quality across the state.

The fourth paragraph states that water quality affects more than just farmers. Indeed, everyone that lives, works, and recreates in the watershed needs to do their part to improve water quality. Considerations are given to all significant sources of nitrate in the WQIP, as depicted in Table 3-8 on page 44. Agricultural land accounts for a significant portion of the overall loading in the watershed, which represents the greatest opportunity for improvements to the overall water quality in the river.

The second sentence of the fourth paragraph of your letter states that "*Farmers are obviously not the only supposed 'violators' or 'victims' of this proposed watershed legislation*". The purpose of a WQIP is to develop a Total Maximum Daily Load (TMDL) to satisfy the requirements of the Clean Water Act. This document is decidedly not "watershed legislation" nor does it point to "violators" or "victims". The WQIP presents the findings of research into what the TMDL for a waterbody is. This information is compared against the current loading, and a percent reduction required to meet the TMDL is identified in the document. The implementation plan (section 5), as discussed above, is designed to offer stakeholders a set of strategies they have at their disposal to improve water quality. Through an integrated community based planning strategy, local groups can affect positive change in the watershed.

If you have further questions, I can be reached at 515-281-4791.

Sincerely,

Jeff Berckes, TMDL Program Coordinator
Watershed Improvement Section

IOWA FARM BUREAU
PEOPLE. PROGRESS. PRIDE.™

September 4, 2007

Jeff Berckes
Environmental Specialist
TMDL & Water Quality Assessment Section
Iowa Department of Natural Resources
Des Moines, IA 50319

RE: Des Moines River Watershed Total Maximum Daily Load

Dear Mr. Berckes:

The Farm Bureau Federation, the state's largest general farm organization, with more than 157,000 members, appreciates the opportunity to comment on the draft Total Maximum Daily Load for the Des Moines River watershed. We support the use of continued voluntary best management practices and the coordinated use of information and education programs to inform all citizens in the watershed about these important issues.

The modeling results from the draft TMDL, while informative, underscores the challenges of the TMDL approach to water quality improvement. The indication that only a 30 percent reduction in fertilizer applications (from 152 to 45 pounds per acre) across all acres in the watershed to achieve the 34 percent nitrate load reduction required by this TMDL, is wholly unacceptable from an agronomic standpoint.

Iowa State University recommends the fertilizer rate for corn after soybeans is 100-150 pounds of nitrogen per acre, depending on the price of fertilizer, the expected price for grain produced and the supply of subsoil moisture. This amount of fertilizer is necessary to produce economically viable corn yields. Unfortunately, this can result in seasonal soil water nitrate concentrations of as high as 22-45 milligrams per liter. If applied N or mineralized organic matter N (conversion from organic to ammonium) would stay in the ammonium form, then losses would not occur.

However, that isn't the way it works. Ammonium is converted to nitrate via nitrification. Nitrate is the form that can be moved out of the soil profile by leaching or lost by denitrification. Potential N loss is dependent upon factors that influence each—for nitrification, soil temperature is very important, and for denitrification soil temperature and soil moisture are important. Conversion to nitrate does not equal loss; it just means the N is susceptible to loss. However, losses occur only with excess leaching or with saturated soils, not from following university fertilizer recommendations.

Soil Organic Mater Concerns

Soil quality and soil sustainability are also important issues related to nutrient management decisions addressed by this TMDL. Mass balance calculations based on zero or N rates below university recommendations on corn have shown soil organic mater content decreases over time. The unintended consequences of a 30 percent reduction in N rates across the watershed would mine the soil of its productive capacity when crop nutrient removal exceeds inputs. The result could be a catastrophic shift in crop production to more environmentally sensitive areas of the state, the U.S. or the world.

Preliminary research by Iowa State University indicates that 170 pounds of N per acre per year for continuous corn is about the "tipping point" at which soil organic matter should not decrease. However, for the corn-soybean rotation, at 120 pounds per acre in the corn year, the N mass balance is at least 80 pounds of N per acres negative over the two-year period of rotation. Thus, any reduction in N rates would increase the "mining" of soil organic matter. Reduced soil organic matter not only reduces soil productivity but also increases other water quality problems, such as erosion and phosphorus loss. Therefore, the department must give consideration to both water and soil quality when making nutrient management recommendations in this TMDL.

In Field Management

According to information presented at the hypoxia science assessment meeting in New Orleans and the Gulf Hypoxia and Local Water Quality Concerns Workshop in Ames, some improvement in in-field nutrient management is possible, but within limits. Off-site practices are also likely needed. There are no easy answers and any improvements will be incremental.

A preliminary case study of the Cedar River Watershed by Iowa State University and the Iowa Department of Agriculture and Land Stewardship indicates that to address nitrates loads such as this both in-field management (N rate/timing, cropping, tillage, cover crops, water management) and off-site management (buffer strips and constructed wetlands) are necessary to address its nitrate TMDL. These results indicate that a similar 30 percent reduction in fertilizer rates in that watershed would result only a 20 percent reduction in the N losses from fields, but would reduce corn yields by around 5 bushels per acre.

What's more, fertilizer reductions in combination with applying all known technologies on the landscape (in field and off-site management practices, including targeted restored wetlands, shifting some N applications to spring, cover crops, etc.) would cost Cedar River watershed residents (or someone) more than $29 million per year to achieve a 35 percent N load reduction necessary for that TMDL. Scaling that type of load reduction to all of Iowa would cost an additional $157 million.

Integrated Drainage & Wetland Landscapes

One hybrid of one of these technologies is detailed in the Iowa Pilot for Integrated Drainage & Wetland Landscapes. This is a proposed demonstration project to document integrated drainage and wetland landscape systems optimized to reduce nitrogen and phosphorus loads to surface waters, improve local surface and drinking water quality, address hypoxia in the Gulf of Mexico, and optimize production and profitability of cultivated croplands should be recognized in the final TMDL. The pilot demonstrations of nutrient removal wetlands through existing locally-led drainage districts initially would develop 25 pilot demonstration sites, with the potential for an additional 200 sites authorized by the Secretary of Agriculture. Initial sites will be assessed to evaluate crop yield responses, wetland mitigation functions, and water quality and wildlife benefits.

The department is aware of the proposal, as it continues to be discussed by it, federal agencies and environmental nonprofits. At its recent TMDL public meeting in Johnston, the department acknowledged that wetlands may be the most effective way to address the nitrate load of the watershed, but also said that it did not consider this technology or model its effectiveness in any way. The department needs to work with the Iowa Department of Agriculture and Land Stewardship to understand the role of this pilot in facilitating improved drainage and crop yields and reducing nutrients in surface waters. IDALS has experience with similar targeted wetland restoration efforts through the Conservation Reserve Enhancement Program and can help the department model how this technology can be applied to cost-effectively address the TMDL's nitrate load.

Targeting

The TMDL suggests that targeting the lower Des Moines River by reducing fertilizer applications near the basin outlet would result in greater proportional reduction in watershed nitrate loads. This will require greater awareness and cooperation among various segments of watershed residents, but more examination and discussion is necessary. This approach alone, however, will not achieve the necessary load reductions, and other applications of technology and management need to be considered.

Targeting of current best management practices and site-specific design of treatment technologies is critical. The potential for relative reductions in nitrate leaching in Iowa and the Corn Belt for specific corn-soybean management changes shows that switching from row crops to perennials may yield the largest relative reduction in N losses, compared with reductions in fertilizer rates, timing of applications or reduced tillage. But limited economic returns and management gaps also currently inhibit the adoption of perennials.

Water Resources Coordinating Council

Farm Bureau supports providing local watershed residents with information they can use in sub-watershed planning. A key step to this will be completion of comprehensive watershed planning and assessment, as directed in Houser File 2400 in 2008. The Water Resource Coordinating Council, led by the Governor's office, is responsible for coordinating this planning. Completion of this planning would help watershed residents and policy-makers direct limited resources to the watersheds with the greatest and most time-sensitive needs in a cost-effective manner.

It is more likely, based on university recommendations and research, that a combination of practices not used in the TMDL modeling exercise, such as optimal rates, placement and timing of fertilizer, in combination with other technologies - such as restored wetland placement on exiting tile lines through the Conservation Reserve Enhancement Program, or the developing the Pilot Program for Integrated Drainage & Wetland Landscapes – will need to be modeled on a watershed basis for sub-watershed planning to be successful.

Care must be taken in the final TMDL to avoid premature policy recommendations that may promote the wrong practices (e.g., a 30 percent reduction in fertilizer applications from 152 to 45 pounds per acre). More discussion of these options, their benefits and limitations is needed in the final TMDL. All options must be considered in the context of the available peer-reviewed science, social structures and political realities are necessary for watershed residents to use the information in a meaningful way.

Other General Comments

Human contributions in this TMDL have been significantly underestimated. As with the Raccoon River TMDL, no contributions were provided for the applications of Waste Water Treatment Plants' sludge for the active plants in the watershed. Per consultant discussions, sludge is applied (at a minimum) three times a year (spring, summer and fall) at agronomic N rates, and, if possible, within a five mile radius of the WWTP. It is applied to either land the facility owns, or on cropland with landowner agreements.

Most of the limitations of this TMDL, and the TMDL endpoints and recommended practices, are a result of method used to create the TMDL. The watershed size is too huge and simply not practical. Therefore assumptions had to be made across the board, and no site specific information could be implemented. As a result, the information obtained is simply broad universal information. For example, on page 10, on the 4th paragraph, first sentence: *Results suggest that global scale reductions in fertilizer applications (everyone reducing at a similar rate) achieved greater nitrate load reductions than specific targeting strategies.* This is simply a modeling factor, and the model assumes the same factor throughout the watershed, so when you assume less overall, the results are less.

Seasonality of monthly mean nitrate concentrations in the Des Moines River at 2nd Ave was discussed. However, the implementation methods do not provide relationships to target or address specifically this seasonality. Also, we ask for a more realistic assessment of each subwatershed, and a determination of the N loading contribution, whether it is coming from groundwater or surface runoff, and act accordingly.

Thank you for the opportunity to comment.

Sincerely,

Rick Robinson
Environmental Policy Advisor

Cc: Allen Bonini

August 6, 2009

Rick Robinson
Iowa Farm Bureau
5400 University Ave
West Des Moines, IA 50266
515-225-5432

Dear Mr. Robinson:

Thank you for taking the time to comment on the Des Moines River Water Quality Improvement Plan (WQIP) for nitrate. The following is a response to your comment letter dated September 4, 2007, sent via e-mail on July 6, 2009:

The DNR would like to thank you for your full support of the modeling and findings of the TMDL. We also appreciate your commentary and opinions offered in response to the implementation section of the report, located in Section 5 of the WQIP. As explained during the June 24th public meeting and during a subsequent telephone conversation to Iowa Farm Bureau (IFB), the implementation plan is designed to offer stakeholders a set of strategies they have at their disposal to address nonpoint source pollution to improve water quality. As stated in the WQIP, page 75:

This section describes how best management practices (BMPs) implemented in the Des Moines River watershed can be used to reduce nitrate loads in the river. An implementation plan is not a required component of a Total Maximum Daily Load but can provide department staff, partners and watershed stakeholders with a strategy for improving Des Moines River water quality…The benefit of this approach is that several load reduction alternatives can be evaluated to see what load reductions are possible if everyone in the watershed or subbasin changed their management practice accordingly. The global assessment provides a best-case set of conditions to compare results from one practice against that of another."

As this paragraph clearly articulates, the discussion in the implementation plan does not represent a "DNR recommendation" for how to attain the TMDL, but rather provides citizens with a starting point for how to meet the load allocation component of the TMDL. To emphasize, the TMDL does not include any policy recommendations; the implementation section simply outlines three scenarios that were modeled to help illustrate the effectiveness of reduction strategies to achieve the load allocation target. In addition to the nitrogen fertilizer reduction modeling scenario you refer to in your letter, two other modeling scenarios discussed in the implementation plan (removing all manure from CAFOs and feedlots in the watershed and removing all human waste) were performed to identify the relative impact of these pollutant sources. Clearly, removing all human or animal waste from the watershed is no more practical than reducing N-fertilizer rates by 70 percent. The WQIP clearly notes that these scenarios are not something that should be considered, as cited on page 75:

"However, the problem with this scale of assessment is that the results are unrealistic. For example, it is fully understood that it is impossible for humans to be removed from the watershed. Thus, the objective of Section 5.1 is to provide a large-scale view of load reduction strategies, in essence, a view from 30,000 feet above the watershed."

In other words, the scenarios were used for modeling purposes to show the relative contribution levels of efficiency in reduction for major sources. The DNR makes no inference as to a defined set of practices that should or should not be implemented in the watershed, but rather provides the modeling results of three hypothetical scenarios to illustrate relative contributions.

For purposes of running a successful "what if" modeling scenario, changes were made to fertilizer application to represent all nitrate reducing strategies in the watershed. The rationale of using fertilizer reductions in the model are explained more explicitly on page 76:

"The reduction in fertilizer application rates served as a surrogate for possible wholesale nitrate reductions that might occur in the subbasin from many possible BMP's. In essence, the combined effects of many BMP's was considered to be equivalent to reducing fertilizer applications to 50 kg/ha (45 lb/ac)."

So, while the model used fertilizer application as the reduction method, the take home message is not to reduce fertilizer application by 70 percent, but to reduce an equivalent amount of nitrate loading to the river through a set of best management practices including, but not limited to, reduction of fertilizer. The modeling used for the implementation plan provides an idea to the level of reductions necessary. It is up to watershed groups to determine what combination of BMPs (such as cover crops, bio-reactors, treatment wetlands, tillage methods, fertilizer application, and controlled drainage) will address nitrate reduction efficiently and effectively. To repeat, the DNR is not recommending specific nitrate reduction practices through the implementation plan; rather we are presenting the results of modeling efforts to help local communities improve water quality in the watershed.

Responses to specific commentary in the letter:

Page 1: "The indication that only a 30 percent reduction in fertilizer applications…is wholly unacceptable from an agronomic standpoint…Iowa State University recommends the fertilizer rate for corn after soybeans is 100-150 pounds of nitrogen per acre…This amount of fertilizer is necessary to produce economically viable corn yields."

The model actually cites a 70 percent reduction in fertilizer application and, as described above, serves as a surrogate for possible wholesale nitrate reductions from many possible BMPs. The WQIP is not designed to incorporate agronomic considerations in the document; rather it is the responsibility of local watershed groups to determine the most cost efficient and environmentally responsible solutions to improve water quality using the most effective BMPs in the watershed.

Page 1: "Ammonium is converted to nitrate via nitrification…However, losses occur only with excess leaching or with saturated soils, not from following university fertilizer recommendations."

The mechanism of losing nitrate through leaching is well known and should be considered when determining BMP implementation by local stakeholders. There is a direct correlation between the amount of subsurface drainage and the amount of fertilizer applied and the amount of nitrate susceptible to loss. A reduction in fertilizer applied to the land reduces the amount of ammonium available to convert to nitrate, thus reducing the volume of nitrate able to be transported to the river. Additionally, fertilizer runoff due to rain events occurring shortly after application and excess fertilizer that is not successfully incorporated in the soil directly washes into the river and its tributaries.

Page 2: ***Soil Organic Mater (sic) Concerns***
"Therefore, the department must give consideration to both water and soil quality when making nutrient management recommendations in the TMDL."

The WQIP makes no recommendations for nutrient management in the document. The purpose of the WQIP is to calculate the total maximum daily load of the impaired waterbody in order to allow it to meet its intended use based on the state's water quality standards. DNR recognizes the importance of soil quality in nutrient management. Those concerns may be better addressed with cover crops and tillage management than with nitrogen application rates.

Page 2: **In Field Management**
"Scaling that type of load reduction to all of Iowa would cost an additional $157 million."

The WQIP is for the Des Moines River basin only and does not apply to the entire state of Iowa. It is the charge of local stakeholders to decide the most cost effective way to reduce nonpoint source pollution. The DNR is available to guide local groups to help determine the most effective course of action through the community based planning process.

Page 3: **Integrated Drainage & Wetland Landscapes**
"One hybrid of one of these technologies is detailed in the Iowa Pilot for Integrated Drainage & Wetland Landscapes… The department needs to work with the Iowa Department of Agriculture and Land Stewardship to understand the role of this pilot in facilitating improved drainage and crop yields and reducing nutrients in surface waters."

The DNR is interested in learning more about the effectiveness of this technology at reducing nitrate loads in streams. In fact, the DNR is pleased to have placed the first such pilot in Pocahontas County in the Clean Water SRF Intended Use Plan. Clearly, this management strategy still needs to be developed and evaluated. The DNR looks to its longstanding partnership with IDALS to keep up to date with relevant information from the testing of this pilot program.

"At its recent TMDL public meeting in Johnston, the department acknowledged that wetlands may be the most effective way to address the nitrate load of the watershed, but also said that it did not consider this technology or model its effectiveness in any way."

As was explained at the meeting, the model did not use wetlands because of model limitations due to the large scale of the watershed. However, to reiterate the point from above, fertilizer application reductions were used as a surrogate and represent all BMPs that reduce nitrate. The use of wetlands for nutrient management purposes is an established BMP. Treatment wetlands should be considered along with other BMPs as options for local watershed groups when determining the most effective and efficient pollutant reduction methods.

Page 4: **Water Resources Coordinating Council**
"*Care must be taken in the final TMDL to avoid premature policy recommendations that may promote the wrong practices (e.g., a 30 percent reduction in fertilizer applications from 152 to 45 pounds per acre).*"

First, to reiterate the TMDL does not include any policy recommendations. Second, the reduction in the implementation section of 70 percent (not 30 percent) was used for modeling purposes to show the relative effectiveness of reduction as discussed above.

"All options must be considered in the context of the available peer-reviewed science, social structures and political realities are necessary for watershed residents to use the information in a meaningful way."

Considering "all" options is not a practical exercise for large watershed TMDLs given resource constraints. The TMDL does rely upon the best available science; a list of references can be found in section 8 on page 96. It is well beyond the scope of the TMDL document to include an interpretation of "social structures and political realities". The DNR realizes the importance for local watershed groups to consider all locally viable options when determining the best course of action for watershed improvement and encourages such an approach through the community based planning process.

Page 4: **Other General Comments**
"Human contributions in this TMDL have been significantly underestimated. As with the Raccoon River TMDL, no contributions were provided for the applications of Waste Water Treatment Plants' sludge for the active plants in the watershed."

Human contributions to nitrate loads were evaluated using the assumption that 9.9 pounds of nitrogen are generated per person per year (0.027 pounds of nitrogen per person per day). As stated in the TMDL report, this value is based on EPA literature (Nitrogen Control Manual, 1993). In the SWAT model, human contributions from septic systems were assumed to directly discharge into receiving streams. Human contributions from NPDES permitted facilities were also assumed to discharge directly into receiving streams. Nitrate contributions from sludge applications were implicitly included by assuming that all nitrate generated per person per day was discharged into the streams. This assumption would overestimate the human contribution to nitrate loads in the Des Moines River

"Most of the limitations of this TMDL, and the TMDL endpoints and recommended practices, are a result of method used to create the TMDL. The watershed size is too huge and simply not practical. Therefore assumptions had to be made across the board, and no site specific

information could be implemented. As a result, the information obtained is simply broad universal information."

The load duration curve method was used to derive the TMDL whereas the SWAT model was used to discuss some potential implementation strategies to achieve the nitrate load reductions. The load duration curve approach is an accepted and straightforward method of evaluating pollutant loads in a watershed regardless of watershed size. The TMDL was based on high frequency nitrate monitoring and daily stream gauging measured at the point of the nitrate impairment and thus provides a suitable location for evaluating the total maximum nitrate load in the watershed. Comments regarding the SWAT modeling portion of the report are misplaced in the context of the TMDL. The SWAT modeling was done simply to provide a frame of reference on how nitrate load reductions could be achieved in the watershed.

"Seasonality of monthly mean nitrate concentrations in the Des Moines River at 2nd Ave was discussed. However, the implementation methods do not provide relationships to target or address specifically this seasonality. Also, we ask for a more realistic assessment of each subwatershed, and a determination of the N loading contribution, whether it is coming from groundwater or surface runoff, and act accordingly."

Seasonal variation was evaluated using the load duration curve approach (Section 3.5.3), which by definition, accounts for seasonality and variable flow conditions. In the SWAT model, results were averaged for an 11-year simulation period. For the implementation plan, the average annual loads modeled using SWAT were sufficient to evaluate potential load reduction strategies. Subwatersheds were modeled using detailed soils, land cover, point source data and weather information that would be included in any "more realistic" assessment of subwatershed nitrate loads. Evaluation of nitrate loading patterns in all of the 173 subbasins in the model would be beyond the scope of the TMDL report. An evaluation of nitrate loads from groundwater and surface water runoff using SWAT was included in the Raccoon River TMDL report. Results showed that nitrate loads were overwhelmingly sourced to groundwater (and tile drainage). The same conditions would apply in the Des Moines River watershed.

More refined assessments of each watershed could potentially be driven by local watershed groups in partnerships with the DNR. Unfortunately, due to resource constraints, it is impossible for the DNR to complete a detailed subwatershed analysis for the entire basin, including source determination relative to surface runoff and groundwater. Regardless of the source, steps can be taken to reduce pollution from surface runoff and groundwater by reducing the amount of nitrate inputs to the land and by treating the water through nutrient management BMPs.

If you have further questions, or require additional clarification of the purpose of the TMDL or the implementation section, I can be reached at 515-281-4791.

Sincerely,

Jeff Berckes, TMDL Program Coordinator
Watershed Improvement Section