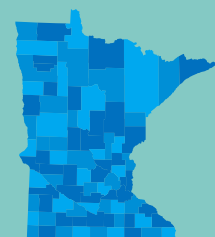June 2021

Redwood River Watershed Stressor Identification Report

Stressor identification for biological impairments in the Redwood River Watershed

MINNESOTA POLLUTION CONTROL AGENCY

Minnesota Pollution Control Agency

Contents

Tables

Redwood River Watershed Stressor Identification Report Minnesota Pollution Control Agency

Figures

Executive summary

Over the past few years, the Minnesota Pollution Control Agency (MPCA) has substantially increased the use of biological monitoring and assessment as a means to determine and report the condition of the state's rivers and streams. This basic approach is to examine fish and aquatic macroinvertebrate communities and related habitat conditions at multiple sites throughout a major watershed. From these data, an Index of Biological Integrity (IBI) score can be developed, which provides a measure of overall community health. If biological impairments are found, stressors to the aquatic community must be identified.

Stressor identification (SID) is a formal and rigorous process that identifies stressors causing biological impairment of aquatic ecosystems and provides a structure for organizing the scientific evidence supporting the conclusions (Cormier et al. 2000). In simpler terms, it is the process of identifying the major factors causing harm to aquatic life. SID is a key component of the major watershed restoration and protection projects being carried out under Minnesota's Clean Water Legacy Act.

This report summarizes SID work in the Redwood River Watershed. There were 23 stream reaches identified with biological impairments within the watershed. Each stream reach
(Assessment Unit Identification (AUID) is described further in Section 2. A summary of the stressors identified in each stream reach is found in Table 16.

After examining many candidate causes for the biological impairments, the following stressors were identified as probable causes of stress to aquatic life:

- Hydrologic Alteration
- Connectivity
- Lack of Physical Habitat
- Dissolved Oxygen (DO)
- Eutrophication
- Suspended Solids
- Nitrates
- Conductivity

1 Introduction

1.1 Monitoring and Assessment

Water quality and biological monitoring in the Redwood River Watershed have been ongoing. As part of the MPCA's Intensive Watershed Monitoring (IWM) approach, monitoring activities increased in rigor and intensity in the Redwood River Watershed during the years of 2017-2018 and focused more on biological monitoring (fish and macroinvertebrates) as a means of assessing stream health. The data collected during this period, as well as historic data dating back to 2010, was used to identify stream impairments (Figure 1).

Once a biological impairment is discovered, the next step is to identify the source(s) of stress to the biological community. A SID analysis is a step-by-step approach for identifying probable causes of an impairment in a particular system. Completion of the SID process does not result in a finished Total Maximum Daily Load (TMDL) study. The product of the SID process is the identification of the stressor(s) for which the TMDL may be developed. For example, the SID process may help investigators nail down excess fine sediment as stressor to biological community, but a separate effort is then required to determine the TMDL and implementation goals needed to restore the impaired condition.
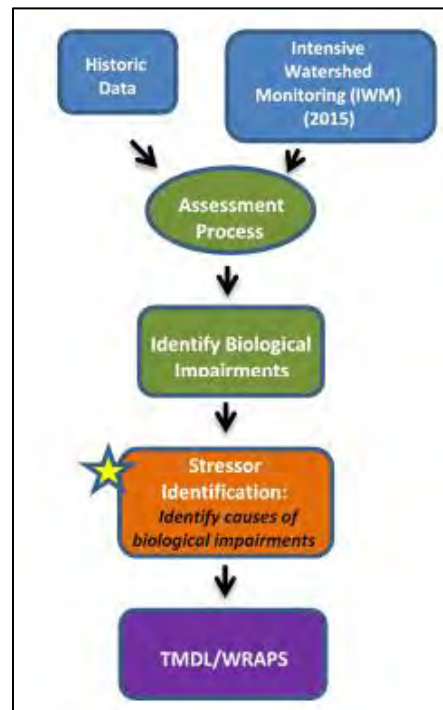
Figure 1. Process map of Intensive Watershed Monitoring.

1.2   Stressor Identification Process

The MPCA follows the U.S. Environmental Protection Agency's (EPA's) process of identifying stressors that cause a biological impairment, which has been used to develop the MPCA's guidance to SID

(Cormier et al. 2000; MPCA 2008). The EPA has also developed an updated, interactive web-based tool, the Causal Analysis/Diagnosis Decision Information System (CADDIS; EPA 2010). This system provides an enormous amount of information designed to guide and assist investigators through the process of SID. Additional information on the SID process using CADDIS can be found here: http://www.epa.gov/caddis. SID is a key component of the major watershed restoration and protection projects being carried out under Minnesota's Clean Water Legacy Act. SID draws upon a broad variety of disciplines and applications, such as aquatic ecology, geology, geomorphology, chemistry, land use analysis, and toxicology. A conceptual model showing the steps in

Figure 2. Stressor Identification process (Cormier et al. 2000).

the SID process is shown (Figure 2). Through a review of available data, stressor scenarios are developed that aim to characterize the biological impairment, the cause, and the sources/pathways of the various stressors.

Strength of evidence (SOE) analysis is used to evaluate the data for candidate causes of stress to biological communities. The relationship between stressor and biological response are evaluated by considering the degree to which the available evidence supports or weakens the case for a candidate cause. Typically, much of the information used in the SOE analysis is from the study watershed (i.e., data from the case). However, evidence from other case studies and the scientific literature is also used in the SID process (i.e., data from elsewhere).

The existence of multiple lines of evidence that support or weaken the case for a candidate cause generally increases confidence in the decision for a candidate cause. Additionally, confidence in the results depends on the quantity and quality of data available to the SID process. In some cases, additional data collection may be necessary to accurately identify the stressor(s) causing impairment. Additional detail on the various types of evidence and interpretation of findings can be found here: http://www.epa.gov/caddis.

1.3   Index of Biological Integrity Scores and Biological Classes

Aquatic biota are known to be responsive to a wide variety of anthropogenic impacts and, at the community level, reflect the integrated result of physical, chemical, and biological processes through time (Barbour et al. 1999). In this manner, aquatic communities provide a direct, comprehensive

perspective on water quality, and lend themselves well to tools that utilize community-level parameters, such as the IBI.

The IBI was originally developed as a tool for assessing the condition of rivers and streams in the Midwestern United States (Karr 1981, Karr et al. 1986). The concept has since been expanded to a wide variety of geographic regions and ecological systems, and has demonstrated its effectiveness in several applications (e.g., condition monitoring, SID). At its core, the IBI provides a framework for translating biological community data into information regarding ecological integrity ("the capability of supporting and maintaining a balanced, integrated, functional organization comparable to that of the natural habitat of the region," Frey 1977). It utilizes a variety of attributes ("metrics") of the biological community, each of which responds in a predictable way to anthropogenic disturbance.

Biological metrics are based on ecological traits of species and represent different aspects of ecological structure and function. The metrics are scored numerically to quantify deviation from least-disturbed conditions, and summed together producing a composite IBI score that characterizes biological integrity (Karr et al.1986). Narrative language within Minnesota Administrative Rule identifies an IBI calculation as the primary determinant for evaluating impairment of aquatic biota (Minn. R. 7050.0150, subp. 6, Impairment of biological community and aquatic habitat). More information on Fish and Invertebrate IBI development can be found here: (MPCA 2014a; MPCA 2014b).

Recognizing that biological communities vary along natural gradients, an effort was undertaken to develop a stream classification framework for Minnesota's riverine fish and invertebrate communities. A classification framework was developed that divides Minnesota rivers and streams into 11 "fish classes," and 9 "invertebrate classes". These classes are differentiated by region, drainage area, gradient, thermal regime, types of habitat sampled, qualitative and quantitative habitat measurements, and observations of flow at the time of sampling (MPCA 2017ab).

The biological classes have been further broken up into three Tiered Aquatic Life Uses (TALU). The aquatic life expectations we have for our streams, as expressed as IBI scores, form the basis for TALU. TALU divides streams into Exceptional, General, and Modified Uses. Exceptional use streams will be high quality waters with fish and invertebrate communities at or near undisturbed conditions. General use streams will be waters with good fish and invertebrate communities that meet minimum goals. Modified use streams will be waters with legally altered habitat that prevents fish and invertebrate communities from meeting minimum goals. Each of these classifications has specific biological threshold scores for both fish and invertebrates (Table 1). Stream reaches addressed in this report contain one or more biological sampling Bio sites that did not meet the threshold for their respective class.

The biologically impaired reaches addressed in this report within the Redwood River Watershed consist of three fish classes and two invertebrate classes, as well as both general and modified uses (Table 1). The biological fish and invertebrate classes are as follows:

Fish Class 1 Southern Rivers

Large warm/cool water rivers in southern Minnesota and the western portion of the Red River Basin

Sites in southern Minnesota and the Glacial Lake Agassiz Basin (GLAB) ecoregion, where watershed area exceeds 300 square miles.

Fish Class 2 Southern Streams

Large warm/cool water streams and small rivers in southern Minnesota and the far-western portion of the Red River Basin

Sites in southern Minnesota and the GLAB ecoregion, where watershed area exceeds 30 square miles but is less than 300 square miles.

Fish Class 3 Southern Headwaters

Small, moderate to high-gradient warm/cool water streams in southern Minnesota and the far-western portion of the Red River Basin

Sites in southern Minnesota and the GLAB ecoregion, where watershed area is less than 30 square miles and gradient is greater than 0.5 m/km.

Table 1. Fish and Invertebrate bio classes and their numeric thresholds addressed within the Redwood River Watershed Stressor ID Report.

Fish				Invertebrates		
Bio Class	IBI Threshold General Use	IBI Threshold Modified Use		Bio Class	IBI Threshold General Use	IBI Threshold Modified Use
Class 1 – Southern Rivers	49	N/A		Class 5 – Southern Streams Rock Riffle	37	24
Class 2 – Southern Streams	50	35		Class 7 – Prairie Streams Glide Pool	41	22
Class 3 – Southern Headwaters	55	33				

1.4   Data used in Stressor Identification

The SOE analysis in SID uses several different types of data from various sources. A variety of published and nonpublished sources were used to assign trophic, reproductive, habitat, tolerance, and life history traits to different taxa known to inhabit Minnesota's rivers and streams (Balon 1975, Pflieger 1975, Becker 1983, Lyons 1992, Barbour et al. 1999, Etnier and Starnes 1999, Goldstein and Meador 2004, Frimpong, and Angermeier 2009).

The biological metric, tolerance value, habitat, and chemical parameter data used in this report is summarized below:

Biological Metrics

Biological metrics are simply different groupings of certain taxa combined into groups based off of commonalities related to their taxonomy, morphometry, behavior, habitat requirements, or life history traits. This type of trait-based approach groups species that experience their environment in a similar fashion and emphasizes the functional structure of biological communities (Karr and Chu 1999).

Tolerance Values- Taxa

Tolerance values were determined for various fish and invertebrate taxa using MPCA biological sampling data to refine existing tolerance attributes derived from literature. Taxa-specific tolerance values were calculated by using a weighted-averaging process (Meador and Carlisle 2007) (Sandberg 2013) using the taxa abundance in a biological sample and the parameter/pollutant (e.g., phosphorus, TSS, nitrate-nitrite, DO, habitat/channel characteristics) concentration/value at the time of the sample. This assigns a tolerance value that indicates the most common concentration/value that each species was found during biological sampling by the MPCA within Minnesota.

Tolerance Index Values - Biological Site

A Tolerance Index Value for bio sites for certain parameters/pollutants is calculated by using a weighted-averaging process of the taxa specific tolerance values of each taxon that is present at a biological Bio site. Each Bio site gets a tolerance index value based off of the tolerance values and number of fish of each species present at the Bio site.

MSHA - Habitat Data

Habitat characteristics are recorded using a qualitative, observation based method modified from Rankin, 1989. The Ohio QHEI is a physical habitat index designed to provide an empirical evaluation of the lotic macro-habitat characteristics that are important to fish communities, which are generally important to other aquatic life. Although similar to the Ohio QHEI, the MSHA has been modified to more adequately assess important characteristics influencing Minnesota streams. The MSHA incorporates measures of watershed land use, riparian quality, bank erosion, substrate type and quality, instream cover, and characteristics of channel morphology, stability, and development.

Monitoring Data

Water samples were collected and analyzed by several different public and private entities throughout Minnesota. This monitoring data is entered into the MPCAs eQuiS database and is used for a variety of purposes, including SID. There are two main types of monitoring data collected in the Minnesota River Headwaters:

Grab Samples

Water samples are collected and sent to a laboratory for analysis. Labs can test for a variety of different parameters and pollutants, such as total phosphorus (TP), total suspended solids (TSS), nitrate-nitrite, Chlorophyll-*a* (Chl-*a*), and many others. Results are usually given in the form of a concentration of total pollutant per unit of water.

Field Measurements

Temperature, specific conductance, DO and pH measurements are recorded with a field meter using point measurements. These measurements indicate the concentration/value at the time of the reading and are usually taken while collecting grab samples. Measurements are typically taken using an YSI Sonde field meter or some equivalent meter.

Diurnal Measurements

Under eutrophic conditions, excessive algae growth during the day produces relatively high concentrations of oxygen and can actually supersaturates the water. Overnight, as photosynthesis stops producing oxygen and bacteria consumes the dead algae, oxygen levels can drop significantly below 5 mg/L. Field meters are deployed for weeks at a time and usually record field measurements every 15 minutes. This allows overnight DO levels to be monitored in order to assess the amount of diurnal DO flux, or the difference between the highest and lowest DO levels in a cycle of approximately a 24- hour period, which recurs every 24 hours.

1.5   Stressors, Biological Metrics, and Tolerance Values

The elements of a healthy stream consist of five main components: stream connections, hydrology, stream channel assessment, water chemistry, and stream biology (Figure 3). The following flowchart shows the five components of a healthy stream. If one or more of the components are unbalanced, the stream ecosystem fails to function properly and may be listed as an impaired waterbody. These dynamics are important to understand when going through SID evaluation.

Common stressors to biological communities are specific aspects within one of the five stream elements. The stressors and biological metrics that are examined in this report are listed and explained below (MPCA 2017c). Metrics are based on ecological traits of species and represent different aspects of ecological structure and function.

Hydrologic Alteration

Hydrologic alteration describes any type of change to the way water moves within a watershed. Many types of alterations have occurred in the past and continue today; including channel alteration, rerouting and ditching of streams, water withdrawals, land cover alteration, subsurface tile drainage, and impoundments or dams. Hydrologic Alteration and its follow-on effects of channel instability, bank erosion, excess sediment, and destruction or reduced habitat are all possible stressors.

The Elements of Stream Health
Stream Health is linked to the 5 main categories below. The MPCA and local partners examine many interrelated factors to identify stressors

Stream Connections
Examples: dams, culverts and drainage tiles

Hydrology
Examples: stream flow and runoff

Stream Channel Assessment
Example: Bank erosion and Channel Stability

Water Chemistry
Example: Dissolved oxygen, nutrients and temperature

Stream Biology
Example: fish and macroinvertebrates

Figure 3. The five components of stream health and conditions that stress streams

Changes in landscape vegetation, pavement, and drainage can increase how fast rainfall runoff reaches stream channels. This creates a stronger pulse of flow, followed later by decreased baseflow levels. According to the authors of a review on flow effects (Poff 1997), "Streamflow quantity and timing are critical components of water supply, water quality, and the ecological integrity of river systems. Indeed, streamflow, which is strongly correlated with many critical physicochemical characteristics of rivers, such as water temperature, channel geomorphology, and habitat diversity, can be considered a 'master

variable'…" Increasing surface water runoff and seasonal variability in stream flows have the potential for both indirect and direct effects on fish populations (Schlosser 1990).

The inverse effect to an increase of stream flow with artificial subsurface drainage and trapezoidal ditches is seen in the reduction of base flow conditions during periods of low precipitation. Within this watershed, there are times where base flows within upland tributaries drastically drop and dry up later in the summer. (Carlisle et al 2011) found a strong correlation between diminished streamflow and impaired biological communities. Numerous studies have found conventional trapezoidal ditches to be inferior to natural streams in terms of sediment transport capacity and channel stability over time (Urban and Rhoads 2004; Landwehr and Roads 2003). Conventional ditches are designed to handle low frequency, high-magnitude flood events. This design may not support adequate water depth and velocities for transporting sediment and maintaining stream features (e.g., glide, riffle, run, pool) during low to moderate flow periods. The common result is excess sedimentation of the stream bed as particles become immobile and aggrade over time. In general, this design does not provide good habitat for aquatic species or provide stability of its streambed and stream banks.

Habitat availability can be scarce when flows are interrupted, low for a prolonged duration, or extremely low, leading to decreased wetted width, cross sectional area, and water depth. Flows that are reduced beyond normal baseflow decrease living space for aquatic organisms and competition for resources increases.

Pollutant concentrations can increase when flows are lower than normal, increasing the exposure dosage to organisms. Tolerant organisms can out-compete others in such limiting situations and will thrive. Low flows of prolonged duration lead to macroinvertebrate and fish communities comprised of generalist species or that have preference for standing water (EPA 2012). Drainage of wetlands within the Minnesota Headwaters Watershed has increased the speed that water moves within the watershed. This has the effect of reducing water storage and the amount of water available during times of low precipitation, lowering groundwater tables, and reducing near channel storage that otherwise sustains lateral drainage during dry periods (Blann et al. 2009). Wetlands tend to slow water down and store it on the landscape, metering out the water over time.

Table 2. Hydrologic alteration related fish metric descriptions

Fish Metric	Metric Description	Response to Hydrologic Alteration Stress
General %	Generalized fish species are correlated with channelization and are adaptable to different habitats through generalized food preferences. Trophic generalists are able to utilize multiple food resources (e.g. macrophytes, plankton, detritus). They are more tolerant of degradation than trophic specialists, because they can survive even if sensitive food resources (e.g. benthic invertebrates) are reduced or eliminated, by switching to other, less sensitive, food resources.	Increase
Nesting Non Lithophilic Spawner %	Relative abundance of nonLithophilic, nest-guarding individuals. The numbers of nest guarder species are positively correlated with low flow conditions. Nonlithophilic nest-builders include species that build and spawn in or over nests constructed from materials other than coarse substrate. Because these species invest time and energy in preparing nests, and frequently also invest time and energy in guarding the nests and/or caring for their eggs and offspring, they	Increase

Fish Metric	Metric Description	Response to Hydrologic Alteration Stress
	experience an advantage in degraded habitats and other stressful environmental conditions.	

Table 3. Hydrologic alteration related invertebrate metric descriptions

Invertebrate Metric	Metric Description	Response to Hydrologic Alteration Stress
Clinger %	Relative abundance (%) of clinger invertebrates. High flows and the associated increased flow velocities can displace macroinvertebrates downstream, and move habitat features like woody debris out of the stream. Woody debris and other habitat features are important as living surfaces for clinging invertebrates.	Decrease
Collector – filterer %	Relative abundance (%) of collector filterer. The number of collector – filterer taxa represents the number of different taxa that collect their food by filtering it out of the water column. The filtering is typically done one of two ways: 1) by using physical adaptation such as a filamentous antennal structure or 2) by constructing a net that filters the water, gathering filtered material from the net. Collector filterer macroinvertebrates that filter food particles from the water column have shown negative responses to low flows.	Decrease
Long – lived %	Macroinvertebrate types may shift from those species having long life cycles to shorter ones, because these species can complete their life cycle within the bounds of the recurrence interval of the elevated flow conditions	Decrease

Connectivity

Connectivity in river ecosystems generally refers to how water features are linked to each other on the landscape or how locations within a stream are connected. Connectivity also pertains to locations adjacent to a stream, such as a stream's connectivity to its floodplain. These different types of connectivity affect biology differently, do not often produce the same effects, and often times are linked to other stressors like habitat

In Minnesota, there are more than 800 dams on streams and rivers for a variety of purposes. Dams usually directly block seasonal fish migration for reproduction and overwintering. Stream channel road crossings also have the potential to become physical barriers to fish movement. Crossings can either be culverts (metal corrugated tubes or concrete boxes) or bridges. The crossings can become barriers when they are not installed properly, either due to incorrect sizing for the stream or put at the wrong elevation and/or slope. Bridges generally don't become barriers because they are wider and the channel can naturally adjust. Culverts are more likely will become a migration barrier if not engineered or installed properly. If culverts are too small, the passing water will increase in velocity. The velocity can become too fast for smaller fish species to move through (Warren and Pardew 1998). Improper slope of the culvert will also lead to high velocity. If culverts are installed at an incorrect elevation, they can be "perched" at the outlet end, meaning the base of the culvert is above the water level of the stream. Minnesota's native fish species are not capable of doing the leaping and surging required for migrating through these situations in the way that salmon, for instance, can navigate ledges in streams. The

denser the road network, and the older the crossing constructions, the more opportunity there is for barriers to be found. Disrupted migration not only alters reproduction of fish; it also impacts mussel species that utilize fish movement to disperse their offspring. Structures, such as dams, have been shown to reduce species richness of systems, while also increasing the abundance of tolerant or undesirable species (Winston 1991), (Santucci V.A. 2005).

Table 4. Connectivity related fish metric descriptions

Fish Metric	Metric / Tolerance Metric Description	Response to Connectivity Stress
Mature Age >3 minus Tolerant Taxa %	Relative abundance (%) of species with a female mature age >=3, excluding tolerant species. Late maturity is a trait adaptive to stable, well-connected environments that allow these species to access the habitats and resources necessary for their life history requirements, over many years of growth and development. Stable environmental conditions are typically associated with minimal human disturbance. Therefore, the presence of large numbers of late-maturing species and/or individuals is an indication of a high quality resource.	Decrease
Migrating Taxa %	Relative abundance (%) of migratory species.	Decrease

Habitat

Habitat is a broad term encompassing all aspects of the physical, chemical, and biological conditions needed to support a biological community. This section will focus on the physical habitat structure including geomorphic characteristics and vegetative features (Griffith, Rashleigh, & Schofield 2010). Excess fine sediment deposition on benthic habitat has been proven to adversely impact fish and macroinvertebrate species that depend on clean, coarse stream substrates for feeding, refuge, and/or reproduction (Newcombe & MacDonald 1991). Specific habitats needed by a healthy biotic community can be minimized or altered by practices on the landscape by way of resource extraction, agriculture, forestry, urbanization, and industry. These landscape alterations can lead to reduced habitat availability, such as decreased riffle habitat, reduced habitat quality, and embedded gravel substrates. Biotic population changes can result from decreases in availability or quality of habitat by way of altered behavior, increased mortality, or decreased reproductive success (Griffith, Rashleigh, & Schofield 2010).

Schlosser (1982) compared the trophic structure, reproductive success, and growth rate in fishes from a natural and modified (ditched) stream in central Illinois. The study found that the ditched stream experienced a loss of pool habitat, increased organic substrates, and a shift in trophic structure to omnivores and herbivores instead of insectivores and piscivores. In a study conducted in the east-central Indiana cornbelt region, Lau et al (2006) found that channelized streams had lower quality fish assemblages when compared to natural streams, and that a reduction in riffle and pool habitats associated with channelization was the most significant factor affecting the fish assemblage. Fish communities are typically influenced through a reduction in spawning habitat or egg survival (Chapman 1988) and a reduction in prey items as a result of decreases in primary production and benthic productivity (Bruton 1985; Gray and Ward 1982).

Table 5. Habitat related fish metric descriptions

Fish Metric	Metric Description	Response to Habitat Stress
Benthic Insect minus Tolerant %	Relative abundance (%) of benthic insectivore individuals (excludes tolerant species). Benthic insectivore and invertivore species rely on undisturbed benthic habitats to feed and reproduce. Many benthic invertivores require clean coarse substrates and an ample supply of aquatic macrophytes or woody debris for cover. Benthic insectivore species occupied the same type of niche as darters. This allows a greater degree of sensitivity in evaluating streams that naturally had few darter species. An increase in benthic insectivore species was correlated with increased biotic integrity.	Decrease
Darter Sculpin Sucker %	Relative abundance (%) of darter, sculpin, and round-bodied sucker individuals. Darters and sculpins are commonly found in riffle habitats, and are considered sensitive to water quality degradation. Darters and sculpins are generally found in higher quality streams. These species are benthic insectivores; they rely on undisturbed benthic habitats to feed and reproduce. The degradation of benthic habitats will cause the species to decline. Because darters and sculpins require clean coarse substrate materials in order to thrive, they tend to disappear in streams that have been affected by siltation or channelization.	Decrease
Lithophilic Spawner %	Relative abundance (%) of lithophilic individuals. This metric uses species that have both guarding and nonguarding spawning behavior that require clean gravel or cobble for success. This metric detects changes in environmental disturbance, particularly siltation.	Decrease
Pioneer %	Relative abundance (%) of pioneer individuals. Pioneer species tend to colonize disturbed and degraded habitats.	Increase
Piscivore %	Relative abundance (%) of piscivorous individuals. The presence of a viable piscivore population indicates a healthy, trophically diverse fish community.	Decrease
Riffle %	Relative abundance (%) of individuals that predominately utilize riffle habitats. Riffle species are those that require riffle habitat as part of their life history either for feeding, reproduction, or both. Sedimentation can decrease this type of habitat thereby negatively impacting these species.	Decrease
Simple Lithophilic Spawner %	Relative abundance (%) of simple lithophilic individuals. This metric uses species that have simple, nonguarding spawning behavior that require clean gravel or cobble for success. This metric detects changes in environmental disturbance, particularly siltation.	Decrease
Tolerant %	Relative abundance (%) of tolerant individuals. Tolerant species are those that are known to persist in poor quality streams. They may become the dominant component in streams that have been chemically or physically altered.	Increase

Table 6. Habitat related invertebrate metric descriptions

Invert Metric	Metric Description	Response to Habitat Stress
Burrower %	Relative abundance (%) of burrowers in subsample. Burrowers "Burrow" into fine sediments or tunnel into plant stems, leaves or roots. Many chironomid midges (Diptera: Chironomidae) and segmented worms (Oligochaeta) are burrowers.	Increase
Climber %	Relative abundance (%) of climbers in subsample, climbers "Climb" up the stems and leaves of submerged plants, roots and woody debris.	Decrease
Clinger %	Relative abundance (%) of clingers in subsample. "Clinger" macroinvertebrate taxa have adaptations for attachment to surfaces in stream riffles. They typically dwell in swift water and attach themselves to the surfaces of coarse substrates or woody debris. They are particularly dependent on the interstitial spaces created by gaps in overlapping coarse material (large gravels, cobbles, boulders, etc.).	Decrease
Ephemeroptera Plecoptera Trichoptera %	Relative abundance (%) of Ephemeroptera, Plecoptera & Trichoptera individuals in subsample. Ephemeroptera, or mayflies, are benthic invertebrates that are sensitive to environmental disturbance. They occupy a variety of habitats including interstitial spaces between rocks, rock surfaces, sediment, and aquatic vegetation.	Decrease
Legless %	Relative abundance (%) of legless individuals in subsample. Legless species are tolerant of degraded habitat conditions.	Increase
Sprawler %	Relative abundance (%) of sprawler individuals in subsample. Sprawlers inhabit surfaces of floating leaves or on the surface of fine sediments.	Decrease

Dissolved Oxygen

DO refers to the concentration of oxygen gas within the water column. Adequate DO is important to growth and reproduction of aquatic life. Oxygen diffuses into water from the atmosphere (turbulent flow enhances this diffusion) and from the release of oxygen by aquatic plants during photosynthesis.

If DO concentrations become limited or fluctuate dramatically, aerobic aquatic life can experience reduced growth or fatality (Allan 1995). Low DO, or highly fluctuating concentrations of DO can have detrimental effects on many fish and macroinvertebrate species (Davis 1975) (Nebeker 1991). Fish and invertebrates require oxygen for respiration. Many species of fish avoid areas where DO concentrations are below 5 mg/L (Raleigh 1986). Additionally, fish growth rates can be significantly affected by low DO levels (Doudoroff and Warren 1965).

In most streams and rivers, the critical seasonal conditions for stream DO usually occur during late summer when water temperatures are at or near the annual high while stream flow volumes and rates are near base flow. The critical daily period for DO is early morning, when the daily DO flux is at its minimum. Human activities can alter many of these driving factors and change the DO concentrations of water resources. Increased nutrient content of surface waters is a common human influence, which can result in excess aquatic plant growth. This situation often leads to a decline in daily minimum oxygen concentrations and an increase in the magnitude of daily DO concentration fluctuations due to the decay of the excess organic material, increased usage of oxygen by plants at night, and their greater oxygen production during the daytime. Humans may directly add organic material by municipal or

industrial effluents. These forms of pollution increase the risk of eutrophication, which can also lead to low DO.

Table 7. Dissolved oxygen related fish metric descriptions

Fish Metric	Metric Description	Response to Low Dissolved Oxygen Stress
DO Sensitive %	Relative abundance (%) of individuals that are sensitive to dissolved oxygen stress	Decrease
Mature Age >3 %	Relative abundance (%) of species with a female mature age > 3 years excluding tolerant species. Late maturity is a trait adaptive to stable, well-connected environments that allow these species to access the habitats and resources necessary for their life history requirements, over many years of growth and development. Stable environmental conditions are typically associated with minimal human disturbance. Therefore, the presence of large numbers of late-maturing species and/or individuals is an indication of a high quality resource.	Decrease
Serial Spawner %	Relative abundance (%) of serial spawning individuals. Serial spawning fish spawn multiple times a year and are more prevalent in streams with low dissolved oxygen conditions.	Increase
Taxa Count	Total taxa richness of fish. The total number of species declines as environmental degradation increases. Hybrids, subspecies and exotics are not included in this metric.	Decrease
DO Index Score	Dissolved Oxygen Tolerance Index Value.	Decrease
DO Tolerant %	Relative abundance (%) of individuals that are tolerant to dissolved oxygen stress.	Increase

Table 8. Dissolved oxygen related invertebrate metric descriptions

Invert Metric	Metric Description	Response to Low Dissolved Oxygen Stress
Low DO Intolerant Taxa %	Relative abundance (%) of dissolved oxygen intolerant taxa.	Decrease
Low DO Tolerant Taxa %	Relative abundance (%) of dissolved oxygen tolerant taxa.	Increase
DO TIV	Dissolved Oxygen Tolerance Index Value.	Decrease
HBI_MN	A measure of pollution based on tolerance values assigned to each individual taxon developed by Chirhart.	Increase

Eutrophication

Phosphorus (P), an important plant nutrient, is typically in short supply in natural systems, but human activity on the landscape often exports phosphorus to waterways, which can impact stream organisms. Phosphorus exists in several forms, with the soluble form, orthophosphorus, readily available for plant and algal uptake. While phosphorus itself is not toxic to aquatic organisms, it can have detrimental effects via other associated chemistry when levels are elevated above natural concentrations. Increased nutrients can cause excessive aquatic plant and algal growth (eutrophication), which alters physical

habitat, food resources, and oxygen levels in streams. Excess plant growth increases DO during daylight hours and saps oxygen from the water during the nighttime. As plant material dies, bacterial decomposition lowers DO through absorption. Streams dominated with submerged macrophytes experience the largest swings in DO and pH (Wilcox R. a. 2001). Suspended algae in the water column (often measured as Chl-*a*) also produce these effects. In some cases, oxygen production leads to extremely high levels of oxygen in the water (supersaturation), which can cause gas bubble disease in fish. The wide daily fluctuations in DO caused by excess plant growth and algae are also correlated to degradation of aquatic communities (Heiskary 2013).

Determining the type of suspended material within a stream (mineral vs organic) is important for proper conclusions about the stressor and source (erosion vs. nutrient enrichment vs. a wastewater discharge). Elevated total suspended volatile solids (TSVS) concentrations can impact aquatic life in a similar manner as suspended sediment, with the suspended particles reducing water clarity. Unusually high concentrations of TSVS can indicate excess nutrients (causing algal growth) and an unstable DO regime.

Table 9. Eutrophication related fish metric descriptions

Fish Metric	Metric Description	Response to Eutrophication Stress
Darter %	Relative abundance (%) of darter individuals. Many darters are considered sensitive to water quality degradation. They require clean coarse substrate material in order to thrive, and tend to disappear in stream affected by siltation, channelization, and eutrophication.	Decrease
Omnivore %	Relative abundance (%) of omnivorous individuals. Omnivores have the ability to utilize multiple food sources allows omnivore species to switch to another food source when one is depleted.	Increase
Sensitive %	Relative abundance (%) of sensitive individuals. An absence of sensitive species indicated an anthropogenic stress or loss of habitat. This metric distinguished between streams of the highest quality.	Decrease
Simple Lithophilic Spawner %	Relative abundance (%) of simple lithophilic individuals. Relative abundance (%) of simple lithophilic individuals. This metric uses species that have simple spawning behavior that requires clean gravel or cobble for success. This metric detects changes in environmental disturbance, particularly siltation.	Decrease
Tolerant %	Relative abundance (%) of tolerant macroinvertebrate individuals in subsample. Tolerant species are those that are known to persist in poor quality streams. They may become the dominant component in streams that have been chemically or physically altered.	Increase

Table 10. Eutrophication related invertebrate metric descriptions

Invert Metric	Metric Description	Response to Eutrophication Stress
Crustacean and Mollusca %	Relative abundance (%) of crustacean and molluscan individuals in subsample	Increase

Invert Metric	Metric Description	Response to Eutrophication Stress
Collector – Gatherer Taxa #	Taxa richness of collector-gatherers. The number of collector-gatherer taxa represents the number of different taxa that collect their food by gathering it from the substrate.	Decrease
Ephemeroptera Plecoptera Trichoptera Taxa %	Relative abundance (%) of Ephemeroptera, Plecoptera & Trichoptera. Ephemeroptera, or mayflies, are benthic invertebrates that are sensitive to environmental disturbance. They occupy a variety of habitats including interstitial spaces between rocks, rock surfaces, sediment, and aquatic vegetation. Plecoptera, or stoneflies, are among the most sensitive indicator organisms. They occupy the interstitial spaces between rocks, woody debris, and vegetation, and require a relatively high amount of dissolved oxygen in order to survive. Trichoptera, or caddisflies, are a diverse group of benthic insects that are considered good indicators of environmental disturbance. As a group, they are somewhat more tolerant to pollution than mayflies, but in the presence of significant impairment they do not persist as a diverse community. Because of their ability to exploit a variety of habitats, their diversity is a good indicator of habitat quality. Their ability to thrive in lentic conditions makes them excellent indicators for use in slow moving streams as well.	Decrease
Intolerant 2 Taxa %	Relative abundance (%) of macroinvertebrates with tolerance values less than or equal to 2, using MN Tolerance Values.	Decrease
Scraper %		Increase
Taxa Count All #	Total taxa richness of macroinvertebrates. Taxa richness is considered a good indicator of environmental quality. In most types of aquatic ecosystems as environmental disturbance increases, taxa richness decreases.	Decrease
Tolerant 2 Taxa %	Relative abundance (%) of taxa with tolerance values equal to or greater than 6, using MN Tolerance Values.	Increase

Suspended Solids

Sediment and turbidity are among the leading pollutant issues affecting stream biological impairment in the United States (EPA 2012). Recent studies in Minnesota have demonstrated that human activities on the landscape have dramatically increased the sediment entering streams and rivers since European settlement (Triplet 2009) and (Engstrom 2009). Sediment can come from land surfaces such as exposed soil or from unstable streambanks. The soil may be unprotected for a variety of reasons, such as construction, mining, agriculture, or insufficiently-vegetated pastures. Human actions on the landscape, such as channelization of waterways, riparian land cover alteration, artificial drainage, and increased impervious surface area can cause stream bank instability leading to sediment input from bank sloughing. Fine sediment often gets deposited on the stream bottom and can cover and embed coarser sediment. Although sediment delivery and transport are an important natural process for all stream

systems, sediment imbalance (either excess suspended sediment or lack of sediment) can be detrimental to aquatic organisms. Organic particles, including algae, can also contribute to TSS.

Excess deposited/bedded fine sediment (DBS) upon benthic habitat has been proven to negatively impact fish and macroinvertebrate species that depend on clean, coarse stream substrates for feeding, refugia, and/or reproduction. Highly embedded coarse substrates reduce spawning habitat and interstitial spaces for the fish and macroinvertebrate taxa, which depend on these microhabitats.

Benthic insectivores are fish species that prey on insect life that occupy benthic (stream bottom) habitats. The abundance and richness of fish species with this trophic trait has been shown to decrease as the percentage of fine sediment increases (Berkman and Rabeni 1987).

Table 11. Suspended solids related fish metric descriptions

Fish	Metric Description	Response to Suspended Solids Stress
Benthic Feeder %	Relative abundance (%) of benthic feeding individuals. Relative abundance (%) of benthic insectivore individuals (excludes tolerant species). Benthic insectivore and invertivore species rely on undisturbed benthic habitats to feed and reproduce. Many benthic invertivores require clean coarse substrates and an ample supply of aquatic macrophytes or woody debris for cover. Benthic insectivore species occupied the same type of niche as darters. This allows a greater degree of sensitivity in evaluating streams that naturally had few darter species. An increase in benthic insectivore species was correlated with increased biotic integrity.	**Decrease**
Centrarchid - Tolerant %	Relative abundance (%) of Centrarchid individuals (excludes tolerant species). These species are sight feeders that can be negatively impacted by increased suspended solids.	**Decrease**
Herbivore %	Relative abundance (%) of herbivorous individuals. Fish species that utilize vegetation. These species are negatively impacted by the loss of vegetation, which can be caused by sedimentation and hydromodification.	**Increase**
Long – lived %	Relative abundance (%) of long – lived individuals. Long lived species typically have long life histories and as a result require more time to recover from disturbance.	**Decrease**
Perciformes - Tolerant %	Relative abundance (%) of Perciformid individuals (excludes tolerant species). Fish species in the family Percidae includes walleye, perch, and darters. Species classified as tolerant are not included in this metric.	**Decrease**
Riffle %	Relative abundance (%) of individuals that predominately utilize riffle habitats. Riffle species are those that require riffle habitat as part of their life history either for feeding, reproduction, or both. Sedimentation can decrease this type of habitat thereby negatively impacting these species.	**Decrease**
Simple Lithophilic Spawner %	Relative abundance (%) of simple lithophilic individuals. Relative abundance (%) of simple lithophilic individuals. This metric uses species that have simple spawning behavior that requires clean gravel or cobble for success. This metric detects changes in environmental disturbance, particularly siltation.	**Decrease**
TSS TIV	Total Suspended Solids Tolerance Index Value.	**Increase**

Table 12. Suspended solids related invertebrate metric descriptions

Invert	Metric Description	Response to Suspended Solids Stress
Collector – filterer %	Relative abundance (%) of collector – filterer individuals in subsample.	Decrease
Plecoptera %	Relative abundance (%) of Plecoptera individuals in subsample. Plecoptera, or stoneflies, are among the most sensitive indicator organisms. They occupy the interstitial spaces between rocks, woody debris, and vegetation, and as such, are sensitive to sedimentation.	Decrease
TSS Intolerant %	Relative abundance (%) of taxa intolerant suspended solids.	Decrease
TSS Tolerant %	Relative abundance (%) of taxa tolerant suspended solids.	Increase
TSS TIV	Total Suspended Solids Tolerance Index Value.	Increase

Nitrates

Nitrate (NO3) and nitrite (NO2) are components of the natural nitrogen cycle in aquatic ecosystems. NO2 anions are naturally present in soil and water, and are readily converted to NO3 by microorganisms as part of the nitrification process of the nitrogen cycle. As a result, nitrate is far more abundant than nitrite. Although the water test commonly used measures both nitrate and nitrite, because a large percentage is nitrate, this report will refer to these data as being nitrate. Nitrate is commonly applied as a crop fertilizer. Nitrate transport pathways can be different depending on the geology and hydrology of the watershed. When water moves quickly through the soil profile, as in the case of watersheds with karst geology or in heavily tiled watersheds, nitrate transport can become significant. Apart from its function as a biological nutrient, some levels of nitrate can become toxic to organisms. Nitrate toxicity depends on concentration and exposure time, as well as the sensitivity of the individual organisms. The intake of nitrate by aquatic organisms converts oxygen carrying pigments into forms that are unable to carry oxygen, thus inducing a toxic effect on fish and macroinvertebrates (Grabda et al 1974). Certain species of caddisflies, amphipods, and salmonid fishes seem to be the most sensitive to nitrate toxicity according to Camargo and Alonso (2006), who cited a maximum level of 2.0 mg/L nitrate N as appropriate for protecting the most sensitive freshwater species and nitrate-N concentrations under 10.0 mg/L to protect several other sensitive fish and aquatic invertebrate taxa.

Table 13. Nitrate related invertebrate metric descriptions

Invert	Metric Description	Response to Nitrate Stress
Nitrate Intolerant Taxa %	Relative abundance (%) of nitrate intolerant species.	Decrease
Nitrate Tolerant Taxa %	Relative abundance (%) of nitrate tolerant species.	Increase
Trichoptera Taxa %	Relative percentage of taxa belonging to Trichoptera.	Decrease
Nitrogen TIV	Nitrogen Tolerance Index Value.	Increase

Chloride

Specific conductance refers to the collective amount of ions in the water. In general, the higher the level of dissolved minerals in a volume of water, the more electrical current (or conductance) can be transmitted through that water. Aquatic organisms maintain a careful water and ion balance, and can become stressed by an increase in ion concentrations (SETAC 2004). Calcium, sodium, and magnesium are all necessary for aquatic health, and occur naturally, but imbalances can be toxic (SETAC 2004). As salinity increases, macroinvertebrate taxa richness and Ephemeroptera richness have been found to decrease (Piscart et al. 2005). Echols et al. (2009) also found a reduction in EPT (ephemeroptera, plecoptera, trichoptera) abundance as ionic strength values increased.

Elevated conductivity may be caused by multiple ions, including elevated chloride. Therefore, it can serve as a surrogate or indicator for issues such as chloride. The negative effects of elevated chloride concentrations on aquatic life have been well documented. The use of road salt and de-icing products has increased considerably in the United States since 1950, putting more urban streams at risk for this stressor (Kostick 1993).

The Redwood River has historically had high levels of chloride, especially in the reach that flows through the city of Marshall. Both household water softeners and applied road salt are thought to contribute to the high levels of chloride in the water body. There is also a corn processing plant that discharges effluent into the river just downstream of the city. The City of Marshall has tried to reduce chloride entering the river through several initiatives, including a city wide water softener system that would eliminate the need for individual water softeners and would allow for more control over the amount and timing of chloride entering the river. Recent chloride testing has shown a reduction in chloride concentrations. Reach 07020006-502 flows through and ends downstream of Marshall. Chloride/conductivity was assessed at this reach as the effects of high chloride levels would be the most prevalent in this reach.

Table 14. Chloride related fish metric descriptions

Invert Metric	Metric Description	Response to Chloride Stress
Centrarchidae - (Sunfish) %	Relative abundance (%) of fish in the family Centrarchidae, which includes sunfish	
Centrarchidae - (Sunfish) Taxa %	Relative abundance (%) of fish taxa in the family Centrarchidae, which includes sunfish	
Conductivity Intolerant %	Relative abundance (%) of different types of conductivity intolerant individuals.	Decrease
Conductivity Tolerant %	Relative abundance (%) of different types of conductivity tolerant individuals.	Increase
Conductivity Intolerant Taxa %	Relative abundance (%) of different types of conductivity intolerant taxa.	Decrease
Conductivity Tolerant Taxa %	Relative abundance (%) of different types of conductivity tolerant taxa.	Increase

Table 15. Chloride related invertebrate metric descriptions

Invert Metric	Metric Description	Response to Chloride Stress
Ephemeroptera %	Relative abundance (%) of Ephemeroptera individuals	**Decrease**
Conductivity TIV Score	Tolerance Index Value score based upon the individual invertebrates tolerance score and its relative abundance at the bio site.	**Increase**
Conductivity Tolerant Taxa %	Relative abundance (%) of different types of conductivity tolerant taxa.	**Increase**
Conductivity Intolerant Taxa %	Relative abundance (%) of different types of conductivity intolerant taxa.	**Decrease**

2 Watershed Description
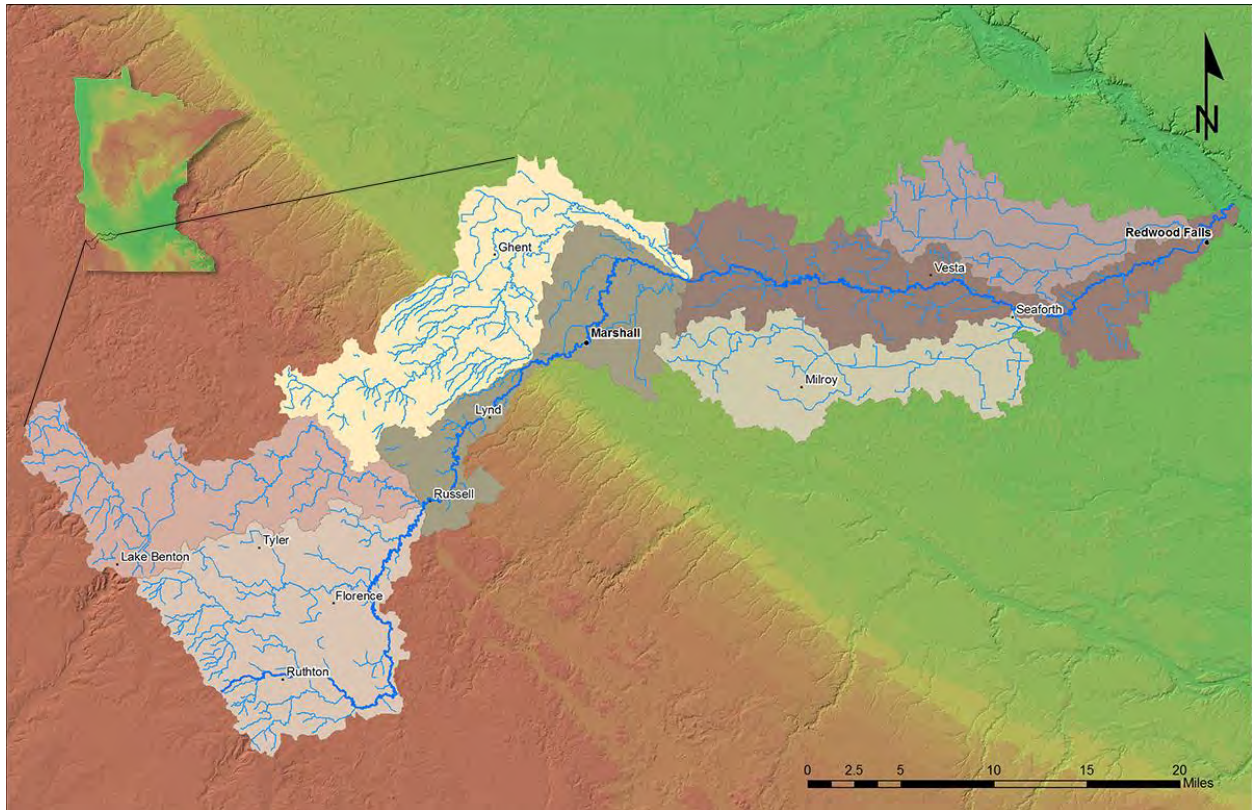
Figure 4. Map of the Redwood River Watershed boundaries.

The headwaters of the Redwood River Watershed lie upon the Coteau des Prairie, where the river itself originates near Ruthton, Minnesota. As the river flows across the landscape it drops roughly 300 feet in elevation over approximately 15 miles between Russell and Marshall, Minnesota. The abrupt change in elevation is due to the landscape left behind by the Des Moines Lobe advance of the Wisconsin glacial period roughly 14,000 years B.P. At Marshall, the river is characterized as being nearly level to gently sloping, where the gradient of the river is only two to three feet per mile. The Redwood River continues to flow in a northeasterly direction as it advances across the landscape once flattened by glacial advance. As the river approaches the Minnesota River Valley, and the city of Redwood Falls, the Redwood River descends an additional 100 feet over the course of approximately one mile; cascading over granite ledges within Alexander Ramsey Park (DNR 2020).

3 Biological Impaired Reaches and Stressors

Figure 5. Map of biological impairments identified in the Redwood River Watershed
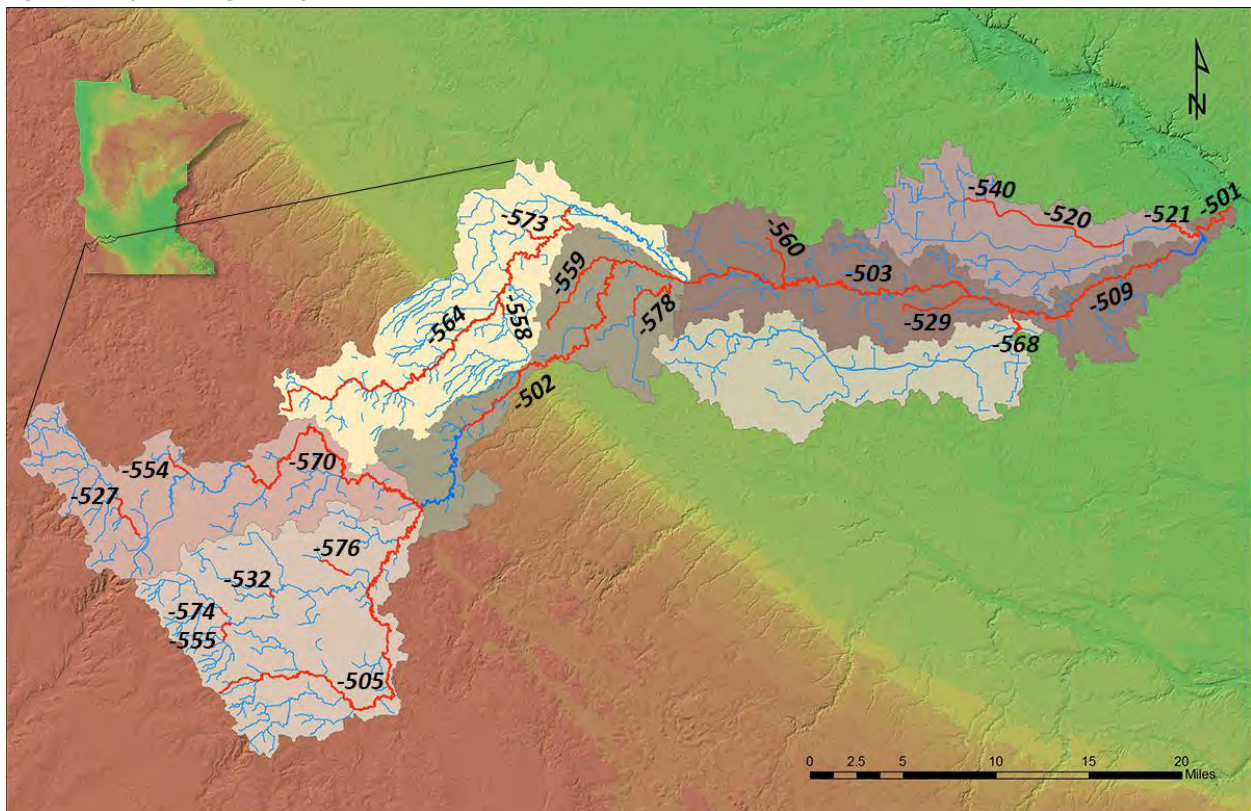
Table 16. Summary of biological impairments and stressors identified in this report

✓ = Stressor ✗ = Not a Stressor O = Inconclusive	Hydrologic Alteration	Connectivity	Habitat	Dissolved Oxygen	Eutrophication	Suspended Solids	Nitrate
07020006-505	✓	✗	✓	O	✓	✓	O
07020006-576	✓	O	✓	O	O	O	✓
07020006-555	✓	O	✓	O	O	O	O
07020006-574	✓	O	✓	O	O	O	✓
07020006-532	✓	✗	✓	O	O	O	✓
07020006-527	✓	✓	✓	O	O	O	O
07020006-554	✓	O	✓	O	O	O	✓
07020006-570	✓	O	✓	O	✓	✓	O
07020006-564	✓	✗	✓	O	O	O	O

✓ = Stressor ✗ = Not a Stressor O = Inconclusive	Hydrologic Alteration	Connectivity	Habitat	Dissolved Oxygen	Eutrophication	Suspended Solids	Nitrate
07020006-558	✓	O	✓	O	O	O	O
07020006-573	✓	✗	✗	O	✓	O	✓
07020006-502	✓	O	✓	O	✓	✓	✓
07020006-559	✓	✓	✓	✓	✓	O	O
07020006-578	✓	O	O	O	✓	O	O
07020006-503	✓	✗	✓	O	✓	✓	✓
07020006-560	✓	✓	O	✓	✓	O	✓
07020006-529	✓	✓	✓	✓	O	O	✓
07020006-509	O	O	O	O	O	✓	✓
07020006-501	O	✗	O	✗	O	✓	O
07020006-568	✗	✗	✗	O	✓	✓	✓
07020006-540	✓	✓	✓	O	✓	✓	✓
07020006-520	O	✓	✓	O	✓	O	✓
07020006-521	✗	✓	O	✗	O	O	✓

3.1 Redwood River Headwaters

3.1.1 07020006-505 Redwood River
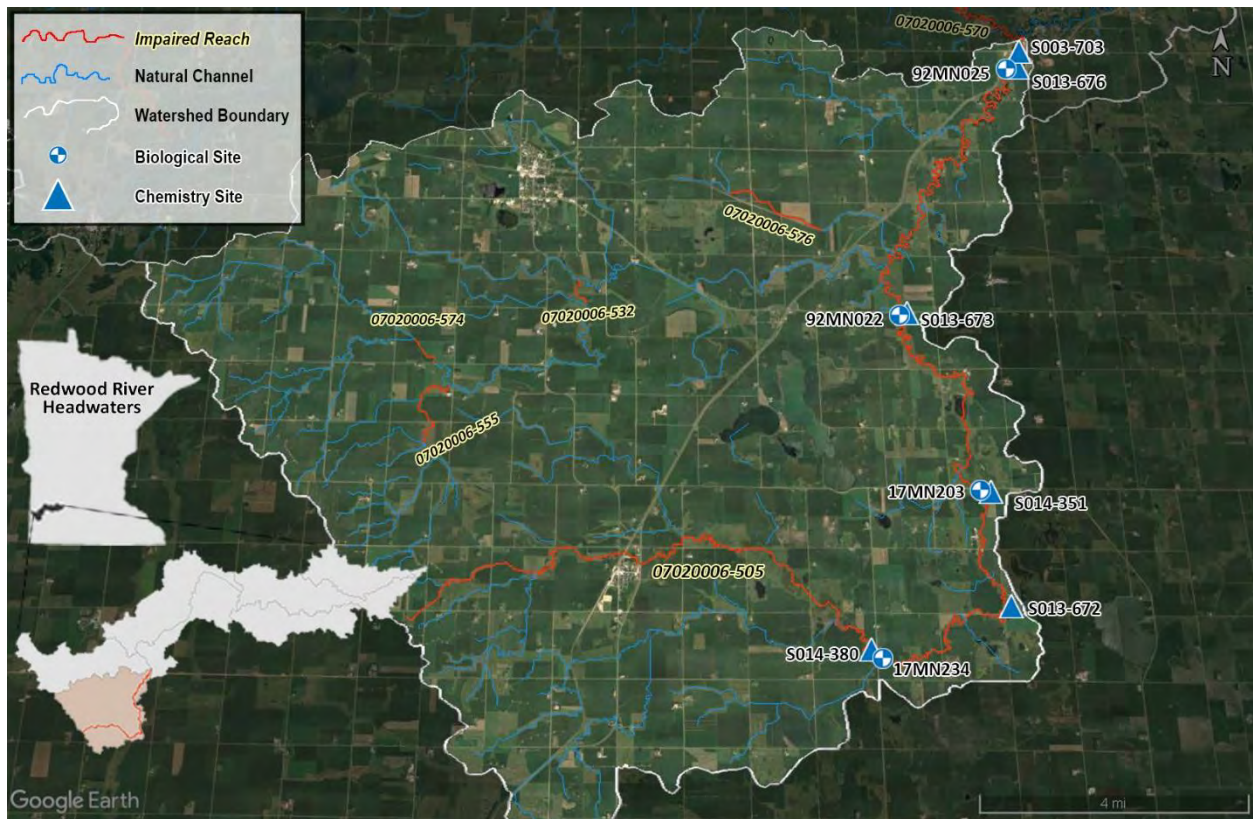
Figure 6. Satellite image of reach 07020006-505 and its watershed

3.1.1.1 Biological Community

Bio site 17MN234 was sampled once for fish in 2017. The Fish IBI (FIBI) score of 32.4 was below the Fish Class 7 General Use Low Gradient threshold of 42 (Table 17). Bio sites 17MN203, 92MN022 and 92MN025 had FIBI scores of 37.2, 58.2, 44.7, 44.1, and 69.2 compared to the Fish Class 2 General Use Southern Stream average of 50 (Table 18). At over 39 miles long reach 07020006-505 is diverse as it is more of a headwater stream in its upper watershed with characteristics of a wetland and transitions to a southern stream towards the middle and lower end of the reach. Because of this it is difficult to generalize the entire reach.

The furthest upstream bio site, 17MN234, was dominated by white suckers, a generalist feeding and tolerant species. The other most common fish were also other generalist feeding and tolerant species.

Bio site 17MN203 is classified as a Fish Class 2 Southern Stream and scored much better than site 17MN234. Overall there were many fish were caught at this station, with the most dominate species being the Iowa Darter, a fast maturing but sensitive species. There were some johnny darters caught as well.

Bio site 92MN022 is classified as a Fish Class 2 Southern Stream and was dominated by generalist feeding and tolerant species, though it did have both Iowa and Fantail Darters, both considered sensitive species.

Bio site 92MN025 is classified as a Fish Class 2 Southern Stream and was dominated by Central Stonerollers, a tolerant but also both a riffle dwelling and lithophilic fish. Common shiners and horny head chubs, both lithophilic spawners, were both prevalent as well.

Overall the fish biology in reach 07020006-505 is better than most biologically impaired streams as sensitive, lithophilic spawning, cold/cool water, and riffle dwelling species were prevalent throughout. The biology in the upstream section seems to be worse than the downstream section as the reach develops from a low gradient headwaters stream with wetland characteristics into a higher gradient stream with decent habitat, substrate, and cold water influences.

Biological Metric Data

Table 17. Fish IBI score and threshold for reach 07020006-505

07020006-505 **Fish Class 7** General Use	Fish IBI Score	Class Threshold Score
17MN234 9/19/2017	32.4	42

Table 18. Fish IBI score and threshold for reach 07020006-505

07020006-505 **Fish Class 2** General Use	Fish IBI Score	Class Threshold Score
17MN203 7/25/2017	37.2	
92MN022 6/27/2017	44.7	50
92MN025 6/28/2017	69.2	

Table 19. Invert IBI score and threshold for bio sites 17MN234 and 17MN203

07020006-505 **Invert Class 7** General Use	Invert IBI Score	Class Threshold Score
17MN234 8/01/2017	5.2	41
17MN203 8/01/2017	18.2	

Table 20. Invert IBI score and threshold for bio sites 92MN022 and 92MN025

07020006-505 **Invert Class 5** General Use	Invert IBI Score	Class Threshold Score
92MN022 08/03/2010	14.0	37
92MN022 08/01/2017	27.9	
92MN025 08/03/2010	16.7	
92MN025 08/03/2017	29.6	

3.1.1.2   Hydrologic Alteration

Hydrologic Alteration Biological Metric Data

Table 21. Hydrologic alteration related fish metrics for reach 07020006-505

07020006-505 **Fish Class 7** General Use	General %	Nesting Non Lithophilic Spawner %
17MN234 9/19/2017	75.6	10.5
Statewide average for Class 7 low gradient bio sites that are meeting the FIBI general use threshold (42.0)	**34.6**	**19.6**
Expected response to **Hydrologic** stress	↑	↑

Table 22. Hydrologic alteration related fish metrics for reach 07020006-505

07020006-505 **Fish Class 2** General Use	General %	Nesting Non Lithophilic Spawner %
17MN203 7/25/2017	36.7	14.8
92MN022 6/27/2017	66.4	28.1
92MN025 6/28/2017	52.2	16.2
Statewide average for Class 2 southern stream bio sites that are meeting the FIBI general use threshold (50.0)	**42.4**	**19.1**
Expected response to **Hydrologic** stress	↑	↑

Table 23. Hydrologic alteration related invert metrics for reach 07020006-505

07020006-505 **Invert Class 7** General Use	Clinger %	Collector – filterer %	Long – lived %	Percent Ditched Tolerant %	Percent Ditched Intolerant %
17MN234 8/01/2017	0	0	29.8	29.2	0.3
17MN203 8/01/2017	16.8	3.1	0.9	37.2	0.3
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI general use threshold (41)	**38.5**	**19.1**	**8.0**	↑	↓
Expected response to **Hydrologic** stress	↓	↓	↓		

07020006-505 Invert Class 5 General Use	Clinger %	Collector – filterer %	Long – lived %		Percent Ditched Tolerant %	Percent Ditched Intolerant %
92MN022 08/03/2010	17.9	11.6	3.3		17.2	0.0
92MN022 08/01/2017	41.3	27.0	4.0		21.4	4.0
92MN025 08/03/2010	5.0	4.0	1.0		1.7	9.3
92MN025 08/03/2017	65.0	40.1	5.5		1.2	26.4
Statewide average for Class 5 prairie stream rock riffle bio sites that are meeting the FIBI general use threshold (37)	**49.5**	**26.9**	**9.0**		↑	↓
Expected response to **Hydrologic** stress	↓	↓	↓			

HSPF Model Flow Data

Table 25. HSPF modeled flow data for reach 07020006-505

07020006-505 HSPF Reach 170 Min: 0.2 cfs Max: 4,003.8 cfs	<5 cfs % (# of values)	<1 cfs % (# of values)	<0.5 cfs % (# of values)
6,210 Total Daily Averages 1996 – 2012	**20.8%** (1,289)	**2.5%** (157)	**0.6%** (39)

Hydrologic Alteration Summary

The fish biological metrics for altered hydrology are mixed. Reach 07020006-505 is a relatively long reach and varies considerably from upstream to downstream. Overall there are fair numbers of generalist and low numbers of nesting species, though they were not an excessively high percentage of the total population of fish caught (Table 21) (Table 22). There were also good numbers of both Iowa and fantail darters, which are both sensitive species.

The invertebrate metrics for altered hydrology were generally worse. There were a good numbers of long – lived species in the upstream section of the reach, though these were crayfish, which are very tolerant. Some caddisfly clinger/collector filterers were observed at the two downstream sites, likely due to increased woody debris along the riparian corridor of the reach. The ratio of percent ditched tolerant to intolerant was good at downstream station 92MN025 compared to the other bio sites.

The HSPF model shows that more than 20% of the daily average flows from 1996 through 2012 are below 5 cfs. Only 2.5% of flows were below 1 cfs. Flows reduced beyond normal base flow will decrease habitat for aquatic organisms and increase competition for resources (Table 25).

17MN234

Figure 7. (Left) Photo of the stream channel of reach 07020006-505 flowing downward in the photo into the culverts under the road crossing just downstream from bio site 17MN234. (Right) Stream channel that has been straightened and ditched through a wetland.

Though bio site is 17MN234 is the furthest upstream bio site, it actually drains over 35 square miles of land in the headwaters area of the Redwood River. The stream reach in this area is being affected by hydrologic alteration in a number of ways. In this part of the reach habitat appears to be limiting the biology as the ditching of the stream channel itself has reduced habitat in those areas due to the lack of riffles, runs, pools, and other naturally forming features that these stream types typically possess. According to the DNR Redwood River Watershed geomorphology study, the channel is moderately incised and entrenched, likely a result of the channel alteration. The depth variability was also very poor and the only 'pools' present do not appear to be developing from a natural meander. The gradient around bio site 17MN234 is very low and the stream displays attributes more typical of a longitudinal wetland than a naturally meandering C or E channel (DNR 2020), likely the result of the fact that it appears that multiple wetlands were ditched through for drainage purposes.

92MN022

Figure 8. Two photos showing the stream channel near bio site 92MN022.

Bio site 92MN022 is located about halfway down reach 07020006-505. This section of the reach is quite a bit different than at 17MN234. According to the Redwood River Watershed Characteristic Report (DNR

2020) the reach here is classified as a B4c, which differs from just a B4 channel in that it has a lower slope of less than 2%. Even so the slope here is quite a bit greater than in the upstream section near bio site 17MN234. The topography and hills throughout this section have created large cut banks where erosion is occurring (Figure 8). The channel here appears to be in a 'poor unstable state of transition. Instability and evidence of channel widening was apparent by the numerous mid-channel bars, indicating a lack of sediment transport capacity." Altered hydrology appears to be causing changes to the stream channel. The channel appears to be being affected by increased drainage upstream. This drainage has decreased water storage upstream and moves water off of the landscape quickly. The channel appears to be changing due to increased flows, which in turn affects the geomorphological structures within the stream that formed within the stream and reduces habitat for both fish and invertebrates. Although the biology at this was better than in the upstream section and there were some sensitive species present, it was still mostly dominated by tolerant or very tolerant species. It is likely that the substrate itself, being mostly gravel, helps provide habitat for both invertebrates to live and for fish to spawn in, which is why they stream here can support a better biological community than it did upstream at bio site 17MN234.

92MN025

Figure 9. Photos near bio site 92MN025. The first photo shows a mid-channel island, which is indicative of a stream channel that is undergoing change (left). The right photo was taken mid stream and shows the incision ad lack of access to the floodplain in this section of the reach.

Bio site 92MN025 is the furthest downstream site within reach 07020006-505. This section of the reach flows through Camden State Park and continues until just upstream of the city of Marshall. Through the river segments surveyed, the channel transitions from an F4 to a B4c channel. "The change in channel type from an F4 to B4c is primarily due to the entrenchment ratio at the riffles within each of the longitudinal surveys (DNR 2020)". The small c indicates a lower than usual slope. This lower slope than what is typical for a B channel has resulted in a little more meander and is probably the reason why the channel has characteristics of an F channel as well as a B channel. B channels are typically caused by a combination of both a moderately steep sloping basin and a relatively narrow valley that limits both the meander and floodplain of the river. "Though B channel types are often regarded as a generally stable stream type, F channels are not. Channels classified as F channels are incised to the point they become entrenched. Incised and entrenched channels cannot access their floodplains during flood flows and therefore cannot relieve the shear stress within the channel. When flood flows are contained within F channels erosion rates are high and bank failures are common. Though portions of the channel were

classified as an F channel, habitat was generally decent throughout the reach. Shear stress created by slope and natural meander bends had carved out adequate pools that would remain roughly three feet or greater even in baseflows" (DNR 2020). Though the lower section of 07020006-505 has some limitations, it appears to have some good substrate and geomorphic features such as riffles, runs, and pools. The glacial deposits that the stream flows through is naturally susceptible to erosion and changes to the hydrology upstream appear to be causing some of the changes here in the downstream section. This is seen in the widening instability within the stream channel. The biological data at bio site 92MN025 is dominated by invert taxa that are sensitive to both altered hydrology as well habitat metrics, compared to the two upstream bio sites that were dominated by taxa that are considered tolerant to those metrics. The biology of this section of reach 07020006-505 appears to be less affected by hydrologic alteration when compared to upstream sections of the reach. Both the biological and geomorphic data show more diversity and habitat within this section of the reach than in the upstream section. The effect that hydrologic alteration is having in this section of the reach appears to be from the drainage upstream, which ultimately increases flows and flow peaks, and then tend to cause the stream to adjust its channel in response.

Based on the mostly poor scores of the biological metrics in the upper section of this reach, hydrologic alteration is a stressor. As the reach is over 39 miles long, altered hydrology affects the reach in different sections in different ways.

3.1.1.3   Connectivity

Connectivity Metric Data

Table 26. Connectivity related fish metrics for reach 07020006-505

07020006-505 Fish Class 7 General Use	Mature Age >3 minus Tolerant Taxa %	Migrating Taxa %
17MN234 9/19/2017	0	20
Statewide average for Class 7 low gradient bio sites that are meeting the FIBI general use threshold (42.0)	**9.9**	**12.8**
Expected response to **Connectivity** stress	↓	↓

Table 27. Connectivity related fish metrics for reach 07020006-505

07020006-505 Fish Class 2 General Use	Mature Age >3 minus Tolerant Taxa %	Migrating Taxa %
17MN203 7/25/2017	4.8	14.3
92MN022 6/27/2017	4.3	13.0
92MN025 6/28/2017	20.0	25.0
Statewide average for Class 2 southern stream bio sites that are meeting the FIBI general use threshold (50.0)	**21.8**	**24.3**
Expected response to **Connectivity** stress	↓	↓

Connectivity Summary

The fish biological metrics for connectivity are mixed. The furthest downstream reach, 92MN025, had some white suckers present, though late maturing fish were scarce throughout the reach. Migrating species were present throughout the entire reach. Due to the presence of migratory species it appears that connectivity is not a stressor throughout the reach.

3.1.1.4 Habitat

Habitat Metric Data

Table 28. Habitat related fish metrics for reach 07020006-505

07020006-505 Fish Class 7 General Use	Benthic Insect minus Tolerant %	Darter Sculpin Sucker %	Lithophilic Spawner %	Pioneer %	Piscivore %	Riffle %	Simple Lithophilic Spawner %	Tolerant %
17MN234 9/19/2017	3.5	3.5	66.3	17.4	2.3	37.2	51.2	80.2
Statewide average for Class 7 low gradient bio sites that are meeting the FIBI general use threshold (42.0)	**8.8**	**7.4**	**34.6**	**12.7**	**4.9**	**12.2**	**24.1**	**48.7**
Expected response to Habitat stress	↓	↓	↓	↑	↓	↓	↓	↑

Table 29. Habitat related fish metrics for reach 07020006-505

07020006-505 **Fish Class 2** General Use	Benthic Insect minus Tolerant %	Darter Sculpin Sucker %	Lithophilic Spawner %	Pioneer %	Piscivore %	Riffle %	Simple Lithophilic Spawner %	Tolerant %
17MN203 7/25/2017	28.5	28.4	34.9	17.7	0.4	22.3	21.9	63.0
92MN022 6/27/2017	9.0	7.3	53.4	28.0	0.2	26.7	39.0	65.3
92MN025 6/28/2017	33.5	33.0	59.5	18.4	3.9	46.4	49.7	43.9
Statewide average for Class 2 southern stream bio sites that are meeting the FIBI general use threshold (50.0)	**20.4**	**18.2**	**58.3**	**19.0**	**5.2**	**32.5**	**39.4**	**44.9**
Expected response to Habitat stress	↓	↓	↓	↑	↓	↓	↓	↑

Table 30. Habitat related invert metrics for reach 07020006-505

07020006-505 **Invert Class 7** General Use	Burrower %	Climber %	Clinger %	Ephemeroptera Plecoptera Trichontera %	Legless %	Sprawler %		MSHA Score Tolerant %	MSHA Score Intolerant %	Percent Embedded Tolerant %	Percent Embedded Intolerant %
17MN234 8/01/2017	11.6	21.9	0	10.0	29.8	63.2		78.4	0.0	47.4	0.0
17MN203 8/01/2017	15.6	53.6	16.8	5.9	88.2	12.5		78.9	0.0	69.0	0.0
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI general use threshold (41)	**7.5**	**21.6**	**38.5**	**38.5**	**39.8**	**20.9**		**24.0**	**2.7**	**24.4**	**2.2**
Expected response to **Habitat** stress	↑	↓	↓	↓	↑	↑		↑	↓	↑	↓

Table 31. Habitat related invert metrics for reach 07020006-505

07020006-505 Invert Class 5 General Use	Burrower %	Climber %	Clinger %	Ephemeroptera Plecoptera Trichoptera %	Legless %	Sprawler %	MSHA Score Tolerant %	MSHA Score Intolerant %	Percent Embedded Tolerant %	Percent Embedded Intolerant %
92MN022 08/01/2017	3.4	42.2	41.3	23.9	62.7	9.3	39.3	4.6	39.6	3.7
92MN025 08/03/2017	2.1	3.6	65.0	85.1	5.5	14.6	2.7	33.7	1.2	33.1
Statewide average for Class 5 prairie stream rock riffle bio sites that are meeting the FIBI general use threshold (37)	**7.5**	**14.7**	**49.5**	**43.9**	**36.0**	**16.8**	**14.1**	**13.4**	**14.6**	**11.2**
Expected response to **Habitat** stress	↑	↓	↓	↓	↑	↑	↑	↓	↑	↓

MPCA Stream Habitat Assessment Score

Table 32. Habitat Assessment score for reach 07020006-505

07020006-505	Land Use	Riparian	Substrate	Cover	Channel Morphology	Total Score
17MN234 8/01/2017	0	7	6	13	14	40
17MN234 9/19/2017	0	9	6	13	16	44
17MN203 7/25/2017	0	11	10	10	14	45
17MN203 8/01/2017	0	8	3	7	14	32
92MN022 8/17/2010	1	9	12.6	11	23	56.6
92MN022 6/27/2017	0	7	16.8	13	17	53.8
92MN022 8/01/2017	1.5	6	14.2	13	19	53.7
92MN025 9/01/2010	2.5	12	21.2	12	25	72.7
92MN025 6/28/2017	0	8	15.8	10	28	61.8
92MN025 8/03/2017	1	7.5	16.8	9	19	53.3
Maximum Attainable Habitat Score	**5**	**14**	**28**	**18**	**35**	**100**

Habitat Summary

The fish metrics related to habitat were mixed throughout reach 07020006-505. The metrics were mostly poor in the three upstream bio sites 17MN234, 17MN203, and 92MN022. The metrics were very good; however, at the furthest downstream site 92MN025 (Table 28 and Table 29). There were good numbers of benthic insectivores, Iowa, johnny, and fantail darters, caught at the three downstream bio sites. There were good numbers of central stonerollers, a riffle dwelling and lithophilic spawning fish, caught at bio sites 17MN203, 92MN022, and 92MN025.

Figure 10. Photo of the culvert at Bio site 17MN234 showing large amounts of dead algae covering the bottom of the stream.

Invert metrics related to habitat were also mixed throughout the reach, with the upper bio sites scoring worse than the downstream bio sites. Although the percentage of legless inverts was low at bio station 17MN234, this was mostly due to the site being dominated by crayfish. There were decent numbers of caenis diminuta, a fairly tolerant mayfly. Bio site 17MN203 was dominated by the snail genus physella as well as tolerant midges that brought up the climber percentage. Species considered tolerant to low MSHA scores and embeddedness of coarse substrate were high at the upstream sites and intolerant species were low (Table 30). Site 92MN022 also had a high climber percentage due to tolerant midges. Site 92MN025 scored well in all but climber metrics and had good population of caddisflies and mayflies. The site had low population of legless and sprawler inverts. There was also a low percentage of low MSHA score and embeddedness tolerant and high percentage of intolerant species (Table 31). The MSHA habitat scores also indicate better habitat the further downstream in the reach (Table 32).

Lack of habitat appears to be stressing the upstream section of reach 07020006-505, it becomes less of a stressor further downstream.

3.1.1.5   Dissolved Oxygen

Dissolved Oxygen Biological Metric Data

Table 33. Dissolved oxygen related fish metrics for reach 07020006-505

07020006-505 **Fish Class 7** **General Use**	Mature Age >3 %	Serial Spawner %	Taxa Count	DO TIV	DO Sensitive %	DO Tolerant %
17MN234 9/19/2017	37.2	5.8	10	8.5	0.0	38.4
Statewide average for Class 7 low gradient bio sites that are meeting the FIBI general use threshold (42.0)	**18.2**	**19.1**	**11.6**	**7.6**	**0.6**	**65.3**
Expected response to **DO** stress	↓	↑	↓	↓	↓	↑

Table 34. Dissolved oxygen related fish metrics for reach 07020006-505

07020006-505 **Fish Class 2** **General Use**	Mature Age >3 %	Serial Spawner %	Taxa Count	DO TIV	DO Sensitive %	DO Tolerant %
17MN203 7/25/2017	14.6	6.9	21	8.3	0	59.4
92MN022 6/27/2017	15.1	25.1	23	8.2	1.5	43.2
92MN025 6/28/2017	32.1	28.8	20	8.5	14.8	8.7
Statewide average for Class 2 southern stream bio sites that are meeting the FIBI general use threshold (50.0)	**23.9**	**28.7**	**19.9**	**8.4**	↓	↑
Expected response to **DO** stress	↓	↑	↓	↓		

Table 35. Dissolved oxygen related invert metrics for reach 07020006-505

07020006-505 **Invert Class 7** General Use	DO TIV	HBI_MN		Low DO Intolerant Taxa %	Low DO Tolerant Taxa %
17MN234 8/01/2017	5.5	8.7		0	45.6
17MN203 8/01/2017	6.7	8.2		1.5	29.1
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI general use threshold (41)	**6.9**	**7.6**		**9.3**	**13.0**
Expected response to **DO** stress	↓	↑		↓	↑

Table 36. Dissolved oxygen related invert metrics for reach 07020006-505

07020006-505 **Invert Class 5** General Use	DO TIV	HBI_MN		Low DO Intolerant Taxa %	Low DO Tolerant Taxa %
92MN022 08/03/2010	7.0	8.2		1.3	6.6
92MN022 08/01/2017	7.0	7.7		7.1	18.9
92MN025 08/03/2010	1.8	6.4		11.0	1.6
92MN025 08/03/2017	7.7	7.3		58.1	0.6
Statewide average for Class 5 prairie stream rock riffle bio sites that are meeting the FIBI general use threshold (37)	**7.1**	**7.0**		**24.6**	**8.6**
Expected response to **DO** stress	↓	↑		↓	↑

Dissolved Oxygen Monitoring Data

Table 37. Dissolved oxygen monitoring data for reach 07020006-505

07020006-505 DO Data 5 mg/L target	Range of Data (mg/L)	% of Monthly Samples < 5 mg/L [# of Samples]							May - Sep <5 mg/L % [# of Samples]
		April	May	June	July	August	Sept	Oct	
S003-703 S013-672 S013-673 S013-676 S014-351 S014-380 (2009-2018)	3.7 – 15.9	-	0% [2]	0% [7]	0% [6]	0% [13]	20% [5]	-	3.0% [33]
		Minimum Value							
		-	9.9	7.0	5.8	6.3	3.7		

Dissolved Oxygen Summary

The low DO related fish metrics in reach 07020006-505 were mixed but were generally worse at the upstream bio sites. Sites 17MN234 and 92MN025 did have an above average late maturing fish percentage, but were due to the abundance of tolerant white suckers (Table 33, Table 34). There were also low numbers fish who are sensitive of low DO and higher numbers of fish who are tolerant of low DO, especially at the upstream bio sites.

The low DO related invertebrate metrics in reach 07020006-505 were mostly poor with the exception of the furthest downstream bio site 92MN025, which had over 58% of low DO sensitive inverts. The other bio sites further upstream got worse and the furthest upstream bio sites, 17MN203 and 17MN234, had 1.5% and 0% low DO sensitive taxa present compared to 29.1% and 45.6% low DO tolerant taxa. The DO TIV scores were all below the class averages with the exception of site 92MN025 (Table 35) (Table 36).

There were 33 DO measurements were taken throughout the reach between 2009 and 2018. None of those measurements were taken before 8:00 a.m., when values are usually the lowest. Only one measurement taken in September was below the warmwater DO standard of 5 mg/L. It was taken at chemistry site S014-380, next to the furthest upstream bio site 17MN234.

Based on the related fish biological metric scores and the measured sonde values, low DO is likely a stressor in the upper part of this reach that is being aggravated by low flow conditions. However, due to lack of supporting evidence is inconclusive at this time.

3.1.1.6   Eutrophication

Eutrophication Biological Metric Data

Table 38. Eutrophication related fish metrics for reach 07020006-505

07020006-505 **Fish Class 7** General Use	Darter %	Omnivore %	Sensitive %	Simple Lithophillic Spawner %	Tolerant %
17MN234 9/19/2017	3.5	45.3	2.3	51.2	80.2
Statewide average for Class 7 low gradient bio sites that are meeting the FIBI general use threshold (42.0)	**6.7**	**13.9**	**19.0**	**24.1**	**48.7**
Expected response to **Eutrophication** stress	↓	↑	↓	↓	↑

Table 39. Eutrophication related fish metrics for reach 07020006-505

07020006-505 **Fish Class 2** General Use	Darter %	Omnivore %	Sensitive %	Simple Lithophillic Spawner %	Tolerant %
17MN203 7/25/2017	28.4	19.3	24.6	21.9	63.0
92MN022 6/27/2017	7.3	32.5	8.8	39.0	65.3
92MN025 6/28/2017	26.0	23.2	26.3	49.7	43.9
Statewide average for Class 2 southern stream bio sites that are meeting the FIBI general use threshold (50.0)	**11.7**	**16.5**	**18.7**	**39.4**	**44.9**
Expected response to **Eutrophication** stress	↓	↑	↓	↓	↑

Table 40. Eutrophication related invert metrics for reach 07020006-505

07020006-505 **Invert Class 7** General Use	Crustacean and Mollusca %	Collector – Gatherer Taxa #	Ephemeroptera Plecoptera Trichoptera Taxa %	Intolerant Two Taxa %	Scraper %	Taxa Count All #	Tolerant Two Taxa %
17MN234 8/01/2017	56.8	8	2.0	0.0	3.6	20	95.0
17MN203 8/01/2017	46.4	13	5.9	0.0	45.2	33	90.9
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI general use threshold (41)	**11.8**	**13.3**	**38.5**	**0.2**	**16.1**	**37.0**	**81.9**
Expected response to **Eutrophic** stress	↑	↓	↓	↓	↑	↓	↑

Table 41. Eutrophication related invert metrics for reach 07020006-505

07020006-505 **Invert Class 5** General Use	Crustacean and Mollusca %	Collector – Gatherer Taxa #	Ephemeroptera Plecoptera Trichoptera Taxa %	Intolerant Two Taxa %	Scraper %	Taxa Count All #	Tolerant Two Taxa %
92MN022 08/03/2010	23.8	9	21.7	0.0	41.1	23	87.0
92MN022 08/01/2017	21.1	14	23.9	0.0	23.3	34	85.3
92MN025 08/03/2010	1.3	9	16.3	0.0	1.3	21	90.5
92MN025 08/03/2017	0.9	9	85.1	0.0	10.9	32	71.9
Statewide average for Class 5 prairie stream rock riffle bio sites that are meeting the FIBI general use threshold (37)	**9.2**	**15.1**	**43.9**	**0.8**	**15.8**	**41.9**	**71.9**
Expected response to **Eutrophic** stress	↑	↓	↓	↓	↑	↓	↑

Eutrophication Monitoring Data

Table 42. Phosphorus monitoring data for reach 07020006-505

07020006-505 P Data 0.150 mg/L target	Range of Data (mg/L)	Monthly Average of Samples (mg/L) [# of Samples]							June-Aug Average (mg/L) [# of Samples]
		April	May	June	July	August	Sept	Oct	
S003-703 **S013-673** **S013-676** **S014-351** **S014-380** (2010-2018)	0.037 – 0.337	-	0.129 [2]	0.119 [5]	0.168 [7]	0.155 [6]	0.133 [5]	-	0.150 [18]
		Maximum Value							
		-	0.207	0.297	0.302	0.211	0.337		

Table 43. DO % Saturation monitoring data for reach 07020006-505

07020006-505 DO% Sat Data	Range of Data (%)	Monthly Average of Samples (%) [# of Samples]							June-Aug Average (%) [# of Samples]
		April	May	June	July	August	Sept	Oct	
S013-673 **S013-676** **S014-351** **S014-380** (2017)	40.8 – 222.1	-	-	105.7 [2]	75 [1]	157.2 [4]	40.8 [1]	-	130.7 [5]

Figure 11. Photo of the culvert at bio site 17MN234 showing algae growth

Eutrophication Summary

The eutrophication related fish metrics in reach 07020006-505 were mixed throughout the reach. Omnivores and tolerant species scored high throughout the reach. The furthest upstream bio site, 17MN234, scored poorly in almost all metrics except simple the lithophillic spawner percentage, which was high due to the 12 common shiners that were caught (Table 38). 17MN203 had a very high number of Iowa darters caught, which is considered a sensitive species. Bio site 92MN022 also had some Iowa darters and site 92MN025 had 35 fantail darters, a sensitive coldwater species. Metrics at bio site 92MN025 were mostly good, with a high number of darters, sensitive, simple lithophilic spawners, and tolerant species present while omnivores were not too far over the class average (Table 39).

Eutrophication related invertebrate metrics in reach 07020006-505 were mostly poor with the exception of the furthest downstream bio site 92MN025, which were mixed. Collector gatherer taxa were generally low, scrapers were generally high except at the two upper bio sites, and the tolerant two most abundant taxa were very high, especially in the upstream sections of the reach. Snails and crayfish dominated the upper and middle section of the reach and the numbers of midges were also high at all bio sites. There were some *caenis* and *baetis* found, two fairly tolerant mayfly taxa. Bio site 92MN025 was dominated by Hydropsychidae, net spinning caddisflies (Table 40 and Table 41).

There were 18 samples were collected and analyzed for phosphorus from 2010 through 2018. The summer average was right at the standard of 0.15 mg/L and there were extremely high values measured in every month from May through September (Table 42). Five DO percent saturation measurements were taken in 2017 (Table 43). The summer average was over 130% saturation.

The biological community is showing the effects of the elevated phosphorus, phosphorus sampling showed elevated concentrations and the percent saturation of DO was abnormally high. Eutrophication is a stressor in the majority of this reach, especially in the upstream section.

3.1.1.7   Suspended Solids

Suspended Solids Biological Metric Data

Table 44. Suspended solids related fish metrics for reach 07020006-505

07020006-505 Fish Class 7 General Use	Benthic Feeder %	Centrarchid - Tolerant %	Herbivore %	Intolerant %	Long – lived %	Perciformes - Tolerant %	Riffle %	Sensitive %	Simple Lithophilic Spawner %	TSS TIV
17MN234 9/19/2017	38.4	2.3	12.8	0.0	10.5	5.8	37.2	2.3	51.2	20.5
Statewide average for Class 7 low gradient bio sites that are meeting the FIBI general use threshold (42.0)	**17.8**	**6.0**	**7.4**	**4.6**	**12.3**	**18.3**	**12.2**	**19.0**	**24.1**	**13.2**
Expected response to **Suspended Solids** stress	↓	↓	↓	↓	↓	↓	↓	↓	↓	↑

Table 45. Suspended solids related fish metrics for reach 07020006-505

07020006-505 Fish Class 2 General Use	Benthic Feeder %	Centrarchid - Tolerant %	Herbivore %	Intolerant %	Long – lived %	Perciformes - Tolerant %	Riffle %	Sensitive %	Simple Lithophilic Spawner %	TSS TIV
17MN203 7/25/2017	26.1	0.7	30.6	0.0	1.7	29.3	22.3	24.6	21.9	18.6
92MN022 6/27/2017	26.9	0.9	19.2	0.0	1.3	8.2	26.7	8.8	39.0	18.1
92MN025 6/28/2017	53.6	0.6	2.2	0.0	11.2	30.4	46.4	26.3	49.7	15.6
Statewide average for Class 2 southern stream bio sites that are meeting the FIBI general use threshold (50.0)	**37.4**	**4.9**	**9.6**	**5.0**	**11.7**	**18.7**	**32.5**	**18.6**	**39.4**	**17.9**
Expected response to **Suspended Solids** stress	↓	↓	↓	↓	↓	↓	↓	↓	↓	↑

Table 46. Suspended solids related invert metrics for reach 07020006-505

07020006-505 **Invert Class 7** General Use	Collector – filterer %	Plecoptera %	Sprawler %	TSS Intolerant Taxa %	TSS Tolerant Taxa %	TSS TIV
17MN234 8/01/2017	0	0	63.2	0	44.7	19.4
17MN203 8/01/2017	3.1	0	12.5	0	54.8	19.8
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI general use threshold (41)	**19.1**	**0.2**	**20.9**	**2.7**	**48.3**	**17.8**
Expected response to **Suspended Solids** stress	↓	↓	↑	↓	↑	↑

Table 47. Suspended solids related invert metrics for reach 07020006-505

07020006-505 **Invert Class 5** General Use	Collector – filterer %	Plecoptera %	Sprawler %	TSS Intolerant Taxa %	TSS Tolerant Taxa %	TSS TIV
92MN022 08/03/2010	11.6	0.0	9.6	0.0	58.4	17.8
92MN022 08/01/2017	27.0	0.0	9.3	1.2	44.9	17.9
92MN025 08/03/2010	4.0	0.0	4.7	0.0	9.3	4.2
92MN025 08/03/2017	40.1	0.3	14.3	0.6	34.7	18.7
Statewide average for Class 5 prairie stream rock riffle bio sites that are meeting the FIBI general use threshold (37)	**26.9**	**0.5**	**16.8**	**5.1**	**35.2**	**15.9**
Expected response to **Suspended Solids** stress	↓	↓	↑	↓	↑	↑

TSS Monitoring Data

07020001-505 TSS Data 65 mg/L target	Range of Data (mg/L)	% of Monthly Samples > 65 mg/L [# of Samples]							% of Total Samples > 65 mg/L [# of Samples]
		April	May	June	July	August	Sept	Oct	
S003-703 S013-673 S013-676 S014-351 S014-380 (2010-2018)	4 – 106	-	50% [2]	25% [6]	12.5% [8]	14.2% [7]	0% [5]	-	17.9% [28]

07020001-505 Secchi Tube Data 10 cm target	Range of Data (mg/L)	% of Monthly Samples < 10 cm [# of Samples]							% of Total Samples < 10 cm [# of Samples]
		April	May	June	July	August	Sept	Oct	
S003-703 S013-673 S013-676 S014-351 S014-380 (2010-2018)	12-100+	-	0% [2]	0% [7]	0% [6]	0% [13]	0% [5]	-	0% [33]

Suspended Solids Summary

The suspended solids related fish metrics in reach 07020006-505 were mixed but were generally worse at the upstream bio sites. In general, there were both riffle dwelling and lithophilic spawning fish caught at all of the bio sites, though this was due to the abundance of white suckers, which is considered tolerant due to its generalist feeding habits and prolific spawning. Bio site 17MN203 was dominated by Iowa darters, a benthic feeder and also had good numbers of central stonerollers, a riffle dwelling and lithophilic spawning fish. The exception to this was the furthest downstream bio site 92MN025, which also had good numbers of fantail darters, a sensitive riffle dwelling fish. 92MN025 also had good numbers of several lithophilic spawning species, including white suckers, common shiners, blacknose dace, hornyhead chubs, northern hogsuckers, creek chubs, golden redhorse, and walleye.

The suspended solids related invertebrate metrics in reach 07020006-505 were mostly poor, especially in the upstream section of the reach. Collector – filterers were generally low and no Plecoptera were observed except at the furthest downstream bio site, 92MN025. TSS intolerant taxa were very low and tolerant taxa very high throughout the reach. The TSS tolerance index values were also higher than the

class averages except at bio site 92MN025, which was very low in 2010 at 4.2 but high in the 2017 site visit.

Twenty-eight samples were collected and analyzed for TSS from 2010 through 2018. Several months had samples exceeding the TSS concentration above 65 mg/L and 17.9% of the total samples taken were above this value (Table 48).

The biological community, especially the invertebrates, are showing the effects of the elevated suspended solids and TSS sampling showed elevated concentrations. Suspended solids are a stressor in the majority of this reach, especially in the upstream section.

Figure 12. Photo at bio site 17MN203 showing sediment and other solids suspended in the water

3.1.1.8 Nitrates

Nitrate Biological Metric Data

Table 50. Nitrate related invert metrics for reach 07020006-505

07020006-505 **Invert Class 7** General Use	Nitrate Intolerant Taxa %	Nitrogen Tolerant Taxa %	Trichoptera Taxa %	Nitrogen TIV
17MN234 8/01/2017	0.0	52.0	0	4.1
17MN203 8/01/2017	0.0	87.3	0	6.4
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI general use threshold (41)	**3.2**	**54.9**	**10.9**	**3.2**
Expected response to **nitrogen** stress	↓	↑	↓	↑

Table 51. Nitrate related invert metrics for reach 07020006-505

07020006-505 **Invert Class 5** General Use	Nitrate Intolerant Taxa %	Nitrogen Tolerant Taxa %	Trichoptera Taxa %	Nitrogen TIV
92MN022 08/03/2010	0.3	69.0	8.7	3.5
92MN022 08/01/2017	0.3	59.4	14.7	4.3
92MN025 08/03/2010	0.3	15.9	23.8	0.8
92MN025 08/03/2017	1.8	50.5	18.8	3.1
Statewide average for Class 5 prairie stream rock riffle bio sites that are meeting the FIBI general use threshold (37)	**2.9**	**47.6**	**13.6**	**3.0**
Expected response to **nitrogen** stress	↓	↑	↓	↑

Nitrate Monitoring Data

Table 52. Nitrate monitoring data for reach 07020006-505

07020006-505 Nitrate/Nitrite Sample Data	2x Highest Reach TIV Average	Range of Data (mg/L) [# of Samples]	Monthly Average [# of Samples]						
			April	May	June	July	August	Sept	Oct
S013-673 **S013-676** **S014-351** **S014-380** (2010-2017)	6.0	0.4 - 4.5 [5]	-	-	2.1 [1]	1.2 [1]	0.4 [2]	2.6 [1]	-
			Highest Value						
			-	-	2.1	1.2	0.4	4.5	-

Summary

The nitrate related invertebrate metrics in reach 07020006-505 were mostly poor, especially in the upstream section of the reach. Bio sites 17MN234 and 17MN203 scored poorly in nearly all nitrate metrics (Table 50). Bio sites 92MN022 and 92MN025 were mixed, indicating that nitrate may be less of a stressor in the downstream section of the reach. There were even some nitrate intolerant species present at bio station 92MN025 and Trichoptera taxa at both downstream sites (Table 51).

Only five samples were collected and analyzed for nitrate/nitrite in the reach (Table 52). None of the collected samples were considered high. Due to the biological response and relatively low nitrate concentrations, nitrates are inconclusive as a stressor to aquatic life in reach 07020006-505, though it appears to be having some effect on the biology at the upstream bio sites.

3.1.1.9   Reach Stressors

Table 53. Summary of stressors for reach 07020006-505

07020006-505	Hydrologic Alteration	Connectivity	Habitat	Dissolved Oxygen	Eutrophication	Suspended Solids	Nitrate
✔ = Stressor ✘ = Not a Stressor O = Inconclusive	✔	✘	✔	O	✔	✔	O

3.1.2 07020006-576   County Ditch 31

Figure 13. Satellite image of reach 07020006-576 and its watershed

3.1.3.1   Biological Community

Biological Metric Data

Table 54. Fish IBI score and threshold for reach 07020006-576

07020006-576 **Fish Class 3** **Modified Use**	Fish IBI Score	Class Threshold Score
17MN210 9/19/2017	32	33

Table 55. Invert IBI score and threshold for reach 07020006-576

07020006-576 **Invert Class 7** **Modified Use**	Invert IBI Score	Class Threshold Score
17MN210 8/02/2017	16.5	22

3.1.3.2   Hydrologic Alteration

Hydrologic Alteration Biological Metric Data

Table 56. Hydrologic alteration related fish metrics for reach 07020006-576

07020006-576 **Fish Class 3** **Modified Use**	General %	Nesting Non Lithophilic Spawner %
17MN210 9/19/2017	22.4	94.7
Statewide average for Class 3 southern headwater bio sites that are meeting the FIBI modified use threshold (33)	**56.3**	**24.0**
Expected response to **Hydrologic** stress	↑	↑

Table 57. Hydrologic alteration related invert metrics for reach 07020006-576

07020006-576 **Invert Class 7** **Modified Use**	Clinger %	Collector – filterer %	Long – lived %	Percent Ditched Tolerant %	Percent Ditched Intolerant %
17MN210 8/02/2017	4.0	0.3	1.0	71.1	0.0
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI modified use threshold (22)	**23.1**	**9.9**	**5.6**	↑	↓
Expected response to **Hydrologic** stress	↓	↓	↓		

Redwood River Watershed Stressor Identification Report   Minnesota Pollution Control Agency

HSPF Model Flow Data

Table 58. HSPF modeled flow data for reach 07020006-576

07020006-505 HSPF Reach 125 Min: 0.0 cfs Max: 242.4 cfs	<5 cfs % (# of values)	<1 cfs % (# of values)	<0.5 cfs % (# of values)
6,210 Total Daily Averages 1996 – 2012	**81.3%** (5,046)	**46.6%** (2,985)	**28.8%** (1,791)

Hydrologic Alteration Summary

The fish biological metrics for altered hydrology are mixed. Fish that are considered generalist species were low, though that was due to the abundance of brook sticklebacks, which is a tolerant and short lived species but not considered a generalist species. The next most abundant fish caught was fathead minnows, a very tolerant generalist species. Both of these species are nesting fish, which contributed to the high percentage of nesting nonlithophilic spawning fish (Table 56). In all, there were only four species caught and 94% of them were either brook sticklebacks or fathead minnows, a very nondiverse and tolerant dominated fish community.

The invertebrate metrics for altered hydrology were poor. Clingers and collector – filterers scored very poorly. The site was dominated by snails, water boatman, and water beetles. The ratio of inverts tolerant to ditched stream channels compared to those that are intolerant was also very high (Table 57).

The HSPF model shows that more than 81.3% of the daily average flows from 1996 through 2012 are below 5 cfs. 46.6% of flows were below 1 cfs. The high percentage of low flows is likely affecting the biology of this reach. Flows reduced beyond normal base flow will decrease habitat for aquatic organisms and increase competition for resources (Table 58).

Based on the poor scores of the biological metrics, extended low flow periods shown in the HSPF model Hydrologic Alteration is a stressor in this reach. The primary impact in this reach from hydrologic alteration is from ditching of the stream by the straightening and deepening of the channel. Cleaning out the bottom of the ditch destroys any morphological habitat that may have developed in the channel and disrupts the movement of sediment in the stream, contributing to the deposition of fine sediments within the ditch. Artificial drainage into the ditch creates a pathway for nutrient overloading of phosphorus and nitrogen, which contributes to eutrophication and can cause high DO flux. This drainage also can contribute to low base flows during times of low precipitation, contributing to the stagnation of the water within the ditch and excessive algae growth.

3.1.3.3   Connectivity

Connectivity Metric Data

Table 59. Connectivity related fish metrics for reach 07020006-576

07020006-576 **Fish Class 3** **Modified Use**	Mature Age >3 minus Tolerant Taxa %	Migrating Taxa %
17MN210 9/19/2017	0.0	0.0
Statewide average for Class 3 southern headwater bio sites that are meeting the FIBI modified use threshold (33)	**3.2**	**20.1**
Expected response to **Connectivity** stress	↓	↓

Connectivity Summary

The fish biological metrics for connectivity are very poor. There were no late-maturing or migrating species caught. During site visits in 2019 and 2020 the culvert at the road crossing was observed to be at the wrong elevation and is likely a fish barrier. This culvert is also relatively long and completely smooth, likely creating velocities that are barriers to fish migration upstream into the upper and headwater areas during high flows. Due to the absence of migratory and late maturing species, as well as the observations of the culvert, connectivity could be a stressor to the bio site, though there are likely other stressors responsible for the low biotic response. It is inconclusive as a stressor at this time.

Figure 14. Photo of the culvert at the road crossing at bio site 17MN210. The bottom of the culvert appears to be at the wrong elevation compared to the bottom of the stream and could be a barrier.

3.1.3.4 Habitat

Habitat Metric Data

Table 60. Habitat related fish metrics for reach 07020006-576

07020006-576 **Fish Class 3** **Modified Use**	Benthic Insect minus Tolerant %	Darter Sculpin Sucker %	Lithophilic Spawner %	Pioneer %	Piscivore %	Riffle %	Simple Lithophilic Spawner %	Tolerant %
17MN210 9/19/2017	0.0	0.0	5.3	21.1	0.0	0.0	1.3	100.0
Statewide average for Class 3 southern headwater bio sites that are meeting the FIBI modified use threshold (33)	**10.9**	**10.6**	**57.9**	**32.5**	**2.0**	**22.6**	**30.1**	**76.7**
Expected response to **Habitat** stress	↓	↓	↓	↑	↓	↓	↓	↑

Table 61. Habitat related invert metrics for reach 07020006-576

07020006-576 **Invert Class 7** **Modified Use**	Burrower %	Climber %	Clinger %	Ephemeroptera Plecoptera Trichoptera %	Legless %	Sprawler %		MSHA Score Tolerant %	MSHA Score Intolerant %	Percent Embedded Tolerant %	Percent Embedded Intolerant %
17MN210 8/02/2017	4.4	60.6	5.4	2.5	62.2	5.1		88.3	0.0	87.3	0.3
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI modified use threshold (22)	**14.1**	**27.5**	**23.1**	**20.6**	**55.8**	**27.0**		**48.0**	**0.8**	**48.0**	**0.6**
Expected response to **Habitat** stress	↑	↓	↓	↓	↑	↑		↑	↓	↑	↓

MPCA Stream Habitat Assessment Score

Table 62. Habitat Assessment scores for reach 07020006-576

07020006-576	Land Use	Riparian	Substrate	Cover	Channel Morphology	Total Score
17MN210 9/19/2017	0	7	1	11	0	19
17MN210 8/02/2017	0	7	5.2	11	9	32.2
Maximum Attainable Habitat Score	5	14	28	18	35	100

Habitat Summary

The fish biological metrics for habitat are all poor with the exception of pioneer species and the scores themselves are very poor. Very few lithophilic spawning fish were present and all fish species caught are considered tolerant (Table 60). Since brook stickleback are not considered pioneer species, and they made up the majority of the total fish caught, that metric looks better

The invertebrate biological metrics for habitat are mixed. Burrowers and sprawlers both scored decent. Climbers scored above average, though this was mostly due to the dominance of snails at the bio site.

Clingers, EPT, and Legless all scored very poorly (Table 61). Overall, the invertebrate habitat related metrics are considered poor.

During the 2019 site visit a clean out of the ditch was being conducted. This cleanout effectively destroyed any sort riparian habitat for fish. The depth of the ditch cuts off the stream to its flood plain, a valuable area of a river system for both habitat and the geomorphology of the river system, which helps dissipate the energy from high flows

Figure 15. Photo of Bio site 17MN210 showing a ditch cleanout during the summer of 2019.

The two MSHA scores conducted during bio visits were both very poor, indicating extreme degradation and lack of habitat for fish and invertebrates. There was very little substrate that would provide good habitat for either fish or invertebrates. The channel morphology, being artificially straightened, dug down in elevation, and disturbed by cleanouts provides no habitat such as riffles and pools, which form in most streams in southwest Minnesota. Habitat is a stressor to the biological community.

3.1.3.5   Dissolved Oxygen

Dissolved Oxygen Biological Metric Data

Table 63. Dissolved oxygen related fish metrics for reach 07020006-576

07020006-576 **Fish Class 3** Modified Use	Mature Age >3 %	Serial Spawner %	Taxa Count	DO TIV	DO Sensitive %	DO Tolerant %
17MN210 9/19/2017	0.0	17.1	4	7.3	0	94.7
Statewide average for Class 3 southern headwater bio sites that are meeting the FIBI modified use threshold (33)	**14.4**	**10.6**	**9.3**	**8.2**	**0.1**	**39.3**
Expected response to **DO** stress	↓	↑	↓	↓	↓	↑

Table 64. Dissolved oxygen related invert metrics for reach 07020006-576

07020006-576 **Invert Class 7** Modified Use	DO TIV	HBI_MN	Low DO Tolerant Taxa %	Low DO Intolerant Taxa %
17MN210 8/02/2017	5.6	9.0	55.9	0.0
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI modified use threshold (22)	**6.2**	**8.0**	**31.4**	**3.1**
Expected response to **DO** stress	↓	↑	↑	↓

Dissolved Oxygen Monitoring Data

Table 65. Dissolved oxygen monitoring data for reach 07020006-576

07020006-576 DO Data 5 mg/L target	Range of Data (mg/L)	% of Monthly Samples < 5 mg/L [# of Samples]							May - Sep <5 mg/L % [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-357 (2017-2019)	9.6 – 21.4	-	-	-	-	0% [2]	0% [1]	-	0% [3]
		Minimum Value							
		-	-	-	-	9.6	21.4	-	

Dissolved Oxygen Summary

The low DO related fish metrics at bio site 17MN210 all scored poorly. There were no late maturing or DO sensitive fish caught. Taxa count was low and both serial spawning and DO tolerant fish were above the class average (Table 63).

The low DO related invertebrate metrics at bio site 17MN210 all scored poorly. There were no low DO sensitive invertebrate taxa caught and low DO tolerant taxa were well above the class average. The DO TIV and HBI scores were also very poor as the majority of inverts caught were snails, which are generally tolerant of low DO aquatic environments (Table 64).

Only three DO measurements were taken during sampling and none were below the warmwater standard of 5 mg/L, none of those measurements were taken before 8:00 a.m., when values are usually the lowest. An YSI Sonde water meter was unable to be deployed during the 2019 field season due to a ditch clean out that was being conducted at the time of the site visit.

Based on the lack of data DO is inconclusive as a stressor in this reach.

3.1.3.6   Eutrophication

Eutrophication Biological Metric Data

Table 66. Eutrophication related fish metrics for reach 07020006-576

07020006-576 **Fish Class 3** Modified Use	Darter %	Omnivore %	Sensitive %	Simple Lithophillic Spawner %	Tolerant %
17MN210 9/19/2017	0.0	17.1	0.0	1.3	100.0
Statewide average for Class 3 southern headwater bio sites that are meeting the FIBI modified use threshold (33)	**10.6**	**19.8**	**6.0**	**30.1**	**76.7**
Expected response to **Eutrophication** stress	↓	↑	↓	↓	↑

Table 67. Eutrophication related invert metrics for reach 07020006-576

07020006-576 **Invert Class 7** Modified Use	Crustacean and Mollusca %	Collector – Gatherer Taxa #	Ephemeroptera Plecoptera Trichoptera Taxa %	Intolerant Two Taxa %	Scraper %	Taxa Count All #	Tolerant Two Taxa %
17MN210 8/02/2017	51.1	10	2.5	0.0	49.8	32	87.5
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI modified use threshold (22)	**23.2**	**11.6**	**20.6**	**0.1**	**17.7**	**33.6**	**86.6**
Expected response to **Eutrophic** stress	↑	↓	↓	↓	↑	↓	↑

Eutrophication Monitoring Data

Table 68. Phosphorus monitoring data for reach 07020006-576

07020006-576 P Data 0.150 mg/L target	Range of Data (mg/L)	Monthly Average of Samples (mg/L) [# of Samples]							June-Aug Average (mg/L) [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-357 (2017-2019)	0.112 – 0.133	-	-	-	-	0.133 [1]	0.112 [1]	-	0.133 [1]
		Maximum Value							
		-	-	-	-	0.133	0.112		

Table 69. DO% Saturation monitoring data for reach 07020006-576

07020006-576 DO% Sat Data	Range of Data (%)	Monthly Average of Samples (%) [# of Samples]							June-Aug Average (%) [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-357 (2017)	117.9 – 267.0	-	-	-	-	132.3 [2]	267.0 [1]	-	132.3 [3]

Eutrophication Summary

The eutrophication related fish metrics at bio site 17MN210 mostly all scored poorly. Though the omnivore percentage was just below the class average, there were no darters or sensitive species. Simple lithophilic spawning fish were very low and all fish caught were tolerant (Table 66).

The eutrophication related invertebrate metrics at bio site 17MN210 all sored poorly. Mollusks dominated the invertebrate community and there were only very few tolerant mayflies that were caught. Scrapers were also very high indicating an abundance of algae. There were no intolerant taxa were present (Table 67).

Only two samples were collected for phosphorus from 2017 through 2019. Neither were above the standard of 0.150 (Table 68). DO % saturation measurements were high during all three site visits indicating algae production of oxygen in the water (Table 69).

An YSI Sonde water meter measured continuous DO data from 7/6/2017 to 7/27/2017. During this deployment, diel DO flux was measured below 5 mg/L.

Figure 16. Photo of the culvert at bio site 17MN210 showing some moderate algae growth in the ditch.

The biological community is showing the effects of the elevated phosphorus. Phosphorus sampling was very limited and did not show elevated concentrations. Moderate algae growth was observed at the station (Figure 16). Eutrophication is inconclusive as a stressor in this reach.

3.1.3.7   Suspended Solids

Suspended Solids Biological Metric Data

Table 70. Suspended solids related fish metrics for reach 07020006-576

07020006-576 Fish Class 3 Modified Use	Benthic Feeder %	Centrarchid - Tolerant %	Herbivore %	Intolerant %	Long – lived %	Perciformes - Tolerant %	Riffle %	Sensitive %	Simple Lithophilic Spawner %	TSS TIV
17MN210 9/19/2017	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	16.0
Statewide average for Class 3 southern headwater bio sites that are meeting the FIBI modified use threshold (33)	**37.9**	**0.9**	**13.3**	**2.0**	**3.6**	**13.9**	**28.3**	**8.6**	**33.7**	**15.0**
Expected response to **Suspended Solids** stress	↓	↓	↓	↓	↓	↓	↓	↓	↓	↑

Table 71. Suspended solids related invert metrics for reach 07020006-576

07020006-576 **Invert Class 7** Modified Use	Collector – filterer %	Plecoptera %	Sprawler %	TSS Intolerant Taxa %	TSS Tolerant Taxa %	TSS TIV
17MN210 8/02/2017	0.3	0.0	5.1	0.0	53.0	19.8
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI modified use threshold (22)	**9.9**	**0.0**	**27.0**	**1.3**	**35.6**	**16.2**
Expected response to **Suspended Solids** stress	↓	↓	↑	↓	↑	↑

TSS Monitoring Data

Table 72. Total suspended solids monitoring data for reach 07020006-576

07020001-576 TSS Sample Data 65 mg/L target	Range of Data (mg/L)	% of Monthly Samples > 65 mg/L [# of Samples]							% of Total Samples > 65 mg/L [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-357 (2017 - 2019)	4.4 – 7.2	-	-	-	-	0% [1]	0% [1]	-	0% [2]

Table 73. Transparency monitoring data for reach 07020006-576

07020001-576 Secchi Tube Data 10 cm target	Range of Data (mg/L)	% of Monthly Samples < 10 cm [# of Samples]							% of Total Samples < 10 cm [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-357 (2017-2018)	79-100+	-	-	-	-	0% [2]	0% [1]	-	0% [3]

Suspended Solids Summary

The suspended solids related fish metrics at bio site 17MN210 all scored very poorly. The only metric that even showed anything was the 1.3% of simple lithophilic spawning fish due to the few creek chubs present (Table 70).

The suspended solids related invertebrate metrics at bio site 17MN210 all scored very poorly. There were no Plecoptera or TSS intolerant taxa and nearly no collector – filterers present. TSS tolerant taxa and the TSS TIV scored poorly well above the class average.

Only two samples were collected and analyzed for TSS from 2017 to 2018. No sample had a TSS concentration above 65 mg/L (Table 72). Only three secchi tube measurements were taken and none fell below 10cm (Table 73).

Suspended solids are inconclusive as a stressor to aquatic life at this time. It is likely that other factors, such as altered hydrology, habitat, and connectivity are causing poor scores in the fish biological metrics, though collecting more TSS data, especially with the exposed stream banks after the cleanout, might show that elevated TSS levels exist in this reach. It is recommended to collect more TSS data and conduct a sediment substrate analysis in order to determine whether TSS is a biological stressor.

3.1.3.8   Nitrates

Nitrate Biological Metric Data

Table 74. Nitrate related invert metrics for reach 07020006-576

07020006-576 **Invert Class 7** Modified Use	Nitrate Intolerant Taxa %	Nitrogen Tolerant Taxa %	Trichoptera Taxa %	Nitrogen TIV
17MN210 8/02/2017	0.0	62.2	0.0	4.6
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI modified use threshold (22)	**2.0**	**59.4**	**5.9**	**3.3**
Expected response to **nitrogen** stress	↓	↑	↓	↑

Nitrate Monitoring Data

Table 75. Nitrate monitoring data for reach 07020006-576

07020001-576 Nitrate/Nitrite Sample Data	2x Highest Reach TIV Average	Range of Data (mg/L) [# of Samples]	Monthly Average [# of Samples]						
			April	May	June	July	August	Sept	Oct
S014-357 (2017-2019)	6.6	6.2 – 7.0 [2]	-	-	-	-	7.0 [1]	6.2 [1]	-
			Highest Value						
			-	-	-	-	7.0	6.2	-

Summary

The nitrate related invertebrate metrics at bio site 17MN210 were all poor. There were no Trichoptera taxa, which tend to decrease in streams with excessive nitrate values. There was a high amount of nitrate tolerant invertebrates as well as complete lack of nitrate intolerant invertebrate species. The nitrogen TIV score was higher than the class average (Table 74).

Two samples were collected in reach 07020006-576 and analyzed for nitrate/nitrite (Table 75). One of the total nitrate samples had concentrations greater than 6.6 mg/L. Due to the biological response and relatively high nitrate concentrations, nitrates appear to be a stressor to aquatic life in reach 07020006-576.

3.1.3.9   Reach Stressors

Table 76. Summary of stressors for reach 07020006-576

07020006-576	Hydrologic Alteration	Connectivity	Habitat	Dissolved Oxygen	Eutrophication	Suspended Solids	Nitrate
✔ = Stressor ✘ = Not a Stressor O = Inconclusive	✔	O	✔	O	O	O	✔

3.1.4 07020006-555   Unnamed Creek
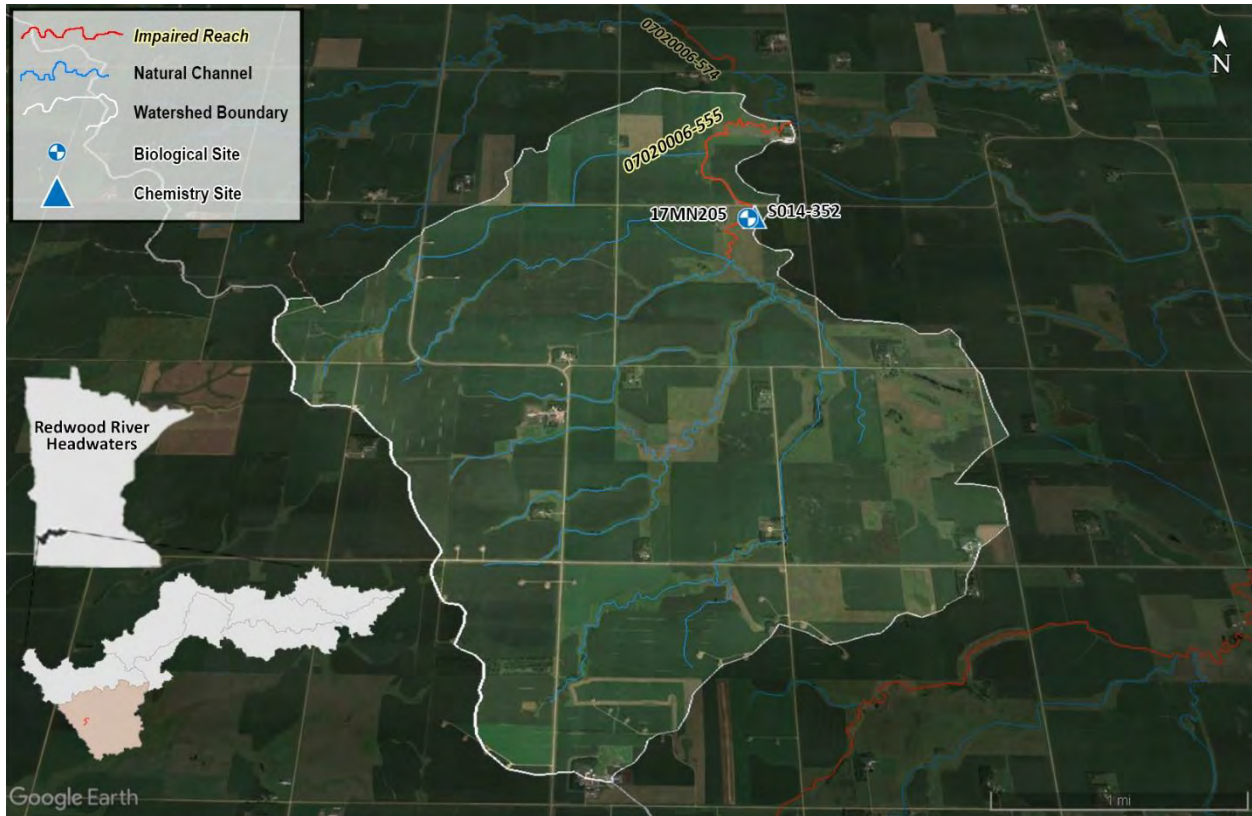
Figure 17. Satellite image of reach 07020006-555 and its watershed

3.1.4.1   Biological Community

Bio site 17MN205 was sampled once for fish in 2017. The FIBI score of 41.7 was below the Fish Class 3 Southern Streams general use threshold of 55 (Table 77). Brook sticklebacks and creek chubs dominated the fish community with fathead minnows and johnny darters present in lower numbers. Bio site 17MN205, for the most, is dominated by short lived, tolerant species.

Biological Metric Data

Table 77. Fish IBI score and threshold for reach 07020006-555

07020006-555 **Fish Class 3** **General Use**	Fish IBI Score	Class Threshold Score
17MN205 6/27/2017	41.7	55

3.1.4.2　Hydrologic Alteration

Hydrologic Alteration Biological Metric Data

Table 78. Hydrologic alteration related fish metrics for reach 07020006-555

07020006-555 **Fish Class 3** General Use	General %	Nesting Non Lithophilic Spawner %
17MN205 6/27/2017	46.0	63.4
Statewide average for Class 3 southern headwater bio sites that are meeting the FIBI modified use threshold (33)	**59.1**	**19.2**
Expected response to **Hydrologic** stress	↑	↑

HSPF Model Flow Data

Table 79. HSPF modeled flow data for reach 07020006-555

07020006-555 HSPF Reach 111 Min: 0.0 cfs Max: 173.7 cfs	<5 cfs % (# of values)	<1 cfs % (# of values)	<0.5 cfs % (# of values)
6,210 Total Daily Averages 1996 – 2012	**83.0%** (5,157)	**48.6%** (3,017)	**34.6%** (2,148)

Hydrologic Alteration Summary

The fish biological metrics for altered hydrology are mixed. There are high numbers of nesting nonlithophilic spawning fish, mostly brook sticklebacks, which is a tolerant, short-lived species. This species is not considered a generalist species and the prevalence of them brought the generalist percentage down below the class average (Table 78).

Reach 07020006-555 is predominantly natural according to the MPCA Hydrologic Alteration layer; though it appears to have been channelized just downstream several of the bio site and several of its tributaries have been channelized As well as many of its wetlands have been tiled and drained.

The HSPF model (Table 79) shows that more than 48% of the daily average flows from 1996 through 2012 are below 1 cfs. Flows reduced beyond normal base flow will decrease habitat for aquatic organisms and increase competition for resources.

Based on the poor scores of the biological metrics and low numbers of nongeneralist fish species, the extended low flow periods shown in the HSPF model, Hydrologic Alteration is a stressor in this reach. The primary impacts in this reach from Hydrologic Alteration is seen by the increased rate of water delivery into the system during large of precipitation events. This faster influx of water tends to cause incision of the stream channel, cutting the stream off from its flood plain and contributing to higher than average bank erosion, which widens the stream channel, causing low water levels that reduces habitat during times of low precipitation. Ditching and tiling of the tributaries and surrounding landscape contributes to low base flows during times of low precipitation, contributing to the stagnation of the water within the ditch and eutrophication of the water causing excessive algae growth from the nutrient overloading of phosphorus, nitrogen.

3.1.4.3   Connectivity

Connectivity Metric Data

Table 80. Connectivity related fish metrics for reach 07020006-555

07020006-555 Fish Class 3 General Use	Mature Age >3 minus Tolerant Taxa %	Migrating Taxa %
17MN205 6/27/2017	0.0	0.0
Statewide average for Class 3 southern headwater bio sites that are meeting the FIBI modified use threshold (33)	**5.3**	**19.5**
Expected response to **Connectivity** stress	↓	↓

Connectivity Summary

The fish biological metrics for connectivity are very poor. There were no late-maturing or migrating species caught though it is unclear if connectivity is the cause of this or some other factor, such as altered hydrology or eutrophication.

3.1.4.4   Habitat

Habitat Metric Data

Table 81. Habitat related fish metrics for reach 07020006-555

07020006-555 **Fish Class 3** General Use	Benthic Insect minus Tolerant %	Darter Sculpin Sucker %	Lithophilic Spawner %	Pioneer %	Piscivore %	Riffle %	Simple Lithophilic Spawner %	Tolerant %
17MN205 6/27/2017	8.0	8.0	35.1	45.7	0.0	0.0	8.0	92.0
Statewide average for Class 3 southern headwater bio sites that are meeting the FIBI general use threshold (55)	**14.2**	**12.6**	**69.2**	**37.8**	**1.6**	**28.3**	**33.7**	**70.6**
Expected response to Habitat stress	↓	↓	↓	↑	↓	↓	↓	↑

MPCA Stream Habitat Assessment Score

Table 82. Habitat Assessment scores for reach 07020006-555

07020006-555	Land Use	Riparian	Substrate	Cover	Channel Morphology	Total Score
17MN205 6/27/2017	0	12	11.8	11	13	47.8
17MN205 8/01/2017	0	4	13	0	6	23
Maximum Attainable Habitat Score	**5**	**14**	**28**	**18**	**35**	**100**

Habitat Summary

The fish biological metrics for habitat and the scores themselves are poor. There were some lithophilic spawning fish present, though far below the class average and 92% of the species caught are considered tolerant. The only darter species present was the fairly tolerant johnny darter. No riffle dwelling fish were present (Table 81).

The MSHA scores conducted during bio visits

Figure 18. Photo of Bio site 17MN205 showing low water levels in the stream. The stream channel itself appears to be widened and incised, which creates low water levels during periods of low flows and precipitation, limiting the habitat that fish need to survive.

were poor, indicating degradation and lack of habitat for fish and invertebrates.

The lower than average numbers of benthic insectivores and lithophilic spawners indicate the substrate is likely a stressor to the biological community stressor at this time. Habitat is a stressor to the biological community, it is likely that altered hydrology and subsequent incision and widening of the channel during high flows followed by low flows are contributing to a limitations in habitat for fish.

3.1.4.5   Dissolved Oxygen

Dissolved Oxygen Biological Metric Data

Table 83. Dissolved oxygen related fish metrics for reach 07020006-555

07020006-555 **Fish Class 3** General Use	Mature Age >3 %	Serial Spawner %	Taxa Count	DO TIV	DO Sensitive %	DO Tolerant %
17MN205 6/27/2017	0.0	10.1	9	7.8	0.0	57.2
Statewide average for Class 3 southern headwater bio sites that are meeting the FIBI general use threshold (55)	**13.3**	**17.1**	**11.8**	**8.4**	**4.5**	**14.2**
Expected response to **DO** stress	↓	↑	↓	↓	↓	↑

Dissolved Oxygen Monitoring Data

Table 84. Dissolved oxygen monitoring data for reach 07020006-555

07020006-555 DO Data 5 mg/L target	Range of Data (mg/L)	% of Monthly Samples < 5 mg/L [# of Samples]							May - Sep <5 mg/L % [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-352 (2017-2019)	5.7 – 12.2	-	-	0% [1]	-	0% [2]	-	-	0% [3]
		Minimum Value							
		-	-	12.2	-	5.7	-	-	
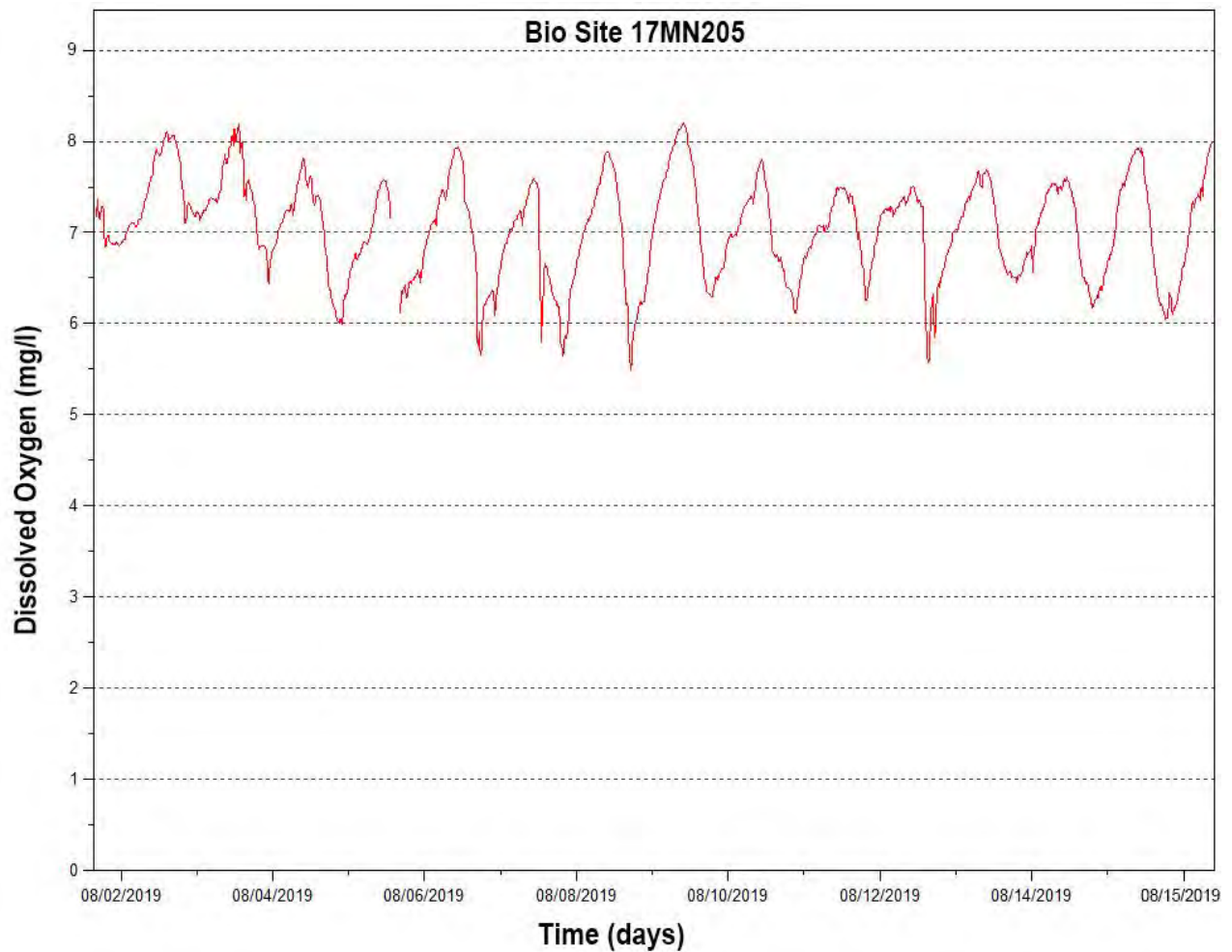
Figure 19. Continuous dissolved oxygen data at site 17MN205

Dissolved Oxygen Summary

The low DO related fish metrics at bio site 17MN205, with the exception of serial spawner %, all scored poorly. There were no late maturing or DO sensitive fish caught. Taxa count was lower than average and DO tolerant fish were above the class average (Table 83).

Although no DO measurements taken during sampling were below the warmwater standard of 5 mg/L, none of those measurements were taken before 8:00 a.m., when values are usually the lowest.

An YSI Sonde water meter measured continuous DO data from 8/02/2019 to 8/15/2019. During this deployment, DO values were not measured below the standard of 5 mg/L (Figure 19).

The related fish biological metric scores indicate that DO may be stressing the fish community. However, the measured values and sonde deployment did not show any low DO values. 2019 had above average precipitation and flows during sonde deployment were moderate, which may have contributed to the high DO values. Because of the conflicting data sets, DO is inconclusive as a stressor in this reach.

3.1.4.6   Eutrophication

Eutrophication Biological Metric Data

Table 85. Eutrophication related fish metrics for reach 07020006-555

07020006-555 **Fish Class 3** General Use	Darter %	Omnivore %	Sensitive %	Simple Lithophillic Spawner %	Tolerant %
17MN205 6/27/2017	8.0	10.1	0.0	8.0	92.0
Statewide average for Class 3 southern headwater bio sites that are meeting the FIBI general use threshold (55)	**12.1**	**14.6**	**8.6**	**33.7**	**70.6**
Expected response to **Eutrophication** stress	↓	↑	↓	↓	↑

Eutrophication Monitoring Data

Table 86. Phosphorus monitoring data for reach 07020006-555

07020006-555 P Sample Data 0.15 mg/L target	Range of Data (mg/L)	Monthly Average of Samples (mg/L) [# of Samples]							June-Aug Average (mg/L) [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-352 (2017-2019)	0.042 – 0.152	-	-	0.042 [1]	-	0.152 [1]	-	-	0.097 [2]
		Maximum Value							
		-	-	0.042	-	0.152	-	-	

Table 87. DO% Saturation monitoring data for reach 07020006-555

07020006-555 DO% Sat Data	Range of Data (%)	Monthly Average of Samples (%) [# of Samples]							June-Aug Average (%) [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-352 (2017-2019)	83.5 – 141.8	-	-	-	-	82.0 [3]	141.8 [1]	-	82.0 [3]

Eutrophication Summary

The eutrophication related fish metrics at bio site 17MN205 mostly scored poorly. The omnivore percentage was just below the class average, there were no sensitive species. Simple lithophilic spawning fish were very low and almost all fish caught were tolerant (Table 85).

Two samples were collected and analyzed for Phosphorus from 2017 to 2019. Because of the low June value, the summer average was below 0.15 mg/L, though the sample in August was just above it (Table 86).

The percent saturation measurement was high during the September site visit at over 141%. The three measurements in August were all below 100% saturation (Table 87).

An YSI Sonde water meter measured continuous DO data from 8/2/2019 to 8/15/2019. During this deployment, diel DO flux was measured below 5 mg/L (Figure 19).

The related fish biological metric scores indicate that eutrophic conditions may be stressing the fish community and the measured values did have a sample that was just above the eutrophication standard of 0.150 mg/l. The sonde deployment did not show high DO flux. Because of the conflicting data sets, eutrophication is inconclusive in this reach.

3.1.4.7   Suspended Solids

Suspended Solids Biological Metric Data

Table 88. Suspended solids related fish metrics for reach 07020006-555

07020006-555 Fish Class 3 General Use	Benthic Feeder %	Centrarchid - Tolerant %	Herbivore %	Intolerant %	Long – lived %	Perciformes - Tolerant %	Riffle %	Sensitive %	Simple Lithophilic Spawner %	TSS TIV
17MN205 6/27/2017	8.0	0.0	1.1	0.0	0.0	8.0	0.0	0.0	8.0	15.7
Statewide average for Class 3 southern headwater bio sites that are meeting the FIBI general use threshold (55)	**37.9**	**0.9**	**13.3**	**2.0**	**3.6**	**13.9**	**28.3**	**8.6**	**33.7**	**15.0**
Expected response to **Suspended Solids** stress	↓	↓	↓	↓	↓	↓	↓	↓	↓	↑

TSS Monitoring Data

Table 89. Total suspended solids monitoring data for reach 07020006-555

07020006-555 TSS Sample Data 65 mg/L target	Range of Data (mg/L)	% of Monthly Samples > 65 mg/L [# of Samples]							% of Total Samples > 65 mg/L [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-552 (2017 - 2019)	9.2 – 81.0	-	-	0% [1]	-	100% [1]	-	-	50% [2]

Table 90. Transparency monitoring data for reach 07020006-555

07020006-555 Secchi Tube Data 10 cm target	Range of Data (mg/L)	% of Monthly Samples < 10 cm [# of Samples]							% of Total Samples < 10 cm [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-352 (2017-2018)	11 – 100+	-	-	0% [1]	-	0% [2]	-	-	0% [3]

Suspended Solids Summary

The suspended solids related fish metrics at bio site 17MN205 scored poorly. There were very few benthic feeders, herbivores, Perciformes, or simple lithophilic spawning fish. There were no Centrarchids, intolerant, long – lived, riffle dwelling, or sensitive fish.

Only two samples were collected and analyzed for TSS from 2017 to 2019. One sample had a TSS concentration above 65 mg/L (Table 89).

Figure 20. Bio site 17MN205 at the road crossing showing silt deposition within the channel.

Due to the very poor biological fish metrics it would appear that suspended solids are stressing the fish community and are probably contributing to poor habitat and siltation and embeddedness of coarse substrates. Due to lack of TSS samples it is inconclusive at this time.

3.1.4.8   Nitrates

Nitrate Biological Metric Data

Table 91. Nitrate related invert metrics for reach 07020006-555

07020006-555	Nitrate Intolerant Taxa %	Nitrogen Tolerant Taxa %	Trichoptera Taxa %	Nitrogen TIV
17MN205 6/27/2017	Low Flow – No Sample Taken			
Statewide average for Class 3 southern headwater bio sites that are meeting the FIBI general use threshold (55)	**2.9**	**3.0**	**47.6**	**3.3**
Expected response to **nitrogen** stress	↓	↑	↓	↑

Nitrate Monitoring Data

Table 92. Nitrate monitoring data for reach 07020006-555

07020006-555 Nitrate/Nitrite Sample Data	2x Highest Reach TIV Average	Range of Data (mg/L) [# of Samples]	Monthly Average [# of Samples]						
			April	May	June	July	August	Sept	Oct
S014-352 (2017-2019)	6.6	4.6 – 9.5 [2]	-	-	9.5 [1]	-	4.6 [1]	-	-
			Highest Value						
			-	-	9.5	-	4.6	-	-

Summary

There was no invert sample collected at bio site 17MN205 due to extremely low flows and very little invert habitat (Table 91).

Two samples were collected in reach 07020006-555 and analyzed for nitrate/nitrite (Table 92). One of the total nitrate samples had concentration of 9.5 mg/L. Due to the lack of biological metrics and the limited nitrate sample, nitrates appear are inconclusive as a stressor to aquatic life in reach 07020006-555.

3.1.4.9   Reach Stressors

Table 93. Summary of stressors for reach 07020006-555

07020006-555	Hydrologic Alteration	Connectivity	Habitat	Dissolved Oxygen	Eutrophication	Suspended Solids	Nitrate
✓ = Stressor ✗ = Not a Stressor O = Inconclusive	✓	O	✓	O	O	O	O

3.1.5 07020006-574   Unnamed Creek
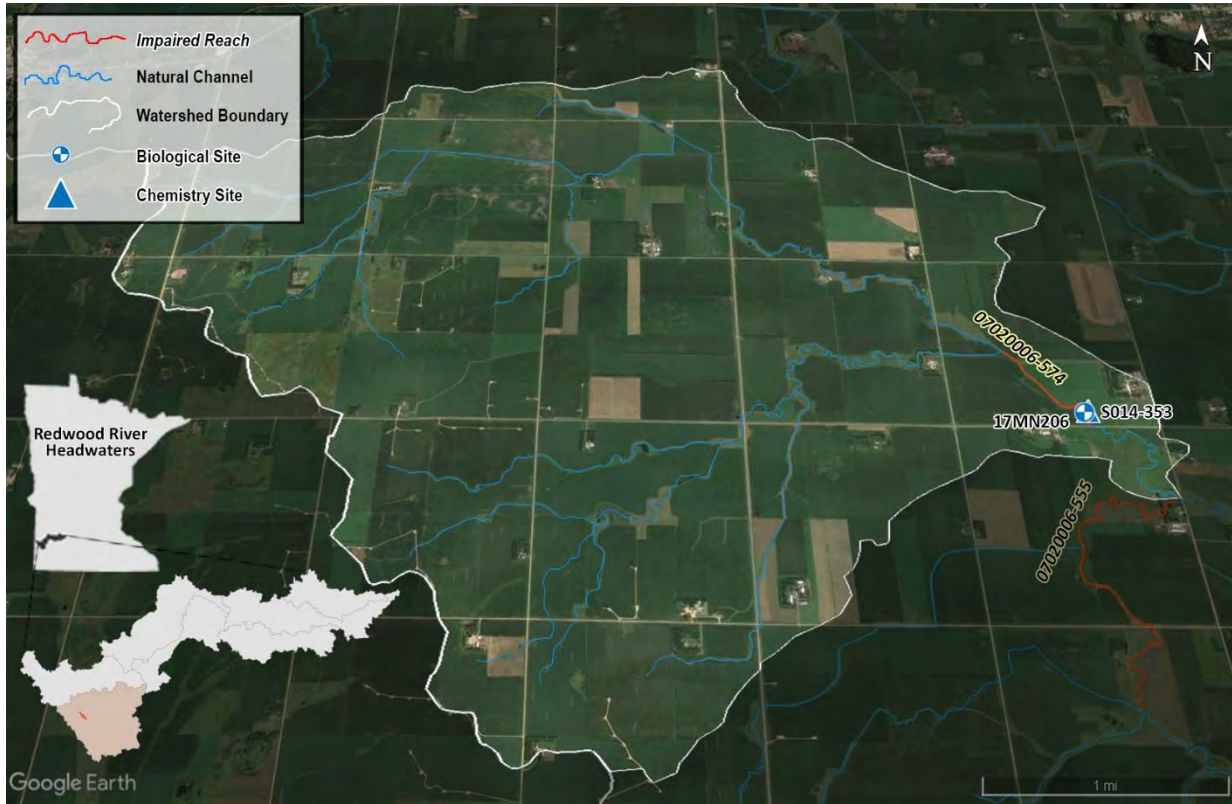
Figure 21. Satellite image of reach 07020006-574 and its watershed

3.1.6.1   Biological Community

Bio site 17MN206 was sampled once for fish in 2017. The site scored very poorly with an Macroinvertebrate IBI (MIBI) score of 2.3, well below the Invert Class 7 prairie stream glide pool modified use threshold of 22 (Table 94). The vast majority of the inverts caught were tolerant species, mostly snails and a few midges, which resulted in the very poor metric score.

Biological Metric Data

Table 94. Invert IBI score and threshold for reach 07020006-574

07020006-574 **Invert Class 7** Modified Use	Invert IBI Score	Class Threshold Score
17MN206 8/01/2017	2.3	22

3.1.6.2   Hydrologic Alteration

Hydrologic Alteration Biological Metric Data

Table 95. Hydrologic alteration related invert metrics for reach 07020006-574

07020006-574 **Invert Class 7** Modified Use	Clinger %	Collector – filterer %	Long – lived %	Percent Ditched Tolerant %	Percent Ditched Intolerant %
17MN206 8/01/2017	0.0	0.3	0.3	19.9	0.0
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI modified use threshold (22)	**23.1**	**9.9**	**5.6**	↑	↓
Expected response to **Hydrologic** stress	↓	↓	↓		

HSPF Model Flow Data

Table 96. HSPF modeled flow data for reach 07020006-574

07020006-574 HSPF Reach 113 Min: 0.0 cfs Max: 329.9 cfs	<5 cfs % (# of values)	<1 cfs % (# of values)	<0.5 cfs % (# of values)
6,210 Total Daily Averages 1996 – 2012	**75.0%** (4,658)	**40.0%** (2,483)	**22.6%** (1,402)

Hydrologic Alteration Summary

The invertebrate metrics for altered hydrology were poor. There were no clingers. Both collector – filterers and long – lived invertebrates were all very low with only one crayfish making up the 0.3% of long – lived individuals. The site was dominated by snails and midges. The ratio of inverts tolerant to ditched stream channels compared to those that are intolerant wasn't as high as other reaches in the basin but there were none that were intolerant to ditching (Table 95).

The HSPF model (Table 79) shows that 40% of the daily average flows from 1996 through 2012 are below 1 cfs. Flows reduced beyond normal base flow will decrease habitat for aquatic organisms and increase competition for resources.

Based on the very poor scores of the biological metrics and extended low flow periods shown in the HSPF model Hydrologic Alteration is a stressor in this reach. The primary impact in this reach from

Hydrologic Alteration is the ditching of the stream itself, which affects biology in several ways. Ditching destroys the natural geomorphology of the stream, which reduces the riffle, run, glide, and pool environments needed to support a diverse invertebrate community. It cuts the stream off from its floodplain, which provides habitat and cover and dissipates some of the streams power during high flows. Ditching and tiling of the tributaries and surrounding landscape contributes to low base flows during times of low precipitation, contributing to the stagnation of the water within the ditch and eutrophication of the water, which causes excessive algae growth from the nutrient overloading of phosphorus and nitrogen.

3.1.6.3 Connectivity

Connectivity Metric Data

07020006-574 **Fish Class 7** **Modified Use**	Mature Age >3 minus Tolerant Taxa %	Migrating Taxa %
17MN206 9/19/2017	0.0	22.2
Statewide average for Class 7 low gradient bio sites that are meeting the FIBI modified use threshold (15)	**8.7**	**13.4**
Expected response to **Connectivity** stress	↓	↓

Table 97. Connectivity related fish metrics for reach 07020006-574

Connectivity Summary

The fish biological metrics for connectivity appear mixed at first glance, though the 22% migrating taxa percentage was due to only two migrating species, the Iowa darter and white sucker, with only one fish being caught of each. There were no late-maturing fish caught.

There are no know barriers in the stream; however, the culvert at the road crossing appears it might impede fish migration during low flows (Figure 22), which according to the model appears to happen frequently in this stream (Table 96). Connectivity could be a stressor to the biological community but is inconclusive at this time.

3.1.6.4   Habitat

Habitat Metric Data

Table 98. Habitat related invert metrics for reach 07020006-574

07020006-574 Invert Class 7 Modified Use	Burrower %	Climber %	Clinger %	Ephemeroptera Plecoptera Trichoptera %	Legless %	Sprawler %
17MN206 8/01/2017	0.3	96.9	0.0	0.0	98.8	0.6
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI modified use threshold (22)	**14.1**	**27.5**	**23.1**	**20.6**	**55.8**	**27.0**
Expected response to **Habitat** stress	↑	↓	↓	↓	↑	↑

MPCA Stream Habitat Assessment Score

Table 99. Habitat Assessment scores for reach 07020006-574

07020006-574	Land Use	Riparian	Substrate	Cover	Channel Morphology	Total Score
17MN206 8/1/2017	1.5	8	7	5	6	27.5
17MN206 9/19/2017	0	11	8	11	5	35
Maximum Attainable Habitat Score	**5**	**14**	**28**	**18**	**35**	**100**

Habitat Summary

The invert biological metrics for habitat and the scores themselves appear to be mixed. However, the metrics that appear to be ok are influenced by the fact that 96% of the total number of invertebrates caught were snails, which are considered clingers. The few species of midges caught were not the burrowing or spawling type. The only darter species present was the fairly tolerant johnny darter. No riffle dwelling fish were present (Table 81).

Figure 23. Photo of Bio site 17MN206 some stream morphology and a vegetated buffer. The stream was straightened in the past and appears to be slowly forming some geomorphic features; however, there appears to be little actual variation in the stream channel.

The MSHA scores conducted during bio visits were poor, indicating degradation and lack of habitat for fish and invertebrates.

Due to the generally poor habitat metrics, lack of any sensitive invertebrates, and the poor habitat scores, habitat is a stressor to the biological community.

3.1.6.5 Dissolved Oxygen

Dissolved Oxygen Biological Metric Data

Table 100. Dissolved oxygen related invert metrics for reach 07020006-574

07020006-574 Invert Class 7 Modified Use	DO TIV	HBI_MN	Low DO Intolerant Taxa %	Low DO Tolerant Taxa %
17MN206 8/01/2017	6.8	8.4	0.0	19.6
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI modified use threshold (22)	**6.2**	**8.0**	**3.1**	**31.4**
Expected response to **DO** stress	↓	↑	↓	↑

Dissolved Oxygen Monitoring Data

07020006-574 DO Data 5 mg/L target	Range of Data (mg/L)	% of Monthly Samples < 5 mg/L [# of Samples]							May - Sep <5 mg/L % [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-353 (2017-2019)	5.3 – 9.0	-	-	-	-	0% [3]	0% [1]	-	0% [4]
		Minimum Value							
		-	-	-	-	5.3	9.0	-	
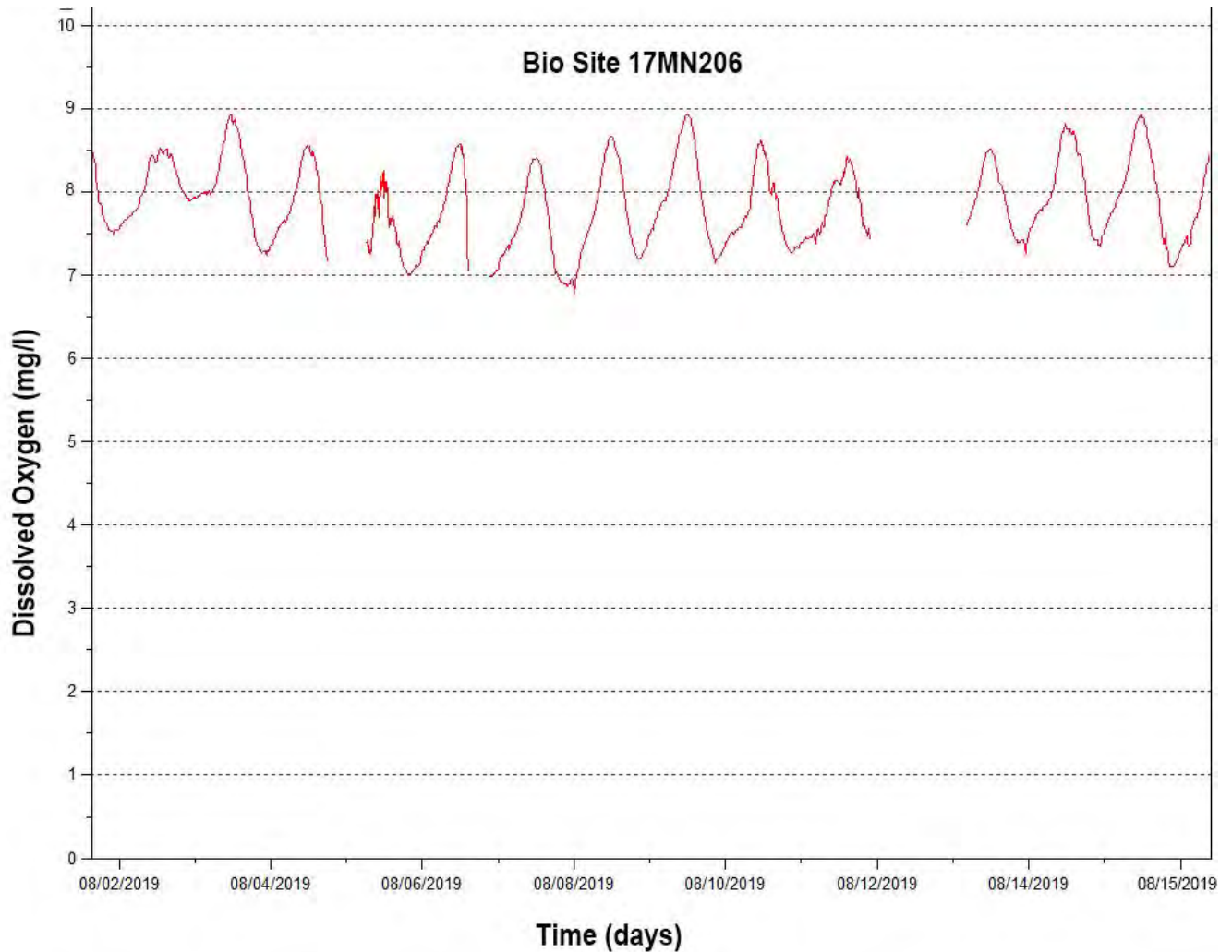
Figure 24. Continuous dissolved oxygen data at site 17MN206

Dissolved Oxygen Summary

The invert community at bio site 17MN206 scored below average in two of the four DO related invert metrics when compared to the average of all other Class 2 southern stream bio sites that meet the FIBI general use threshold (Table 100). The TIV score was higher than the class average and the low DO tolerant species were lower than the class average at 19.6% of the invert population. There were no intolerant species present and the HBI_MN score was also a bit higher than the average.

Although no DO measurements taken during sampling were below the warmwater standard of 5 mg/L, none of those measurements were taken before 8:00 a.m., when values are usually the lowest.

An YSI Sonde water meter measured continuous DO data from 8/02/2019 to 8/15/2019. During this deployment, DO values were not measured below the standard of 5 mg/L (Figure 24).

The related invert biological metric scores are mixed and the measured values and sonde deployment did not show any low DO values. 2019 had above average precipitation and flows during sonde deployment were moderate, which may have contributed to the high DO values when the sonde was deployed. Because of the mixed metrics and data sets that did not show low DO, DO is inconclusive as a stressor in this reach.

3.1.6.6   Eutrophication

Eutrophication Biological Metric Data

Table 102. Eutrophication related invert metrics for reach 07020006-574

07020006-574 **Invert Class 7** Modified Use	Crustacean and Mollusca %	Collector – Gatherer Taxa #	Ephemeroptera Plecoptera Trichoptera Taxa %	Intolerant Two Taxa %	Scraper %	Taxa Count All #	Tolerant Two Taxa %
17MN206 8/01/2017	97.5	2	0.0	0.0	96.6	11	90.9
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI modified use threshold (22)	**23.2**	**11.8**	**20.6**	**0.1**	**17.7**	**33.6**	**86.6**
Expected response to **Eutrophic** stress	↑	↓	↓	↓	↑	↓	↑

Eutrophication Monitoring Data

07020006-574 P Sample Data 0.15 mg/L target	Range of Data (mg/L)	Monthly Average of Samples (mg/L) [# of Samples]							June-Aug Average (mg/L) [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-353 (2017-2019)	0.057 – 0.090	-	-	0.069 [1]	-	0.090 [1]	0.058 [2]	-	0.079 [2]
		Maximum Value							
		-	-	0.069	-	0.090	0.058	-	

07020006-574 DO% Sat Data	Range of Data (%)	Monthly Average of Samples (%) [# of Samples]							June-Aug Average (%) [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-353 (2017-2019)	73.1 – 99.9	-	-	-	-	86.8 [3]	99.9 [1]	-	86.8 [3]

Eutrophication Summary

The fish community at bio site 17MN206 scored very poorly in all eutrophication related invert metrics when compared to the average of all other Class 7 prairie stream glide pool bio sites that meet the MIBI modified use threshold. The bio site was dominated by snails, which formed the vast majority of the inverts caught at the bio site (Table 102). The high relative abundance of snails has a very large effect on the eutrophication metrics, as crustacean and Mollusca, scraper, and tolerant two percentages were very high. The collector-gatherer, EPT, and intolerant two percentages as well as taxa count was very low.

Four samples were collected and analyzed for Phosphorus from 2017 to 2018. The summer average was well below the standard of 0.15 mg/L (Table 103).

An YSI Sonde water meter measured continuous DO data from 8/2/2019 to 8/15/2019. During this deployment, diel DO flux was not measured at or above 5 mg/L (Figure 24).

The biological community appears to be showing the effects eutrophication. Phosphorus sampling did not show elevated concentrations, though the number of samples was very limited. Diurnal DO flux was not measured at 5 mg/L or greater, though 2019 was a wetter than average year and the stream flow was still pretty moderate when the sonde was deployed. Algae growth was observed at the station (Figure 25). Although there were very poor related metrics, some of the supporting data is inconclusive, eutrophication is inconclusive as a stressor in this reach.

Figure 25. Photo of bio site 17MN206 showing algae growth just downstream of the road crossing right where the stream turns into a straightened ditch. There is also substantial sediment deposition on the right side of the photo.

3.1.6.7   Suspended Solids

Suspended Solids Biological Metric Data

Table 105. Suspended solids related invert metrics for reach 07020006-574

07020006-574 Invert Class 7 Modified Use	Collector – filterer %	Plecoptera %	Sprawler %	TSS Intolerant Taxa %	TSS Tolerant Taxa %	TSS TIV
17MN206 8/01/2017	0.3	0.0	0.6	0.0	91.0	24.2
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI modified use threshold (22)	**9.9**	**0.0**	**27.0**	**1.3**	**35.6**	**16.2**
Expected response to **Suspended Solids** stress	↓	↓	↑	↓	↑	↑

TSS Monitoring Data

Table 106. Total suspended solids monitoring data for reach 07020006-574

07020006-574 TSS Sample Data 65 mg/L target	Range of Data (mg/L)	% of Monthly Samples > 65 mg/L [# of Samples]							% of Total Samples > 65 mg/L [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-353 (2017 - 2019)	2.0 – 35.0	-	-	-	-	0% [1]	0% [1]	-	0% [2]

Table 107. Transparency monitoring data for reach 07020006-574

07020006-574 Secchi Tube Data 10 cm target	Range of Data (mg/L)	% of Monthly Samples < 10 cm [# of Samples]							% of Total Samples < 10 cm [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-353 (2017-2018)	18 – 100+	-	-	-	-	0% [3]	0% [1]	-	0% [4]

Suspended Solids Summary

The fish community at bio site 17MN206 scored below average in all five suspended solids related invert metrics when compared to the average of all other Class 7 prairie stream glide pool bio sites that meet the MIBI modified use threshold. There were very few collector-filterer, Plecoptera, or TSS intolerant invertebrates present. Ninety-one percent of the taxa caught are considered tolerant to TSS and the TSS TIV scored above the class average (Table 104).

Only two samples were collected and analyzed for TSS from 2017-2019. No sample had a TSS concentration above 65 mg/L (Table 106). Secchi tube data also did not show any low levels of transparency (Table 107).

Suspended solids are inconclusive as a stressor to aquatic life at this time. There is significant sediment deposition just downstream of the road crossing so it is likely that elevated levels of TSS does occur. It is also likely that the alteration and ditching of the stream channel has caused a sediment imbalance, which causes sediment to build up at the location (Figure 25). It is likely that other factors, such as altered hydrology or habitat are also contributing to the poor scores in the invertebrate biological metrics. It is recommended that more TSS data be collected during high flows and during low late summer flows in order to help determine whether it is stressing the biological community.

3.1.6.8   Nitrates

Nitrate Biological Metric Data

Table 108. Nitrate related invert metrics for reach 07020006-574

07020006-574 Invert Class 7 Modified Use	Nitrate Intolerant Taxa %	Nitrogen Tolerant Taxa %	Trichoptera Taxa %	Nitrogen TIV
17MN206 8/01/2017	0.0	98.1	0.0	8.8
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI modified use threshold (22)	**2.0**	**59.4**	**5.9**	**3.3**
Expected response to **nitrogen** stress	↓	↑	↓	↑

Nitrate Monitoring Data

Table 109. Nitrate monitoring data for reach 07020006-574

07020006-574 Nitrate/Nitrite Sample Data	2x Highest Reach TIV Average	Range of Data (mg/L) [# of Samples]	Monthly Average [# of Samples]						
			April	May	June	July	August	Sept	Oct
S014-353 (2017-2019)	6.6	7.2 – 9.2 [3]	-	-	8.2	-	7.2 [1]	9.2 [1]	-
			Highest Value						
			-	-	8.2	-	7.2	9.2	-

Summary

The macroinvertebrate assemblage at site 17MN206 scored very poorly in all four nitrate related metrics evaluated when compared to all other macroinvertebrate Class 7 prairie stream glide pool bio sites that meet the MIBI modified use threshold (Table 108). The biological bio site had no Trichoptera taxa, which tend to decrease in streams with excessive nitrate values. Nitrate tolerant invertebrates comprised over 98% of the total inverts caught and there were no nitrate intolerant invertebrate species. The nitrogen TIV score also indicates a macroinvertebrate community that is generally tolerant to high levels of nitrates.

Three samples were collected in reach 07020006-574 and analyzed for nitrate/nitrite (Table 109). All of the samples collected were relatively high. Due to the biological response and relatively high nitrate concentrations, nitrates are a stressor to aquatic life in reach 07020006-574.

3.1.6.9   Reach Stressors

Table 110. Summary of stressors for reach 07020006-574

07020006-574	Hydrologic Alteration	Connectivity	Habitat	Dissolved Oxygen	Eutrophication	Suspended Solids	Nitrate
✓ = Stressor ✗ = Not a Stressor O = Inconclusive	✓	O	✓	O	O	O	✓

3.1.7 07020006-532   Unnamed Creek
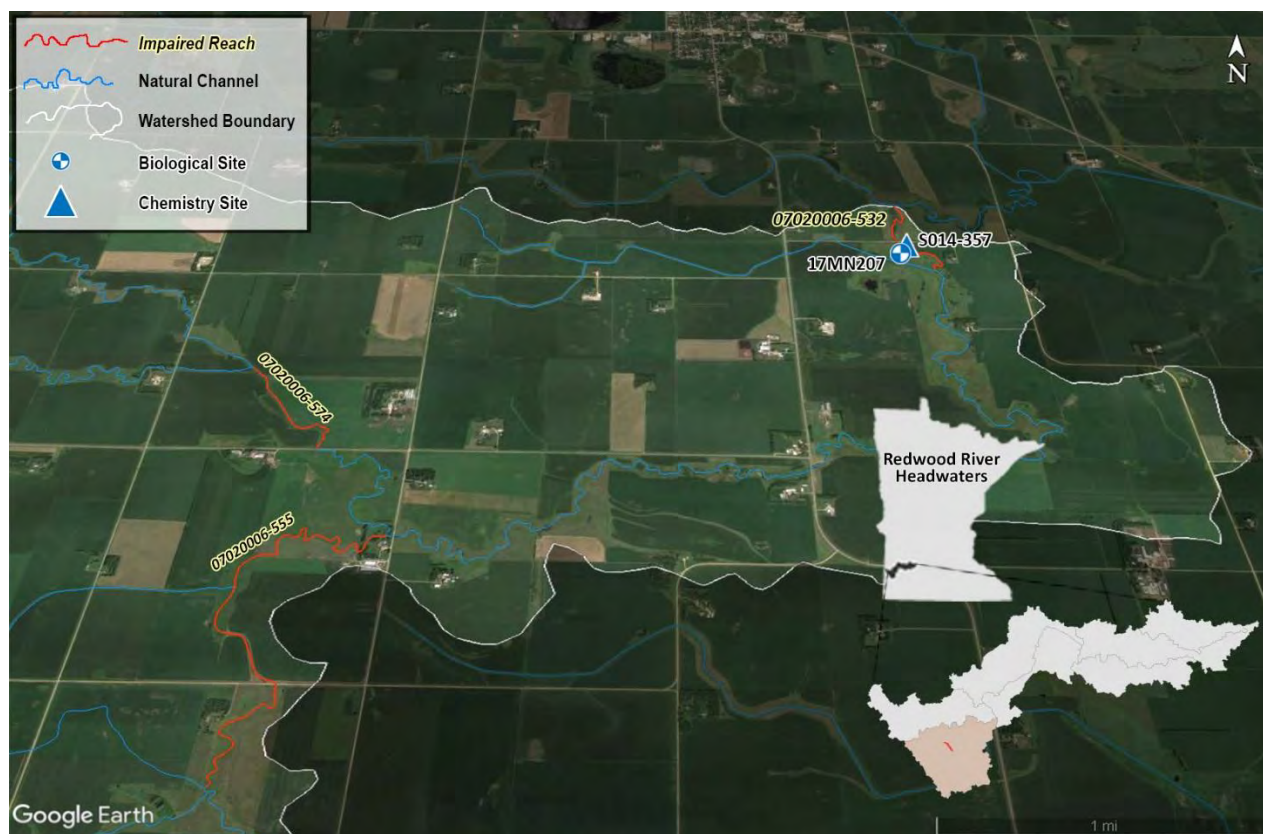
Figure 26. Satellite image of reach 07020006-532 and its watershed

3.1.8.1   Biological Community

Bio site 17MN207 was sampled once for both fish and inverts in 2017. The FIBI score of 24.8 was well below the Fish Class 7 low gradient streams general use threshold of 42 (Table 109). Blacknose dace, creek chubs, and white suckers dominated the fish community as well as other short lived and tolerant taxa resulting in a poor metric score.

The MIBI score of 34.4 was below the invert class 7 southern prairie stream glide pool general use threshold of 41 (Table 112). The bio site was dominated by *hyellella*, a tolerant amphipod. The next two numerous taxa were *caenis* diminuta and *stenacron*, both fairly tolerant mayflies that helped bring up the IBI score. There were also several species of midges present.

Biological Metric Data

Table 111. Fish IBI score and threshold for reach 07020006-532

07020006-532 **Fish Class 7** General Use	Fish IBI Score	Class Threshold Score
17MN207 9/19/2017	24.8	42

Table 112. Invert IBI score and threshold for reach 07020006-532

07020006-532 **Invert Class 7** General Use	Invert IBI Score	Class Threshold Score
17MN207 8/02/2017	34.4	41

3.1.8.2   Hydrologic Alteration

Hydrologic Alteration Biological Metric Data

Table 113. Hydrologic alteration related fish metrics for reach 07020006-532

07020006-532 **Fish Class 7** General Use	General %	Nesting Non-Lithophilic Spawner %
17MN207 9/19/2017	82.9	12.9
Statewide average for Class 7 low gradient bio sites that are meeting the FIBI general use threshold (42)	**34.6**	**19.6**
Expected response to **Hydrologic** stress	↑	↑

07020006-532 **Invert Class 7** General Use	Clinger %	Collector – filterer %	Long – lived %	Percent Ditched Tolerant %	Percent Ditched Intolerant %
17MN207 8/02/2017	16.5	2.2	2.8	34.9	0.0
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI general use threshold (41)	**38.5**	**19.1**	**8.0**	↑	↓
Expected response to **Hydrologic** stress	↓	↓	↓		

HSPF Model Flow Data

Table 115. HSPF modeled flow data, 1994-2012

07020006-532 HSPF Reach 115 Min: 0.0 cfs Max: 576.7 cfs	<5 cfs % (# of values)	<1 cfs % (# of values)	<0.5 cfs % (# of values)
6,210 Total Daily Averages 1996 – 2012	**58.6%** (3,638)	**20.4%** (1,268)	**9.4%** (584)

Hydrologic Alteration Summary

The fish biological metrics for altered hydrology are mixed. There were relatively low numbers of nesting nonlithophilic spawning fish, mostly blacknose dace, creek chubs, and white suckers, which are all lithophilic spawning fish. Generalist species were very high at over 82% (Table 113).

Hydrologic alteration related invert metrics scored poorly. There were some Clingers, which were mostly the mayfly stenocron. Both collector – filterers and long – lived invertebrates were both very low. The ratio of inverts tolerant to ditched stream channels compared to those that are intolerant was fairly high and there were none that were intolerant to ditching (Table 114).

The HSPF model (Table 115) shows that 20.4% of the daily average flows from 1996 through 2012 are below 1 cfs. Flows reduced beyond normal base flow will decrease habitat for aquatic organisms and increase competition for resources.

Based on the mostly poor scores of the biological metrics and moderate low flow periods shown in the HSPF model Hydrologic Alteration is a stressor in this reach. The primary impact in this reach from Hydrologic Alteration is the ditching and tiling of the tributaries and surrounding landscape, which contributes to low base flows during times of low precipitation. This reach appears to be less affected by

hydrologic alteration and has better biology than the two reaches upstream, 07020006-574 and 07020006-555. This is likely due to the fact that it is a mostly natural channel and that it is a little further down in the watershed, which makes it less prone to very low flows.

3.1.8.3 Connectivity

Connectivity Metric Data

07020006-532 **Fish Class 7** **General Use**	Mature Age >3 minus Tolerant Taxa %	Migrating Taxa %
17MN207 9/19/2017	0.0	8.3
Statewide average for Class 7 low gradient bio sites that are meeting the FIBI general use threshold (42)	**9.9**	**12.8**
Expected response to **Connectivity** stress	↓	↓

Connectivity Summary

The fish biological metrics for connectivity are poor. There were no late-maturing fish caught. White suckers, a relatively tolerant fish, were the only migrating taxa caught. There are no know barriers in the stream, due to the presence of migratory species it appears that connectivity is not a stressor at this section of the reach.

3.1.8.4 Habitat

Habitat Metric Data

Table 117. Habitat related fish metrics for reach 07020006-532

07020006-532 **Fish Class 7** **General Use**	Benthic Insect minus Tolerant %	Darter Sculpin Sucker %	Lithophilic Spawner %	Pioneer %	Piscivore %	Riffle %	Simple Lithophilic Spawner %	Tolerant %
17MN207 9/19/2017	5.7	5.7	80.0	37.1	1.4	20.0	50.0	88.6
Statewide average for Class 7 low gradient bio sites that are meeting the FIBI general use threshold (42)	**8.8**	**7.4**	**34.6**	**12.7**	**4.9**	**12.2**	**24.1**	**48.7**
Expected response to **Habitat** stress	↓	↓	↓	↑	↓	↓	↓	↑

Table 118. Habitat related invert metrics for reach 07020006-532

07020006-532 **Invert Class 7** General Use	Burrower %	Climber %	Clinger %	Ephemeroptera Plecoptera Trichoptera %	Legless %	Sprawler %
17MN207 8/02/2017	5.6	17.7	16.5	36.0	25.5	56.2
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI general use threshold (41)	**7.5**	**21.6**	**38.5**	**38.5**	**39.8**	**20.9**
Expected response to **Habitat** stress	↑	↓	↓	↓	↑	↑

MPCA Stream Habitat Assessment Score

Table 119. Habitat Assessment scores for reach 07020006-532

07020006-532	Land Use	Riparian	Substrate	Cover	Channel Morphology	Total Score
17MN207 8/02/2017	2.5	8.5	8	6	6	31
17MN207 9/19/2017	0	9.5	11.8	12	12	45.3
Maximum Attainable Habitat Score	**5**	**14**	**28**	**18**	**35**	**100**

Habitat Summary

The fish biological metrics for habitat and the scores themselves are mostly poor, though there are some good numbers of lithophilic spawning and riffle dwelling fish present. There were few benthic insectivores and the only darter species present was the fairly tolerant johnny darter. Fish considered tolerant

Figure 27. Photo showing the bridge crossing at bio site 17MN207 showing some sand deposition and geomorphological development. Even so, the stream appears to be widened and shallow, which provides little habitat for fish.

were 88.6 of the total fish caught (Table 117).

The invert biological metrics for habitat were also mostly poor, though most of the scores themselves were not terribly poor.

The MSHA scores conducted during bio visits were poor, indicating degradation and lack of habitat for fish and invertebrates.

Habitat appears to be stressing the fish community more than the invertebrate community. The substrate appears to be at least partially adequate as it supports both lithophilic spawning and riffle dwelling fish as well as some mayflies. Silt deposition may having an effect on the high number of sprawlers present at the bio site.

3.1.8.5   Dissolved Oxygen

Dissolved Oxygen Biological Metric Data

Table 120. Dissolved oxygen related fish metrics for reach 07020006-532

07020006-532 **Fish Class 7** General Use	Mature Age >3 %	Serial Spawner %	Taxa Count	DO TIV	DO Sensitive %	DO Tolerant %
17MN207 9/19/2017	20.0	8.6	12	8.4	0.0	14.3
Statewide average for Class 7 low gradient bio sites that are meeting the FIBI general use threshold (42)	**18.2**	**19.1**	**11.6**	**7.6**	**0.6**	**65.3**
Expected response to **DO** stress	↓	↑	↓	↓	↓	↑

Table 121. Dissolved oxygen related invert metrics for reach 07020006-532

07020006-532 **Invert Class 7** General Use	Low DO Intolerant Taxa %	Low DO Tolerant Taxa %	DO TIV	HBI_MN
17MN207 8/02/2017	2.2	59.9	6.3	8.0
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI general use threshold (41)	**9.3**	**13.0**	**6.9**	**7.6**
Expected response to **DO** stress	↓	↑	↓	↑

Dissolved Oxygen Monitoring Data

Table 122. Dissolved oxygen monitoring data for reach 07020006-532

07020006-532 DO Data 5 mg/L target	Range of Data (mg/L)	% of Monthly Samples < 5 mg/L [# of Samples]							May - Sep <5 mg/L % [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-354 (2017-2019)	5.0 – 8.5	-	-	-	-	0% [3]	0% [1]	-	0% [4]
		Minimum Value							
		-	-	-	-	5.0	7.2	-	
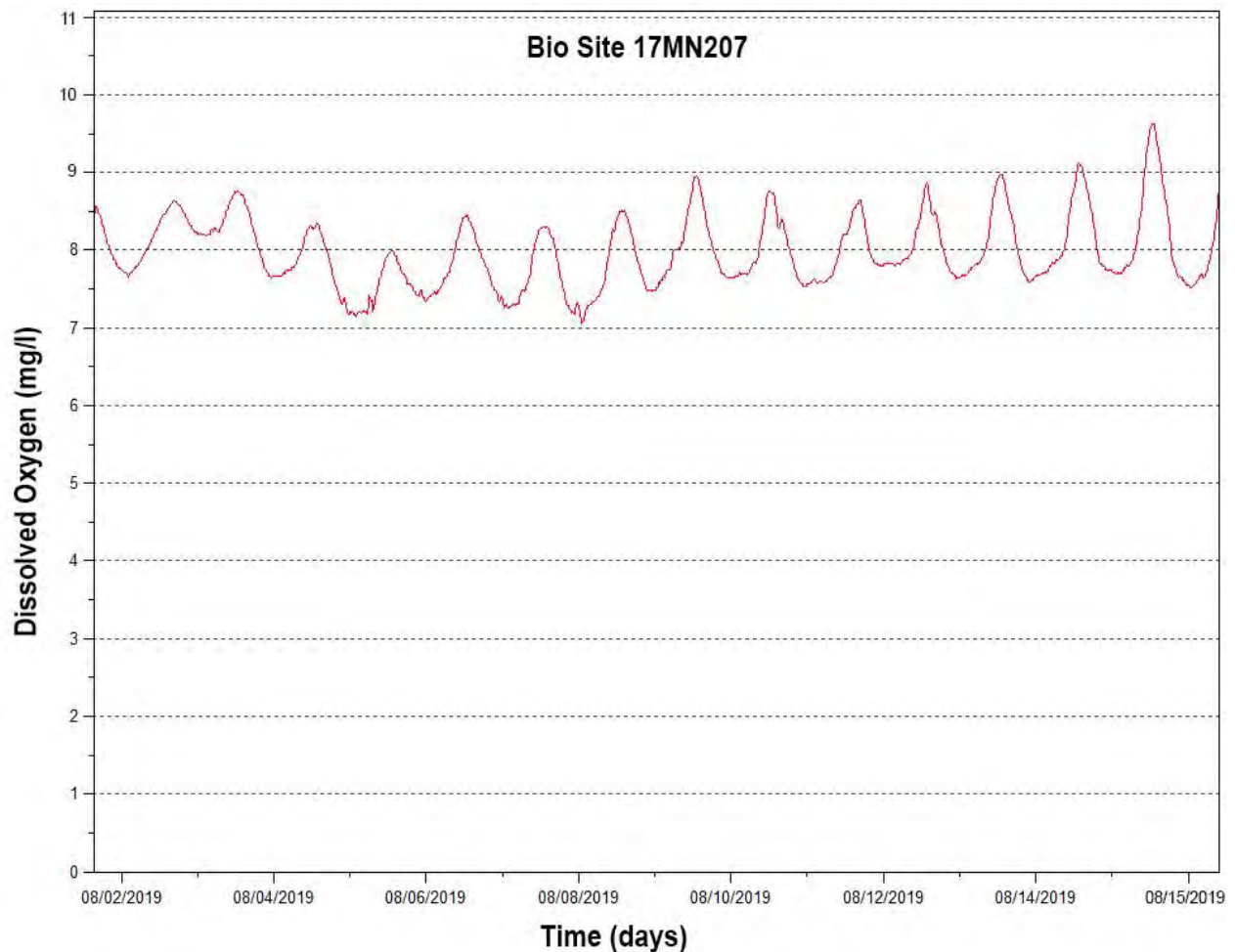
Figure 28. Continuous dissolved oxygen data at site 17MN207
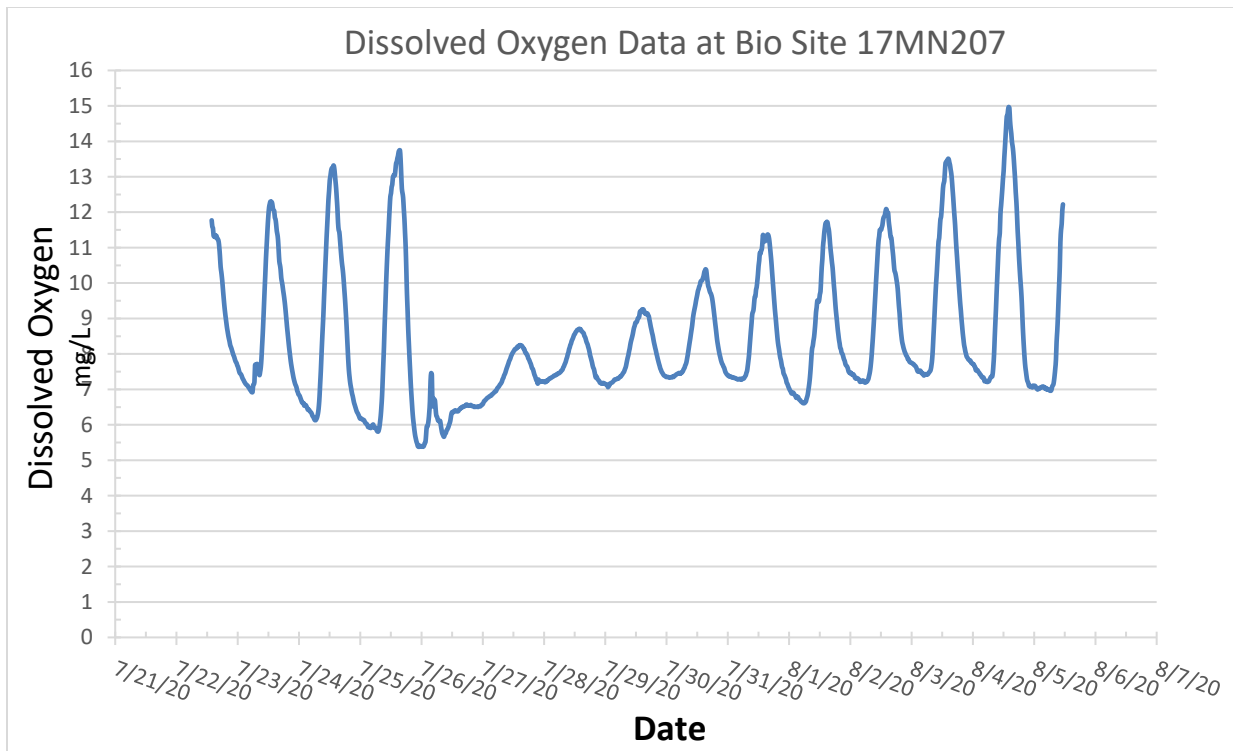
Figure 29. Continuous dissolved oxygen data at site 17MN207

Dissolved Oxygen Summary

The low DO related fish metrics at bio site 17MN207 were mostly good. There were above average late maturing, taxa count, and the site had a good fish TIV score. Serial spawning and low DO tolerant fish were below average. There were no DO sensitive fish, though the class average is only 0.6 %. (Table 120).

The low DO related metrics for inverts were poor. There were few low DO intolerant taxa and an abundance of low DO tolerant taxa. The invert TIV score for bio site was below and the HBI score was above their respective class averages.

Although no DO measurements taken during sampling were below the warmwater standard of 5 mg/L, none of those measurements were taken before 8:00 a.m., when values are usually the lowest.

An YSI Sonde water meter measured continuous DO data from 8/02/2019 to 8/15/2019. During this deployment, DO values were not measured below the standard of 5 mg/L (Figure 28).

Based on the mostly good related fish biological metric scores and the measured sonde values, DO is inconclusive as a stressor in this reach.

3.1.8.6   Eutrophication

Eutrophication Biological Metric Data

Table 123. Eutrophication related fish metrics for reach 07020006-532

07020006-532 Fish Class 7 General Use	Darter %	Omnivore %	Sensitive %	Simple Lithophillic Spawner %	Tolerant %
17MN207 9/19/2017	5.7	21.4	0.0	50.0	88.6
Statewide average for Class 7 low gradient bio sites that are meeting the FIBI general use threshold (42)	**6.7**	**13.9**	**19.0**	**24.1**	**48.7**
Expected response to **Eutrophication** stress	↓	↑	↓	↓	↑

Table 124. Eutrophication related invert metrics for reach 07020006-532

07020006-532 Invert Class 7 General Use	Crustacean and Mollusca %	Collector – Gatherer Taxa #	Ephemeroptera Plecoptera Trichoptera Taxa %	Intolerant Two Taxa %	Scraper %	Taxa Count All #	Tolerant Two Taxa %
17MN207 8/02/2017	36.6	12	36.0	0.0	8.7	35	94.3
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI general use threshold (41)	**11.8**	**13.3**	**28.8**	**0.2**	**16.1**	**37.0**	**81.9**
Expected response to **Eutrophic** stress	↑	↓	↓	↓	↑	↓	↑

Eutrophication Monitoring Data

Table 125. Phosphorus monitoring data for reach 07020006-532

07020001-532 P Sample Data 0.150 mg/L target	Range of Data (mg/L)	Monthly Average of Samples (mg/L) [# of Samples]							June-Aug Average (mg/L) [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-354 (2017-2019)	0.078 – 0.146	-	-	-	-	0.146 [1]	0.078 [1]	-	0.146 [1]
		Maximum Value							
		-	-	-	-	0.146	0.078	-	

Table 126. DO% Saturation monitoring data for reach 07020006-532

07020006-532 DO% Sat Data	Range of Data (%)	Monthly Average of Samples (%) [# of Samples]							June-Aug Average (%) [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-354 (2017-2019)	58.8 – 97.0	-	-	-	-	82.2 [3]	81.7 [1]	-	82.2 [3]

Eutrophication Summary

The eutrophication related fish metrics at bio site 17MN207 mostly scored poorly. Darters were just below the class average, though there were only four johnny darters that were caught. Omnivores were higher than average and tolerant fish were very high. There was a good number of tolerant simple lithophilic spawning fish as blacknose dace and white suckers were abundant (Table 123).

The eutrophication related invertebrate metrics were also mostly poor. The abundance of amphipods caused the crustacean percentage to be well above the class average. EPT taxa were better than average as were scraper invertebrates. The tolerant two taxa was very high and one of those was a mayfly, though it was the tolerant caenis diminuta, which contributed to the higher than average the EPT percentage. Scrapers were not abundant, which would indicate that algae production is not too bad at the site (Table 124).

Two samples were collected and analyzed for Phosphorus from 2017 through 2019. The summer average was just below 0.15 mg/L (Table 125).

The percent saturation measurement was low during all three site visits (Table 126).

An YSI Sonde water meter measured continuous DO data from 8/2/2019 to 8/15/2019. During this deployment, diel DO flux was not measured above 5 mg/L (Figure 28).

The related fish biological metric scores indicate that eutrophic conditions may be stressing the fish community; however, the collected samples were below the eutrophication standard of 0.150 mg/l. The sonde deployment did not show high DO flux and there was not excessive algae observed during site visits. Because of the conflicting data sets, eutrophication is inconclusive in this reach.

3.1.8.7   Suspended Solids

Suspended Solids Biological Metric Data

Table 127. Suspended solids related fish metrics for reach 07020006-532

07020006-532 Fish Class 7 General Use	Benthic Feeder %	Centrarchid - Tolerant %	Herbivore %	Intolerant %	Long – lived %	Perciformes - Tolerant %	Riffle %	Sensitive %	Simple Lithophilic Spawner %	TSS TIV
17MN207 9/19/2017	25.7	1.4	4.3	0.0	1.4	7.1	20.0	0.0	50.0	16.3
Statewide average for Class 7 low gradient bio sites that are meeting the FIBI general use threshold (42)	**17.8**	**6.0**	**7.4**	**4.6**	**12.3**	**18.3**	**12.2**	**19.0**	**24.1**	**13.2**
Expected response to **Suspended Solids** stress	↓	↓	↓	↓	↓	↓	↓	↓	↓	↑

Table 128. Suspended solids related invert metrics for reach 07020006-532

07020006-532 Invert Class 7 General Use	Collector – filterer %	Plecoptera %	Sprawler %	TSS Intolerant Taxa %	TSS Tolerant Taxa %	TSS TIV
17MN207 8/02/2017	2.2	0.0	56.2	0.0	27.2	17.4
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI general use threshold (41)	**19.1**	**0.2**	**20.9**	**2.7**	**48.3**	**17.8**
Expected response to **Suspended Solids** stress	↓	↓	↑	↓	↑	↑

TSS Monitoring Data

Table 129. Total suspended solids monitoring data for reach 07020006-532

07020001-532 TSS Sample Data 65 mg/L target	Range of Data (mg/L)	% of Monthly Samples > 65 mg/L [# of Samples]							% of Total Samples > 65 mg/L [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-354 (2017 - 2019)	10 – 58	-	-	-	-	0% [1]	0% [1]	-	0% [2]

Table 130. Transparency monitoring data for reach 07020006-532

07020001-532 Secchi Tube Data 10 cm target	Range of Data (mg/L)	% of Monthly Samples < 10 cm [# of Samples]							% of Total Samples < 10 cm [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-354 (2017-2019)	20 – 75	-	-	-	-	0% [3]	0% [1]	-	0% [3]

Suspended Solids Summary

The suspended solids related fish metrics at bio site 17MN207 mostly poor, though there were some good metric scores and some that were close to the class averages. There were above average benthic feeders, riffle dwelling, and simple lithophilic spawners present. There were very few Centrarchids, herbivores, long – lived, or perciformes, There were no intolerant or sensitive fish caught at all (Table 127).

The suspended solids related invert metrics were also mixed. There were low numbers of collector – filterers and no Plecoptera or TSS intolerant species. Sprawler invertebrates were well above the class average. The TSS tolerant percentage was lower than the class average and the site TIV score was just lower than the class average (Table 128).

Only two samples were collected and analyzed for TSS from 2017-2018. No samples had a TSS concentration above 65 mg/L (Table 129).

Due to the somewhat mixed biological fish metrics and the low TSS values, suspended solids and the deposition of fine sediments are likely a stressor to the biological community but with the mixed biological metrics and lack of samples are inconclusive. It is recommended to collect more TSS data and conduct a sediment substrate analysis in order to determine whether TSS is a biological stressor.

3.1.8.8   Nitrates

Nitrate Biological Metric Data

Table 131. Nitrate related invert metrics for reach 07020006-532

07020006-532 **Invert Class 7** General Use	Nitrate Intolerant Taxa %	Nitrogen Tolerant Taxa %	Trichoptera Taxa %	Nitrogen TIV
17MN207 8/02/2017	0.0	50.6	5.7	3.3
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI general use threshold (41)	**3.2**	**54.9**	**10.9**	**3.2**
Expected response to **nitrogen** stress	↓	↑	↓	↑

Nitrate Monitoring Data

Table 132. Nitrate monitoring data for reach 07020006-532

07020006-532 Nitrate/Nitrite Sample Data	2x Highest Reach TIV Average	Range of Data (mg/L) [# of Samples]	Monthly Average [# of Samples]						
			April	May	June	July	August	Sept	Oct
S014-354 (2017-2019)	6.4	2.9 – 8.2 [3]	-	-	6.5 [1]	-	8.2 [1]	2.9 [1]	-
			Highest Value						
			-	-	6.5	-	8.2	2.9	-

Summary

The macroinvertebrate assemblage at site 17MN207 scored below average in three of the four nitrate related metrics when compared to all other macroinvertebrate Class 5 streams bio sites that meet the MIBI general use threshold. The bio site did not have any nitrate intolerant taxa and tolerant taxa scored pretty close to the class average. There were some trichoptera taxa present, though it was still below the class average. Nitrogen TIV score was just above the class average and indicates a macroinvertebrate community that is generally tolerant to high levels of nitrates (Table 131).

Three samples were collected in reach 07020006-532 and analyzed for nitrate/nitrite (Table 132). Two out of the three samples had total nitrate concentrations greater than 6.4 mg/L. Due to the mostly poor biological response and relatively high nitrate concentrations, nitrates are a stressor to aquatic life in reach 07020006-532.

3.1.8.9   Reach Stressors

07020006-532	Hydrologic Alteration	Connectivity	Habitat	Dissolved Oxygen	Eutrophication	Suspended Solids	Nitrate
✔ = Stressor ✘ = Not a Stressor O = Inconclusive	✔	✘	✔	O	O	O	✔

3.2   Coon Creek

3.2.1 07020006-527   Norwegian Creek

Figure 30. Satellite image of reach 07020006-527 and its watershed

3.2.1.1   Biological Community

Bio site 92MN026 was sampled once for both fish and invertebrates in 2017. The FIBI score of 25.9 is well below the Fish Class 3 Southern Headwaters general use threshold of 55. Fathead minnows dominated the fish community resulting in a poor metric score. Orange sunfish and white suckers, both lithophilic spawning fish, were present and helped the IBI score (Table 134).

The MIBI score of 18.4 was below the invert class 7 southern prairie stream glide pool general use threshold of 41 (Table 135). The bio site was dominated by *hyellella*, a tolerant amphipod. Other species present were midges, limpets, crayfish, worms, and snails, all of which are tolerant species.

Biological Metric Data

Table 134. Fish IBI score and threshold for reach 07020006-527

07020006-527 **Fish Class 3** General Use	Fish IBI Score	Class Threshold Score
92MN026 9/20/2017	25.9	55

Table 135. Invert IBI score and threshold for reach 07020006-527

07020006-527 **Invert Class 7** General Use	Invert IBI Score	Class Threshold Score
92MN026 8/01/2017	18.4	41

3.2.1.2   Hydrologic Alteration

Hydrologic Alteration Biological Metric Data

Table 136. Hydrologic alteration related fish metrics for reach 07020006-527

07020006-527 **Fish Class 3** General Use	General %	Nesting Non Lithophilic Spawner %
92MN026 9/20/2017	83.8	80.9
Statewide average for Class 3 Southern Headwater bio sites that are meeting the FIBI general use threshold (55)	**59.1**	**19.2**
Expected response to **Hydrologic** stress	↑	↑

07020006-527 **Invert Class 7** General Use	Clinger %	Collector – filterer %	Long – lived %		Percent Ditched Tolerant %	Percent Ditched Intolerant %
92MN026 8/01/2017	1.0	1.3	7.1		21.9	0.6
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI general use threshold (41)	**38.5**	**19.1**	**8.0**		↑	↓
Expected response to **Hydrologic** stress	↓	↓	↓			

HSPF Model Flow Data

Table 138. HSPF modeled flow data for reach 07020006-527

07020006-527 HSPF Reach 161 Min: 0.1 cfs Max: 1060.8 cfs	<5 cfs % (# of values)	<1 cfs % (# of values)	<0.5 cfs % (# of values)
6,210 Total Daily Averages 1996 – 2012	**61.0%** (3,789)	**23.2%** (1,443)	**8.7%** (540)

Hydrologic Alteration Summary

The fish biological metrics for hydrologic alteration are very poor. The community was dominated mostly fathead minnows, a short-lived and very tolerant species (Table 136). Fathead minnows and brook sticklebacks, both generalist, nesting, short-lived, and tolerant species comprised over 98% of the total number of fish caught.

Invert biological metrics for hydrologic alteration are also very poor. Both clingers and collector filterer percentages were very low and although long – lived percentage was close to the class average, this was due to the prevalence of crayfish, a very tolerant invertebrate. The bio site was dominated by the amphipod hyalella, the midge polypedilum, and the limpet ferrissia, all of which are generally tolerant. Hyallela is considered tolerant to low depth variability as well as several habitat metrics.

The HSPF model shows that more than 23% of the daily average flows from 1996 through 2012 are below 1 cfs (Table 138). Flows reduced beyond normal base flow will decrease habitat for aquatic organisms and increase competition for resources.

Reach 07020006-527 near bio site 92MN026 is a natural channel, though there are sections of the reach that have been straightened and many of its small tributaries are also ditched. The Minnesota DNR watershed characterization report (DNR 2020) lists this stream as an E channel, which is a relatively narrow and deep stream channel that generally forms in valleys with low slopes. The water slope was measured at 0.25% and the stream has been ditched in several places upstream of the bio site. The upstream areas of this reach are surrounded by pasture land, and cattle have access to the stream. There were several locations where erosion and other affects from livestock trampling were evident and it appears that erosion in the upstream section of the reach is being exasperated by it (DNR 2020).

Figure 31. Artificial riffle made from cobble and boulders just upstream of the road crossing appears to be a fish barrier during low flows.

Based on the very poor scores of the biological metrics and extended low flow periods shown in the HSPF model, Hydrologic Alteration is a stressor in this reach. The primary impact in this reach from Hydrologic Alteration is seen by the nutrient overloading of phosphorus, nitrogen, and the subsequent effects to eutrophication and DO levels, which is exasperated by low flows during periods of low precipitation.

3.2.1.3   Connectivity

Connectivity Metric Data

Table 139. Connectivity related fish metrics for reach 07020006-527

07020006-527 **Fish Class 3** General Use	Mature Age >3 minus Tolerant Taxa %	Migrating Taxa %
92MN026 9/20/2017	0.0	20
Statewide average for Class 3 Southern Headwater bio sites that are meeting the FIBI general use threshold (55)	**5.3**	**19.5**
Expected response to **Connectivity** stress	↓	↓

Connectivity Summary

The fish biological metrics for connectivity are mixed. There were no late-maturing fish caught. Although migrating taxa percentage was higher than the class average, the only migrating taxa caught were six white suckers. White suckers are considered a tolerant species. The artificial riffle at the road crossing appears to be a fish barrier during low flows.

3.2.1.4   Habitat

Habitat Metric Data

Table 140. Habitat related fish metrics for reach 07020006-527

07020006-527 **Fish Class 3** General Use	Benthic Insect minus Tolerant %	Darter Sculpin Sucker %	Lithophilic Spawner %	Pioneer %	Piscivore %	Riffle %	Simple Lithophilic Spawner %	Tolerant %
92MN026 9/20/2017	2.9	2.9	19.1	77.9	0	8.8	8.8	97.1
Statewide average for Class 3 Southern Headwater bio sites that are meeting the FIBI general use threshold (55)	**14.2**	**12.6**	**69.2**	**37.8**	**1.6**	**28.3**	**33.7**	**70.6**
Expected response to **Habitat** stress	↓	↓	↓	↑	↓	↓	↓	↑

Table 141. Habitat related invert metrics for reach 07020006-527

07020006-527 Invert Class 7 General Use	Burrower %	Climber %	Clinger %	Ephemeroptera Plecoptera Trichoptera %	Legless %	Sprawler %
92MN026 8/01/2017	10.0	36.5	1.0	3.2	49.7	41.6
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI general use threshold (41)	**7.5**	**21.6**	**38.5**	**38.5**	**39.8**	**20.9**
Expected response to **Habitat** stress	↑	↓	↓	↓	↑	↑

MPCA Stream Habitat Assessment Score

Table 142. Habitat Assessment scores for reach 07020006-527

07020006-532	Land Use	Riparian	Substrate	Cover	Channel Morphology	Total Score
92MN026 8/01/2017	0	10	9	12	14	45
92MN026 9/20/2017	0	4	14	12	13	43
Maximum Attainable Habitat Score	**5**	**14**	**28**	**18**	**35**	**100**

Habitat Summary

All of the fish biological metrics for habitat and the scores themselves are very poor. Fathead minnows dominated the fish population, which negatively affected all of the habitat related fish metrics (Table 140).

Invert metrics related to habitat were only slightly better. Climber percentage scored decent; however, it was due to the prevalence of the midge polypedilum, ferrissia, and snails, all of which are considered tolerant (Table 141).

The MSHA scores conducted during bio visits were poor, indicating degradation and lack of habitat for fish and invertebrates.

Habitat appears to be stressing both the fish and invertebrate community. The bio site appears to have excessive amounts of fine sediment, which affects both fish and inverts and may be having an effect on the high number of sprawler inverts present, as well as the low number of lithophilic spawning and riffle dwelling fish.

3.2.1.5   Dissolved Oxygen

Dissolved Oxygen Biological Metric Data

Table 143. Dissolved oxygen related fish metrics for reach 07020006-527

07020006-527 **Fish Class 3** General Use	Mature Age >3 %	Serial Spawner %	Taxa Count	DO TIV	DO Sensitive %	DO Tolerant %
92MN026 9/20/2017	8.8	85.3	5	8.3	0.0	88.2
Statewide average for Class 3 Southern Headwater bio sites that are meeting the FIBI general use threshold (55)	**13.3**	**17.1**	**11.8**	**8.4**	**4.5**	**14.2**
Expected response to **DO** stress	↓	↑	↓	↓	↓	↑

Table 144. Dissolved oxygen related invert metrics for reach 07020006-527

07020006-527 **Invert Class 7** General Use	Low DO Intolerant Taxa %	Low DO Tolerant Taxa %	DO TIV	HBI_MN
92MN026 8/01/2017	0.0	44.5	5.9	8.0
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI general use threshold (41)	**9.3**	**13.0**	**6.9**	**7.6**
Expected response to **DO** stress	↓	↑	↓	↑

Dissolved Oxygen Monitoring Data

Table 145. Dissolved oxygen monitoring data for reach 07020006-527

07020006-527 DO Data 5 mg/L target	Range of Data (mg/L)	% of Monthly Samples < 5 mg/L [# of Samples]							May - Sep <5 mg/L % [# of Samples]
		April	May	June	July	August	Sept	Oct	
S013-677 (2010-2019)	5.2 – 9.7	-	-	-	-	0% [3]	0% [1]	-	0% [4]
		Minimum Value							
		-	-	-	-	5.2	5.2	-	

Dissolved Oxygen Summary

All low DO related fish metrics at bio site 92MN206 are poor. There were some late maturing fish, though well below the class average and those were just six white suckers. Due to the high numbers of fathead minnows both the serial spawner and DO tolerant percentages were very high compared to the class averages (Table 143).

Invert low DO metrics were also poor as there were no low DO intolerant taxa caught and DO tolerant taxa were well above the class average. The TIV score was below the average and the HBI_MN score was above. In all the taxa that were observed at the bio site are indicative of an invert community that is tolerant of low DO conditions.

Although no DO measurements taken during sampling were below the warmwater standard of 5 mg/L, none of those measurements were taken before 8:00 a.m., when values are usually the lowest.

Based on the related fish biological metric scores, DO is likely a stressor in this reach, though it is inconclusive at this time.

3.2.1.6   Eutrophication

Eutrophication Biological Metric Data

Table 146. Eutrophication related fish metrics for reach 07020006-527

07020006-527 **Fish Class 3** General Use	Darter %	Omnivore %	Sensitive %	Simple Lithophillic Spawner %	Tolerant %
92MN026 9/20/2017	2.9	83.8	0.0	8.8	97.1
Statewide average for Class 3 Southern Headwater bio sites that are meeting the FIBI general use threshold (55)	**12.1**	**14.6**	**8.6**	**33.7**	**70.6**
Expected response to **Eutrophication** stress	↓	↑	↓	↓	↑

Table 147. Eutrophication related invert metrics for reach 07020006-527

07020006-527 **Invert Class 7** General Use	Crustacean and Mollusca %	Collector – Gatherer Taxa #	Ephemeroptera Plecoptera Trichoptera Taxa %	Intolerant Two Taxa %	Scraper %	Taxa Count All #	Tolerant Two Taxa %
92MN026 8/01/2017	52.9	13	3.2	0.0	14.8	32	93.8
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI general use threshold (41)	**11.8**	**13.3**	**28.8**	**0.2**	**16.1**	**37.0**	**81.9**
Expected response to **Eutrophic** stress	↑	↓	↓	↓	↑	↓	↑

Eutrophication Monitoring Data

07020001-527 P Sample Data 0.150 mg/L target	Range of Data (mg/L)	Monthly Average of Samples (mg/L) [# of Samples]							June-Aug Average (mg/L) [# of Samples]
		April	May	June	July	August	Sept	Oct	
S013-677 (2017-2019)	0.140 – 0.413	-	-	-	-	0.277 [2]	0.160 [1]	-	0.277 [1]
		Maximum Value							
		-	-	-	-	0.146	0.078	-	

07020006-527 DO% Sat Data	Range of Data (%)	Monthly Average of Samples (%) [# of Samples]							June-Aug Average (%) [# of Samples]
		April	May	June	July	August	Sept	Oct	
S013-677 (2017-2019)	56.9 – 102.7	-	-	-	-	91.9 [2]	56.9 [1]	94.4 [1]	91.9 [2]

Figure 32. Photo of bio site 92MN026 showing excessive algae growth

---

Eutrophication Summary

The eutrophication related fish metrics at bio site 92MN026 scored very poorly. Darters were well below the class average and consisted of only four johnny darters that were caught. Omnivores were very high compared to the average and tolerant fish were very high. There were low numbers of simple lithophilic spawning fish and no sensitive fish (Table 146).

Invert eutrophication metrics were mostly poor. Crustaceans and Mollusca dominated the community. Collector-gatherers were just below the class average. EPT taxa were very low and there were no intolerant taxa caught as the two most numerous tolerant species comprised over 93% of the total number of inverts caught. Scrapers scored decent, though there were some present (Table 144).

Three samples were collected and analyzed for Phosphorus from 2017 through 2019. The summer average was 0.277, above the standard of 0.15 mg/L (Table 148).

The percent saturation measurements were not too excessive, though there was one measurement above 100% (Table 149).

An YSI Sonde water meter measured continuous DO data from 8/2/2019 to 8/15/2019. During this deployment, diel DO flux was measured below 5 mg/L (Figure 28).

The related fish and invert biological metric scores indicate that eutrophic conditions are likely stressing the fish community and the collected samples were showed elevated phosphorus levels. Eutrophication is likely a stressor in this reach though it is inconclusive at this time.

3.2.1.7   Suspended Solids

Suspended Solids Biological Metric Data

Table 150. Suspended solids related fish metrics for reach 07020006-527

07020006-527 **Fish Class 3** General Use	Benthic Feeder %	Centrarchid - Tolerant %	Herbivore %	Intolerant %	Long – lived %	Perciformes - Tolerant %	Riffle %	Sensitive %	Simple Lithophilic Spawner %	TSS TIV
92MN026 9/20/2017	11.8	0.0	0.0	0.0	0.0	2.9	8.8	0.0	8.8	24.3
Statewide average for Class 3 Southern Headwater bio sites that are meeting the FIBI general use threshold (55)	**37.9**	**0.9**	**13.3**	**2.0**	**3.6**	**13.9**	**28.3**	**8.6**	**33.7**	**15.0**
Expected response to **Suspended Solids** stress	↓	↓	↓	↓	↓	↓	↓	↓	↓	↑

07020006-527 **Invert Class 7** General Use	Collector – filterer %	Plecoptera %	Sprawler %	TSS Intolerant Taxa %	TSS Tolerant Taxa %	TSS TIV
92MN026 8/01/2017	1.3	0.0	41.6	0.0	40.0	18.1
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI general use threshold (41)	**19.1**	**0.2**	**20.9**	**2.7**	**48.3**	**17.8**
Expected response to **Suspended Solids** stress	↓	↓	↑	↓	↑	↑

TSS Monitoring Data

Table 152. Total suspended solids monitoring data for reach 07020006-527

07020001-527 TSS Sample Data 65 mg/L target	Range of Data (mg/L)	% of Monthly Samples > 65 mg/L [# of Samples]							% of Total Samples > 65 mg/L [# of Samples]
		April	May	June	July	August	Sept	Oct	
S013-677 (2010-2017)	14 – 36	-	-	-	-	36 [1]	14 [1]	-	0% [2]

Table 153. Transparency monitoring data for reach 07020006-527

07020001-527 Secchi Tube Data 10 cm target	Range of Data (mg/L)	% of Monthly Samples < 10 cm [# of Samples]							% of Total Samples < 10 cm [# of Samples]
		April	May	June	July	August	Sept	Oct	
S013-677 (2010-2019)	21 – 60	-	-	-	-	0% [3]	0% [1]	-	0% [4]

Suspended Solids Summary

The suspended solids related fish metrics at bio site 92MN026 were all poor. There were no intolerant or sensitive fish caught at all as most of the fish caught were fathead minnows, a generally tolerant species (Table 150).

Invert related metrics were mostly poor as TSS tolerant taxa percentage was just below the class average. There were no Plecoptera or TSS intolerant taxa caught. Sprawler invertebrates were well above the class average, which would indicate there was excess fine sediment and siltation deposited on the stream bottom.

Only two samples were collected and analyzed for TSS from 2010-2017. No samples had a TSS concentration above 65 mg/L (Table 152). Four transparency measurements were taken between 2010 through 2019. No measurements were below the standard of 10 cm.

Suspended solids are likely a stressor to the biological community by the deposition of fine sediments and its effect on habitat. Due to the lack of chemistry data, they are inconclusive as a stressor. It is recommended to collect more TSS data and conduct a sediment substrate analysis in order to determine whether TSS is a biological stressor.

3.2.1.8   Nitrates

Nitrate Biological Metric Data

Table 154. Nitrate related invert metrics for reach 07020006-527

07020006-527 **Invert Class 7** General Use	Nitrate Intolerant Taxa %	Nitrogen Tolerant Taxa %	Trichoptera Taxa %	Nitrogen TIV
92MN026 8/01/2017	0.0	34.8	0.0	3.2
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI general use threshold (41)	**3.2**	**54.9**	**10.9**	**3.2**
Expected response to **nitrogen** stress	↓	↑	↓	↑

Nitrate Monitoring Data

Table 155. Nitrate monitoring data for reach 07020006-527

07020006-527 Nitrate/Nitrite Sample Data	2x Highest Reach TIV Average	Range of Data (mg/L) [# of Samples]	Monthly Average [# of Samples]						
			April	May	June	July	August	Sept	Oct
S013-677 (2010-2019)	6.4	1.3 – 2.5 [3]	-	-	-	-	1.8 [2]	2.5 [1]	-
			Highest Value						
			-	-	-	-	1.3	2.5	-

Summary

The macroinvertebrate assemblage at site 17MN207 scored below average in two of the four nitrate related metrics when compared to all other macroinvertebrate Class 7 prairie stream glide poor bio sites that meet the MIBI general use threshold. The biological site did not have any nitrate intolerant taxa. Tolerant taxa scored below the class average. There were no trichoptera taxa present, and the Nitrogen TIV score was right at the class average (Table 154).

Three samples were collected in reach 07020006-532 and analyzed for nitrate/nitrite (Table 155). All of the samples had total nitrate concentrations greater below 6.4 mg/L.

Due to the mixed biological response and relatively low nitrate concentrations, nitrates are inconclusive as a stressor to aquatic life in reach 07020006-527.

3.2.1.9   Reach Stressors

Table 156. Summary of stressors for reach 07020006-527

07020006-527	Hydrologic Alteration	Connectivity	Habitat	Dissolved Oxygen	Eutrophication	Suspended Solids	Nitrate
✔ = Stressor ✘ = Not a Stressor O = Inconclusive	✔	✔	✔	O	O	O	O

3.2.2 07020006-554   Judicial Ditch 30

Figure 33. Satellite image of reach 07020006-554 and its watershed

3.2.2.1   Biological Community

Bio site 17MN231 was sampled once for fish in 2017. The FIBI scores of 29.0 was below the Fish Class 3 Southern Headwaters modified use threshold of 33. Fathead minnows dominated the fish community resulting in a poor metric score (Table 157).

Biological Metric Data

Table 157. Fish IBI score and threshold for reach 07020006-554

07020006-554 Fish Class 3 Modified Use	Fish IBI Score	Class Threshold Score
17MN231 9/20/2017	29	33

3.2.2.2   Hydrologic Alteration

Hydrologic Alteration Biological Metric Data

Table 158. Hydrologic alteration related fish metrics for reach 07020006-554

07020006-554 **Fish Class 3** Modified Use	General %	Nesting Non Lithophilic Spawner %
17MN231 9/20/2017	98.5	99.3
Statewide average for Class 3 southern headwater bio sites that are meeting the FIBI modified use threshold (33)	**56.3**	**24.0**
Expected response to **Hydrologic** stress	↑	↑

HSPF Model Flow Data

Table 159. HSPF modeled flow data for reach 07020006-554

07020006-554 HSPF Reach 165 Min: 0.0 cfs Max: 215.6 cfs	<5 cfs % (# of values)	<1 cfs % (# of values)	<0.5 cfs % (# of values)
6,210 Total Daily Averages 1996 – 2012	**88.7%** (5,507)	**55.7%** (3,457)	**41.0%** (2,543)

Hydrologic Alteration Summary

The biological metrics all scored very poorly when compared to the average of Class 3 headwater stream bio sites that meet the IBI modified use threshold. Generalized fish species are correlated with channelization and are adaptable to different habitats through generalized food preferences. Bio site 17MN231 had a population of generalist fish of 98.5% of the population. Nesting fish comprised 99.3% of the total fish population (Table 158).

The HSPF model shows that more than 55% of the daily average flows from 1996 through 2012 are below 1 cfs (Table 159). Flows reduced beyond normal base flow will decrease habitat for aquatic organisms and increase competition for resources.

Based on the very poor scores of the biological metrics and extended low flow periods shown in the HSPF model Hydrologic Alteration is a stressor in this reach. The primary impact in this reach from

Hydrologic Alteration is the ditching of the stream itself, which affects biology in several ways. Ditching destroys the natural geomorphology of the stream, which reduces the riffle, run, glide, and pool environments needed to support a diverse invertebrate community. It cuts the stream off from its floodplain, which provides habitat and cover and dissipates some of the streams power during high flows. Ditching and tiling of the tributaries and surrounding landscape contributes to low base flows during times of low precipitation, contributing to the stagnation of the water within the ditch and eutrophication of the water causing excessive algae growth from the nutrient overloading of phosphorus, nitrogen.

3.2.2.3   Connectivity

Connectivity Metric Data

Table 160. Connectivity related fish metrics for reach 07020006-554

07020006-554 **Fish Class 3** Modified Use	Mature Age >3 minus Tolerant Taxa %	Migrating Taxa %
17MN231 9/20/2017	16.7	0.0
Statewide average for Class 3 southern headwater bio sites that are meeting the FIBI modified use threshold (33)	**3.2**	**20.1**
Expected response to **Connectivity** stress	↓	↓

Connectivity Summary

At first glance connectivity related bio metrics seem to be mixed but there was only one long-maturing taxa present, yellow perch, and only one perch was caught. There were no migrating taxa present (Table 160).

The culvert at the road crossing near bio site 17MN231 is relatively long and completely smooth, likely creating velocities that are barriers to fish migration upstream into the upper and headwater areas during high flows. Due to the poor fish metrics it appears connectivity is a stressor to this ditch though is inconclusive at this time.

3.2.2.4 Habitat

Habitat Metric Data

Table 161. Habitat related fish metrics for reach 07020006-554

07020006-554 **Fish Class 3** Modified Use	Benthic Insect minus Tolerant %	Darter Sculpin Sucker %	Lithophilic Spawner %	Pioneer %	Piscivore %	Riffle %	Simple Lithophilic Spawner %	Tolerant %
17MN231 9/20/2017	0.0	0.0	0.0	98.3	0.2	0.0	0.0	99.3
Statewide average for Class 3 southern headwater bio sites that are meeting the FIBI modified use threshold (33)	**10.9**	**10.6**	**57.9**	**32.5**	**2.0**	**22.6**	**30.1**	**76.7**
Expected response to **Habitat** stress	↓	↓	↓	↑	↓	↓	↓	↑

MPCA Stream Habitat Assessment Score

Table 162. Habitat Assessment scores for reach 07020006-554

07020006-554	Land Use	Riparian	Substrate	Cover	Channel Morphology	Total Score
17MN231 8/01/2017	0	6	7.5	9	8	30.5
17MN231 9/20/2017	0	11	5	12	2	30
Maximum Attainable Habitat Score	**5**	**14**	**28**	**18**	**35**	**100**

Habitat Summary

The fish community at bio site 17MN231 scored very poorly in all eight habitat related fish metrics when compared to all other Class 3 southern headwater bio sites that meet the FIBI modified use threshold. The lack of benthic insectivores as well as lower than average lithophilic spawners indicate habitat may be a stressor to the biological community in the reach due to lack of clean course substrate. (Table 161).

Figure 34. Photo of Bio site 17MN231 showing sediment deposition within the ditched stream.

The MSHA scores for both visits were poor. Heavy siltation and severe embeddedness of coarse substrates were observed during biological sampling of the ditch (Table 162).

Habitat is stressing the fish community in reach 07020006-554. There are several factors that are contributing in the reach, including the ditching of the stream channel itself. Ditching the stream has caused a lack of riffle, run, glide, and pool environments needed to support a diverse fish community. Although these geomorphological features begin to form over time, even in a ditch, they are destroyed by regular ditch cleanouts. The bio site appears to have excessive amounts of fine sediment deposition and it is likely that low flows, are also contributing to a limitations in habitat for fish.

3.2.2.5   Dissolved Oxygen

Dissolved Oxygen Biological Metric Data

Table 163. Dissolved oxygen related fish metrics for reach 07020006-554

07020006-554 **Fish Class 3** Modified Use	Mature Age >3 %	Serial Spawner %	Taxa Count	DO TIV	DO Sensitive %	DO Tolerant %
17MN231 9/20/2017	0.2	98.5	6	8.2	0.0	99.8
Statewide average for Class 3 southern headwater bio sites that are meeting the FIBI modified use threshold (33)	**14.4**	**10.6**	**9.3**	**8.2**	**0.1**	**39.3**
Expected response to **DO** stress	↓	↑	↓	↓	↓	↑

Dissolved Oxygen Monitoring Data

07020006-554 DO Data 5 mg/L target	Range of Data (mg/L)	% of Monthly Samples < 5 mg/L [# of Samples]							May - Sep <5 mg/L % [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-377 (2017-2019)	6.8 – 10.7	-	-	-	-	0% [3]	0% [1]	-	0% [4]
		Minimum Value							
		-	-	-	-	6.8	8.2	-	
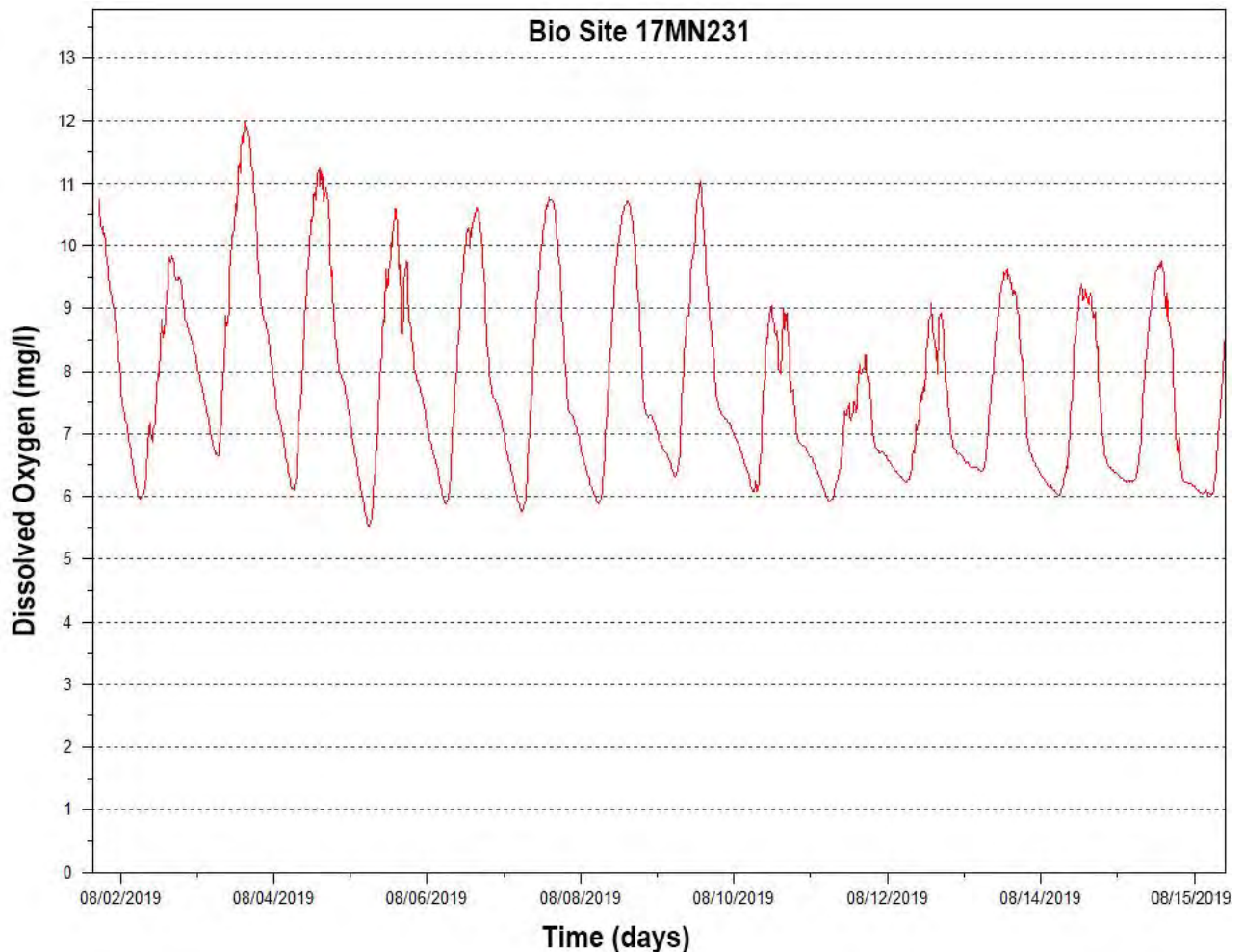
Figure 35. Continuous dissolved oxygen data at site 17MN231

Dissolved Oxygen Summary

The fish community at bio site 17MN231 scored below average in all five out of six DO related fish metrics when compared to the average of all other Class 3 southern headwater bio sites that meet the

FIBI modified use threshold. There were no fish caught who are sensitive to low DO. Species with females that take more than three years to mature comprised 0.2% of the total fish population, well below class average. DO tolerant species were 99.8% of the fish population (Table 163).

Although no DO measurements taken during sampling were below the warmwater standard of 5 mg/L, none of those measurements were taken before 8:00 a.m., when values are usually the lowest. An YSI Sonde water meter measured continuous DO data from 7/6/2017 to 7/27/2017. During this deployment, DO values did not get below the standard of 5 mg/L.

Based on the related fish biological metric scores and the measured sonde values, DO may be a stressor in this reach. During the sonde deployment in 2019 there was above average precipitation and stream flows, which tended to keep DO values higher than normal for late summer. DO is inconclusive as a stressor at this time.

3.2.2.6   Eutrophication

Eutrophication Biological Metric Data

Table 165. Eutrophication related fish metrics for reach 07020006-554

07020006-554 Fish Class 3 Modified Use	Darter %	Omnivore %	Sensitive %	Simple Lithophillic Spawner %	Tolerant %
17MN231 9/20/2017	0.0	98.5	0.0	0.0	99.3
Statewide average for Class 3 southern headwater bio sites that are meeting the FIBI modified use threshold (33)	**10.6**	**19.8**	**6.0**	**30.1**	**76.7**
Expected response to **Eutrophication** stress	↓	↑	↓	↓	↑

Eutrophication Monitoring Data

Table 166. Phosphorus monitoring data for reach 07020006-554

07020001-554 P Sample Data 0.150 mg/L target	Range of Data (mg/L)	Monthly Average of Samples (mg/L) [# of Samples]							June-Aug Average (mg/L) [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-377 (2017-2019)	0.060 – 0.107	-	-	0.107 [1]	-	0.060 [1]	0.106 [1]	-	0.084 [2]
		Maximum Value							
		-	-	0.107	-	0.060	0.106	-	

Table 167. DO% Saturation monitoring data for reach 07020006-554

07020006-554 DO% Sat Data	Range of Data (%)	Monthly Average of Samples (%) [# of Samples]							June-Aug Average (%) [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-377 (2017-2019)	76.9 – 118	-	-	135.1 [1]	-	96.7 [3]	88.9 [1]	-	115.9 [3]

Figure 36. Photo of bio site 17MN231 showing algae covered in fine sediment

Eutrophication Summary

The fish community at bio site 17MN231 scored below average in all five eutrophication related fish metrics when compared to the average of all other Class 3 southern headwater bio sites that meet the FIBI modified use threshold. There were no darters, sensitive, or simple lithophilic spawning fish. Omnivorous fish comprised 98.5% of the population. Nearly all individuals present were tolerant species (Table 165).

Three samples were collected and analyzed for Phosphorus from 2017 through 2020. The summer average was below the standard of 0.15 mg/L (Table 166).

An YSI Sonde water meter measured continuous DO data from 8/2/2019 to 8/15/2019. During this deployment, diel DO flux was measured above 5 mg/L. Such high DO flux during this time indicates that eutrophication is likely even worse during dry periods of low precipitation.

The biological community is showing the effects of the elevated phosphorus, phosphorus sampling showed moderate concentrations, and DO flux was 5 mg/L or greater. Algae growth was observed at the

station (Figure 36). Eutrophication appears to be a stressor in this reach though is inconclusive at this point. It is recommended that more TP data be collected.

3.2.2.7   Suspended Solids

Suspended Solids Biological Metric Data

07020006-554 **Fish Class 3** Modified Use	Benthic Feeder %	Centrarchid - Tolerant %	Herbivore %	Intolerant %	Long – lived %	Perciformes - Tolerant %	Riffle %	Sensitive %	Simple Lithophilic Spawner %	TSS TIV
17MN231 9/20/2017	0.0	0.2	0.0	0.0	1.0	0.5	0.0	0.0	0.0	23.7
Statewide average for Class 3 southern headwater bio sites that are meeting the FIBI modified use threshold (33)	**31.4**	**1.0**	**10.8**	**0.5**	**4.9**	**12.4**	**22.6**	**6.0**	**30.1**	**16.9**
Expected response to **Suspended Solids** stress	↓	↓	↓	↓	↓	↓	↓	↓	↓	↑

TSS Monitoring Data

07020001-554 TSS Sample Data 65 mg/L Target	Range of Data (mg/L)	% of Monthly Samples > 65 mg/L [# of Samples]							% of Total Samples > 65 mg/L [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-377 (2017-2019)	7.6 – 9.6	-	-	-	-	0% [1]	0% [1]	-	0% [2]

07020001-554 Secchi Tube Data 10 cm target	Range of Data (mg/L)	% of Monthly Samples < 10 cm [# of Samples]							% of Total Samples < 10 cm [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-377 (2017-2019)	56 – 100+	-	-	-	-	0% [3]	0% [1]	-	0% [4]

Suspended Solids Summary

The fish community at bio site 17MN231 scored poorly in all 10 suspended solids related fish metrics when compared to the average of all other Class 3 southern headwater bio sites that meet the FIBI modified use threshold (Table 168). The dominance of fathead minnows at the site negatively affected all of these metrics.

Four samples were collected and analyzed for TSS from 2011 through 2015. No sample had a TSS concentration above 65 mg/L (Table 169). Stream transparency was high (Table 170).

Suspended solids are inconclusive as a stressor to aquatic life at this time. It is likely that other factors, such as altered hydrology, connectivity, or habitat are causing poor scores in the fish biological metrics. TSS is likely contributing to the fine sediment deposited and embeddedness within the stream channel. It is recommended to collect more TSS data and conduct a sediment substrate analysis in order to determine whether TSS is a biological stressor.

3.2.2.8   Nitrates

Nitrate Biological Metric Data

Table 171. Nitrate related invert metrics for reach 07020006-554

07020006-554 **Invert Class 7** Modified Use	Nitrate Intolerant Taxa %	Nitrogen Tolerant Taxa %	Trichoptera Taxa %	Nitrogen TIV
17MN231 9/20/2017	0.3	43.8	7.4	4.0
Statewide average for Class 3 southern headwater bio sites that are meeting the FIBI modified use threshold (33)	**2.0**	**59.4**	**5.9**	**3.3**
Expected response to **nitrogen** stress	↓	↑	↓	↑

Nitrate Monitoring Data

Table 172. Nitrate monitoring data for reach 07020006-554

07020006-554 Nitrate/Nitrite Sample Data	2x Highest Reach TIV Average	Range of Data (mg/L) [# of Samples]	Monthly Average [# of Samples]						
			April	May	June	July	August	Sept	Oct
S014-377 (2017-2020)	6.6	6.7 – 11.0 [3]	-	-	6.7 [1]	-	8.1 [1]	11 [1]	-
			Highest Value						
			-	-	6.7	-	8.1	11	-

Summary

The macroinvertebrate assemblage at site 17MN231 scored below average in two of the four nitrate related metrics when compared to all other macroinvertebrate Class 7 prairie stream glide pool bio sites that meet the MIBI modified use threshold (Table 171). The biological bio site did show some Trichoptera taxa, though it was just one individual invert from two different taxa. There was a moderate amount of nitrate tolerant invertebrates as well as almost a complete lack of nitrate intolerant invertebrate species. The nitrogen TIV score also indicates a macroinvertebrate community that is generally tolerant to high levels of nitrates.

Three samples were collected in reach 07020001-541 and analyzed for nitrate/nitrite (Table 172). All of the nitrate samples had concentrations greater than 6.6 mg/L. Due to the biological response and relatively high nitrate concentrations, nitrates are a stressor to aquatic life in reach 07020006-554.

3.2.2.9   Reach Stressors

Table 173. Summary of stressors for reach 07020006-554

07020006-554	Hydrologic Alteration	Connectivity	Habitat	Dissolved Oxygen	Eutrophication	Suspended Solids	Nitrate
✔ = Stressor ✘ = Not a Stressor O = Inconclusive	✔	O	✔	O	O	O	✔

3.2.3 07020006-570   Coon Creek
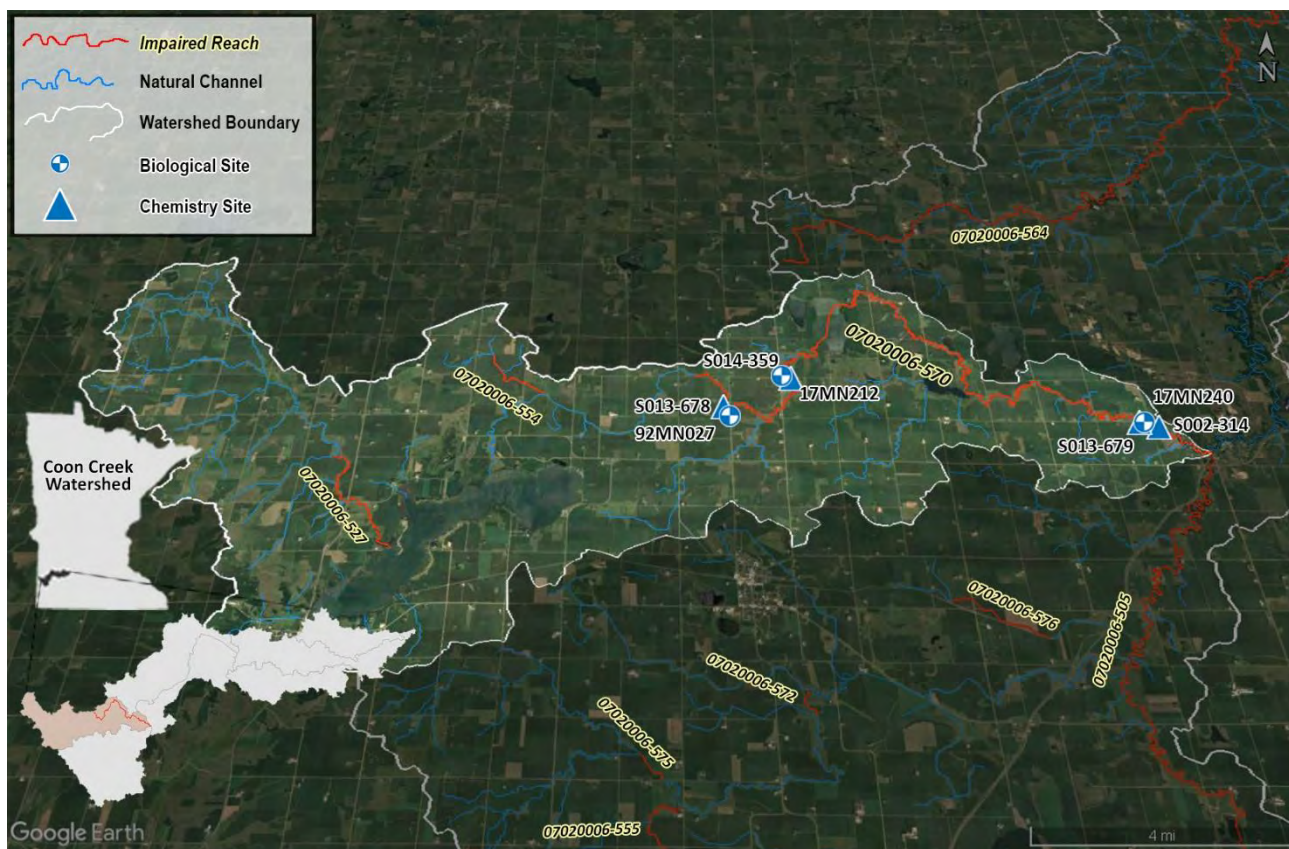
Figure 37. Satellite image of reach 07020006-570 and its watershed

3.2.3.1   Biological Community

Bio sites 92MN027, 92MN028, 17MN212, and 17MN240 were not sampled for fish in 2017 or 2018 due to the timing of visits and periods of high flows.

Bio sites 92MN027, 17MN212, and 17MN240 were all sampled for invertebrates once in 2017. The MIBI scores of 21, 18.7, and 21.7 were all below the Invert class 5 southern stream rock riffle general use threshold of 37 (Table 174). Amphipods, midges, and crayfish dominated 92MN027, the furthest upstream site. 17MN212 was dominated by the mayfly heptagenia and also had good numbers of labiobaetis dardanus and caenis hilaris, all of which are considered generally more tolerant mayflies. There were also several tolerant caddisfly taxa as well. Bio site 17MN240 also had good numbers baetis mayflies as well as net-spinning caddisflies.

Biological Metric Data

Table 174. Invert IBI score and threshold for reach 07020006-570

07020006-570 **Invert Class 5** General Use	Invert IBI Score	Class Threshold Score
92MN027 8/01/2017	21.0	
17MN212 8/01/2017	18.7	37
17MN240 8/03/2017	21.7	

3.2.3.2   Hydrologic Alteration

Hydrologic Alteration Biological Metric Data

Table 175. Hydrologic alteration related invert metrics for reach 07020006-570

07020006-570 **Invert Class 5** General Use	Clinger %	Collector – filterer %	Long – lived %		Percent Ditched Tolerant %	Percent Ditched Intolerant %
92MN027 8/01/2017	25.3	16.8	8.2		11.4	4.4
17MN212 8/01/2017	47.6	13.2	7.4		14.5	14.5
17MN240 8/03/2017	61.1	38.0	0.9		2.2	31.4
Statewide average for Class 5 prairie stream rock riffle bio sites that are meeting the FIBI general use threshold (37)	**49.5**	**26.9**	**9.0**		↑	↓
Expected response to **Hydrologic** stress	↓	↓	↓			

HSPF Model Flow Data

Table 176. HSPF modeled flow data for reach 07020006-570

07020006-570 HSPF Reach 175 Min: 0.0 cfs Max: 1,368.5 cfs	**<5 cfs %** (# of values)	**<1 cfs %** (# of values)	**<0.5 cfs %** (# of values)
6,210 Total Daily Averages 1996 – 2012	**45.6%** (2,831)	**24.6%** (1,526)	**16.4%** (1,021)

Hydrologic Alteration Summary

Invert biological metrics for hydrologic alteration are mostly poor. The upstream bio sites scored worse than the downstream ones. At bio site 92MN027 both clingers and collector filterer percentages were low and although long – lived percentage was close to the class average, this was due to the prevalence of crayfish, a very tolerant invertebrate. The ratio between the percent ditched tolerant and intolerant was also poor. Bio site 17MN212 had more clingers, though they were still below the class average. Collector filterers and Long – lived were similar to the upstream site, thought the ratio of percent ditched tolerant to intolerant was one to one. Bio site 17MN240 scored well in all metrics except long lived individuals. It also had a very large amount of percent ditched intolerant and low amounts of tolerant species.

The HSPF model (Table 25) shows that more than 24% of the daily average flows from 1996 through 2012 are below 1 cfs. Flows reduced beyond normal base flow will decrease habitat for aquatic organisms and increase competition for resources.

92MN027

Bio site 92MN027 is located in between Lake Benton and Coon Lake. This part of the reach has a very low slope and is located on a natural part of the channel. Just upstream of the site, the stream channel has been altered and ditched downstream of the outlet from Lake Benton. The DNR Watershed Characterization Report shows that the reach has good access to its floodplain and adequate pool depths (DNR 2020). The reach is located in between two lakes, which tend to have a moderating effect on erosion and incision of streams. The biological community at this bio site

Figure 38. Photo showing the road crossing near bio site 92MN027.

was dominated by the amphipod hyalella, the midge polypedilum, and the black fly simulium, all of which are tolerant taxa.

17MN212

Bio site 17MN212 is a few miles downstream of 92MN027 and as such, it is likely similar in geomorphic features. However, the biology of the site is a bit different than the upstream site. The site was

dominated by the two mayflies' heptagenia and labiobaetis, both more tolerant mayfly taxa and both are considered tolerant to low flows. The four most numerous invertebrates present are considered tolerant or very tolerant to habitat metrics.

17MN240

Bio site 17MN240 is the furthest downstream bio site sampled in 2017. It is located in a natural section of the stream reach and is just upstream near the confluence with the Redwood River. The bio site was dominated by the mayfly baetis, which is considered intolerant to both stream ditching, depth variability, and low cover.

Since this reach is very long and diverse, the effects of hydrologic alteration is very different from upstream to downstream. The primary impact in this reach from hydrologic alteration is from the alteration of the stream channel in the upper section of the reach as well as the tributaries in that same section. This reduces high quality habitat by interrupting the stream morphology and reducing the habitats that aquatic organisms need to thrive. This alteration also contributes to nutrient overloading of phosphorus, nitrogen, and the subsequent effects to eutrophication and DO levels as well as stream bank erosion due to water moving off the landscape quicker, increasing peak flows with the channel. Coon Lake, is roughly in the middle of the reach. It is also a very shallow and eutrophic reservoir that appears to be a source of nutrients to the stream, resulting in eutrophic conditions downstream of the lake, where a fish kill was observed in 2014 (Figure 46). Hydrologic alteration is a stressor to this reach, especially in the upstream and middle sections.

3.2.3.3   Connectivity

Connectivity Summary

Since fish were not sampled there are no metrics to assess for connectivity. It would appear that the culvert located near bio site 92MN027 would impede fish migration during both high and low flows. The bridge near bio site 17MN212 looked like it would not impede fish passage. Several road crossings were identified as possible fish barriers. The outlet of Coon Lake is a concrete culvert and is a definite fish barrier as well. Connectivity appears that it would be a stressor to the upstream fish community but due to the lack of fish sampling, it is inconclusive at this time.

Figure 39. Culvert at the road crossing near bio site 92MN027.

3.2.3.4   Habitat

Habitat Metric Data

Table 177. Habitat related invert metrics for reach 07020006-570

07020006-570 **Invert Class 5** General Use	Burrower %	Climber %	Clinger %	Ephemeroptera Plecoptera Trichoptera %	Legless %	Sprawler %
92MN027 8/01/2017	1.3	28.8	25.3	19.0	28.2	30.7
17MN212 8/01/2017	7.4	11.3	47.6	63.7	10.0	16.7
17MN240 8/03/2017	1.6	9.3	61.1	67.3	17.4	9.7
Statewide average for Class 5 prairie stream rock riffle bio sites that are meeting the FIBI general use threshold (37)	**7.5**	**14.7**	**49.5**	**43.9**	**36.0**	**16.8**
Expected response to **Habitat** stress	↑	↓	↓	↓	↑	↑

MPCA Stream Habitat Assessment Score

Table 178. Habitat Assessment scores for reach 07020006-570

07020006-570	Land Use	Riparian	Substrate	Cover	Channel Morphology	Total Score
92MN027 8/01/2017	0	9	16.4	5	15	45.4
17MN212 8/01/2017	0	5	11	5	14	35
17MN240 8/03/2017	0	8	19.9	14	32	73.9
Maximum Attainable Habitat Score	**5**	**14**	**28**	**18**	**35**	**100**

Habitat Summary

The habitat related invert metrics were mostly good. There were few burrowing invertebrates throughout the reach. Both climbers and clingers were mixed throughout the reach, though the higher than average percent of climbers at bio site 92MN027 was partly due to the high numbers of the midge polypedilum as well as physella snails. EPT taxa were well above average for both 17MN212 and 17MN240. There were good numbers of both fairly tolerant mayflies such as heptagenia, labiobaetis, caenis, as well as fairly tolerant net spinning caddisflies such cheumatopsyche, and ceratopsyche. Sprawlers were also low at the two downstream bio sites.

Figure 40. Looking downstream from the culvert road crossing at the furthest upstream bio site 92MN027

The MSHA scores were poor at the two upstream bio sites, but was good for the downstream site 17MN240. Site 17MN240 scored very well in channel morphology as there was good depth variability between the riffles and pools, channel stability, sinuosity and stream velocity. The substrate was also pretty good as there was different sized sediment observed and very little embeddedness of coarse substrate or siltation present. Bio site 17MN212 and 92MN027 had less development and morphological structures as well as less depth variability in pools and riffles, or lacked them all together. The coarse substrate was more embedded with fine sediment at the upstream bio sites as well and there was less woody debris to act as cover and habitat at those sites.

Figure 41. Photo looking downstream of the middle bio site 17MN212.

Habitat appears to be a stressor to the upstream section of this reach as there is very little suitable habitat for invertebrates or fish in this areas. Further downstream near bio site 17MN240 instream habitat is much better and appears to be having much less of an effect on the biological community.

3.2.3.5   Dissolved Oxygen

Dissolved Oxygen Biological Metric Data

Table 179. Dissolved oxygen related invert metrics for reach 07020006-570

07020006-570 Invert Class 5 General Use	Low DO Intolerant Taxa %	Low DO Tolerant Taxa %	DO TIV	HBI_MN
92MN027 8/01/2017	2.2	30.7	6.7	8.0
17MN212 8/01/2017	5.8	23.5	6.8	8.2
17MN240 8/03/2017	49.1	3.4	7.6	7.2
Statewide average for Class 5 prairie stream rock riffle bio sites that are meeting the FIBI general use threshold (37)	**24.6**	**8.6**	**7.1**	**7.0**
Expected response to **DO** stress	↓	↑	↓	↑

Dissolved Oxygen Monitoring Data

Table 180. Dissolved oxygen monitoring data for reach 07020006-570

07020006-570 DO Data 5 mg/L target	Range of Data (mg/L)	% of Monthly Samples < 5 mg/L [# of Samples]							May - Sep <5 mg/L % [# of Samples]
		April	May	June	July	August	Sept	Oct	
S002-314 **S013-678** **S013-679** **S014-359** (2017-2019)	4.7 – 11.3	-	0% [2]	0% [5]	0% [7]	9.1% [11]	0% [3]	0% [1]	3.5% [29]
		Minimum Value							
		-	9.8	6.8	5.2	4.7	7.8	10.0	
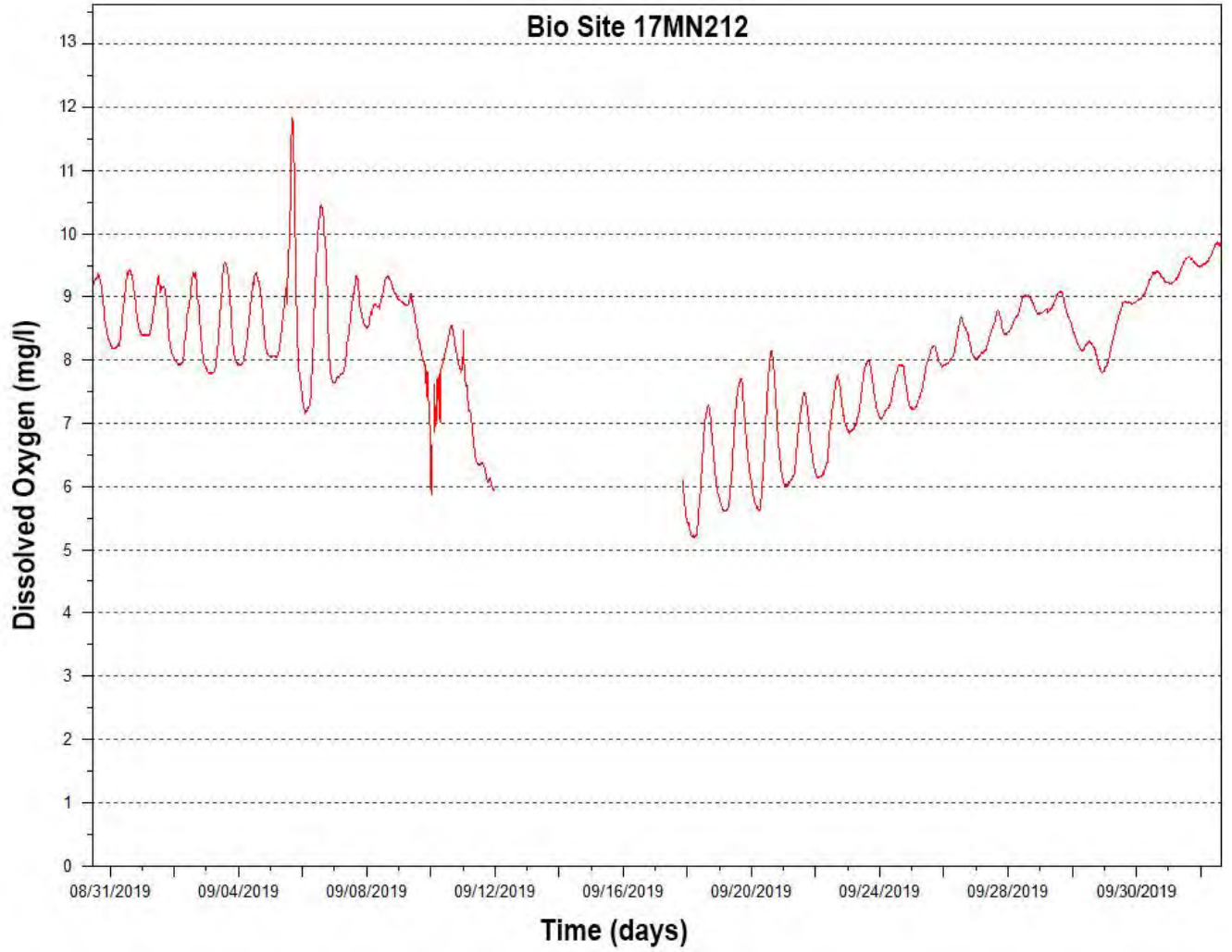
Figure 42. Continuous dissolved oxygen data at site 17MN212
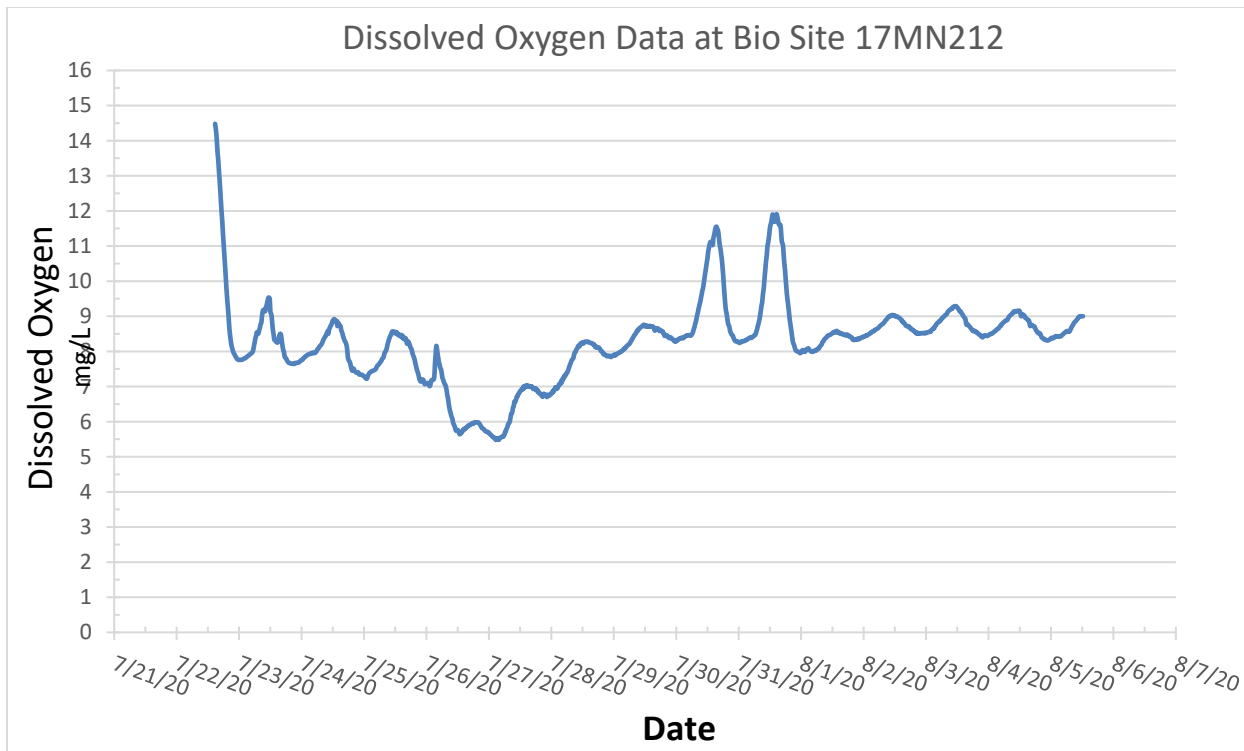
Figure 43. Continuous dissolved oxygen data at site 17MN212
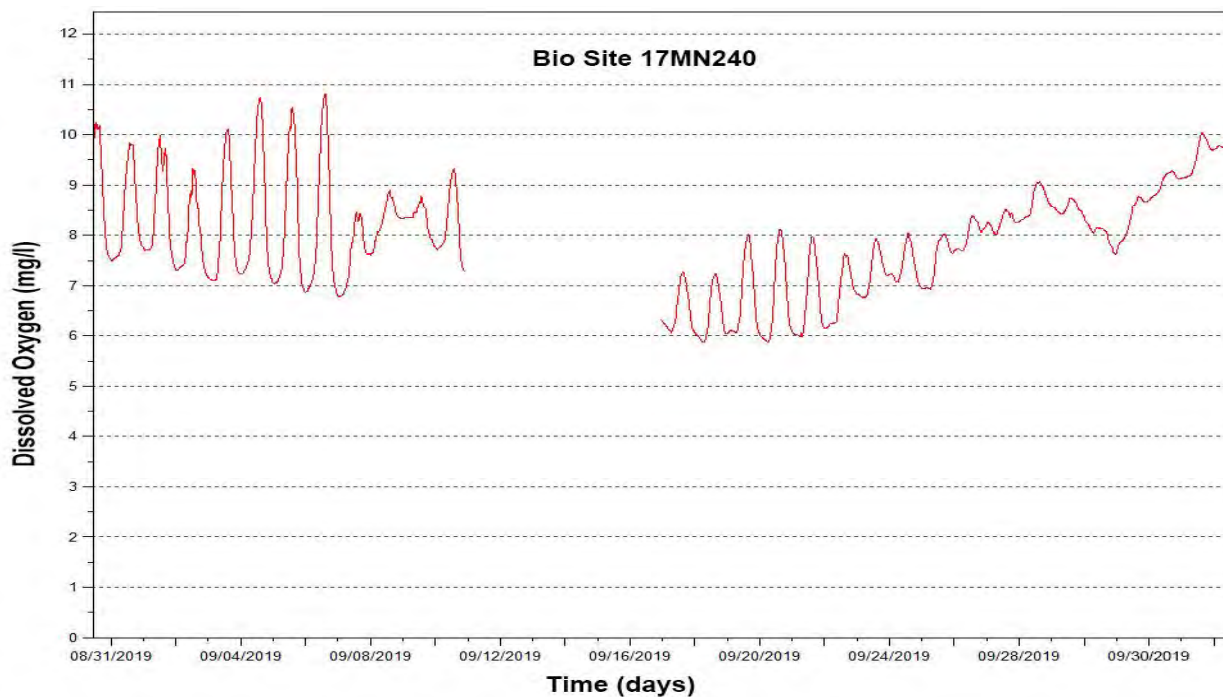
Figure 44. Continuous dissolved oxygen data at site 17MN240

Dissolved Oxygen Summary

The invertebrate community in the two upstream bio sites in reach 07020006-570 scored poorly in most of the DO related invert metrics when compared to the average of all other Class 5 southern stream rock riffle bio sites that meet the MIBI general use threshold (Table 179). The metrics for 17MN240 scored well.

There was one DO measurement taken at the upstream bio site during sampling that was below the warmwater standard of 5 mg/L. An YSI Sonde water meter measured continuous DO data from 8/31/2019 to 9/30/2019 at both bio sites 17MN212 and 17MN240. During this deployment, DO values did not get below the standard.

Based on the related invert biological metric scores and the measured values, DO is inconclusive as a stressor in this reach.

3.2.3.6   Eutrophication

Eutrophication Biological Metric Data

Table 181. Eutrophication related invert metrics for reach 07020006-570

07020006-570 Invert Class 5 General Use	Crustacean and Mollusca %	Collector – Gatherer Taxa #	Ephemeroptera Plecoptera Trichoptera Taxa %	Intolerant Two Taxa %	Scraper %	Taxa Count All #	Tolerant Two Taxa %
92MN027 8/01/2017	32.9	8	19.0	0.0	11.1	33	97.0
17MN212 8/01/2017	17.4	11	63.7	0.0	29.3	34	94.1
17MN240 8/03/2017	3.7	16	67.3	0.0	6.2	38	89.5
Statewide average for Class 5 prairie stream rock riffle bio sites that are meeting the FIBI general use threshold (37)	**9.5**	**15.1**	**30.5**	**0.8**	**15.8**	**41.9**	**74.3**
Expected response to **Eutrophic** stress	↑	↓	↓	↓	↑	↓	↑

Eutrophication Monitoring Data

07020001-570 P Sample Data 0.150 mg/L target	Range of Data (mg/L)	Monthly Average of Samples (mg/L) [# of Samples]							June-Aug Average (mg/L) [# of Samples]
		April	May	June	July	August	Sept	Oct	
S002-314 S014-359 (2017-2019)	0.064 – 0.253	-	0.124 [2]	0.129 [3]	0.154 [4]	0.175 [5]	0.184 [3]	-	0.156 [12]
		Maximum Value							
		-	0.169	0.243	0.204	0.244	0.253	-	

07020006-570 DO% Sat Data	Range of Data (%)	Monthly Average of Samples (%) [# of Samples]							June-Aug Average (%) [# of Samples]
		April	May	June	July	August	Sept	Oct	
S002-314 S013-359 S014-359 (2017-2019)	58.4 – 99	-	-	-	-	84.4 [5]	-	91.2 [2]	84.4 [5]

Eutrophication Summary

The invertebrate community in reach 07020006-570 scored mostly poor in eutrophication related metrics when compared to the average of all other Class 5 southern stream rock riffle bio sites that meet the MIBI general use threshold. The abundance of darter individuals was very low and omnivorous fish comprised around 70% of the population. There were almost no sensitive species and nearly all individuals present were tolerant species (Table 16).

Figure 45. Algae growing along the shoreline of stream at bio site 92MN027

Twelve samples were collected and analyzed for Phosphorus from 2011 through 2019. The summer average was above standard of 0.15 mg/L (Table 182).

An YSI Sonde water meter measured continuous DO data from 8/31/2019 to 9/31/2019 at both bio sites 17MN212 and 17MN240. During this deployment, diel DO flux was measured at or above 5 mg/L only once, thought there was some flux shown before the precipitation event around 9/12/2020 (Figure 42) (Figure 44).

Figure 46. Photo from a field visit in 2020 showing algae growing on the culvert at the road crossing near bio site 92MN027 (left). Photo showing the creek just downstream from Coon Lake during an active fish kill (right).

In 2014, the MPCA staff responded to a call from Lyon County staff saying that the creek was the color blue. When they arrived at the creek, photos were taken and DO was measured using a YSI Sonde. A strong odor was present at the road crossing in Figure 46. Due to the strong odor, strange color, and low DO it is safe to assume that there was something moving through the water at this site at the time of the visit. The MPCA water quality staff then drove to other Coon Creek road crossings, moving upstream. At these other sites the water looked very cloudy/murky and gray (Figure 45). There were numerous dead fish floating along the edge of the creek. Moving upstream the DO readings ranged from 2.3 to 6.46 mg/L.

The biological community is showing the effects of elevated phosphorus, phosphorus sampling showed elevated concentrations, and DO flux was 5 mg/L or greater. Algae growth was observed at in the reach, a fish kill was observed and blue-green algae was identified in water samples taken during the 2014 event (Figure 45) (Figure 46). Eutrophication is a stressor in this reach.

3.2.3.7   Suspended Solids

Suspended Solids Biological Metric Data

Table 184. Suspended solids related invert metrics for reach 07020006-570

07020006-570 **Invert Class 5** General Use	Collector – filterer %	Plecoptera %	TSS Intolerant Taxa %	TSS Tolerant Taxa %	TSS TIV
92MN027 8/01/2017	16.8	0.0	0.0	52.2	19.6
17MN212 8/01/2017	13.2	0.0	0.0	61.7	22.9
17MN240 8/03/2017	23.1	0.0	0.0	25.5	16.4
Statewide average for Class 5 prairie stream rock riffle bio sites that are meeting the FIBI general use threshold (37)	**26.9**	**0.5**	**5.1**	**35.2**	**15.9**
Expected response to **Suspended Solids** stress	↓	↓	↓	↑	↑

TSS Monitoring Data

Table 185. Total suspended solids monitoring data for reach 07020006-570

07020006-570 TSS Sample Data 65 mg/L target	Range of Data (mg/L)	% of Monthly Samples > 65 mg/L [# of Samples]							% of Total Samples > 65 mg/L [# of Samples]
		March	April	May	June	July	August	Sept	Oct	
S002-314 (2017-2018)	11 – 113	-	-	50% [2]	0% [5]	0% [6]	20% [5]	0% [3]	-	9.5% [21]

Table 186. Transparency monitoring data for reach 07020006-570

07020001-570 Secchi Tube Data 10 cm target	Range of Data (mg/L)	% of Monthly Samples < 10 cm [# of Samples]							% of Total Samples < 10 cm [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-377 (2017-2019)	10 – 84	-	0% [2]	0% [5]	0% [7]	0% [10]	0% [3]	-	0% [27]

Suspended Solids Summary

The fish community in reach 07020006-570 scored poorly in almost all suspended solids related invert metrics when compared to the average of all other Class 5 southern stream rock riffle bio sites that meet the MIBI general use threshold (Table 184). There were some collector – filterers though they were mostly the black fly simulium. No Plecoptera or TSS intolerant taxa were observed at any of the bio sites and TSS tolerant taxa were high at the two upstream bio sites. The TSS tolerance index score was also higher than the class average at all sites.

21 samples were collected and analyzed for TSS from 2017 through 2018. Two samples had a TSS concentration above 65 mg/L (Table 185).

Due to the very poor biological metrics throughout the entire reach and the TSS chemistry data showing elevated levels at a couple of visits it would appear that TSS is a stressor to the biological community in this reach. It appears to be more of a stressor in the upper and middle section of the reach.

3.2.3.8   Nitrates

Nitrate Biological Metric Data

Table 187. Nitrate related invert metrics for reach 07020006-570

07020006-570 Invert Class 5 General Use	Nitrate Intolerant Taxa %	Nitrogen Tolerant Taxa %	Trichoptera Taxa %	Nitrogen TIV
92MN027 8/01/2017	0.0	50.0	12.1	3.8
17MN212 8/01/2017	0.0	70.1	14.7	4.0
17MN240 8/03/2017	0.0	56.5	15.8	3.2
Statewide average for Class 5 prairie stream rock riffle bio sites that are meeting the FIBI general use threshold (37)	**2.9**	**47.6**	**13.6**	**3.0**
Expected response to **nitrogen** stress	↓	↑	↓	↑

Nitrate Monitoring Data

Table 188. Nitrate monitoring data for reach 07020006-570

07020001-570 Nitrate/Nitrite Sample Data	2x Highest Reach TIV Average	Range of Data (mg/L) [# of Samples]	Monthly Average [# of Samples]							
			March	April	May	June	July	August	Sept	Oct
S002-314 **S014-359** (2019)	6.0	0.6 – 2.7 [2]	-	-	-	-	-	1.7 [2]	-	-
			Highest Value							
			-	-	-	-	-	2.7	-	-

Nitrate Summary

The macroinvertebrate assemblage in reach 07020006-570 scored mostly poorly in four nitrate related metrics evaluated when compared to all other macroinvertebrate Class 5 stream rock riffle bio sites that meet the MIBI general use threshold (Table 187). There were some more tolerant net-spinning Trichoptera taxa as well as some nectopsyche, which tend to decrease in streams with excessive nitrate values. There were high amounts of nitrate tolerant invertebrates as well as a complete lack of nitrate intolerant invertebrate species. The nitrogen TIV score also indicates a macroinvertebrate community that is generally tolerant to high levels of nitrates.

Only two samples were collected in reach 07020001-570 and analyzed for nitrate/nitrite (Table 188). None of the total nitrate samples had concentrations greater than 6.0 mg/L. Though the biological response was mostly poor, the fact that there were some Trichoptera present and there were low number of nitrate samples, nitrates are inconclusive as a stressor.

3.2.3.9   Reach Stressors

Table 189. Summary of stressors for reach 07020006-570

07020006-570	Hydrologic Alteration	Connectivity	Habitat	Dissolved Oxygen	Eutrophication	Suspended Solids	Nitrate
✔ = Stressor ✘ = Not a Stressor O = Inconclusive	✔	O	✔	O	✔	✔	O

3.3 Three Mile Creek

3.3.1 07020006-564   Threemile Creek
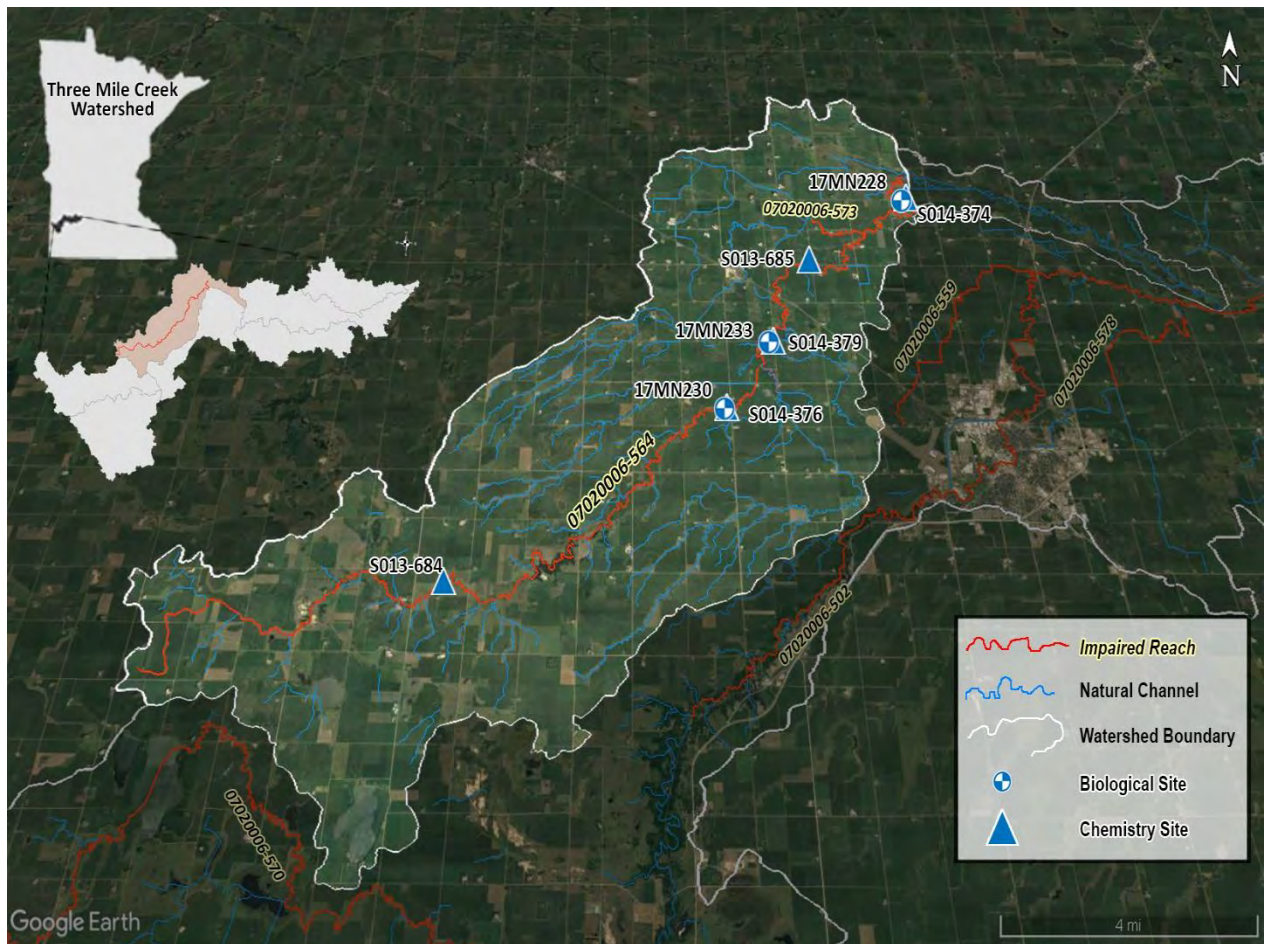
Figure 47. Satellite image of reach 07020006-564 and its watershed

3.3.1.1 Biological Community

"Consisting mostly of Threemile Creek, and it's mostly unnamed tributaries, this subwatershed totals 117 sq. mi. (75,000 ac.) of mostly Lyon County, with a small portion in Lincoln County. Threemile Creek predominantly flows northeast before joining the Redwood River several miles downstream of Marshall. All of the streams are considered warmwater with 50% of the stream reach lengths considered altered, and 39% natural channels. Impounded stream reaches account for less than 1%, while no definable channel comprises 11% of the reach lengths" (MPCA 2020).

Bio sites 17MN230, 17MN233, and 17MN228 were all sampled once for fish in 2017. The FIBI scores of 32.2, 22.0, and 31.8 are well below the Fish Class 2 Southern Streams general use threshold of 50 (Table 190). Creek chubs dominated the fish community in the upper bio sites with common shiners and blacknose dace, all generalist species. Blunt nose minnows dominated the lowest bio site and there high numbers of spot fin shiners, white suckers, and creek chubs. The lowest site also had decent numbers of blackside darters, a more sensitive species. In all, the biology of the lowest bio site looked a lot different than the other two with more diverse, sensitive, and migrating species.

The invert scores for reach 07020006-564 were not too bad compared to the class 7 southern prairie stream glide pool general use threshold of 41. The two upstream sites scored in the mid-thirties while the downstream site actually scored above the threshold score (Table 191). Several types of mayflies, caddisflies, and riffle beetles seemed to dominate the biological community. The fairly tolerant mayfly tricorthodes was prevalent at all three bio sites and dominated the two upper sites by a large margin. Bios site 17MN228 scored well due to several factors, including the large number of caddisflies, including non-Hydropsychidae. There were also several species of mayflies and even a stonefly present at bio site 17MN228.

Biological Metric Data

Table 190. Fish IBI score and threshold for reach 07020006-564

07020006-564 **Fish Class 2** **General Use**	Fish IBI Score	Class Threshold Score
17MN230 9/20/2017	32.2	
17MN233 9/20/2017	22.0	50
17MN228 7/12/2017	31.8	

Table 191. Invert IBI score and threshold for reach 07020006-564

07020006-564 **Invert Class 7** **General Use**	Invert IBI Score	Class Threshold Score
17MN230 8/02/2017	34.8	
17MN233 8/01/2017	36.2	41
17MN228 8/02/2017	60.4	

3.3.1.2   Hydrologic Alteration

Hydrologic Alteration Biological Metric Data

Table 192. Hydrologic alteration related fish metrics for reach 07020006-564

07020006-564 **Fish Class 2** **General Use**	General %	Nesting Non Lithophilic Spawner %
17MN230 9/20/2017	74.5	6.1
17MN233 9/20/2017	68.4	26.3
17MN228 7/12/2017	70.5	52.3
Statewide average for Class 2 Southern Stream bio sites that are meeting the FIBI general use threshold (50)	**42.4**	**19.1**
Expected response to **Hydrologic** stress	↑	↑

Table 193. Hydrologic alteration related invert metrics for reach 07020006-564

07020006-564 **Invert Class 7** **General Use**	Clinger %	Collector – filterer %	Long – lived %		Percent Ditched Tolerant Taxa %	Percent Ditched Intolerant Taxa %
17MN230 8/02/2017	21.3	3.4	9.1		4.4	7.2
17MN233 8/01/2017	9.0	0.6	2.9		8.3	4.5
17MN228 8/02/2017	54.2	15.5	30.0		17.2	7.3
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI general use threshold (41)	**38.5**	**19.1**	**8.0**		↑	↓
Expected response to **Hydrologic** stress	↓	↓	↓			

HSPF Model Flow Data

0107020006-564 HSPF Reach 296 Min: 0.1 cfs Max: 744.5 cfs	**<5 cfs %** (# of values)	**<1 cfs %** (# of values)	**<0.5 cfs %** (# of values)
6,210 Total Daily Averages 1996 – 2012	**52.2%** (3,244)	**10.1%** (629)	**2.7%** (169)

Hydrologic Alteration Summary

17MN230

This bio site is the furthest upstream reach that was sampled in 2017. The fish community was dominated by generalist and tolerant species. The invertebrate community was dominated by the mayfly tricorythodes, which are considered very tolerant to low flows. The next two most numerous invertebrates were snails and riffle beetles, both of which are considered tolerant. The fish community was dominated by creek chubs, common shiners, and blacknose dace, which are all generalist species. The bio site is located on a natural section of the reach, thought there are altered sections just upstream. "The entrenchment ratio was measured to be 2.33, an adjective rating of 'slightly entrenched.' The adjective rate for the entrenchment ratio indicates that the channel has adequate floodplain access; however, the riffle cross section indicates that the adjective rating is misleading. The flood-prone elevation at the riffle cross section may be 2.33 times wider than the bank full width, but the channel is 0.5 feet too incised to access a much more expansive floodplain" (DNR 2020).

17MN233

In this part of the reach the ditching of the stream channel itself has reduced habitat in those areas due to the lack of riffles, runs, pools, and other naturally forming features that help support aquatic life. The invertebrate biological community was dominated by two low-flow tolerant invertebrates, the mayfly tricorythodes and the caddisfly nectopsyche. The five most numerous inverts present are all either very tolerant or tolerant to low cover. There were also several
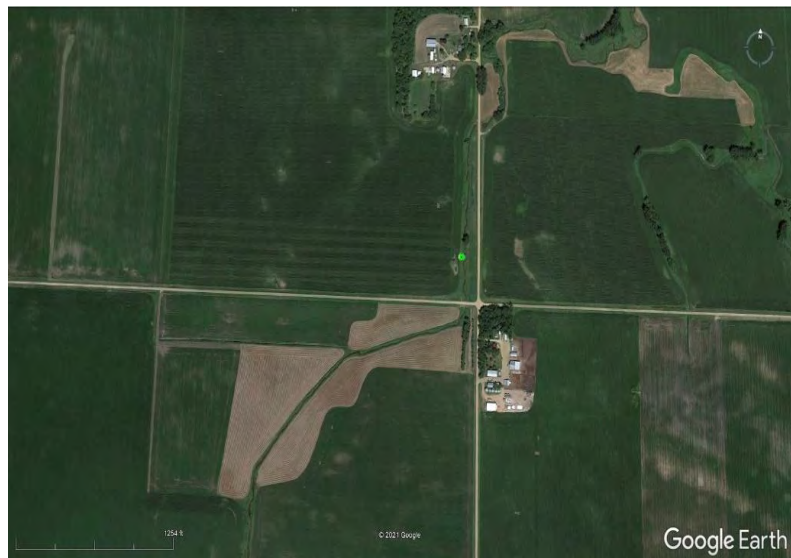
Figure 48. Google earth satellite image showing bio site 17MN233 and the surrounding landscape.

habitat tolerant and very tolerant taxa present. Only 19 fish were caught and almost all were tolerant or very tolerant species.

17MN228

Bio site 17MN228 is the furthest downstream site sampled in 2017. The site itself sits within a small wooded area and has good vegetative cover. The DNR geomorphic site is located in between bio site 17MN228 and 17MN233. "Many locations lack adequate riparian vegetative width and much of the stream appears to be getting encroached upon by row crop land use.

Figure 49. Photo of reach 07020006-564 near bio site 17MN228. The stream here is sheltered by tree cover.

Substrate within the reach was primarily comprised of silt, clay and sand, while the riffles had primarily sands and small gravels. Overall, the channel held little quality habitat throughout the reach surveyed. The longitudinal profile identified that very little pool habitat existed in the reach, most likely attributed to the longer section without significant meander bends" (DNR 2020).

The HSPF model shows that only around 10% of the daily average flows from 1996 through 2012 are below 1 cfs, a relatively low number compared to other streams in the Redwood River Watershed (Table 194).

Most of the biological metrics scored poorly when compared to the average of Class 2 streams bio sites that meet the IBI general use threshold (Table 192). Generalized fish species are correlated with channelization and are adaptable to different habitats through generalized food preferences. Reach 07020006-564 had a population of generalist fish ranging from 68.4% to 74.5% of the population, well above the class average of 42.4. The nesting percentage was low at the upstream bio site 17MN230 as creek chubs, common shiners, and blacknose dace dominated the bio community, all of which are lithophilic spawning fish. Only 19 total fish were caught at bio site 17MN233 with creek chubs being the most prevalent.

Nesting fish were very high at the downstream bio site due to the 257 blunt nose minnows that were caught, which comprised over 45% of the total number of fish caught at the site.

Hydrologic alteration related invert metrics were mostly poor (Table 193). The upstream bio site 17MN233 score poorly in all related metrics as there were very few clingers or collector – filterers present. Bio site 17MN230 had more clingers, collector filterers, and long – lived inverts as well as a better ditched tolerant to intolerant ratio. The clinger percentage was mostly due to the midge polypedilum. 17MN228 scored well in both clingers and long – lived individuals and had some collector –

filterers. The high clinger and long – lived percentage was due to mostly to the two tolerant riffle beetles dubiraphia and stenelmis.

Reach 07020006-564 is a fairly long reach that flows over a landscape that varies both geographically and topographically. The reach itself is actually mostly a natural stream channel with only a few short sections of the main stem that have been altered. Most of the tributaries have been extensively straightened. The biological communities throughout the reach all are dominated by low flow tolerant and several habitat metrics, especially percent cover and habitat. The evidence suggests that hydrologic alteration is a stressor in reach 07020006-564.

3.3.1.3   Connectivity

Connectivity Metric Data

Table 195. Connectivity related fish metrics for reach 07020006-564

07020006-564 **Fish Class 2** General Use	Mature Age >3 minus Tolerant Taxa %	Migrating Taxa %
17MN230 9/20/2017	0.0	21.4
17MN233 9/20/2017	0.0	20.0
17MN228 7/12/2017	14.3	23.8
Statewide average for Class 2 Southern Stream bio sites that are meeting the FIBI general use threshold (50)	**21.8**	**24.3**
Expected response to **Connectivity** stress	↓	↓

Connectivity Summary

Metrics for fish taxa whose females take greater than three years to mature were low and creek chubs were the only long-maturing species present. Migrating taxa were present and close to the average for southern streams that meet the standard, though only 10% of the total number of fish were migrating, most of them being white suckers.

Several water retention structures were identified in the Watershed Characterization Report (Figure 50)

Figure 50. Road retention structure found in the upper Three Mile Creek is very likely a fish barrier.

(DNR 2020). Due to the poor biological metrics and the presence of fish barriers within the stream itself, connectivity is a stressor to the biological community within reach 07020006-564.

3.3.1.4   Habitat

Habitat Metric Data

Table 196. Habitat related fish metrics for reach 07020006-564

07020006-564 **Fish Class 2** General Use	Benthic Insect minus Tolerant %	Darter Sculpin Sucker %	Lithophilic Spawner %	Pioneer %	Piscivore %	Riffle %	Simple Lithophilic Spawner %	Tolerant %
17MN230 9/20/2017	5.5	4.8	81.8	37.0	0.0	10.3	42.4	69.7
17MN233 9/20/2017	15.8	10.5	57.9	47.4	0.0	21.1	21.1	84.2
17MN228 7/12/2017	6.7	6.4	29.5	59.2	1.8	13.4	17.0	79.2
Statewide average for Class 2 Southern Stream bio sites that are meeting the FIBI general use threshold (50)	**20.4**	**18.2**	**58.3**	**19.0**	**5.2**	**32.5**	**39.4**	**44.9**
Expected response to **Habitat** stress	↓	↓	↓	↑	↓	↓	↓	↑

Table 197. Habitat related invert metrics for reach 07020006-564

07020006-564 **Invert Class 7** General Use	Burrower %	Climber %	Clinger %	Ephemeroptera Plecoptera Trichoptera %	Legless %	Sprawler %
17MN230 8/02/2017	2.8	11.6	21.3	71.2	19.1	58.0
17MN233 8/01/2017	1.0	28.5	9.0	72.1	19.2	49.4
17MN228 8/02/2017	0.0	18.8	54.2	54.2	14.2	18.0
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI general use threshold (41)	**7.5**	**21.6**	**38.5**	**38.5**	**39.8**	**20.9**
Expected response to **Habitat** stress	↑	↓	↓	↓	↑	↑

MPCA Stream Habitat Assessment Score

Table 198. Habitat Assessment scores for reach 07020006-564

07020006-564	Land Use	Riparian	Substrate	Cover	Channel Morphology	Total Score
17MN230 8/02/2017	0	12	11	14	17	**54**
17MN230 9/20/2017	0	7	11.4	13	16	**47.4**
17MN233 8/02/2017	0	5.5	12.4	4	11	**32.9**
17MN233 9/20/2017	0	8	11	7	5	**31**
17MN228 7/12/2017	0	7.5	8.3	15	14	**44.8**
17MN228 8/02/2017	0	6	10	15	19	**50**
Maximum Attainable Habitat Score	5	14	28	18	35	100

Habitat Summary

Figure 51. Photo of bio site 17MN230 a mid-channel gravel bar. The stream channel has some coarse sediment, though it is highly embedded by fine silt and clay.

The fish community in reach 07020001-564 was mostly poor in the habitat related fish metrics when compared to all other Class 2 southern stream bio sites that meet the FIBI general use threshold (Table 196). The up-stream bio site 17MN230 did have an above average percentage of lithophilic spawners, though this was due to creek chubs, common shiners, and blacknose dace, all generalist taxa. The next bio site, 17MN233, also has lithophilic spawning fish, though these were only five creek chubs, two blacknose dace, and two white suckers out of the 19 total fish caught at the site. The downstream bio site, 17MN228, scored poorly in all the habitat metrics and had less lithophilic spawners than the upstream sites. It was dominated by blunt nose minnows, a very tolerant nesting fish.

Figure 52. Photo of altered channel near bio site 17MN233 (top) and a photo near bio site 17MN228 showing a more natural channel (bottom).

Habitat related invert metrics were mixed. There were high numbers of mayflies and to a lesser extent, caddisflies. The dominant mayfly at all the bio sites was tricorthodes, a sprawler that is adapted to fine sediments and silt. Even so, there were some clinger mayflies and caddisflies, which indicates some woody debris and other available habitat.

There were some fair MSHA scores at both the upstream and downstream bio sites, with lower scores at the middle site. The stream has some geomorphic structure and some depth variability at both the upstream and downstream sites. The middle site has been altered, which reduced depth variability and channel morphology.

Habitat data appears to be stressing the fish community, especially at bio site 17MN233. There appears to be little suitable habitat for fish in this area. Invertebrate bio community looked better overall as there were some EPT taxa, though fine sediment and embeddedness of coarse material seems to be causing some negative response to the bio community. Habitat appears to be a minor stressor to the biological community in reach 07020006-564.

3.3.1.5   Dissolved Oxygen

Dissolved Oxygen Biological Metric Data

Table 199. Dissolved oxygen related fish metrics for reach 07020006-564

07020006-564 Fish Class 2 General Use	Mature Age >3 %	Serial Spawner %	Taxa Count	DO TIV	DO Sensitive %	DO Tolerant %
17MN230 9/20/2017	2.4	19.4	14	8.5	0.0	1.2
17MN233 9/20/2017	10.5	15.8	10	8.4	0.0	21.1
17MN228 7/12/2017	11.8	60.6	21	8.6	0.0	8.3
Statewide average for Class 2 Southern Stream bio sites that are meeting the FIBI general use threshold (50)	**23.9**	**28.7**	**19.9**	**8.4**	**5.8**	**16.3**
Expected response to **DO** stress	↓	↑	↓	↓	↓	↑

Table 200. Dissolved oxygen related invert metrics for reach 07020006-564

07020006-564 Invert Class 7 General Use	Low DO Intolerant Taxa %	Low DO Tolerant Taxa %	DO TIV	HBI_MN
17MN230 8/02/2017	8.2	4.1	7.2	8.2
17MN233 8/01/2017	1.0	8.6	7.3	8.7
17MN228 8/02/2017	16.6	1.2	7.4	8.3
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI general use threshold (41)	**9.3**	**13.0**	**6.9**	**7.6**
Expected response to **DO** stress	↓	↑	↓	↑

Dissolved Oxygen Monitoring Data

Table 201. Dissolved oxygen monitoring data for reach 07020006-564

07020006-564 DO Data 5 mg/L target	Range of Data (mg/L)	% of Monthly Samples < 5 mg/L [# of Samples]							May - Sep <5 mg/L % [# of Samples]
		April	May	June	July	August	Sept	Oct	
S013-684 S013-685 S014-374 S014-376 S014-379 (2009-2017)	7.0 – 13.2	-	0% [3]	0% [3]	0% [7]	0% [4]	0% [2]	-	0% [19]
		Minimum Value							
		-	11.3	7.0	7.0	8.2	9.2	-	
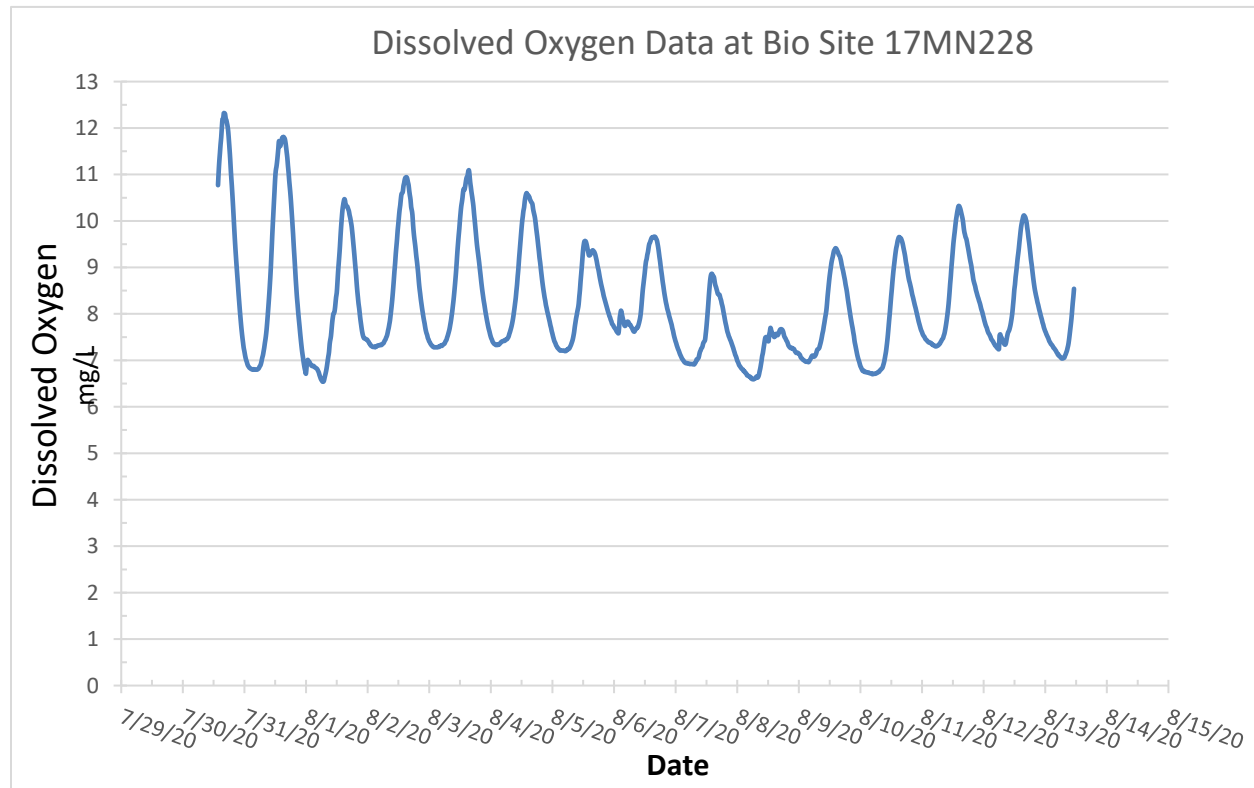
Figure 53. Continuous dissolved oxygen data at site 92MN026

Dissolved Oxygen Summary

The fish community at bio sites 17MN230 and 17MN228 scored below average in half of the six DO related fish metrics when compared to the average of all other Class 2 southern stream bio sites that meet the FIBI general use threshold. Bio site 17MN233 scored poorly in four of the metrics. There were some females that take more than three years to mature at the downstream sites. No DO sensitive fish were caught. DO tolerant species were generally low except at the middle bio site 17MN233 (Table 199).

DO related invertebrate metrics were better than the fish metrics overall. There were even above average low DO intolerant taxa at downstream bio site 17MN228. Low DO tolerant taxa were low throughout the entire reach and the DO TIV scores were all above average as well (Table 200).

No DO measurements taken during sampling were below the warmwater standard of 5 mg/L, none of those measurements were taken before 8:00 a.m., when values are usually the lowest. An YSI Sonde water meter measured continuous DO data from 7/6/2017 to 7/27/2017. During this deployment, DO values were measured below the standard 14 out of 21 days.

Based on the mixed fish and invertebrate biological metric scores and the measured DO values, DO is inconclusive as a stressor in this reach.

3.3.1.6   Eutrophication

Eutrophication Biological Metric Data

Table 202. Eutrophication related fish metrics for reach 07020006-564

07020006-564 Fish Class 2 General Use	Darter %	Omnivore %	Sensitive %	Simple Lithophilic Spawner %	Tolerant %
17MN230 9/20/2017	4.8	2.4	3.6	42.4	69.7
17MN233 9/20/2017	10.5	21.1	0.0	21.1	84.2
17MN228 7/12/2017	5.1	10.4	0.2	17.0	79.2
Statewide average for Class 2 Southern Stream bio sites that are meeting the FIBI general use threshold (50)	**11.7**	**16.5**	**18.7**	**39.4**	**44.9**
Expected response to **Eutrophication** stress	↓	↑	↓	↓	↑

Table 203. Eutrophication related invert metrics for reach 07020006-564

07020006-564 Invert Class 7 General Use	Crustacean and Mollusca %	Collector – Gatherer Taxa #	Ephemeroptera Plecoptera Trichoptera Taxa %	Intolerant Two Taxa %	Scraper %	Taxa Count All #	Tolerant Two Taxa %
17MN230 8/02/2017	8.5	12	71.2	0.0	20.7	32	81.3
17MN233 8/01/2017	9.3	11	72.1	0.0	11.5	32	84.4
17MN228 8/02/2017	6.1	12	54.2	0.0	17.0	40	85.0
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI general use threshold (41)	**11.8**	**13.3**	**28.8**	**0.2**	**16.1**	**37.0**	**81.9**
Expected response to **Eutrophic** stress	↑	↓	↓	↓	↑	↓	↑

Eutrophication Monitoring Data

Table 204. Phosphorus monitoring data for reach 07020006-564

07020001-564 P Sample Data 0.150 mg/L target	Range of Data (mg/L)	Monthly Average of Samples (mg/L) [# of Samples]							June-Aug Average (mg/L) [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-374 **S014-376** **S014-379** (2013-2017)	0.029 – 0.273	-	0.059 [3]	0.158 [4]	0.068 [5]	0.031 [1]	0.043 [2]	-	0.108 [10]
		Maximum Value							
		-	0.080	0.273	0.111	0.031	0.044	-	

Eutrophication Summary

The fish community in reach 07020006-564 scored mostly poor in all of the eutrophication related fish metrics when compared to the average of all other Class 2 southern stream bio sites that meet the FIBI general use threshold. The abundance of darter individuals was low throughout the reach. Omnivorous fish were fairly low. There were almost no sensitive species and tolerant species comprised 69.7% to 84.2% of the total number of fish caught. There were a fair number of simple lithophilic spawners at bio site 17MN230 and all of the bio sites had some lithophilic spawning fish. Darters were generally low at all of the sites, though there were some present. The percentage of darters seems higher at bio site 17MN233 but that is mostly due to the low number of fish caught as there were only two johnny darters

caught. Bio site 17MN228 had 22 blackside darters but the percentage of darters was low compared to the total number of fish caught do to the dominance of the 257 bluntnose minnows that were caught, which is a nesting fish (Table 202).

Eutrophication related invertebrate metrics were mostly poor. The reach scored well in crustacean and Mollusca percentage as well as EPT taxa as there were an abundance of mayflies and caddisflies, though they were more tolerant taxa such as tricorthodes and caenis. Tricorthodes dominated all three of the bio sites (Table 203).

Ten samples were collected and analyzed for Phosphorus from 2013 through 2017. The summer average below the standard of 0.15 mg/L (Table 204).

An YSI Sonde water meter measured continuous DO data from 7/6/2017 to 7/27/2017. During this deployment, diel DO flux was measured at or above 5 mg/L several times.

The biological community seems to be showing the effects of elevated phosphorus, though phosphorus sampling did not show elevated concentrations. Eutrophication is inconclusive as a stressor in this reach.

3.3.1.7   Suspended Solids

Suspended Solids Biological Metric Data

Table 205. Suspended solids related fish metrics for reach 07020006-564

07020006-564 **Fish Class 2** General Use	Benthic Feeder %	Centrarchid - Tolerant %	Herbivore %	Intolerant %	Long – lived %	Perciformes - Tolerant %	Riffle %	Sensitive %	Simple Lithophilic Spawner %	TSS TIV
17MN230 9/20/2017	9.1	0.0	4.8	0.0	0.0	4.8	10.3	3.6	42.4	14.9
17MN233 9/20/2017	36.8	0.0	10.5	0.0	10.5	10.5	21.1	0.0	21.1	18.2
17MN228 7/12/2017	16.1	0.0	6.0	0.0	3.0	5.7	13.4	0.2	17.0	22.9
Statewide average for Class 2 Southern Stream bio sites that are meeting the FIBI general use threshold (50)	**37.4**	**4.9**	**9.6**	**5.0**	**11.7**	**18.7**	**32.5**	**18.6**	**39.4**	**17.9**
Expected response to **Suspended Solids** stress	↓	↓	↓	↓	↓	↓	↓	↓	↓	↑

07020006-564 Invert Class 7 General Use	Collector – filterer %	Plecoptera %	TSS Intolerant Taxa %	TSS Tolerant Taxa %	TSS TIV
17MN230 8/02/2017	3.4	0.3	0.0	79.0	25.7
17MN233 8/01/2017	0.6	0.0	0.0	81.8	26.6
17MN228 8/02/2017	15.5	0.3	0.3	61.0	22.8
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI general use threshold (41)	**19.1**	**0.2**	**2.7**	**48.3**	**17.8**
Expected response to **Suspended Solids** stress	↓	↓	↓	↑	↑

TSS Monitoring Data

Table 207. Total suspended solids monitoring data for reach 07020006-564

07020006-564 TSS Sample Data 65 mg/L target	Range of Data (mg/L)	% of Monthly Samples > 65 mg/L [# of Samples]								% of Total Samples > 65 mg/L [# of Samples]
		March	April	May	June	July	August	Sept	Oct	
S014-374 **S014-376** **S014-379** (2017)	9.2 – 36	-	-	-	-	0% [1]	-	0% [2]	-	0% [3]

Suspended Solids Summary

The fish community in reach 07020006-564 mostly scored poorly in all suspended solids related fish metrics when compared to the average of all other Class 2 southern stream bio sites that meet the FIBI general use threshold. There were some benthic feeders, perciformes, riffle dwellers, and simple lithophillic spawners present though they were mostly below the class average (Table 205).

The invertebrate community in reach 07020006-564 mostly scored poorly in all suspended solids related invert metrics when compared to the average of all other Class southern prairie stream glide pool bio sites that meet the MIBI general use threshold. There were some Plecoptera present at both the furthest upstream and furthest downstream sites. Collector – filterers were present, though they were below the class average throughout the reach, with bio site 17MN228 having good numbers of the

caddisfly ceratopsyche. TSS tolerant taxa percentages were well above the class average and there were almost no TSS intolerant taxa present (Table 206).

Only three samples were collected and analyzed for TSS in 2017. No sample had a TSS concentration above 65 mg/L (Table 48).

Both the fish and invertebrate metrics indicate that suspended solids are a stressor to aquatic life at this time. Even though the chemistry did not show elevated levels it is likely that the limited dataset is not representative of conditions. Extensive deposits of fine sediments were observed during a site visit, which indicates that there is excessive fine sediments within the stream channel. The stream channel itself appears to be incised as well and is likely receiving sediment from streambank erosion due to the stream power eroding the bank during high flows (Figure 54). Due to the lack of supporting data, suspended solids are inconclusive at this time.

Figure 54. Photo looking downstream of the road crossing near Bio site 17MN228. A lot of fine sediment deposition is shown in the foreground of the photo and erosion on the steam bank is shown in the background.

3.3.1.8   Nitrates

Nitrate Biological Metric Data

Table 208. Nitrate related invert metrics for reach 07020006-564

07020006-564 **Invert Class 7** General Use	Nitrate Intolerant Taxa %	Nitrogen Tolerant Taxa %	Trichoptera Taxa %	Nitrogen TIV
17MN230 8/02/2017	0.9	80.9	9.4	4.2
17MN233 8/01/2017	0.0	92.0	9.4	4.5
17MN228 8/02/2017	0.3	71.0	17.5	4.3
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI general use threshold (41)	**3.2**	**54.9**	**10.9**	**3.2**
Expected response to **nitrogen** stress	↓	↑	↓	↑

Nitrate Monitoring Data

Table 209. Nitrate monitoring data for reach 07020006-564

07020001-564 Nitrate/Nitrite Sample Data	2x Highest Reach TIV Average	Range of Data (mg/L) [# of Samples]	Monthly Average [# of Samples]						
			April	May	June	July	August	Sept	Oct
S014-374 **S014-376** **S014-379** (2017 - 2020)	6.4	2.2 – 3.8 [5]	-	-	3.2 [2]	3.8 [1]	-	2.5 [2]	-
			Highest Value						
			-	-	3.4	3.8	-	2.7	-

Summary

The macroinvertebrate assemblage in reach 07020006-564 scored poorly in most of the nitrate related metrics evaluated when compared to all other macroinvertebrate Class 7 southern prairie stream glide pool bio sites that meet the MIBI general use threshold (Table 208). The furthest downstream bio site 17MN228 did show a healthy amount of Trichoptera taxa, which tend to decrease in streams with excessive nitrate values. There was a high amount of nitrate tolerant invertebrates as well as almost a complete lack of nitrate intolerant invertebrate species. The nitrogen TIV score also indicates a macroinvertebrate community that is generally tolerant to high levels of nitrates.

Only five samples were collected in reach 07020001-568 and analyzed for nitrate/nitrite (Table 209). None of the total nitrate samples had concentrations greater than 6.4 mg/L. Due to the biological response and mixed data sets, nitrates are inconclusive as a stressor to aquatic life in reach 07020001-564.

3.3.1.9   Reach Stressors

Table 210. Summary of stressors for reach 07020006-564

07020006-564	Hydrologic Alteration	Connectivity	Habitat	Dissolved Oxygen	Eutrophication	Suspended Solids	Nitrate
✔ = Stressor ✘ = Not a Stressor O = Inconclusive	✔	✘	✔	O	O	O	O

3.3.2 07020006-558   Unnamed Creek
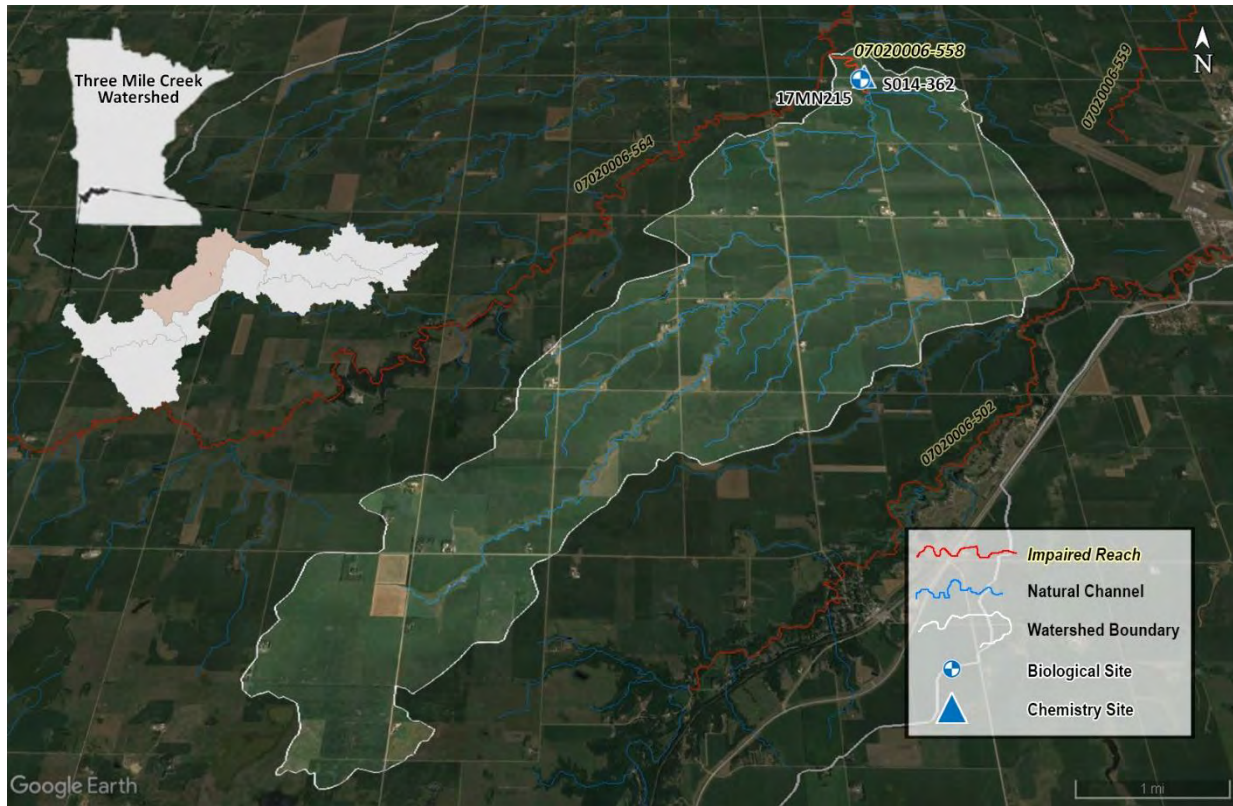
Figure 55. Satellite image of reach 07020006-558 and its watershed

3.3.2.1   Biological Community

Bio site 17MN215 was sampled once for invertebrates in 2017. The MIBI score of 18.8 was below the Invert Class 7 southern prairie stream glide pool modified use threshold of 22 (Table 211). The amphipod hyalella dominated the invertebrate community. The next most common invert was the snail physella. These two taxa comprised over 50% of the invertebrate community at the bio site. The top five most abundant inverts are all considered tolerant to low depth variability as well as several habitat related metrics as well. The rest of the invert community was mostly comprised of midges and insects, both of which are considered tolerant.

Biological Metric Data

Table 211. Invert IBI score and threshold for reach 07020006-558

07020006-558 **Invert Class 7** Modified Use	Invert IBI Score	Class Threshold Score
17MN215 8/02/2017	18.8	22

3.3.2.2 Hydrologic Alteration

Hydrologic Alteration Biological Metric Data

Table 212. Hydrologic alteration related invert metrics for reach 07020006-558

07020006-558 **Invert Class 7** Modified Use	Clinger %	Collector – filterer %	Long – lived %		Percent Ditched Tolerant %	Percent Ditched Intolerant %
17MN215 8/02/2017	9.9	0.6	0.0		33.7	0.3
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI modified use threshold (22)	**23.1**	**9.9**	**5.6**		↑	↓
Expected response to **Hydrologic** stress	↓	↓	↓			

HSPF Model Flow Data

Table 213. HSPF modeled flow data for reach 07020006-558

07020006-558 HSPF Reach 301 Min: 0.0 cfs Max: 415.1 cfs	<5 cfs % (# of values)	<1 cfs % (# of values)	<0.5 cfs % (# of values)
6,210 Total Daily Averages 1996 – 2012	**67.0%** (4,161)	**36.0%** (2,235)	**21.4%** (1,330)

Hydrologic Alteration Summary

The hydrologic related biological invertebrate metrics all scored poorly when compared to the average of Class 7 stream bio sites that meet the MIBI modified use threshold. Bio site 17MN215 had a population of clingers of 9.9% while collector – filters comprised only 0.6% of the total number of inverts caught. There were no long – lived inverts caught. The ratio of inverts who are considered tolerant vs intolerant to ditching was also relatively high (Table 212).

The HSPF model shows that 36% of the daily average flows from 1996 through 2012 were below 1 cfs. Flows reduced beyond normal base flow will decrease habitat for aquatic organisms and increase competition for resources (Table 213).

Based on the very poor scores of the biological metrics and extended low flow periods shown in the HSPF model hydrologic alteration is a stressor in this reach. The primary impact in this reach from hydrologic alteration is from the alteration of the stream channel itself. Lack of habitat appears to be limiting the biology as the ditching of the stream channel itself has reduced habitat in those areas due to the lack of riffles, runs, pools, and other naturally forming features that these stream types typically possess.

Figure 56. Photo of reach 07020006-558 near bio site 17MN215 showing an altered channel that has been ditched.

3.3.2.3   Connectivity

Connectivity Metric Data

Table 214. Connectivity related fish metrics for reach 07020006-558

07020006-558 **Invert Class 7** Modified Use	Mature Age >3 minus Tolerant Taxa %	Migrating Taxa %
17MN215 8/02/2017	0.0	10.0
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI modified use threshold (22)	**8.7**	**13.4**
Expected response to **Connectivity** stress	↓	↓

Connectivity Summary

Fish metrics related to connectivity were both poor. There were no fish taxa whose females take greater than three years to mature. Migrating taxa were present and close to the average for southern streams that meet the standard; however, it was only one taxa out of the 10 present and consisted of only three white suckers, a tolerant species. Connectivity appears to be a stressor to the biological community in reach 07020006-558 but at this time is inconclusive.

3.3.2.4   Habitat

Habitat Metric Data

Table 215. Habitat related invert metrics for reach 07020006-558

07020006-558 **Invert Class 7** Modified Use	Burrower %	Climber %	Clinger %	Ephemeroptera Plecoptera Trichoptera %	Legless %	Sprawler %
17MN215 8/02/2017	5.9	23.1	9.9	3.0	38.0	48.1
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI modified use threshold (22)	**14.1**	**27.5**	**23.1**	**20.6**	**55.8**	**27.0**
Expected response to **Habitat** stress	↑	↓	↓	↓	↑	↑

MPCA Stream Habitat Assessment Score

Table 216. Habitat Assessment scores for reach 07020006-558

07020006-576	Land Use	Riparian	Substrate	Cover	Channel Morphology	Total Score
17MN215 8/2/2017	0	8.5	7	5	4	24.5
17MN215 9/19/2017	0	7.5	7	5	3	22.5
Maximum Attainable Habitat Score	**5**	**14**	**28**	**18**	**35**	**100**

Habitat Summary

The invertebrate community in reach 07020006-558 scored mostly poor in habitat related invert metrics when compared to all other Class 7 southern stream glide pool bio sites that meet the MIBI modified use threshold. Burrowers were relatively low and 38% of the community was made up of legless individuals, mostly the snail physella (Table 215).
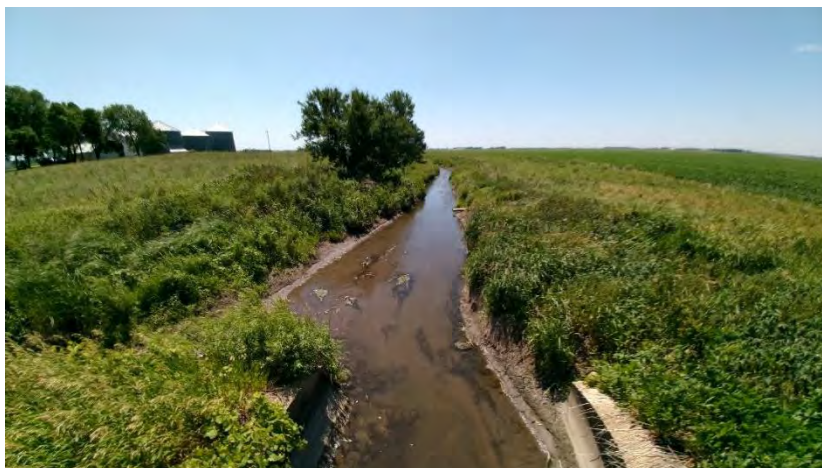
Figure 57. Photo of Bio site 17MN215 showing a ditched channel with very little variability in depth and high amount of fine sediment.

The MSHA scores were both poor. Severe embeddedness was observed during both visits along with high amounts of silt. There were no riffles present, poor channel development, poor sinuosity, and poor depth variability (Table 216).

The majority of invert habitat metrics were poor and the two that scored below the class average were highly influenced by the dominance of the amphipod hyalella. The lack of EPT taxa as well as lower than average clingers and higher than average sprawlers indicate habitat is a stressor to the biological community in the reach due to lack of clean, course substrate, depth variability, and geomorphic features. It is likely that low flows are contributing to a limitations in habitat. Habitat is a stressor to the biological community.

3.3.2.5   Dissolved Oxygen

Dissolved Oxygen Biological Metric Data

Table 217. Dissolved oxygen related invert metrics for reach 07020006-558

07020006-558 **Invert Class 7** **Modified Use**	Low DO Intolerant Taxa %	Low DO Tolerant Taxa %	DO TIV	HBI_MN
17MN215 8/02/2017	0.9	65.0	6.2	8.0
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI modified use threshold (22)	**3.1**	**31.4**	**6.2**	**8.0**
Expected response to **DO** stress	↓	↑	↓	↑

Dissolved Oxygen Monitoring Data

Table 218. Dissolved oxygen monitoring data for reach 07020006-558

07020006-558 DO Data 5 mg/L target	Range of Data (mg/L)	% of Monthly Samples < 5 mg/L [# of Samples]							May - Sep <5 mg/L % [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-362 (2017-2019)	9.1 – 14.5	-	-	-	0% [1]	0% [2]	0% [1]	-	0% [4]
		Minimum Value							
		-	-	-	10.0	9.8	9.1	-	

Dissolved Oxygen Summary

The fish community at bio site 17MN215 scored below average in half of the DO related invert metrics when compared to the average of all other Class 7 southern stream bio sites that meet the FIBI general use threshold (Table 217). The low DO intolerant to tolerant taxa ratio was very bad at 0.9% to 65%. The DO TIV score and HBI_MN score was right at the class averages for those metrics.

Although no DO measurements taken during sampling were below the warmwater standard of 5 mg/L, none of those measurements were taken before 8:00 a.m., when values are usually the lowest. Based on the mixed biological metric scores and lack of data, DO is inconclusive as a stressor in this reach.

3.3.2.6   Eutrophication

Eutrophication Biological Metric Data

Table 219. Eutrophication related invert metrics for reach 07020006-558

07020006-558 Invert Class 7 Modified Use	Crustacean and Mollusca %	Collector – Gatherer Taxa #	Ephemeroptera Plecoptera Trichoptera Taxa %	Intolerant Two Taxa %	Scraper %	Taxa Count All #	Tolerant Two Taxa %
17MN215 8/02/2017	50.9	10	1.2	0.0	8.6	29	96.6
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI modified use threshold (22)	**23.2**	**11.8**	**15.2**	**0.1**	**17.7**	**33.6**	**86.6**
Expected response to **Eutrophic** stress	↑	↓	↓	↓	↑	↓	↑

Eutrophication Monitoring Data

Table 220. Phosphorus monitoring data for reach 07020006-558

07020001-558 P Sample Data 0.150 mg/L target	Range of Data (mg/L)	Monthly Average of Samples (mg/L) [# of Samples]							June-Aug Average (mg/L) [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-362 (2017-2019)	0.064 – 0.133	-	-	0.064 [1]	0.079 [1]	-	0.133 [1]	-	0.072 [2]
		Maximum Value							
		-	-	0.064	0.079	-	0.133	-	

Table 221. DO% Saturation monitoring data for reach 07020006-558

07020006-558 DO% Sat Data	Range of Data (%)	Monthly Average of Samples (%) [# of Samples]							June-Aug Average (%) [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-362 (2017-2019)	100.7 – 187.5	-	-	-	116.0 [1]	146.4 [2]	100.7 [1]	-	136.3 [3]

Eutrophication Summary

The invertebrate community at bio site 17MN215 scored poorly in all but one of the eutrophication related invert metrics when compared to the average of all other Class 7 southern prairie stream glide pool bio sites that meet the MIBI modified use

Figure 58. Photo showing the culvert near bio site 17MN215. Some dead algae lines the bottom of the culvert.

threshold. Crustacean and Mollusca were half of all the inverts collected. EPT taxa percentage was very low and there were no intolerant taxa present. Collector – gatherers were close to the class average, as was the total taxa count, and the percentage of scrapers scored decent (Table 219).

Only three samples were collected and analyzed for Phosphorus from 2017 through 2020. The summer average was below the standard of 0.15 mg/L (Table 220). During site visits the percent saturation was relatively high as several measurements were above 100%.

The biological community is showing some effects from eutrophication, phosphorus sampling did not show elevated concentrations. Some algae growth was observed at the station (Figure 58). Eutrophication is inconclusive as a stressor in this reach.

3.3.2.7   Suspended Solids

Suspended Solids Biological Metric Data

Table 222. Suspended solids related invert metrics for reach 07020006-558

07020006-558 Invert Class 7 Modified Use	Collector – filterer %	Plecoptera %	TSS Intolerant Taxa %	TSS Tolerant Taxa %	TSS TIV
17MN215 8/02/2017	0.6	0.0	0.0	31.9	17.5
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI modified use threshold (22)	**9.9**	**0.0**	**1.3**	**35.6**	**16.2**
Expected response to **Suspended Solids** stress	↓	↓	↓	↑	↑

TSS Monitoring Data

Table 223. Total suspended solids monitoring data for reach 07020006-558

07020006-558 TSS Sample Data 65 mg/L target	Range of Data (mg/L)	% of Monthly Samples > 65 mg/L [# of Samples]							% of Total Samples > 65 mg/L [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-362 (2017-2019)	30 – 38	-	-	-	0% [1]	-	0% [1]	-	0% [2]

Table 224. Transparency monitoring data for reach 07020006-558

07020001-558 Secchi Tube Data 10 cm target	Range of Data (mg/L)	% of Monthly Samples < 10 cm [# of Samples]							% of Total Samples < 10 cm [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-362 (2017-2020)	29 – 92	-	-	0% [1]	0% [1]	0% [2]	0% [1]	-	0% [5]

Suspended Solids Summary

The invertebrate community at bio site 17MN215 scored below average in all four out of five suspended solids related fish metrics when compared to the average of all other Class 7 southern prairie stream glide pool bio sites that meet the MIBI general use threshold. There were very few collector- filterers present and no Plecoptera or TSS intolerant taxa. TSS tolerant taxa were just below the class average and the TSS tolerance index value was above the class average (Table 222).

Only two samples were collected and analyzed for TSS from 2017 through 2019. No sample had a TSS concentration above 65 mg/L (Table 223). Five transparency tube measurements were taken between 2017 and 2020, none were below 10 cm.

Suspended solids are inconclusive as a stressor to aquatic life at this time. It is likely that other factors, such as altered hydrology or habitat could be contributing to the poor scores in the invert biological metrics. It is recommended to collect more TSS data and conduct a sediment substrate analysis in order to determine whether TSS is a biological stressor.

3.3.2.8   Nitrates

Nitrate Biological Metric Data

Table 225. Nitrate related invert metrics for reach 07020006-558

07020006-558 Invert Class 7 Modified Use	Nitrate Intolerant Taxa %	Nitrogen Tolerant Taxa %	Trichoptera Taxa %	Nitrogen TIV
17MN215 8/02/2017	0.0	37.4	3.4	3.3
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI modified use threshold (22)	**2.0**	**59.4**	**5.9**	**3.3**
Expected response to **nitrogen** stress	↓	↑	↓	↑

Nitrate Monitoring Data

Table 226. Nitrate monitoring data for reach 07020006-558

07020006-558 Nitrate/Nitrite Sample Data	2x Highest Reach TIV Average	Range of Data (mg/L) [# of Samples]	Monthly Average [# of Samples]						
			April	May	June	July	August	Sept	Oct
S014-362 (2017-2020)	6.6	4.1 – 7.5 [3]	-	-	4.7 [1]	7.5 [1]	-	4.1 [1]	-
			Highest Value						
			-	-	4.7	7.5	-	2.9	-

Summary

The macroinvertebrate assemblage at site 17MN215 scored below average in two of the four nitrate related metrics evaluated when compared to all other macroinvertebrate Class 7 southern prairie stream glide pool bio sites that meet the MIBI modified use threshold (Table 225). The biological bio site had below average numbers of Trichoptera taxa, which tend to decrease in streams with excessive nitrate values. There was a complete lack of nitrate intolerant invertebrate species, though tolerant taxa were below the class average. The nitrogen TIV score was right at the class average.

Three samples were collected in reach 07020006-558 and analyzed for nitrate/nitrite (Table 226). Only one out of the three nitrate samples had concentrations greater than 6.6 mg/L. Due to the mixed biological response and limited nitrate samples, nitrates are inconclusive as a stressor to aquatic life in this reach.

3.3.2.9   Reach Stressors

Table 227. Summary of stressors for reach 07020006-558

07020006-558	Hydrologic Alteration	Connectivity	Habitat	Dissolved Oxygen	Eutrophication	Suspended Solids	Nitrate
✔ = Stressor ✘ = Not a Stressor O = Inconclusive	✔	O	✔	O	O	O	O

3.3.3 07020006-573   Unnamed Creek
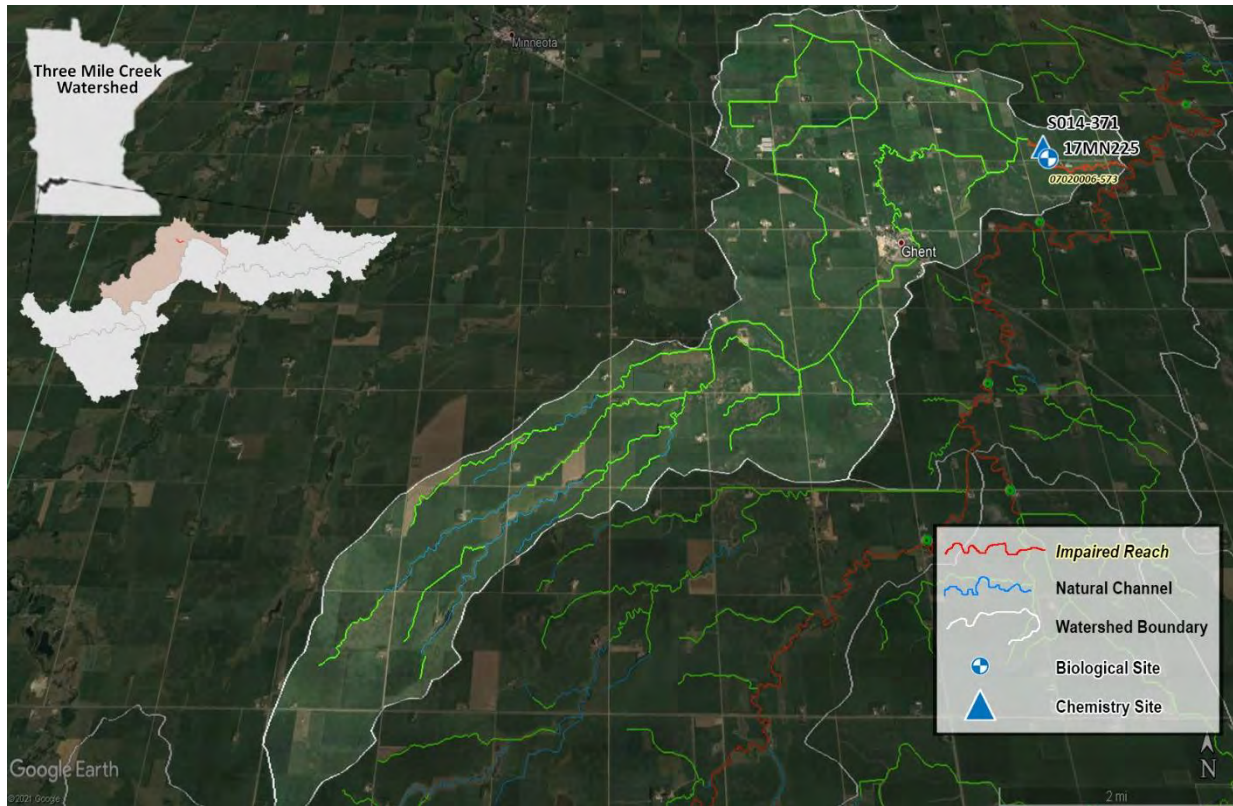
Figure 59. Satellite image of reach 07020006-573 and its watershed

3.3.3.1   Biological Community

Bio site 17MN225 was sampled once for fish in 2017. The FIBI score of 43.8 was below the Fish Class 3 southern headwaters general use threshold of 55 (Table 228). Creek chubs, a generalist pioneer species, were the dominant fish with blacknose dace and johnny darters prevalent as well. Both creek chubs and blacknose dace are lithophillic spawners that require coarse substrate for reproduction.

Bio site 17MN225 was sampled once for invertebrates in 2017. The MIBI score of 18.5 was below the Invert Class 5 southern stream rock riffle general use threshold of 37 (Table 229).The snail physella dominated the invertebrate community. There were also large numbers of amphipods and midges present, both of which are considered tolerant.

Biological Metric Data

Table 228. Fish IBI score and threshold for reach 07020006-573

07020006-573 **Fish Class 3** **General Use**	Fish IBI Score	Class Threshold Score
17MN225 8/16/2010	43.8	55

Table 229. Invert IBI score and threshold for reach 07020006-573

07020006-573 **Invert Class 5** General Use	Invert IBI Score	Class Threshold Score
17MN225 7/31/2017	18.5	37

3.3.3.2 Hydrologic Alteration

Hydrologic Alteration Biological Metric Data

Table 230. Hydrologic alteration related fish metrics for reach 07020006-573

07020006-573 **Fish Class 3** General Use	General %	Nesting Non Lithophilic Spawner %
17MN225 8/16/2010	65.0	30.9
Statewide average for Class 3 Southern Headwater bio sites that are meeting the FIBI general use threshold (55)	**59.1**	**19.2**
Expected response to **Hydrologic** stress	↑	↑

Table 231. Hydrologic alteration related invert metrics for reach 07020006-573

07020006-573 **Invert Class 5** General Use	Clinger %	Collector – filterer %	Long – lived %	Percent Ditched Tolerant %	Percent Ditched Intolerant %
17MN225 7/31/2017	44.0	22.8	7.0	26.7	1.6
Statewide average for Class 5 prairie stream rock riffle bio sites that are meeting the FIBI general use threshold (37)	**49.5**	**26.9**	**9.0**	↑	↓
Expected response to **Hydrologic** stress	↓	↓	↓		

HSPF Model Flow Data

Table 232. HSPF modeled flow data for reach 07020006-573

07020006-573 HSPF Reach 307 Min: 0.0 cfs Max: 452.3 cfs	**<5 cfs %** (# of values)	**<1 cfs %** (# of values)	**<0.5 cfs %** (# of values)
6,210 Total Daily Averages 1996 – 2012	**70.8%** (4,396)	**43.2%** (2,685)	**31.6%** (1,962)

Hydrologic Alteration Summary

The hydrologic related biological fish metrics all scored poorly when compared to the average of Class 3 headwater stream bio sites that meet the FIBI general use threshold. Bio site 17MN225 had a general population 65% while nesting fish comprised over 30% of the total number of fish caught (Table 230).

The hydrologic related biological invertebrate metrics all scored poorly when compared to the average of Class 7 stream bio sites that meet the MIBI modified use threshold. Bio site 17MN225 had a population of clingers of 44%, which wasn't too far below the class average of 49.5%. Collector – filterers comprised 22.8% of the population. Both metrics were influenced by the high numbers of net spinning caddisflies present. Long – lived inverts were 7% of the population, which were two riffle beetle taxa. The ratio of inverts who are considered tolerant vs intolerant to ditching was also relatively high (Table 231). The most common invert was the snail physella, which is considered generally very tolerant. The next most common invert was the caddisfly cheumatopsyche, a net spinning caddisfly, which is considered tolerant to both low flows and low cover of the stream channel. Four out of the five most numerous invertebrates are considered tolerant to both depth variability as well as several habitat metrics.

The HSPF model shows that 43.2% of the daily average flows from 1996 through 2012 were below 1 cfs. Flows reduced beyond normal base flow will decrease habitat for aquatic organisms and increase competition for resources (Table 232).

Based on the poor scores of the biological metrics and extended low flow periods shown in the HSPF model, hydrologic alteration is a stressor in this reach. Although the bio site is located on a short stretch of a natural channel, the primary impact in this reach is from the alteration and channelization upstream, as almost the entire watershed upstream has been altered (Figure 58).

3.3.3.3   Connectivity

Connectivity Metric Data

Table 233. Connectivity related fish metrics for reach 07020006-573

07020006-573 **Fish Class 3** General Use	Mature Age >3 minus Tolerant Taxa %	Migrating Taxa %
17MN225 8/16/2010	0.0	14.3
Statewide average for Class 3 Southern Headwater bio sites that are meeting the FIBI general use threshold (55)	**5.3**	**19.5**
Expected response to **Connectivity** stress	↓	↓

Connectivity Summary

There were no taxa whose females take greater than three years to mature. Migrating taxa were present and were not too far below the average for southern headwater streams that meet the standard. There are no known barriers on this reach and due to the presence of migrating species, connectivity does not appear to be a stressor.

3.3.3.4   Habitat

Habitat Metric Data

Table 234. Habitat related fish metrics for reach 07020006-573

07020006-573 **Fish Class 3** General Use	Benthic Insect minus Tolerant %	Darter Sculpin Sucker %	Lithophilic Spawner %	Pioneer %	Piscivore %	Riffle %	Simple Lithophilic Spawner %	Tolerant %
17MN225 8/16/2010	19.5	15.4	65.0	54.5	0.0	10.6	25.2	74.8
Statewide average for Class 3 Southern Headwater bio sites that are meeting the FIBI general use threshold (55)	**14.2**	**12.6**	**69.2**	**37.8**	**1.6**	**28.3**	**33.7**	**70.6**
Expected response to **Habitat** stress	↓	↓	↓	↑	↓	↓	↓	↑

Table 235. Habitat related invert metrics for reach 07020006-573

07020006-573 Invert Class 5 General Use	Burrower %	Climber %	Clinger %	Ephemeroptera Plecoptera Trichoptera %	Legless %	Sprawler %
17MN225 7/31/2017	2.5	30.1	44.0	31.3	47.2	21.2
Statewide average for Class 5 prairie stream rock riffle bio sites that are meeting the FIBI general use threshold (37)	**7.5**	**14.7**	**49.5**	**43.9**	**36.0**	**16.8**
Expected response to **Habitat** stress	↑	↓	↓	↓	↑	↑

MPCA Stream Habitat Assessment Score

Table 236. Habitat Assessment scores for reach 07020006-573

07020006-573	Land Use	Riparian	Substrate	Cover	Channel Morphology	Total Score
17MN225 7/31/2017	0	9.5	21	13	22	65.5
17MN225 8/16/2017	0	8	19.6	12	21	60.6
Maximum Attainable Habitat Score	**5**	**14**	**28**	**18**	**35**	**100**

Habitat Summary

The fish community in reach 07020006-573 scored poorly in six out of eight habitat related fish metrics when compared to all other Class 3 southern headwater bio sites that meet the FIBI general use threshold. The rest of the metrics besides Piscivores, though they are considered poor scores, were not too far from the class averages (Table 234).
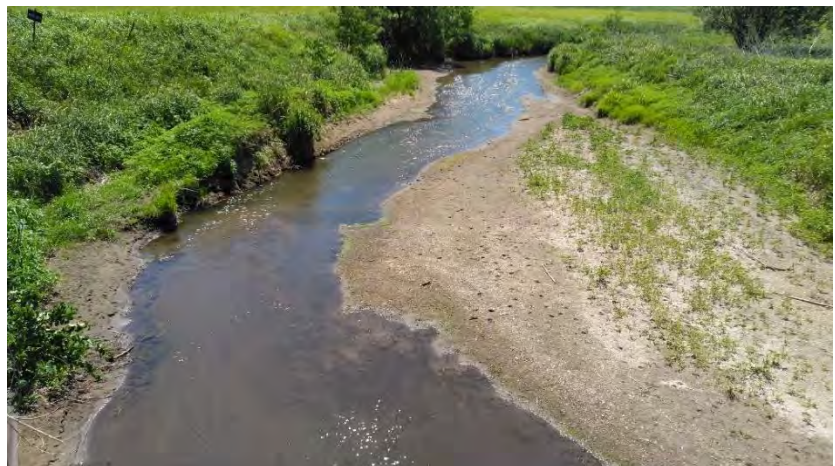
Figure 60. Photo of Bio site 17MN225 showing a low water levels and some channel development within the stream channel

Four of the six habitat related invertebrate metrics score poorly when compared to the average of all other Class 5 southern stream

rock riffle general use threshold. There were low numbers of burrowers and high numbers of climbers, though the climbers are from the dominance of the snail physella. The rest of the poor metrics, like the fish, were not too far from their respective class averages.

The MSHA scores were moderate. Only light embeddedness was observed during both visits along with normal amounts of silt. There were riffles present, good channel development and sinuosity, and depth variability (Table 236)

Due to the decent habitat assessment and biological metric scores, habitat does not appear to be a stressor to the biological community at bio site 17MN225. It is likely a factor upstream of the bio site as almost the entire watershed upstream has been altered.

3.3.3.5   Dissolved Oxygen

Dissolved Oxygen Biological Metric Data

Table 237. Dissolved oxygen related fish metrics for reach 07020006-573

07020006-573 **Fish Class 3** General Use	Mature Age >3 %	Serial Spawner %	Taxa Count	DO TIV	DO Sensitive %	DO Tolerant %
17MN225 8/16/2010	2.4	13.8	14	8.4	0.0	10.6
Statewide average for Class 3 Southern Headwater bio sites that are meeting the FIBI general use threshold (55)	**13.3**	**17.1**	**11.8**	**8.4**	**4.5**	**14.2**
Expected response to **DO** stress	↓	↑	↓	↓	↓	↑

07020006-573 Invert Class 5 General Use	Low DO Intolerant Taxa %	Low DO Tolerant Taxa %	DO TIV	HBI_MN
17MN225 7/31/2017	8.2	32.4	6.8	8.0
Statewide average for Class 5 prairie stream rock riffle bio sites that are meeting the FIBI general use threshold (37)	**24.6**	**8.6**	**7.1**	**7.0**
Expected response to **DO** stress	↓	↑	↓	↑

Dissolved Oxygen Monitoring Data

Table 239. Dissolved oxygen monitoring data for reach 07020006-573

07020006-573 DO Data 5 mg/L target	Range of Data (mg/L)	% of Monthly Samples < 5 mg/L [# of Samples]							May - Sep <5 mg/L % [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-371 (2017-2019)	8.8 – 13.7	-	-	-	0% [2]	0% [2]	-	-	0% [4]
		Minimum Value							
		-	-	-	13.3	8.8	-	-	
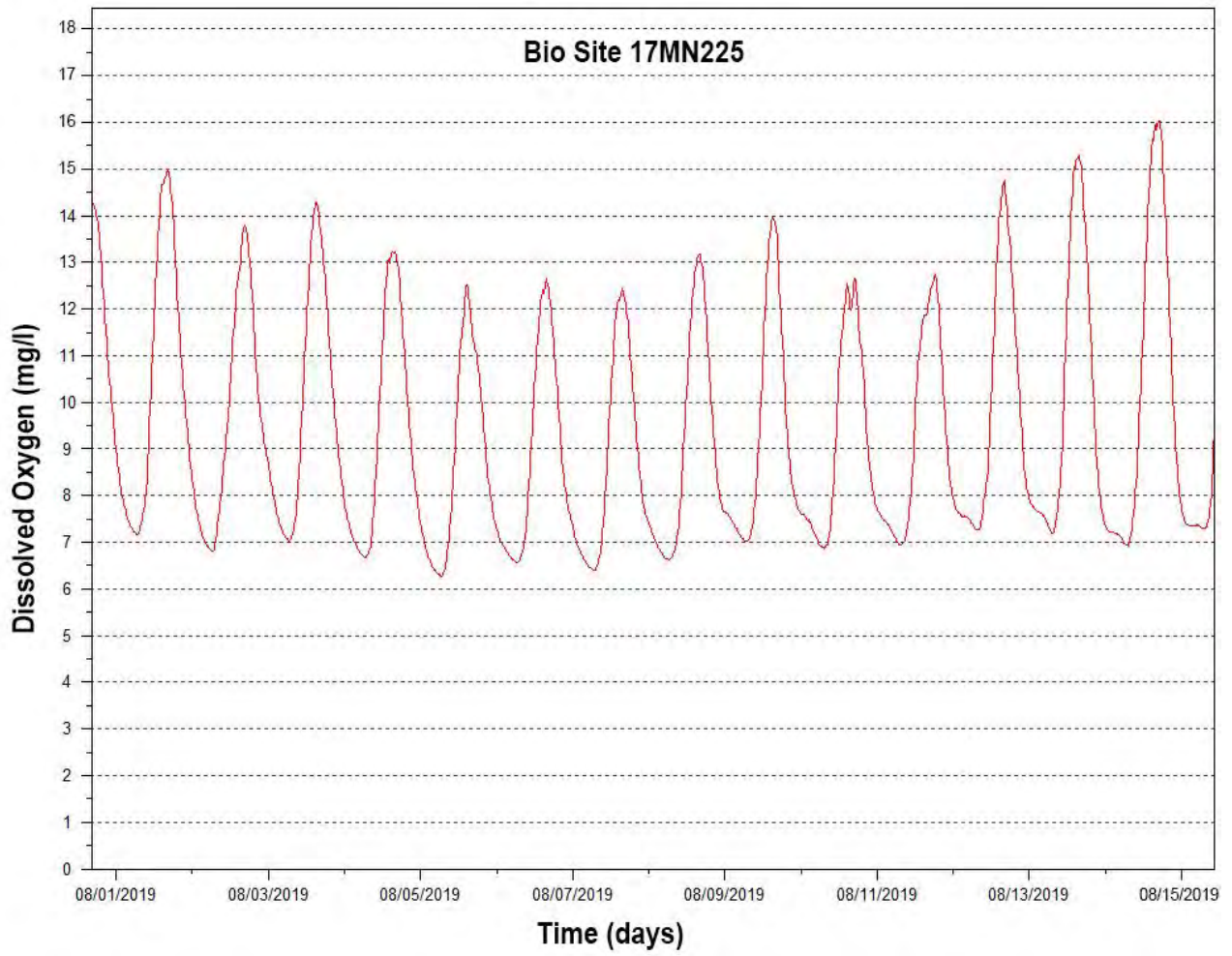
Figure 61. 2019 continuous dissolved oxygen data at site 17MN225
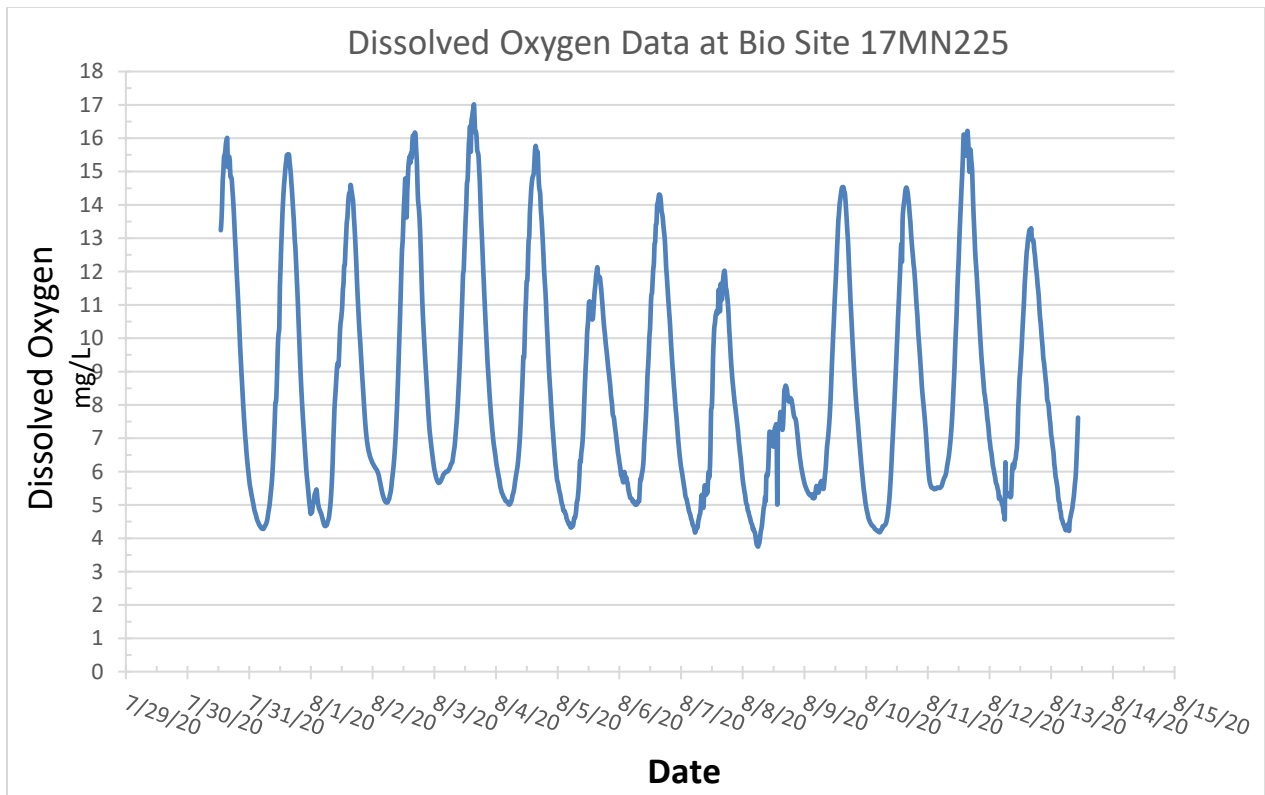
Figure 62. 2020 continuous dissolved oxygen data at site 17MN225

Dissolved Oxygen Summary

The fish community at bio site 17MN225 scored poorly in only two out of the six DO related fish metrics when compared to the average of all other Class 3 southern headwater bio sites that meet the FIBI general use threshold. There were no fish caught who are sensitive to low DO. Species with females that take more than three years to mature comprised 2.4% of the total number of fish caught, well below class average. DO tolerant species comprised about only 10.6% the fish population, serial spawners only 13.8%, and there was an above average number of taxa present. The DO tolerance index score was right at the class average of 8.4 (Table 237).

All four of the DO related invertebrate metrics scored poorly at bio site 17MN225. Low DO intolerant taxa were low at 8.2% compared to low DO tolerant taxa, which were 32.4%. Both scores are considered poor. The DO tolerance index value was also below the class average and the HBI_MN biotic index score was above the class standard (Table 238).

Although no DO measurements taken during sampling were below the warmwater standard of 5 mg/L, none of those measurements were taken before 8:00 a.m., when values are usually the lowest. An YSI Sonde water meter measured continuous DO data from 8/1/2019 to 8/15/2019. During this deployment, DO values were not measured below the standard of 5 mg/L. On 7/30/2020 a sonde was deployed until 8/12/2020. During this second deployment DO levels did dip below 5 mg/L several nights.

Based on the mixed biological metric scores and the measured sonde values, DO is inconclusive as a stressor in this reach.

3.3.3.6   Eutrophication

Eutrophication Biological Metric Data

Table 240. Eutrophication related fish metrics for reach 07020006-573

07020006-573 **Fish Class 3** General Use	Darter %	Omnivore %	Sensitive %	Simple Lithophillic Spawner %	Tolerant %
17MN225 8/16/2010	15.4	4.1	0.0	25.2	74.8
Statewide average for Class 3 Southern Headwater bio sites that are meeting the FIBI general use threshold (55)	**12.1**	**14.6**	**8.6**	**33.7**	**70.6**
Expected response to **Eutrophication** stress	↓	↑	↓	↓	↑

Table 241. Eutrophication related invert metrics for reach 07020006-573

07020006-573 **Invert Class 5** General Use	Crustacean and Mollusca %	Collector – Gatherer Taxa #	Ephemeroptera Plecoptera Trichoptera Taxa %	Intolerant Two Taxa %	Scraper %	Taxa Count All #	Tolerant Two Taxa %
17MN225 7/31/2017	38.3	12	31.3	0.0	29.7	35	88.6
Statewide average for Class 5 prairie stream rock riffle bio sites that are meeting the FIBI general use threshold (37)	**9.2**	**15.1**	**30.5**	**0.8**	**15.8**	**41.9**	**74.3**
Expected response to **Eutrophic** stress	↑	↓	↓	↓	↑	↓	↑

Eutrophication Monitoring Data

Table 242. Phosphorus monitoring data for reach 07020006-573

07020001-573 P Sample Data 0.150 mg/L target	Range of Data (mg/L)	Monthly Average of Samples (mg/L) [# of Samples]							June-Aug Average (mg/L) [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-371 (2017-2019)	0.073 – 0.231	-	-	-	0.073 [1]	0.231 [1]		-	0.152 [2]
		Maximum Value							
		-	-	-	0.073	0.231	-	-	

Table 243. DO% Saturation monitoring data for reach 07020006-573

07020006-573 DO% Sat Data	Range of Data (%)	Monthly Average of Samples (%) [# of Samples]							June-Aug Average (%) [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-371 (2017-2019)	101.3 – 183.8	-	-	-	176.4 [2]	104.2 [2]	-	-	140.3 [4]

Eutrophication Summary

The eutrophication related fish metrics at bio site 17MN225 were mixed when compared to the average of all other Class 3 southern headwater bio sites that meet the FIBI general use threshold. Darter percentage was above average, though johnny darters are considered a more tolerant species. There were also low numbers of omnivorous. There were some lithophilic spawning fish present, though the percentage was below the class average and there were no sensitive fish caught. Tolerant species were 74% of the total number of fish caught (Table 240).

Invertebrate eutrophication related metrics mostly all scored poorly when compared to the average of all other Class 5 southern stream rock riffle bio sites that meet the MIBI general use threshold. Crustacean and Mollusca percentage was very high and collector – filterer taxa were below the class average. There were no intolerant taxa and scrapers were higher than the class average. Overall taxa count was low and the two most tolerant taxa comprised 88.6% of the population (Table 241).

Only two samples were collected and analyzed for Phosphorus from 2017 through 2019. The summer average was 0.152, above the standard of 0.150 mg/L (Table 242).

An YSI Sonde water meter measured continuous DO data from 8/1/2019 to 8/15/2019 and 7/30/2020 to 8/12/2020. During this deployment, diel DO flux was measured at or above 5 mg/L every night it was deployed.

The biological community is showing the effects of the elevated phosphorus, phosphorus sampling showed elevated concentrations, and DO flux was 5 mg/L or greater during both sonde deployments. Eutrophication appears to be a stressor within this reach.

3.3.3.7   Suspended Solids

Suspended Solids Biological Metric Data

Table 244. Suspended solids related fish metrics for reach 07020006-573

07020006-573 Fish Class 3 General Use	Benthic Feeder %	Centrarchid - Tolerant %	Herbivore %	Intolerant %	Long – lived %	Perciformes - Tolerant %	Riffle %	Sensitive %	Simple Lithophilic Spawner %	TSS TIV
17MN225 8/16/2010	30.1	0.0	8.1	0.0	0.8	15.4	10.6	0.0	25.2	15.2
Statewide average for Class 3 Southern Headwater bio sites that are meeting the FIBI general use threshold (55)	**37.9**	**0.9**	**13.3**	**2.0**	**3.6**	**13.9**	**28.3**	**8.6**	**33.7**	**15.0**
Expected response to **Suspended Solids** stress	↓	↓	↓	↓	↓	↓	↓	↓	↓	↑

Table 245. Suspended solids related invert metrics for reach 07020006-573

07020006-573 Invert Class 5 General Use	Collector – filterer %	Plecoptera %	TSS Intolerant Taxa %	TSS Tolerant Taxa %	TSS TIV
17MN225 7/31/2017	22.8	0.0	0.0	44.0	18.3
Statewide average for Class 5 prairie stream rock riffle bio sites that are meeting the FIBI general use threshold (37)	**26.9**	**0.5**	**5.1**	**35.2**	**15.9**
Expected response to **Suspended Solids** stress	↓	↓	↓	↑	↑

TSS Monitoring Data

Table 246. Total suspended solids monitoring data for reach 07020006-573

07020001-573 TSS Sample Data 65 mg/L target	Range of Data (mg/L)	% of Monthly Samples > 65 mg/L [# of Samples]							% of Total Samples > 65 mg/L [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-371 (2017-2020)	8.4 – 12	-	-	0% [1]	0% [1]	0% [1]	-	-	0% [3]

Table 247. Transparency monitoring data for reach 07020006-558

07020001-573 Secchi Tube Data 10 cm target	Range of Data (cm)	% of Monthly Samples < 10 cm [# of Samples]							% of Total Samples < 10 cm [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-371 (2017-2020)	76 – 100+	-	-	0% [1]	0% [2]	0% [2]	-	-	0% [5]

Suspended Solids Summary

The fish community at bio site 17MN225 scored poorly in 9 out of 10 suspended solids related fish metrics when compared to the average of all other Class 3 southern headwater bio sites that meet the FIBI general use threshold. There were some decent numbers of benthic feeders, herbivores, riffle dwelling, and simple lithophillic spawners present though they were below the class average. The Perciformes percentage of 15.4% was above the class average. There were no centrachids or sensitive fish present and very few long – lived fish at the bio site (Table 244).

The invertebrate community at bio site 17MN225 scored poorly in all five suspended solids related invert metrics when compared to the average of all other Class 5 southern stream rock riffle bio sites that meet the MIBI general use threshold. There were some collector – filterers present, though at 22.8% they were below the class average. There were no Plecoptera present or any TSS intolerant taxa. TSS tolerant taxa were high and the TSS TIV indicates an invertebrate community that is generally tolerant of suspended solids (Table 245).

Only three samples were collected and analyzed for TSS from 2017 through 2020. No sample had a TSS concentration above 65 mg/L (Table 246).

Suspended solids are inconclusive as a stressor to aquatic life at this time. It is likely that other factors, such as altered hydrology or habitat are causing poor scores in the fish biological metrics. It is recommended to collect more TSS data and conduct a sediment substrate analysis in order to determine whether TSS is a biological stressor.

3.3.3.8   Nitrates

Nitrate Biological Metric Data

07020006-573 **Invert Class 5** General Use	Nitrate Intolerant Taxa %	Nitrogen Tolerant Taxa %	Trichoptera Taxa %	Nitrogen TIV
17MN225 7/31/2017	0.0	65.7	14.3	4.7
Statewide average for Class 5 prairie stream rock riffle bio sites that are meeting the FIBI general use threshold (37)	**2.9**	**47.6**	**13.6**	**3.0**
Expected response to **nitrogen** stress	↓	↑	↓	↑

Nitrate Monitoring Data

Table 249. Nitrate monitoring data for reach 07020006-573

07020001-573 Nitrate/Nitrite Sample Data	2x Highest Reach TIV Average	Range of Data (mg/L) [# of Samples]	Monthly Average [# of Samples]						
			April	May	June	July	August	Sept	Oct
S014-362 (2017-2020)	6.0	0.5 – 7.5 [4]	-	-	4.7 [1]	7.3 [2]	-	0.5 [1]	-
			Highest Value						
			-	-	4.7	7.5	-	0.5	-

Summary

The macroinvertebrate assemblage at site 17MN225 scored below average in three of the four nitrate related metrics evaluated when compared to all other macroinvertebrate Class 5 streams bio sites that meet the MIBI general use threshold (Table 249). The biological bio site had an above average number of Trichoptera taxa, thought it was mostly the net spinning cheumatopsyche, a more tolerant caddisfly. There was a high amount of nitrate tolerant invertebrates as well as complete lack of nitrate intolerant invertebrate species. The nitrogen TIV score also indicates a macroinvertebrate community that is generally tolerant to high levels of nitrates.

Four samples were collected and analyzed for nitrate/nitrite (Table 249). Two of the July samples had total nitrate samples had concentrations greater than 6 mg/L. Due to the biological response and relatively high nitrate concentrations, nitrates are a stressor to aquatic life in reach 07020006-573.

3.3.3.9　　Reach Stressors

Table 250. Summary of stressors for reach 07020006-573

07020006-573	Hydrologic Alteration	Connectivity	Habitat	Dissolved Oxygen	Eutrophication	Suspended Solids	Nitrate
✔ = Stressor ✘ = Not a Stressor O = Inconclusive	✔	✘	✘	O	✔	O	✔

3.4　Middle Redwood River

3.4.1　07020006-502　　Redwood River
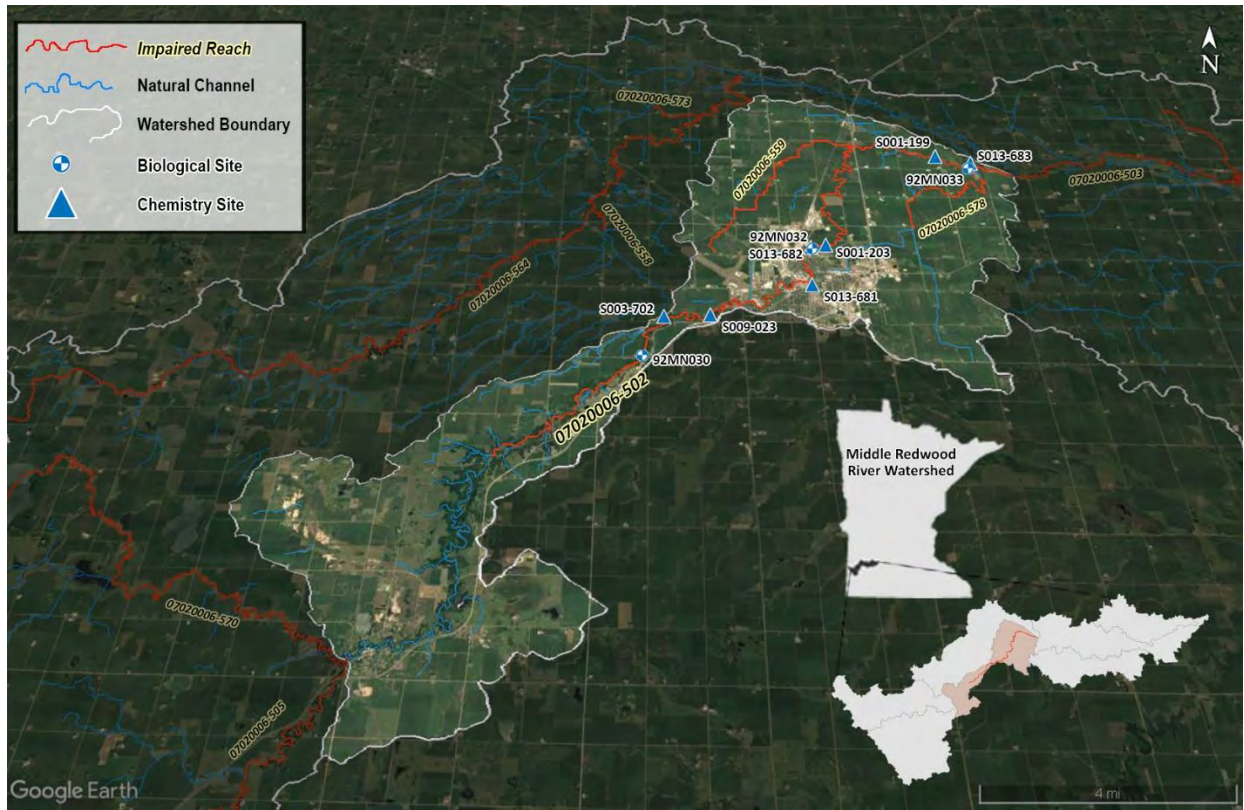
Figure 63. Satellite image of reach 07020006-502 and its direct watershed

3.4.1.1　　Biological Community

Reach 07020006-502 was sampled three times at two different bio sites for fish in 2017. The FIBI scores of 53.7 and 48.6 are slightly above and slightly below the fish class 2 southern streams general use threshold of 50 (Table 251). Bio site 92MN033 had a score of 38.0, below the fish class 1 southern river general use threshold of 49 (Table 252). Reach 07020006-502 is a relatively longer reach and is the main stem Redwood River. The bio site classifications change from a class 2 southern stream at bio site

92MN032 to a class 1 southern river from bio site down at bio site 92MN033. The biological metrics used to assess the two bio classes are different and the downstream site has scored worse than the upstream site. Common shiners, a lithophilic spawning generalist species, dominated the fish community throughout the entire reach. In general, upstream bio site 92MN032 was dominated more by lithophilic spawning and invertivores/insectivores than bio site 92MN033, which was dominated more by tolerant species.

Reach 07020006-502 was sampled four times for invertebrates within the last 10 years, with three of those visits in 2017. Bio sites 92MN030 and 92MN032 scored a 23.7 and 49.2, below and above the class 5 threshold of 37 (Table 253). Both sites were dominated by net spinning caddisflies, sprawling mayflies, and midges; all of which are considered tolerant. Bio site 92MN032 had decent numbers of Baetis intercalaris, a swimming caddisfly. The downstream bio site 92MN033 scored a 41.6 and 36.6, above and below the class 7 average of 41 (Table 254). The site was dominated the swimming mayfly Fallceon and also had good numbers of the caddisfly Nectopsyche as well as the more tolerant mayflies Baetis and Tricorythodes.

Biological Metric Data

Table 251. Fish IBI score and threshold for reach 07020006-502

07020006-502 **Fish Class 2** General Use	Fish IBI Score	Class Threshold Score
92MN032 7/13/2017	53.7	50
92MN032 9/19/2017	48.6	

Table 252. Fish IBI score and threshold for reach 07020006-502

07020006-502 **Fish Class 1** General Use	Fish IBI Score	Class Threshold Score
92MN033 7/10/2017	38.0	49

Table 253. Invert IBI score and threshold for reach 07020006-502

07020006-502 Invert Class 5 General Use	Invert IBI Score	Class Threshold Score
92MN030 8/03/2010	23.7	37
92MN032 8/03/2017	53.8	

Table 254. Invert IBI score and threshold for reach 07020006-502

07020006-502 Invert Class 7 General Use	Invert IBI Score	Class Threshold Score
92MN033 8/24/2010	41.6	41
92MN033 7/31/2017	36.6	

3.4.1.2   Hydrologic Alteration

Hydrologic Alteration Biological Metric Data

Table 255. Hydrologic alteration related fish metrics for reach 07020006-502

07020006-502 Fish Class 2 General Use	General %	Nesting Non Lithophilic Spawner %
92MN030 8/31/2010	57.2	8.1
92MN032 7/13/2017	59.4	24.0
92MN032 9/19/2017	56.1	27.0
Statewide average for Class 2 Southern Stream bio sites that are meeting the FIBI general use threshold (50)	**42.4**	**19.1**
Expected response to **Hydrologic** stress	↑	↑

Table 256. Hydrologic alteration related fish metrics for reach 07020006-502

07020006-502 **Fish Class 1** General Use	General %	Nesting Non Lithophilic Spawner %
92MN033 7/10/2017	31.3	33.0
Statewide average for Class 1 Southern River bio sites that are meeting the FIBI general use threshold (49)	**20.7**	**16.0**
Expected response to **Hydrologic** stress	↑	↑

Table 257. Hydrologic alteration related invert metrics for reach 07020006-502

07020006-502 **Invert Class 5** General Use	Clinger %	Collector – filterer %	Long – lived %		Percent Ditched Tolerant %	Percent Ditched Intolerant %
92MN030 8/03/2010	36.3	32.7	0.7		0.7	12.1
92MN032 8/03/2017	62.9	38.3	6.5		0.6	14.6
Statewide average for Class 5 prairie stream rock riffle bio sites that are meeting the FIBI general use threshold (37)	**49.5**	**26.9**	**9.0**		↑	↓
Expected response to **Hydrologic** stress	↓	↓	↓			

07020006-502 Invert Class 7 General Use	Clinger %	Collector – filterer %	Long – lived %		Percent Ditched Tolerant %	Percent Ditched Intolerant %
92MN033 8/24/2010	24.3	12.5	8.5		19.0	2.6
92MN033 7/31/2017	15.7	6.8	3.4		0.0	7.1
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI general use threshold (41)	**38.5**	**19.1**	**8.0**		↑	↓
Expected response to **Hydrologic** stress	↓	↓	↓			

HSPF Model Flow Data

Table 259. HSPF modeled flow data for reach 07020006-502

07020006-502 HSPF Reach 290 Min: 5.4 cfs Max: 6,047.6 cfs	<5 cfs % (# of values)	<1 cfs % (# of values)	<0.5 cfs % (# of values)
6,210 Total Daily Averages 1996 – 2012	**0%** (0)	**0%** (0)	**0%** (0)

Hydrologic Alteration Summary

The hydrologic alteration related fish biological metrics all scored poorly when compared to the average of class 2 and class 1 bio sites that meet the IBI general use threshold (Table 255, Table 256). Both bio sites 92MN032 and 92MN033 had high numbers of generalized fish and nesting species that were well above their class averages.

The hydrologic alteration related invertebrate biological metrics were mixed when compared to the average of class 5 and class 7 bio sites that meet the IBI general use threshold (Table 257, Table 258). The two upstream bio sites 92MN030 and 92MN032 scored better than the downstream bio site 92MN033. There were large numbers of clinging net spinning caddisflies, which also are collector filterers. Bio site 92MN032 had some long – lived species as well, though they were below the class average. Both bio sites had a high ditched intolerant to tolerant percentage, though this would be expected of a river with a natural channel. The hydrologic alteration related metrics scored worse at the downstream bio site 92MN033 as there were less net spinning caddisfly species and had less numbers of them present. Long – lived percentage was better than average in 2010 but less in the 2017. Percent

ditched tolerant vs intolerant was the opposite as the 2010 scores were poor but the 2017 scores were very good, with no ditched tolerant species present.

The HSPF model shows that none of the daily average flows from 1996 through 2012 were below 1 cfs (Table 261, Table 231). This reach is the main stem middle Redwood River and it is unlikely that flows get reduced below 1 cfs simply because of the size of the river.

92MN030

Biological fish data at bio site 92MN030 is from 2010. The site is located just upstream of the diversion channel that goes around the city of Marshall. The fish biological community of the reach at this bio site shows high generalist species and was dominated by the common shiner. The next five species are considered tolerant or very tolerant. There were several sensitive species present such as fantail darters, northern hogsuckers, and hornyhead chubs. Unfortunately both the fish and invert data is from 2010. "The reach at this location is classified as an F4. F4 stream types are gravel dominated, deeply incised, entrenched channels (Rosgen 1996). Because the channel is fully entrenched, the bankfull elevation within F4 channels is well below the 'top of banks' elevation (Rosgen 1996)" (DNR 2020).

92MN032

There is diversion channel in the middle of the reach that diverts water around the city of Marshall. This channel then flows back in to the river just before bio site 92MN032. The river here appears to be incised and lacks access to its floodplain and the river bank has been armored in several locations in order to prevent damage to roadways from bank erosion. It appears that the flow from the

Figure 64. Photo near bio site 92MN032 showing an eroding bank.

diversion channel is likely having an effect on the geomorphology of the channel and causing the channel to incise. The fact that the channel is a relatively natural meandering river at this site appears to be supporting a healthier biological community compared to the other bio sites both up and downstream of bio site 92MN032. Both fish and inverts had IBI scores above their thresholds. The fish community was dominated by the common shiner, a lithophilic spawning fish. Five out of the seven most numerous fish taxa present are considered lithophilic spawners. The invertebrate community was dominated by the caddisfly ceratopsyche, which is considered very intolerant to low depth variability as well as several habitat related metrics. Seven of the top eight most numerous inverts caught are considered either very tolerant or tolerant to depth variability. Nine out of the top 10 inverts caught were caddisflies and mayflies.

92MN033

This bio site is located just downstream of Marshall past where the diversion channel reenters the river. The channel here was channelized, as can be seen in the 1930 aerial photo of the area (Figure 65). According to the DNR Watershed Characterization Report the river here is deeply incised and entrenched and there have been extensive alterations of the river channel in the area as well as downstream of the survey location. The stream channel has gone through extensive changes due to both the alteration of the stream channel itself, as well as alteration of stream flow in the watershed upstream." Simple GIS measurements taken from the 1938 aerial photograph georeferenced with the 2017 aerial photograph shows the channel increased in width from approximately 17 feet to the 48 foot width measured during the riffle cross section survey (DNR 2020).
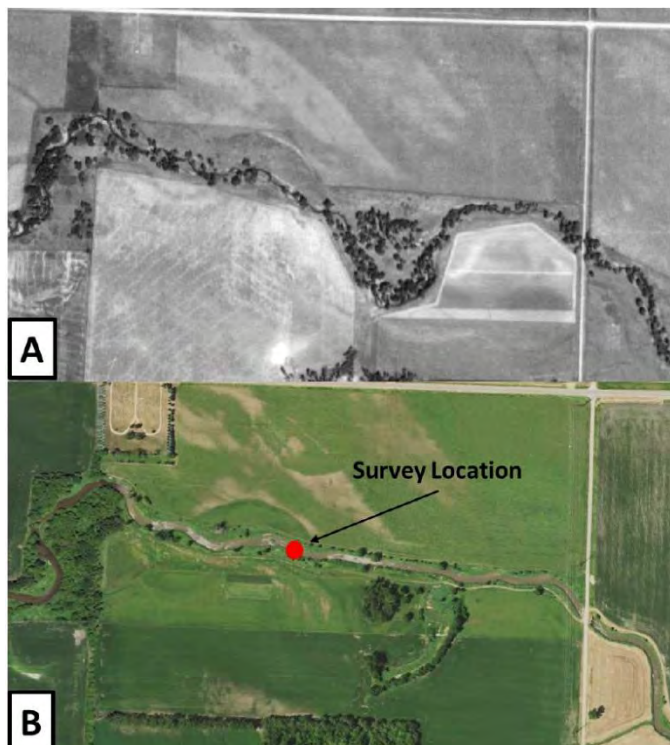
Figure 65. Image taken from the DNR Watershed Characterization Report comparing the DNR survey location from a 1930s aerial photograph of the Redwood River. The channel has both been altered and appears to have widened since the 1930s photo.

The fish biological community at 92MN033 by spotfin shiners and bluntnose minnows. Both of which are not considered lithophilic spawners. Four of the top five fish caught are considered very tolerant and only one of those, the common carp, is considered long-lived. The invertebrate community was dominated by the mayfly fallceon, which is considered very tolerant to low flows as well as several habitat metrics. The next two most numerous inverts, the caddisfly nectopsyche and the mayfly tricorythodes, are also very tolerant to low flow as well as several habitat metrics. Overall the biology at this site appears to be worse off and comprised of more tolerant taxa than the two upstream bio sites.

Overall reach 07020006-502 is a very long and diverse reach that differs greatly as it flows downstream through the town of Marshall. Upstream of Marshall near bio site 92MN030 the stream seems to be incising and down cutting, likely affected by increased flows from upstream. The middle bio site 92MN032 is located just downstream of Marshall and the diversion channel that redirects water around the town. The river at this location is definitely going through changes, both from historical upstream alterations as well as from the construction of the diversion channel, which appear to be causing both incision and entrenchment as well as bank erosion. However, the area around this bio site appears to be the best as far as geomorphology as well as biologically. This is likely due to the lower gradient around the city of Marshall that would dissipate the stream force naturally, as well as the fact that the diversion channel is relatively new and thus, the river is currently undergoing changes from the increased flows that result from channelization. Further downstream the river channel itself has been directly altered

and channelized, which appears to be stressing the biological community. Hydrologic alteration is a stressor to reach 07020006-502.

3.4.1.3   Connectivity

Connectivity Metric Data

Table 260. Connectivity related fish metrics for reach 07020006-502

07020006-502 **Fish Class 2** General Use	Mature Age >3 minus Tolerant Taxa %	Migrating Taxa %
92MN030 8/31/2010	18.2	22.7
92MN032 7/13/2017	21.7	13.0
92MN032 9/19/2017	21.7	21.7
Statewide average for Class 2 Southern Stream bio sites that are meeting the FIBI general use threshold (50)	**21.8**	**24.3**
Expected response to **Connectivity** stress	↓	↓

Table 261. Connectivity related fish metrics for reach 07020006-502

07020006-502 **Fish Class 1** General Use	Mature Age >3 minus Tolerant Taxa %	Migrating Taxa %
92MN033 7/10/2017	26.1	17.4
Statewide average for Class 1 Southern River bio sites that are meeting the FIBI general use threshold (49)	**41.5**	**30.7**
Expected response to **Connectivity** stress	↓	↓

Connectivity Summary

Metrics related to connectivity all scored below the class averages. The upstream bio sites were closer to the class 2 averages than the downstream bio site, which is a fish class 1 southern river. Due to the presence of some migratory and late maturing species, connectivity is inconclusive as a stressor in this reach.

3.4.1.4   Habitat

Habitat Metric Data

Table 262. Habitat related fish metrics for reach 07020006-502

07020006-502 Fish Class 2 General Use	Benthic Insect minus Tolerant %	Darter Sculpin Sucker %	Lithophilic Spawner %	Pioneer %	Piscivore %	Riffle %	Simple Lithophilic Spawner %	Tolerant %
92MN030 8/31/2010	13.1	8.1	73.1	17.8	0.3	31.3	44.8	53.5
92MN032 7/13/2017	9.4	9.1	49.7	19.0	7.9	16.4	45.6	53.5
92MN032 9/19/2017	10.3	10.1	45.1	22.2	6.5	11.6	41.8	50.8
Statewide average for Class 2 Southern Stream bio sites that are meeting the FIBI general use threshold (50)	**20.4**	**18.2**	**58.3**	**19.0**	**5.2**	**32.5**	**39.4**	**44.9**
Expected response to **Habitat** stress	↓	↓	↓	↑	↓	↓	↓	↑

Table 263. Habitat related fish metrics for reach 07020006-502

07020006-502 Fish Class 1 General Use	Benthic Insect minus Tolerant %	Darter Sculpin Sucker %	Lithophilic Spawner %	Pioneer %	Piscivore %	Riffle %	Simple Lithophilic Spawner %	Tolerant %
92MN033 7/10/2017	11.2	10.3	21.0	22.3	10.7	3.1	14.7	46.0
Statewide average for Class 1 Southern River bio sites that are meeting the FIBI general use threshold (49)	**20.6**	**18.5**	**29.2**	**5.2**	**15.2**	**14.0**	**25.0**	**22.1**
Expected response to **Habitat** stress	↓	↓	↓	↑	↓	↓	↓	↑

Table 264. Habitat related invert metrics for reach 07020006-502

07020006-502 **Invert Class 5** General Use	Burrower %	Climber %	Clinger %	Ephemeroptera Plecoptera Trichoptera %	Legless %	Sprawler %
92MN030 8/03/2010	3.3	24.2	36.3	55.9	36.6	19.3
92MN032 8/03/2017	0.6	6.9	62.9	77.6	9.0	15.6
Statewide average for Class 5 prairie stream rock riffle bio sites that are meeting the FIBI general use threshold (41)	**7.5**	**14.7**	**49.5**	**43.9**	**36.0**	**16.8**
Expected response to **Habitat** stress	↑	↓	↓	↓	↑	↑

Table 265. Habitat related invert metrics for reach 07020006-502

07020006-502 **Invert Class 7** General Use	Burrower %	Climber %	Clinger %	Ephemeroptera Plecoptera Trichoptera %	Legless %	Sprawler %
92MN033 8/24/2010	3.9	33.1	24.3	24.9	56.7	32.5
92MN033 7/31/2017	0.6	20.1	15.7	89.5	6.2	13.9
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI general use threshold (41)	**7.5**	**21.6**	**38.5**	**38.5**	**39.8**	**20.9**
Expected response to **Habitat** stress	↑	↓	↓	↓	↑	↑

MPCA Stream Habitat Assessment Score

Table 266. Habitat Assessment scores for reach 07020006-502

07020006-564	Land Use	Riparian	Substrate	Cover	Channel Morphology	Total Score
92MN030 8/31/2010	2.5	9.5	21.8	7	33	73.8
92MN031 8/31/2010	1.3	9	15.1	6	17	48.4

07020006-564	Land Use	Riparian	Substrate	Cover	Channel Morphology	Total Score
92MN032 7/13/2017	0	8	15.6	13	19	55.6
92MN032 8/03/2017	0	4.5	15.6	7	15	42.1
92MN032 9/19/2017	0	7.5	17	15	15	54.5
92MN033 8/30/2010	2.4	9.5	14	7	21	54
92MN033 7/10/2017	1.3	6	15	13	13	48.3
92MN033 7/31/2017	2.5	6	12.8	6	13	40.3
Maximum Attainable Habitat Score	**5**	**14**	**28**	**18**	**35**	**100**

Habitat Summary

The fish community in reach 07020006-502 scored poorly in the majority of the habitat related fish metrics when compared to all other bio sites that meet the FIBI general use thresholds. The metrics at the upstream bio site, 92MN032, had a few good scores (Table 234). It generally had low numbers of

Figure 66. Photo of Bio site 17MN225 showing a low water levels and some channel development within the stream channel

pioneer species, had some Piscivore and lithophilic spawning species. Tolerant species percentage weren't too much above the class average. Habitat related metrics at bio site 92MN033 scored worse, with none of them scoring better than the fish class 1 average.

The habitat related invertebrate metrics were mixed though they generally scored better than the fish metrics for habitat. There were low numbers of burrowers and high numbers of nectopsyche, a climbing

caddisfly, at the downstream bio site 92MN033. There were also good numbers of clinger caddisflies from the Hydropsychidae family. Legless and sprawler inverts were also low in the 2017 invert samples.

The MSHA scores were moderate with some poor scores (Table 266). Only light to moderate embeddedness was observed at the upstream bio sites during both visits along with normal amounts of silt. There were riffles present, good to excellent channel development and sinuosity, as well as depth variability. Downstream bio site 92MN033 had similar overall scores. There was still good depth variability and sinuosity and decent channel development, though the channel stability was low, likely due to high flows from several tributaries entering the river as well as the diversion channel around Marshall. Channel stability got worse the further downstream.

Due to the decent habitat assessment and biological metric scores, habitat does not appear to be a stressor to the biological community at the upstream bio sites. Downstream at bio site 92MN033 the lack of riffles seems to be a stressor to the fish community, likely due to the altered hydrology of the diversion channel around Marshall.

3.4.1.5   Dissolved Oxygen

Dissolved Oxygen Biological Metric Data

Table 267. Dissolved oxygen related fish metrics for reach 07020006-502

07020006-502 **Fish Class 2** General Use	Mature Age >3 %	Serial Spawner %	Taxa Count	DO TIV	DO Sensitive %	DO Tolerant %
92MN030 8/31/2010	7.3	25.6	22	8.6	7.2	4.3
92MN032 7/13/2017	22.5	40.1	23	8.6	0.9	8.5
92MN032 9/19/2017	13.7	44.9	23	8.5	3.2	12.4
Statewide average for Class 2 Southern Stream bio sites that are meeting the FIBI general use threshold (50)	**23.9**	**28.7**	**19.9**	**8.4**	↓	↑
Expected response to **DO** stress	↓	↑	↓	↓		

Table 268. Dissolved oxygen related fish metrics for reach 07020006-502

07020006-502 **Fish Class 1** General Use	Mature Age >3 %	Serial Spawner %	Taxa Count	DO TIV	DO Sensitive %	DO Tolerant %
92MN033 7/10/2017	16.1	59.8	23	8.5	0.0	22.3
Statewide average for Class 1 Southern River bio sites that are meeting the FIBI general use threshold (49)	**40.4**	**35.6**	**21.6**	**8.6**	↓	↑
Expected response to **DO** stress	↓	↑	↓	↓		

Table 269. Dissolved oxygen related invert metrics for reach 07020006-502

07020006-502 **Invert Class 5** General Use	DO TIV	HBI_MN	Low DO Intolerant Taxa %	Low DO Tolerant Taxa %
92MN030 8/03/2010	7.6	7.7	29.6	0.0
92MN032 8/03/2017	7.6	7.6	30.5	0.0
Statewide average for Class 5 prairie stream rock riffle bio sites that are meeting the FIBI general use threshold (37)	**7.1**	**7.0**	↓	↑
Expected response to **DO** stress	↓	↑		

07020006-502 Invert Class 7 General Use	DO TIV	HBI_MN	Low DO Intolerant Taxa %	Low DO Tolerant Taxa %
92MN033 8/24/2010	7.1	8.1	3.9	12.1
92MN033 7/31/2017	7.6	9.3	9.8	0.3
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI general use threshold (41)	**6.9**	**7.6**	↓	↑
Expected response to **DO** stress	↓	↑		

Dissolved Oxygen Monitoring Data

Table 271. Dissolved oxygen monitoring data for reach 07020006-502

07020006-502 DO Data 5 mg/L target	Range of Data (mg/L)	% of Monthly Samples < 5 mg/L [# of Samples]							May - Sep <5 mg/L % [# of Samples]
		April	May	June	July	August	Sept	Oct	
S001-203 **S013-681** **S013-682** **S013-683** (2009-2018)	6.9 – 13.3	0% [12]	0% [18]	0% [24]	0% [21]	0% [19]	0% [12]	0% [10]	0% [94]
		Minimum Value							
		9.5	7.7	6.9	7.0	7.7	7.6	8.7	

Dissolved Oxygen Summary

The fish community scored mostly poor in DO related fish metrics when compared to the averages that meet the FIBI general use threshold (Table 267, Table 268). There were very few fish caught in the reach who are considered sensitive to low DO. There were some fish with females that take more than three years to mature. The ratio of low DO sensitive to low DO tolerant individuals was very poor.

Invertebrate metrics related to low DO were mostly good (Table 269, Table 270). Both 2017 site visits had decent scores in three out of the four DO related metrics, with only the HBI score scoring poorly. The upstream site, 92MN032, was comprised of 30.5% low DO intolerant taxa percentage with no low DO tolerant taxa present. Further downstream at 92MN033 there were less low DO intolerant taxa present, and low DO tolerant was also very low. The DO TIV score was the same at both sites at 7.6. Two

of the top three most prevalent invertebrates present at site 92MN032, the caddisfly ceratopsyche morose and the mayfly baetis intercalaris, are considered very intolerant to low DO.

Although no DO measurements taken during sampling were below the warmwater standard of 5 mg/L, none of those measurements were taken before 8:00 a.m., when values are usually the lowest (Table 271).

Based on the mixed low DO related biological metric scores and the measured sonde values, DO is inconclusive as a stressor in this reach.

3.4.1.6   Eutrophication

Eutrophication Biological Metric Data

Table 272. Eutrophication related fish metrics for reach 07020006-502

07020006-502 **Fish Class 2** General Use	Darter %	Omnivore %	Sensitive %	Simple Lithophillic Spawner %	Tolerant %
92MN032 7/13/2017	1.8	14.6	8.2	45.6	53.5
92MN032 9/19/2017	5.3	9.7	8.9	41.8	50.8
Statewide average for Class 2 Southern Stream bio sites that are meeting the FIBI general use threshold (50)	**11.7**	**16.5**	**18.7**	**39.4**	**44.9**
Expected response to **Eutrophication** stress	↓	↑	↓	↓	↑

Table 273. Eutrophication related fish metrics for reach 07020006-502

07020006-502 **Fish Class 1** General Use	Darter %	Omnivore %	Sensitive %	Simple Lithophillic Spawner %	Tolerant %
92MN033 7/10/2017	5.4	9.4	0.9	14.7	46.0
Statewide average for Class 1 Southern River bio sites that are meeting the FIBI general use threshold (49)	**4.4**	**15.2**	**13.5**	**25.0**	**22.1**
Expected response to **Eutrophication** stress	↓	↑	↓	↓	↑

Table 274. Eutrophication related invert metrics for reach 07020006-502

07020006-502 Invert Class 5 General Use	Crustacean and Mollusca %	Collector – Gatherer Taxa #	Ephemeroptera Plecoptera Trichoptera Taxa %	Intolerant Two Taxa %	Scraper %	Taxa Count All #	Tolerant Two Taxa %
92MN030 8/03/2010	0.7	11	36.7	0.0	3.6	30	80.0
92MN032 8/03/2017	0.0	10	77.6	0.0	6.9	36	75.0
Statewide average for Class 5 prairie stream rock riffle bio sites that are meeting the FIBI general use threshold (37)	**9.2**	**15.1**	**30.5**	**0.8**	**15.8**	**41.9**	**74.3**
Expected response to **Eutrophic** stress	↑	↓	↓	↓	↑	↓	↑

Table 275. Eutrophication related invert metrics for reach 07020006-502

07020006-502 Invert Class 7 General Use	Crustacean and Mollusca %	Collector – Gatherer Taxa #	Ephemeroptera Plecoptera Trichoptera Taxa %	Intolerant Two Taxa %	Scraper %	Taxa Count All #	Tolerant Two Taxa %
92MN033 8/24/2010	5.2	15	22.5	0.0	7.5	40	90.0
92MN033 7/31/2017	0.6	7	89.5	0.0	4.3	24	83.3
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI general use threshold (41)	**11.8**	**13.3**	**28.8**	**0.2**	**16.1**	**37.0**	**81.9**
Expected response to **Eutrophic** stress	↑	↓	↓	↓	↑	↓	↑

Eutrophication Monitoring Data

Table 276. Total phosphorus monitoring data for reach 07020006-502

07020001-502 TP Sample Data 0.150 mg/L target	Range of Data (mg/L)	Monthly Average of Samples (mg/L) [# of Samples]							June-Aug Average (mg/L) [# of Samples]
		April	May	June	July	August	Sept	Oct	
S001-203 S013-680 S013-681 S013-683 (2017-2019)	0.060 – 4.7	0.629 [19]	0.423 [25]	0.447 [30]	0.427 [26]	0.555 [23]	1.149 [18]	0.615 [22]	0.471 [79]
		Maximum Value							
		2.220	1.880	1.180	0.670	2.230	4.700	2.510	

Table 277. DO% Saturation monitoring data for reach 07020006-502

07020006-502 DO% Sat Data	Range of Data (%)	Monthly Average of Samples (%) [# of Samples]							June-Aug Average (%) [# of Samples]
		April	May	June	July	August	Sept	Oct	
S013-682 S013-683 (2017)	93.8 – 121	-	-	-	110.0 [3]	96.5 [1]	96.5 [1]	-	106.6 [4]

Eutrophication Summary

The fish community in reach 07020006-502 was mixed in its eutrophication related metrics (Table 272, Table 273). The abundance of darter individuals was low, though 92MN033 did score just above the class average at 5.4%. Omnivorous fish were relatively low throughout the reach. Sensitive species were low and there were almost none at site 92MN033. About half of all individuals present were tolerant species at every site visit. Lithophilic spawners were low at the downstream bio site.

The invertebrate community in reach 07020006-502 was also mixed in its eutrophication related metrics (Table 274, Table 275). All of the bio sites had low crustaceans and mollusks, high EPT taxa, and low scrapers as well as low numbers of collector – gatherer taxa, intolerant taxa, taxa counts, and high numbers of tolerant taxa. The mayfly Fallceon, which is considered very tolerant to high phosphorus concentrations, was prevalent at both bio site 92MN032 and 92MN033 and was almost half of all the invertebrates caught at bio site 92MN033.

There were 79 samples collected and analyzed for TP from 2017-2019. The summer average was very high, well over the standard of 0.15 mg/L (Table 276). There were very high values recorded every month from April through October and the monthly averages were well above the standard of 0.150 mg/L.

The biological community is showing the effects of the elevated phosphorus and phosphorus sampling showed elevated concentrations. Eutrophication is a stressor in this reach.

3.4.1.7   Suspended Solids

Suspended Solids Biological Metric Data

Table 278. Suspended solids related fish metrics for reach 07020006-502

07020006-502 Fish Class 2 General Use	Benthic Feeder %	Centrarchid - Tolerant %	Herbivore %	Intolerant %	Long – lived %	Perciformes - Tolerant %	Riffle %	Sensitive %	Simple Lithophilic Spawner %	TSS TIV
92MN032 7/13/2017	16.4	0.9	0.0	0.0	18.4	5.3	16.4	8.2	45.6	22.0
92MN032 9/19/2017	12.4	0.2	4.9	0.0	10.1	7.4	11.6	8.9	41.8	21.0
Statewide average for Class 2 Southern Stream bio sites that are meeting the FIBI general use threshold (50)	**37.4**	**4.9**	**9.6**	**5.0**	**11.7**	**18.7**	**32.5**	**18.6**	**39.4**	**17.9**
Expected response to **Suspended Solids** stress	↓	↓	↓	↓	↓	↓	↓	↓	↓	↑

Table 279. Suspended solids related fish metrics for reach 07020006-502

07020006-502 Fish Class 1 General Use	Benthic Feeder %	Centrarchid - Tolerant %	Herbivore %	Intolerant %	Long – lived %	Perciformes - Tolerant %	Riffle %	Sensitive %	Simple Lithophilic Spawner %	TSS TIV
92MN033 7/10/2017	11.6	4.9	0.4	0.0	22.8	14.3	3.1	0.9	14.7	27.5
Statewide average for Class 1 Southern River bio sites that are meeting the FIBI general use threshold (49)	**21.4**	**4.1**	**1.0**	**4.6**	**43.6**	**18.0**	**13.9**	**13.5**	**25.0**	**34.1**
Expected response to **Suspended Solids** stress	↓	↓	↓	↓	↓	↓	↓	↓	↓	↑

Table 280. Suspended solids related invert metrics for reach 07020006-502

07020006-502 **Invert Class 5** General Use	Collector – filterer %	Plecoptera %	TSS Intolerant Taxa %	TSS Tolerant Taxa %	TSS TIV
92MN030 8/03/2010	32.7	0.0	0.0	53.1	19.3
92MN032 8/03/2017	38.3	0.6	0.3	53.3	20.6
Statewide average for Class 5 prairie stream rock riffle bio sites that are meeting the FIBI general use threshold (37)	**26.9**	**0.5**	**5.1**	**35.2**	**15.9**
Expected response to **Suspended Solids** stress	↓	↓	↓	↑	↑

Table 281. Suspended solids related invert metrics for reach 07020006-502

07020006-502 **Invert Class 7** General Use	Collector – filterer %	Plecoptera %	TSS Intolerant Taxa %	TSS Tolerant Taxa %	TSS TIV
92MN033 8/24/2010	12.5	0.0	0.0	62.4	19.3
92MN033 7/31/2017	6.8	0.0	0.0	87.7	33.6
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI general use threshold (41)	**19.1**	**0.2**	**2.7**	**48.3**	**17.8**
Expected response to **Suspended Solids** stress	↓	↓	↓	↑	↑

TSS Monitoring Data

Table 282. Total suspended solids monitoring data for reach 07020006-502

07020006-502 TSS Sample Data	Range of Data (mg/L)	% of Monthly Samples > 65 mg/L [# of Samples]							% of Total Samples > 65 mg/L [# of Samples]
		April	May	June	July	August	Sept	Oct	
S001-199 S001-203 S003-702 S009-023 S013-680 S013-681 S013-683 (2009-2019)	3 - 1140	52.5 [40]	42.5 [40]	55.1 [49]	65 [40]	27.3 [33]	31.8 [22]	45 [20]	47.5 [244]

Table 283. Transparency monitoring data for reach 07020006-502

07020001-502 Secchi Tube Data 10 cm target	Range of Data (cm)	% of Monthly Samples < 10 cm [# of Samples]							% of Total Samples < 10 cm [# of Samples]
		April	May	June	July	August	Sept	Oct	
S001-203 S003-702 S008-887 S013-680 S013-682 S013-683 (2009-2019)	2 – 100+	25.8 [31]	11.1 [36]	31.0 [42]	24.4 [41]	5 [40]	13.3 [30]	33.3 [18]	18.5 [238]

Suspended Solids Summary

The fish community in reach 07020006-502 scored below average in most of the suspended solids related fish metrics when compared to the average of all other Class one and two bio sites that meet the FIBI general use threshold (Table 278, Table 279). There were some benthic feeders, perciformes, and riffle dwelling fish present at bio site 92MN032, though they were below the class average. Long – lived fish also scored above the class average on one of the visits. Simple lithophilic spawners scored above average during both visits. Bio site 92MN033 scored mostly poor as well, with only the Centrarchid and TSS tolerance index value scoring better than average. There were some benthic feeders, long – lived, perciformes, and simple lithophilic spawners present as well, though they were well below the class 1 southern river average. There were very little herbivores, riffle dwelling, or sensitive fish and no intolerant fish present at the bio site.

The invertebrate community at bio sites 92MN030 and 92MN032 scored poorly in most of the suspended solids related invert metrics when compared to the average of all other Class 5 southern stream rock riffle bio sites that meet the MIBI general use threshold (Table 280). Collector – filterers scored well as there were good numbers of net-spinning caddisflies present at both bio sites. There were two individuals from two species of Plecoptera present in the 2017 sample. TSS ratio intolerant to tolerant taxa was very low. The TSS TIV indicates a invertebrate community that is generally tolerant of suspended solids. Bio site 92MN033 scored worse as there were fewer collector- filterers and no Plecoptera or TSS intolerant taxa (Table 281). TSS tolerant taxa and the TSS TIV were very high in 2017.

244 samples were collected and analyzed for TSS from 2009-2019. 47.5% of the samples had a suspended solid concentration above 65 mg/L (Table 282). Suspended solids were relatively high during all months April through October. Transparency data also shows low transparency in the measurements from 2009 through 2019 (Table 283).

Due to the mostly poor suspended solids fish and invertebrate metrics as well as the extensive dataset showing exceedances of the TSS/transparency standard, TSS is a stressor to aquatic life in reach 07020006-502.

3.4.1.8   Nitrates

Nitrate Biological Metric Data

Table 284. Nitrate related invert metrics for reach 07020006-502

07020006-502 Invert Class 5 General Use	Nitrate Intolerant Taxa %	Nitrogen Tolerant Taxa %	Trichoptera Taxa %	Nitrogen TIV
92MN030 8/03/2010	0.0	67.4	16.7	3.5
92MN032 8/03/2017	0.3	50.8	22.2	3.6
Statewide average for Class 5 prairie stream rock riffle bio sites that are meeting the FIBI general use threshold (37)	**2.9**	**47.6**	**13.6**	**3.0**
Expected response to **nitrogen** stress	↓	↑	↓	↑

Table 285. Nitrate related invert metrics for reach 07020006-502

07020006-502 **Invert Class 7** General Use	Nitrate Intolerant Taxa %	Nitrogen Tolerant Taxa %	Trichoptera Taxa %	Nitrogen TIV
92MN033 8/24/2010	0.0	79.1	7.5	3.9
92MN033 7/31/2017	0.0	88.9	20.8	7.7
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI general use threshold (41)	**3.2**	**54.9**	**10.9**	**3.2**
Expected response to **nitrogen** stress	↓	↑	↓	↑

Nitrate Monitoring Data

Table 286. Nitrate monitoring data for reach 07020006-502

07020001-502 Nitrate/Nitrite Sample Data	2x Highest Reach TIV Average	Range of Data (mg/L) [# of Samples]	Monthly Average [# of Samples]						
			April	May	June	July	August	Sept	Oct
S001-203 **S013-680** **S013-681** **S013-683** (2010-2019)	6.4	0.1 – 11.6 [151]	4.3 [19]	4.8 [25]	5.4 [26]	3.5 [22]	2.9 [20]	4.3 [19]	5.1 [20]
			Maximum Value						
			8.1	11.6	10.0	7.2	6.1	8.1	8.0

Summary

The macroinvertebrate assemblage in reach 07020006-502 scored poorly in most of the nitrate related metrics evaluated when compared to other bio sites that meet the MIBI general use threshold (Table 276, Table 285). These biological bio sites did show a healthy amount of Trichoptera taxa, though with the exception of ceratopsyche, they were mostly nitrogen tolerant taxa. There was a high amount of nitrate tolerant invertebrates as well as almost a complete lack of nitrate intolerant invertebrate species. The nitrogen TIV score also indicates a macroinvertebrate community that is generally tolerant to high levels of nitrates. Bio site 92MN033 scored worse than the upstream bio sites, with no nitrogen intolerant taxa present and a very high percentage of nitrogen tolerant taxa. Trichoptera taxa percentage was higher than average, though they were mostly nitrogen tolerant taxa. The site was dominated by the mayfly Fallceon, which is classified as very tolerant to nitrogen.

One hundred fifty-one samples were collected in reach 07020006-502 and analyzed for nitrate/nitrite (Table 285). The monthly averages for all months analyzed were below the 2x TIV average of 6.4. There were; however, high nitrate/nitrite values that were measured. It is likely the higher volume of water moving through this reach dilutes the water enough over time to affect the averages. Due to the biological response and high measured nitrate concentrations, nitrates are a stressor to aquatic life in reach 07020006-502.

3.4.1.9   Chloride/Conductivity

Biological Metric Data

Table 287. Chloride / conductivity related fish metrics for reach 07020006-502

07020006-502 Fish Class 2 General Use	Centrarchidae - (Sunfish) %	Centrarchidae - (Sunfish) Taxa %	Conductivity Intolerant %	Conductivity Tolerant %	Conductivity Intolerant Taxa %	Conductivity Tolerant Taxa %
92MN032 7/13/2017	1.8	17.4	0	32.7	0	26.1
92MN032 9/19/2017	0.2	4.3	0	33.3	0	26.1
Statewide average for Class 2 Southern River bio sites that are meeting the FIBI general use threshold (50)	**7.6**	**11.4**	↓	↑	↓	↑
Expected response to **Suspended Solids** stress	↑	↑				

Table 288. Chloride / conductivity related fish metrics for reach 07020006-502

07020006-502 Fish Class 1 General Use	Centrarchidae - (Sunfish) %	Centrarchidae - (Sunfish) Taxa %	Conductivity Intolerant %	Conductivity Tolerant %	Conductivity Intolerant Taxa %	Conductivity Tolerant Taxa %
92MN033 7/10/2017	13.4	17.4	0	36.2	0	26.1
Statewide average for Class 1 Southern River bio sites that are meeting the FIBI general use threshold (49)	**5.6**	**10.3**	↓	↑	↓	↑
Expected response to **Suspended Solids** stress	↑	↑				

Table 289. Chloride/conductivity related invertebrate metrics for reach 07020006-502

07020006-502 Invert Class 5 General Use	Ephemeroptera %	Conductivity TIV	Conductivity Intolerant Taxa %	Conductivity Tolerant Taxa %
92MN030 8/03/2010	35.3	568.6	0.0	52.8
92MN032 8/03/2017	34.9	572.1	0.3	38.0
Statewide average for Class 5 prairie stream rock riffle bio sites that are meeting the FIBI general use threshold (37)	**22.9**	**512.6**	↓	↑
Expected response to **nitrogen** stress	↓	↑		

Table 290. Chloride/conductivity related invertebrate metrics for reach 07020006-502

07020006-502 Invert Class 7 General Use	Ephemeroptera %	Conductivity TIV	Conductivity Intolerant Taxa %	Conductivity Tolerant Taxa %
92MN033 8/24/2010	17.1	606.7	0.3	69.1
92MN033 7/31/2017	66.7	807.1	0	87.4
Statewide average for Class 5 prairie stream rock riffle bio sites that are meeting the FIBI general use threshold (37)	**24.7**	**549.9**	↓	↑
Expected response to **nitrogen** stress	↓	↑		

Table 291. Chloride monitoring data for reach 07020006-502

07020001-502 Chloride Data Chronic Standard: 230 Max Standard: 860	Range of Data (mg/L) [# of Samples]	Monthly Average (mg/L) [# of Samples]						
		April	May	June	July	August	Sept	Oct
S001-203 (2017)	27.5 – 124 [11]	-	35.0 [2]	44.0 [2]	75.1 [3]	77.5 [2]	55.4 [2]	-
		Maximum Value						
		-	42.4	52.1	87.9	124	57.1	-

Summary

The conductivity related fish biological metrics were mostly poor when compared to the average of class 2 and class 1 bio sites that meet the FIBI general use threshold (Table 287, Table 288). Bio site 92MN032 was sampled twice for fish in 2017. There were also no fish caught who are considered intolerant to high conductivity. Bio site 92MN033 had a higher percentage of both sunfish and sunfish taxa. Bio metrics at bio site 92MN033 were a little better as over 13% of the total number of fish caught are considered sunfish and over 17% of the taxa caught were sunfish.

The hydrologic alteration related invertebrate biological metrics were mostly poor when compared to the average of class 5 and class 7 bio sites that meet the IBI general use threshold (Table 289, Table 290). The two upstream bio sites 92MN030 and 92MN032 scored similarly to bio site 92MN033, though their biological communities were a bit different. Site 92MN032 was dominated by the caddisfly ceratopsyche as well as the two mayflies' tricorythodes and baetis intercalaris. Only tricorythodes is considered tolerant to high conductivity concentrations. Further downstream, at bio site 92MN033, the three most dominant inverts, the mayfly fallceon, caddisfly nectopsyche, and the mayfly thricoythodes, are all considered very tolerant to high conductivity concentrations.

Conductivity concentrations were relatively low from the 2017 sampling season (Table 291). There is old chloride data from 2003 to 2007 that generally had higher concentrations of chloride. There have been several projects and initiatives within the watershed and the city of Marshall to reduce chloride in the Redwood River and based off of the limited dataset available, it might have had a beneficial effect on chloride within reach 07020006-502.

Conductivity related biological metrics in reach 07020006-502 were somewhat mixed. There was a high percentage of Ephemeroptera at the furthest downstream bio site, 92MN033. The conductivity TIV at site 92MN033 was quite a bit higher than the upstream TIV score. Because of the prevalence of Ephemeroptera and Trichoptera within the reach, as well as relatively low chloride concentrations, chloride is inconclusive as a stressor within reach 07020006-502.

3.4.1.10   Reach Stressors

Table 292. Summary of stressors for reach 07020006-502

07020006-502	Hydrologic Alteration	Connectivity	Habitat	Dissolved Oxygen	Eutrophication	Suspended Solids	Nitrate	Chloride/ Conductivity
✔ = Stressor ✘ = Not a Stressor O = Inconclusive	✔	O	✔	O	✔	✔	✔	O

3.4.2 07020006-559   Unnamed Creek

Figure 67. Satellite image of reach 07020006-559 and its watershed

3.4.2.1   Biological Community

Bio site 17MN221 was sampled once for fish in 2017. No fish were caught resulting in a score of zero (Table 293). Only crayfish were caught during sampling.

Biological Metric Data

Table 293. Fish IBI score and threshold for reach 07020006-559

07020006-559 **Fish Class 3** **Modified Use**	Fish IBI Score	Class Threshold Score
17MN221 6/26/2017	0	33

3.4.2.2　　Hydrologic Alteration

Hydrologic Alteration Biological Metric Data

Table 294. Hydrologic alteration related fish metrics for reach 07020006-559

07020006-559 **Fish Class 3** Modified Use	General %	Nesting Non Lithophilic Spawner %
17MN221 6/26/2017	No Fish Collected	
Statewide average for Class 3 southern headwater bio sites that are meeting the FIBI modified use threshold (33)	**56.3**	**24.0**
Expected response to **Hydrologic** stress	↑	↑

HSPF Model Flow Data

Table 295. HSPF modeled flow data for reach 07020006-559

07020006-559 HSPF Reach 251 Min: 0.3 cfs Max: 397.9 cfs	<5 cfs % (# of values)	<1 cfs % (# of values)	<0.5 cfs % (# of values)
6,210 Total Daily Averages 1996 – 2012	**50.3%** (3,123)	**0.0%** (1)	**0.0%** (0)

Hydrologic Alteration Summary

Figure 68. Photo showing both the ditched stream channel and culvert near bio site 17MN221 during fish sampling in 2017 (left). Photo of the same culvert in 2019 showing the stream water levels very low and actually flowing underneath the concrete bottom

No fish were caught during sampling in 2017, although water levels were high enough to support fish. The reach itself as well as its tributaries have been extensively altered and ditched. The culvert near the bio site also seems to be overly wide and placed at the wrong elevation as well.

The HSPF model (Table 295) shows only one of the daily average flows from 1996 – 2012 are below 1 cfs. Over 50% of the flows are below 5 cfs. It would appear that this reach has flow issues that are not being captured in the HSPF model. Flow is likely being overestimated due to the relatively large drainage area that the stream has. Ditching and tiling within the watershed has caused the water to move through this system quickly, resulting in a flashy hydrology and low flows.

Based on the fact that no fish were caught, there were low flows shown in the HSPF model, as well as the extensive ditching and tiling within the watershed of this reach, Hydrologic Alteration is a stressor in this reach. The primary impact in this reach from Hydrologic Alteration is seen in alteration of the entire stream into a ditch, as well as drainage within the watershed that changes the timing and delivery of water, causing low flows during periods of low precipitation.

3.4.2.3   Connectivity

Connectivity Metric Data

07020006-559 **Fish Class 3** **Modified Use**	Mature Age >3 minus Tolerant Taxa %	Migrating Taxa %
17MN221 6/26/2017	No Fish Collected	
Statewide average for Class 3 southern headwater bio sites that are meeting the FIBI modified use threshold (33)	**3.2**	**20.1**
Expected response to **Connectivity** stress	↓	↓

Connectivity Summary

There were no fish caught at the bio site. The box culvert at the road crossing near bio site 17MN221 appears to be a barrier itself as the culvert is at the wrong elevation, which creates a barrier to fish movement as the culvert is set above the stream channel. The downstream end of the culvert is so high that during low flows the stream actually flows into a crack underneath the last concrete slab of the culvert (Figure 68). Downstream of the box culvert there is also a perched round culvert that is clearly a fish barrier as well (Figure 69).

Due to the absence of any fish and several road crossings with likely fish barriers, connectivity is a stressor in this reach. It is recommended that all road crossings in this reach be evaluated for fish barriers as connectivity is a major stressor in reach 07020006-559.

Figure 69. Photo of the perched culvert downstream of bio site 17MN221.

3.4.2.4   Habitat

Habitat Metric Data

Table 297. Habitat related fish metrics for reach 07020006-559

07020006-559 **Fish Class 3** Modified Use	Benthic Insect minus Tolerant %	Darter Sculpin Sucker %	Lithophilic Spawner %	Pioneer %	Piscivore %	Riffle %	Simple Lithophilic Spawner %	Tolerant %
17MN221 6/26/2017	No Fish Collected							
Statewide average for Class 3 southern headwater bio sites that are meeting the FIBI modified use threshold (33)	**10.9**	**10.6**	**57.9**	**32.5**	**2.0**	**22.6**	**30.1**	**76.7**
Expected response to Habitat stress	↓	↓	↓	↑	↓	↓	↓	↑

MPCA Stream Habitat Assessment Score

Table 298. Habitat Assessment scores for reach 07020006-559

07020006-559	Land Use	Riparian	Substrate	Cover	Channel Morphology	Total Score
17MN221 6/26/2017	0	9	10	11	3	33
17MN221 7/31/2017	0	5.5	2	4	4	15.5
Maximum Attainable Habitat Score	**5**	**14**	**28**	**18**	**35**	**100**

Habitat Summary

Both MSHA scores were very poor (Table 298). The stream channel had almost no depth variability, no sinuosity, no riffles, no channel development, and slow water velocity. The channel substrate was mostly muck and silt with no coarse substrates present. The only real positive habitat attribute was the vegetative cover provided by the grasses on both sides of the channel.

The lack of any fish being caught and the fact that

Figure 70. Photo just downstream of bio site 17MN221. The stream channel has been ditched and straightened.

invert sampling was unable to be conducted due to low water levels at the time of sampling indicates that this reach is severely limited in its capacity to support biological life. It is likely that low flows and altered hydrology are contributing to a limitations in habitat for fish, which in turn is a stressor to the biology within the reach.

3.4.2.5   Dissolved Oxygen

Dissolved Oxygen Biological Metric Data

Table 299. Dissolved oxygen related fish metrics for reach 07020006-559

07020006-559 Fish Class 3 Modified Use	Mature Age >3 %	Serial Spawner %	Taxa Count	DO TIV	DO Sensitive %	DO Tolerant %
17MN221 6/26/2017	No Fish Collected					
Statewide average for Class 3 southern headwater bio sites that are meeting the FIBI modified use threshold (33)	**14.4**	**10.6**	**9.3**	**8.2**	**0.1**	**39.3**
Expected response to **DO** stress	↓	↑	↓	↓	↓	↑

Dissolved Oxygen Monitoring Data

Table 300. Dissolved oxygen monitoring data for reach 07020006-559

07020006-559 DO Data 5 mg/L target	Range of Data (mg/L)	% of Monthly Samples < 5 mg/L [# of Samples]							May - Sep <5 mg/L % [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-376 (2017-2019)	7.9 – 14.8	-	-	0% [1]	0% [2]	0% [1]	-	-	0% [4]
		Minimum Value							
		-	-	14.8	8.6	7.9	-	-	
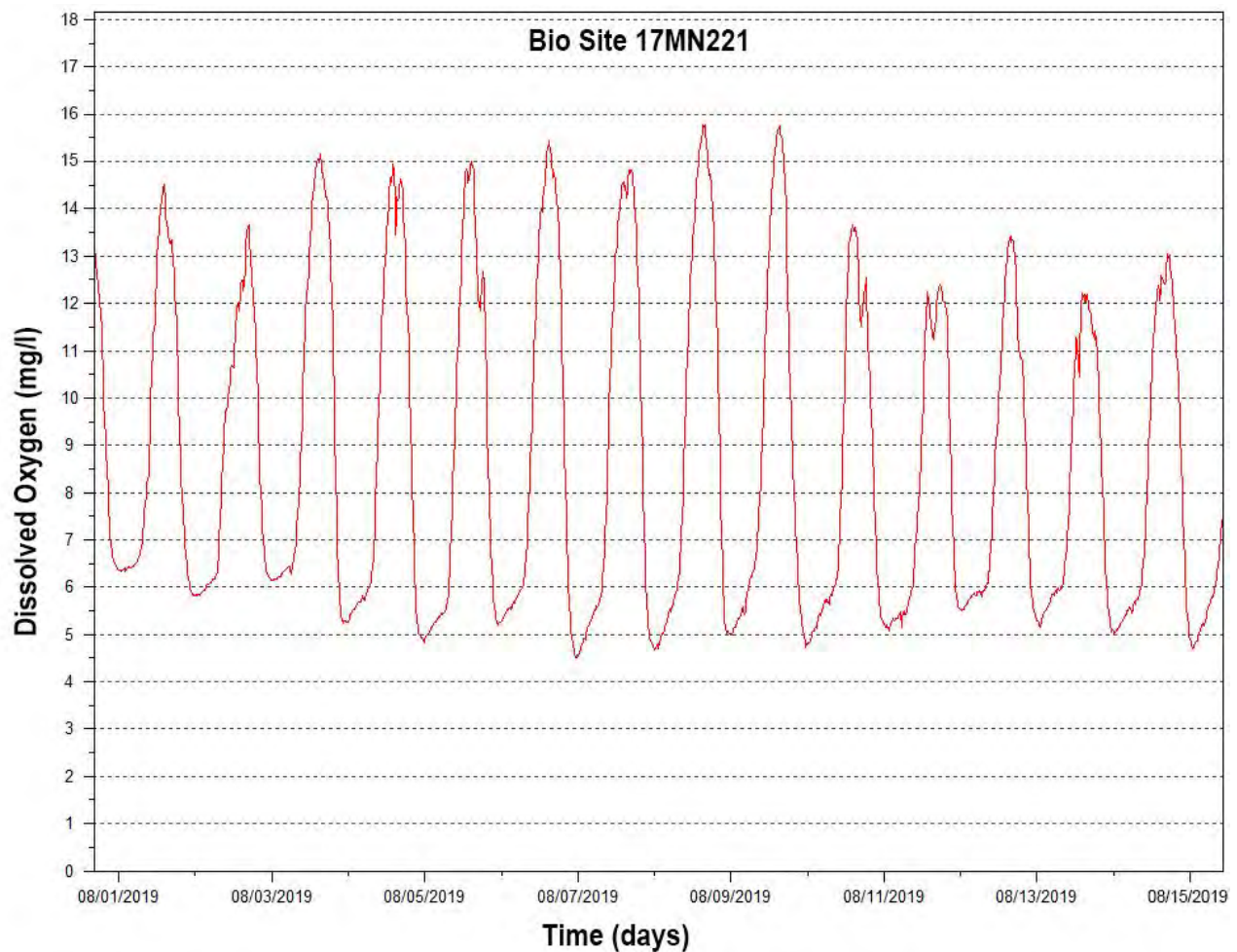
Figure 71. Continuous dissolved oxygen data at site 17MN221

Dissolved Oxygen Summary

Since no fish were caught during fish sampling, only DO data can be analyzed. There were only four measurements taken from 2017 through 2019 and none were below 5 mg/L (Table 300). However, none of these measurements were taken during the night when DO levels are often at their lowest. An YSI Sonde water meter measured continuous DO data from 8/1/2019 to 8/15/2019. During this deployment, DO values were measured below the standard six of the days (Figure 71). Although the values dipped just below the standard of 5 mg/L, 2019 was a relatively wet year, with many of the streams having relatively higher flows throughout the summer. Many of these streams in the same general vicinity had DO levels that were much higher than the sonde deployed within reach 07020006-559.

Based on measured sonde values, DO is a stressor in this reach. It is likely aggravated by low flow conditions and hydrologic alteration throughout the watershed.

3.4.2.6   Eutrophication

Eutrophication Biological Metric Data

Table 301. Eutrophication related fish metrics for reach 07020006-559

07020006-559 **Fish Class 3** Modified Use	Darter %	Omnivore %	Sensitive %	Simple Lithophillic Spawner %	Tolerant %
17MN221 6/26/2017	No Fish Collected				
Statewide average for Class 3 southern headwater bio sites that are meeting the FIBI modified use threshold (33)	**10.6**	**19.8**	**6.0**	**30.1**	**76.7**
Expected response to **Eutrophication** stress	↓	↑	↓	↓	↑

Eutrophication Monitoring Data

Table 302. Phosphorus monitoring data for reach 07020006-559

07020001-559 P Sample Data 0.150 mg/L target	Range of Data (mg/L)	Monthly Average of Samples (mg/L) [# of Samples]							June-Aug Average (mg/L) [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-367 (2017-2019)	0.047 – 0.137	-	-	0.047 [1]	0.137 [1]	-	-	-	0.092 [2]
		Maximum Value							
		-	-	0.047	0.137	-	-	-	

Table 303. DO% Saturation monitoring data for reach 07020006-559

07020006-559 DO% Sat Data	Range of Data (%)	Monthly Average of Samples (%) [# of Samples]							June-Aug Average (%) [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-367 (2017-2019)	86.1 – 164.4	-	-	164.4 [1]	136.3 [2]	86.1 [1]	-	-	130.8 [4]

Eutrophication Summary

Since no fish were caught during fish sampling, only chemical data will be analyzed.

Only two samples were collected and analyzed for Phosphorus from 2017 through 2019. The summer average was not above the standard of 0.15 mg/L (Table 302), though two samples is not considered a representative number of samples. DO saturation was very high in three out of four site visits from 2017 through 2019 (Table 303).

An YSI Sonde water meter measured continuous DO data from 8/1/2019 to 8/15/2019 (Figure 71). During this deployment, diel DO flux was measured at or above 5 mg/L every single day it was deployed.

Although phosphorus sampling was limited, and DO flux was 5 mg/L or greater and DO percent saturation was high. Eutrophication is a stressor in this reach.

3.4.2.7   Suspended Solids

Suspended Solids Biological Metric Data

Table 304. Suspended solids related fish metrics for reach 07020006-559

07020006-559 **Fish Class 3** Modified Use	Benthic Feeder %	Centrarchid - Tolerant %	Herbivore %	Intolerant %	Long – lived %	Perciformes - Tolerant %	Riffle %	Sensitive %	Simple Lithophilic Spawner %	TSS TIV
17MN221 6/26/2017	No Fish Collected									
Statewide average for Class 3 southern headwater bio sites that are meeting the FIBI modified use threshold (33)	**31.4**	**1.0**	**10.8**	**0.5**	**4.9**	**12.4**	**22.6**	**6.0**	**30.1**	**16.9**
Expected response to **Suspended Solids** stress	↓	↓	↓	↓	↓	↓	↓	↓	↓	↑

TSS Monitoring Data

Table 305. Total suspended solids monitoring data for reach 07020006-559

07020001-559 TSS Sample Data	Range of Data (mg/L)	% of Monthly Samples > 65 mg/L [# of Samples]							% of Total Samples > 65 mg/L [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-367 (2017-2019)	2.4 - 12	-	-	0 [1]	0 [1]	-	-	-	0 [2]

Table 306. Transparency monitoring data for reach 07020006-559

07020001-559 Secchi Tube Data 10 cm target	Range of Data (cm)	% of Monthly Samples < 10 cm [# of Samples]							% of Total Samples < 10 cm [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-367 (2017-2019)	33 – 100+	-	-	0 [1]	0 [2]	0 [1]	-	-	0 [4]

Suspended Solids Summary

Since no fish were caught during fish sampling, only chemical data will be analyzed.

Only two samples were collected and analyzed for TSS from 2017 through 2019. No sample had a TSS concentration above 65 mg/L (Table 305). Transparency data similarly did not show any poor values (Table 306).

Suspended solids are inconclusive as a stressor to aquatic life at this time. It is likely that other factors, such as altered hydrology, connectivity, and habitat are affecting the biology of this reach. It is recommended that more TSS data be collected during high flows in order to determine whether it is a biological stressor.

3.4.2.8   Nitrates

Nitrate Biological Metric Data

Table 307. Nitrate related invert metrics for reach 07020006-559

07020006-559	Nitrate Intolerant Taxa %	Nitrogen Tolerant Taxa %	Trichoptera Taxa %	Nitrogen TIV
17MN221 7/31/2017	Not Sampled - no wetted invert habitat			

Nitrate Monitoring Data

Table 308. Nitrate monitoring data for reach 07020006-559

07020001-559 Nitrate/Nitrite Sample Data	2x Highest Reach TIV Average	Range of Data (mg/L) [# of Samples]	Monthly Average [# of Samples]						
			April	May	June	July	August	Sept	Oct
S014-367 (2017-2019)	6.4	13 – 24 [2]	-	-	13.0 [1]	24.0 [1]	-	-	-
			Highest Value						
			-	-	13.0	24.0	-	-	-

Summary

Only two samples were collected in reach 07020006-559 and analyzed for nitrate/nitrite (Table 308). Both samples were very high. Due to the lack of invert sampling nitrates are inconclusive as stressor to aquatic life in reach 07020006-559, though the fact that nitrate concentrations are so high it is likely a stressor.

3.4.2.9 Reach Stressors

Table 309. Summary of stressors for reach 07020006-559

07020006-559	Hydrologic Alteration	Connectivity	Habitat	Dissolved Oxygen	Eutrophication	Suspended Solids	Nitrate
✔ = Stressor ✗ = Not a Stressor O = Inconclusive	✔	✔	✔	✔	✔	O	O

3.4.3 07020006-578   County Ditch 60
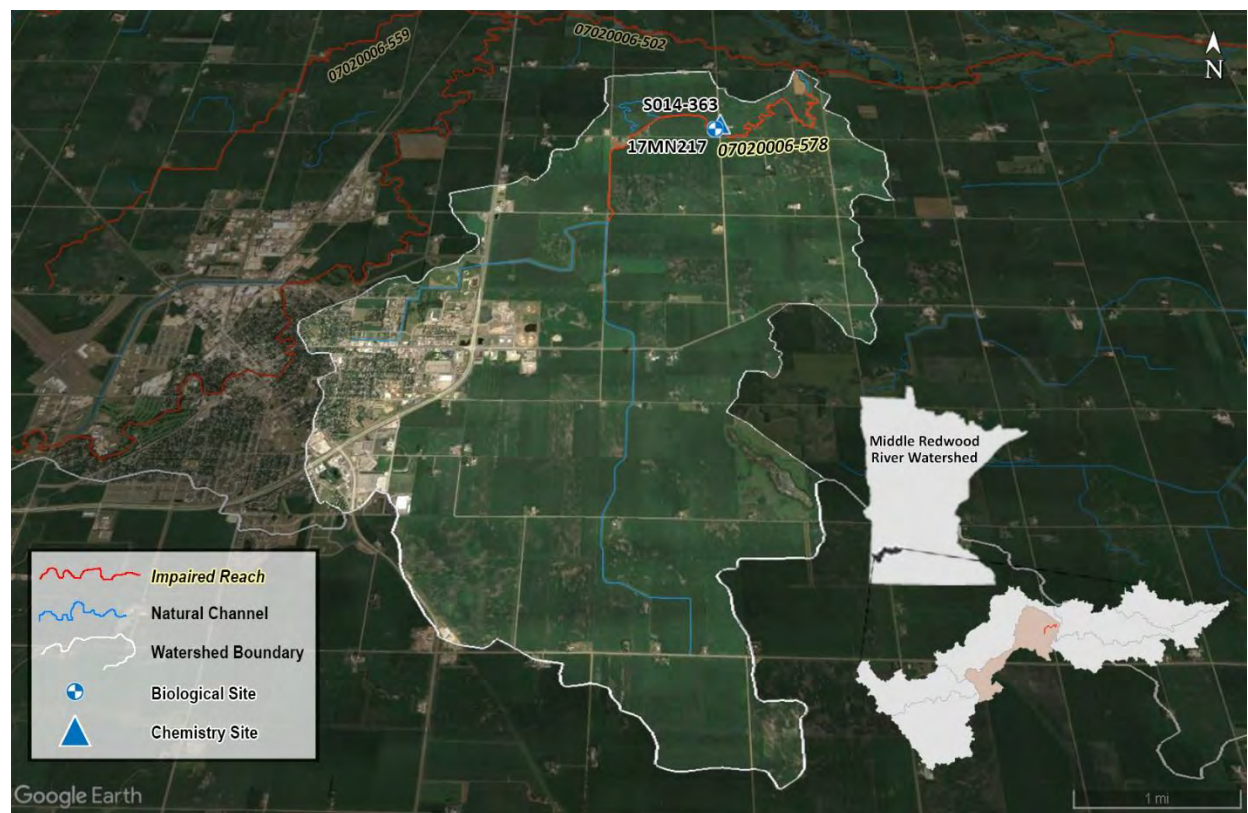
Figure 72. Satellite image of reach 07020006-578 and its watershed

---

3.4.3.1   Biological Community

Bio site 17MN217 was sampled twice for fish in 2017. The FIBI scored 13.8 in July and 58.5 in September (Table 310). Although the second site visit scored higher than the class 3 southern headwater modified use threshold of 33, it mainly did so because of the fact that only three out of the seven taxa caught are considered generalists and short lived taxa and generalist taxa was part of the IBI score. Serial spawning and short lived metrics were only looked at through a relative abundance compared to total number of fish caught. So while there were several short lived taxa present during the September visit, the total number of these types of fish caught were low. Also, only one fish caught during the September visit is considered a serial spawning species. Blacknose dace and creek chubs dominated the fish community during both visits and the total number of fish caught during both visits were both relatively low.

Bio site 17MN217 was sampled for inverts once in 2017. The MIBI score of 21.4 was just below the invert class 5 modified use threshold of 24 (Table 311). The site was dominated by the snail physella, the riffle beetle dubiraphia, which are considered tolerant species. There were some decent numbers of the amphipod hyalella and the caddisfly nectopsyche, both of which are considered tolerant as well.

Biological Metric Data

Table 310. Fish IBI score and threshold for reach 07020006-578

07020006-578 **Fish Class 3** Modified Use	Fish IBI Score	Class Threshold Score
17MN217 7/19/2017	13.8	33
17MN217 9/20/2017	58.5	

Table 311. Invert IBI score and threshold for reach 07020006-578

07020006-578 **Invert Class 5** Modified Use	Invert IBI Score	Class Threshold Score
17MN217 7/31/2017	21.4	24

3.4.3.2   Hydrologic Alteration

Hydrologic Alteration Biological Metric Data

Table 312. Hydrologic alteration related fish metrics for reach 07020006-578

07020006-578 **Fish Class 3** **Modified Use**	General %	Nesting Non Lithophilic Spawner %
17MN217 7/19/2017	85.7	23.8
17MN217 9/20/2017	64.0	24.0
Statewide average for Class 3 Southern Headwater bio sites that are meeting the FIBI modified use threshold (33)	**56.3**	**24.0**
Expected response to **Hydrologic** stress	↑	↑

Table 313. Hydrologic alteration related invert metrics for reach 07020006-578

07020006-578 **Invert Class 5** **Modified Use**	Clinger %	Collector – filterer %	Long – lived %	Percent Ditched Intolerant %	Percent Ditched Tolerant %
17MN217 7/31/2017	30.2	0.6	28.1	2.5	26.1
Statewide average for Class 5 prairie stream rock riffle bio sites that are meeting the FIBI modified use threshold (24)	**39.2**	**22.1**	**6.5**	↓	↑
Expected response to **Hydrologic** stress	↓	↓	↓		

HSPF Model Flow Data

Table 314. HSPF modeled flow data for reach 07020006-578

07020006-578 HSPF Reach 271 Min: 0.0 cfs Max: 635.6 cfs	**<5 cfs %** (# of values)	**<1 cfs %** (# of values)	**<0.5 cfs %** (# of values)
6,210 Total Daily Averages 1996 – 2012	**66.5%** (4,132)	**34.2%** (2,125)	**22.1%** (1,370)

Hydrologic Alteration Summary

The fish biological metrics were mixed when compared to the average of Class 3 stream bio sites that meet the IBI modified use threshold (Table 312). However, there were very few fish caught, as only 21 total fish were caught. Bio site 17MN217 had a population of generalist fish ranging from 64% to 85.7% of

Figure 73. Photo showing the ditched stream channel at bio site 17MN217.

the population. Nesting fish, which was from three green sunfish caught, were just below and right at the class average of 24%.

Hydrologic related invertebrate metrics were mostly poor at bio site 17MN217 (Table 313). The snail physella dominated the bio community with the riffle beetle with the beetle dubiraphia the next most numerous invert. There were fair numbers of the caddisfly nectopsyche, though it is considered very tolerant to low flows as well as several habitat metrics. Clingers were below the class average and there were almost no collector – filterers present. Long – lived species were above the class average, though that was mostly due to the riffle beetles that were present in large numbers. Ditched tolerant to intolerant species was high.

The HSPF model shows that 34.2% of the daily average flows from 1996 through 2012 were below 1 cfs (Table 314). Flows reduced beyond normal base flow will decrease habitat for aquatic organisms and increase competition for resources.

Based on the mostly poor scores of the biological metrics and extended low flow periods shown in the HSPF model, hydrologic alteration is a stressor in this reach. The primary impact in this reach from Hydrologic Alteration is seen in alteration of the stream into a ditch. Drainage within the watershed that has changed the timing and delivery of water and nutrients, causing low flows during periods of low precipitation as well as eutrophication issues within the stream due to excess nutrients within the stream.

3.4.3.3   Connectivity

Connectivity Metric Data

Table 315. Connectivity related fish metrics for reach 07020006-578

07020006-578 **Fish Class 3** Modified Use	Mature Age >3 minus Tolerant Taxa %	Migrating Taxa %
17MN217 7/19/2017	0.0	25.0
17MN217 9/20/2017	0.0	14.3
Statewide average for Class 3 Southern Headwater bio sites that are meeting the FIBI modified use threshold (33)	**3.2**	**20.1**
Expected response to **Connectivity** stress	↓	↓

Connectivity Summary

Connectivity related fish metrics were mostly poor (Table 315). There were no females that take greater than three years to mature Migrating taxa were present and close to the average for southern streams that meet the standard, though it was from only three white suckers, one central stoneroller, and one Iowa darter that were caught between the two visits. Connectivity appears to be a stressor to the biological community but is inconclusive at this time.

3.4.3.4   Habitat

Habitat Metric Data

Table 316. Habitat related fish metrics for reach 07020006-578

07020006-578 **Fish Class 3** Modified Use	Benthic Insect minus Tolerant %	Darter Sculpin Sucker %	Lithophilic Spawner %	Pioneer %	Piscivore %	Riffle %	Simple Lithophilic Spawner %	Tolerant %
17MN217 7/19/2017	4.8	0.0	71.4	38.1	0.0	19.0	42.9	95.2

07020006-578 **Fish Class 3** Modified Use	Benthic Insect minus Tolerant %	Darter Sculpin Sucker %	Lithophilic Spawner %	Pioneer %	Piscivore %	Riffle %	Simple Lithophilic Spawner %	Tolerant %
17MN217 9/20/2017	20.0	20.0	68.0	32.0	8.0	0.0	48.0	72.0
Statewide average for Class 3 Southern Headwater bio sites that are meeting the FIBI modified use threshold (33)	**8.8**	**7.4**	**34.6**	**12.7**	**4.9**	**12.2**	**24.1**	**48.7**
Expected response to **Habitat** stress	↓	↓	↓	↑	↓	↓	↓	↑

Table 317. Habitat related invert metrics for reach 07020006-578

07020006-578 **Invert Class 5** Modified Use	Burrower %	Climber %	Clinger %	Ephemeroptera Plecoptera Trichoptera %	Legless %	Sprawler %
17MN217 7/31/2017	1.2	54.0	30.2	14.2	48.5	12.3
Statewide average for Class 5 prairie stream rock riffle bio sites that are meeting the FIBI modified use threshold (24)	**9.0**	**21.5**	**39.2**	**33.6**	**45.5**	**21.3**
Expected response to **Habitat** stress	↑	↓	↓	↓	↑	↑

MPCA Stream Habitat Assessment Score

Table 318. Habitat Assessment scores for reach 07020006-578

07020006-578	Land Use	Riparian	Substrate	Cover	Channel Morphology	Total Score
17MN217 7/19/2017	0	6	17.3	10	11	44.3
17MN217 7/31/2017	0	6	10.5	9	10	35.5
17MN217 9/20/2017	0	7	18.3	12	12	49.3
Maximum Attainable Habitat Score	**5**	**14**	**28**	**18**	**35**	**100**

Habitat Summary

The habitat related fish metrics in reach 07020006-578 were mixed when compared to all other Class 3 southern headwater bio sites that meet the FIBI modified use threshold (Table 316). The September visit scored better that the July visit in most of the habitat metrics. The benthic insectivore percentage was 20% at

Figure 74. Photo of Bio site 17MN217 showing a straightened ditch that has been incised. There is obvious erosion along the banks.

the September visit, though it was from only four johnny and one Iowa darter that was caught out of 25 total fish. Piscivore percentage was above average at 8% due to two largemouth bass. Lithophilic spawning fish were above average as well as blacknose dace and creek chubs were the dominate fish caught during both visits.

Invert habitat related metrics were also mixed. Climber metrics score well, though the metric was skewed due to the dominance of the snail physella. Without the 144 physella snails the remaining climber percentage is only 9.5%. There were 26 nectopsyche that were caught, which is a climbing caddisfly. Otherwise there were several beetles that are clingers, which caused that metric to be just below the class average. In all, the invertebrate community was pretty poor as the top three invertebrates were a snail, beetle, and amphipod.

The MSHA scores were mostly poor, with the September site visit scoring just above the poor threshold. All visits indicated poor depth variability, no sinuosity, very little pool and riffle development, and moderate embeddedness of coarse substrates. There was some cobble, gravel, and sand observed and siltation was minimal. Every fish habitat related fish metric scored well below the average for Class 2 streams.

Though it is inconclusive as a stressor to the fish population it is likely that the channelization of the stream reach and lack of riffles and pools are contributing to the low numbers of fish within the stream. There are other stressors that are also contributing to the lack of fish; however, it is difficult to determine based off of the limited number of fish caught, how much of an effect habitat is having. Due to the mostly poor invertebrate metrics, habitat is a stressor to the invertebrate community, likely due to the lack of geomorphic features within the stream channel.

3.4.3.5   Dissolved Oxygen

Dissolved Oxygen Biological Metric Data

Table 319. Dissolved oxygen related fish metrics for reach 07020006-578

07020006-578 Fish Class 3 Modified Use	Mature Age >3 %	Serial Spawner %	Taxa Count	DO TIV	DO Sensitive %	DO Tolerant %
17MN217 7/19/2017	14.3	9.5	8	8.4	0.0	33.3
17MN217 9/20/2017	0.0	4.0	7	8.5	0.0	20.0
Statewide average for Class 3 Southern Headwater bio sites that are meeting the FIBI modified use threshold (33)	**14.4**	**10.6**	**9.3**	**8.2**	↓	↑
Expected response to **DO** stress	↓	↑	↓	↓		

Table 320. Dissolved oxygen related invert metrics for reach 07020006-578

07020006-578 Invert Class 5 Modified Use	DO TIV	HBI_MN	Low DO Intolerant Taxa %	Low DO Tolerant Taxa %
17MN217 7/31/2017	7.0	8.3	3.1	12.3
Statewide average for Class 5 prairie stream rock riffle bio sites that are meeting the FIBI modified use threshold (24)	**6.7**	**7.6**	↓	↑
Expected response to **DO** stress	↓	↑		

Dissolved Oxygen Monitoring Data

Table 321. Dissolved oxygen monitoring data for reach 07020006-578

07020006-578 DO Data 5 mg/L target	Range of Data (mg/L)	% of Monthly Samples < 5 mg/L [# of Samples]							May - Sep <5 mg/L % [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-363 (2017-2019)	9.3 – 13.2	-	-	-	0% [3]	0% [1]	0% [1]	-	0% [5]
		Minimum Value							
		-	-	-	9.3	10.4	10.4	-	
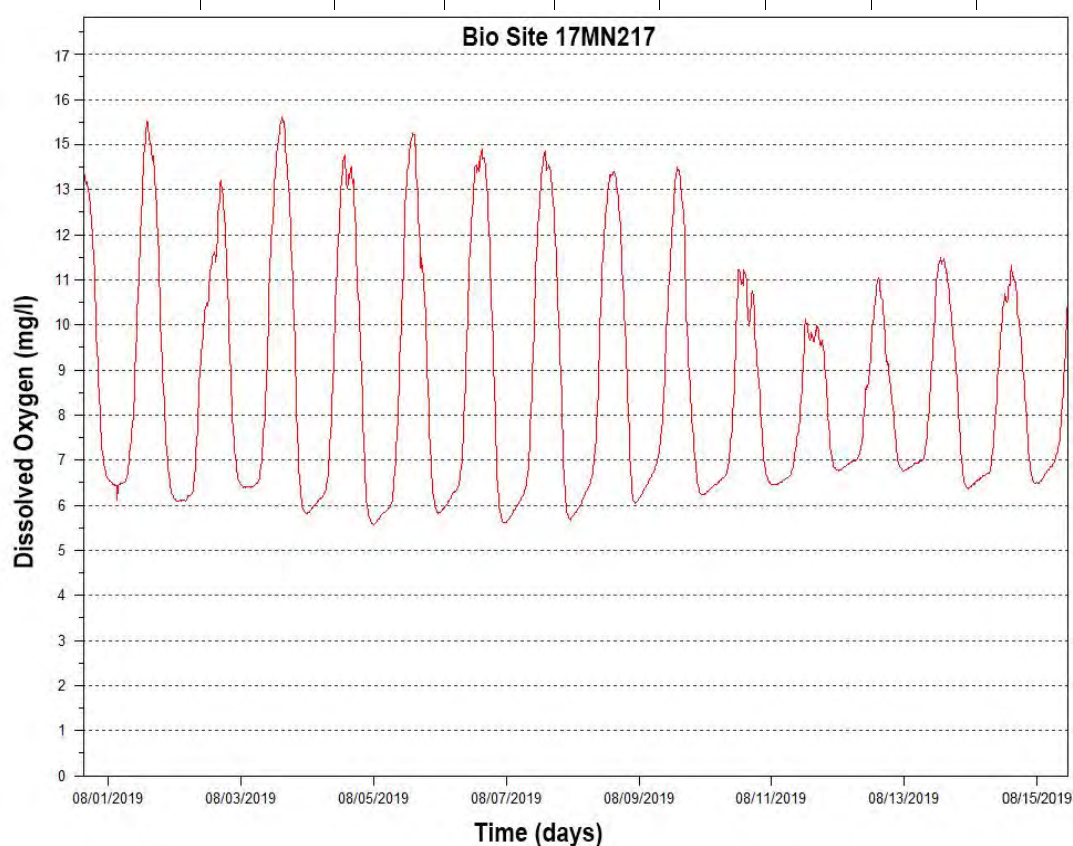
Figure 75. Continuous dissolved oxygen data at site 17MN217

Dissolved Oxygen Summary

The DO related bio metrics were mixed when compared to the average of all other Class 3 southern headwater bio sites that meet the FIBI modified use threshold (Table 319). There were no fish caught who are sensitive to low DO. Species with females that take more than three years to mature comprised 14.3% and 0%, both below class averages. No DO sensitive fish were caught. DO tolerant species were from 20% to 33.3% of the fish population.

The DO related invert metrics were worse. The DO tolerance index score was decent at 7, though the HBI_MN score scored poorly. Low ratio of DO tolerant verses intolerant was poor and the amphipod hyalella, a low DO tolerant species, was prevalent at the bio site.

Although no DO measurements taken during sampling were below the warmwater standard of 5 mg/L, there were only five and none of those measurements were taken before 8:00 a.m., when values are usually the lowest. An YSI Sonde water meter measured continuous DO data from 8/1/2019 to 8/15/2019. During this deployment, DO values did not get below the standard of 5 mg/l.

Based on the mixed biological metric scores and DO data, DO is inconclusive.

3.4.3.6   Eutrophication

Eutrophication Biological Metric Data

Table 322. Eutrophication related fish metrics for reach 07020006-578

07020006-578 **Fish Class 3** **Modified Use**	Darter %	Omnivore %	Sensitive %	Simple Lithophillic Spawner %	Tolerant %
17MN217 7/19/2017	0.0	19.0	0.0	42.9	95.2
17MN217 9/20/2017	20.0	0.0	4.0	48.0	72.0
Statewide average for Class 3 Southern Headwater bio sites that are meeting the FIBI modified use threshold (33)	**10.6**	**19.8**	**6.0**	**30.1**	**76.7**
Expected response to **Eutrophication** stress	↓	↑	↓	↓	↑

07020006-578 **Invert Class 5** Modified Use	Crustacean and Mollusca %	Collector – Gatherer Taxa #	Ephemeroptera Plecoptera Trichoptera Taxa %	Intolerant Two Taxa %	Scraper %	Taxa Count All #	Tolerant Two Taxa %
17MN217 7/31/2017	52.8	7	14.2	0.0	12.3	26	88.5
Statewide average for Class 5 prairie stream rock riffle bio sites that are meeting the FIBI modified use threshold (24)	**15.6**	**12.8**	**22.9**	**0.1**	**13.5**	**36.8**	**81.8**
Expected response to **Eutrophic** stress	↑	↓	↓	↓	↑	↓	↑

Eutrophication Monitoring Data

Table 324. Phosphorus monitoring data for reach 07020006-578

07020001-578 P Sample Data 0.15 mg/L target	Range of Data (mg/L)	Monthly Average of Samples (mg/L) [# of Samples]							June-Aug Average (mg/L) [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-363 (2017-2019)	0.059 – 0.149	-	-	-	0.104 [2]	-	0.063 [2]	-	0.104 [2]
		Maximum Value							
		-	-	-	0.149	-	0.064	-	

Table 325. DO% Saturation monitoring data for reach 07020006-578

07020006-578 DO% Sat Data	Range of Data (%)	Monthly Average of Samples (%) [# of Samples]							June-Aug Average (%) [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-363 (2017-2019)	112.6 – 149.5	-	-	-	136.7 [3]	117.7 [1]	122.6 [1]	-	132.0 [4]

Eutrophication Summary

The fish community at bio site 17MN217 was mixed in the eutrophication related fish metrics when compared to the average of all other Class 3 southern stream bio sites that meet the FIBI modified use threshold. Darter individuals were scored well on the September visit, though it was mostly from the low numbers of fish and the five darters that were caught. Sensitive species

Figure 76. Photo of the culvert bio site 17MN217 showing algae growth

were very low and tolerant species were relatively high. Simple lithophilic spawning fish percentage did score decent (Table 322).

Invert eutrophication metrics scored worse than the fish metrics. Crustacean and Mollusca percentage was very high as the snail physella dominated the invert community. There were very few collector – filterers or EPT taxa and no intolerant species were caught. The percentage of scrapers was just below the class average and both taxa count and the percentage of the tolerant two taxa scored poorly.

Only two samples were collected and analyzed for Phosphorus from 2017 to 2019 and the summer average was below the standard of 0.15 mg/L (Table 324). DO percent saturation was high; however, during all of the site visits from 2017 through 2019.

An YSI Sonde water meter measured continuous DO data from 8/01/2019 to 8/15/2019. During this deployment, diel DO flux was measured at or above 5 mg/L nine of the nights it was deployed. The flows in 2019 were higher than average and many streams in the area did not show the DO flux response that this site did.

The biological community is showing the effects of the elevated phosphorus and although the phosphorus sampling did not show elevated concentrations, sampling was very limited. DO flux was 5 mg/L or greater even with decent flows. Algae growth was observed at the station (Figure 76). Eutrophication is a stressor in this reach.

3.4.3.7   Suspended Solids

Suspended Solids Biological Metric Data

Table 326. Suspended solids related fish metrics for reach 07020006-578

07020006-578 **Fish Class 3** **Modified Use**	Benthic Feeder %	Centrarchid - Tolerant %	Herbivore %	Intolerant %	Long – lived %	Perciformes - Tolerant %	Riffle %	Sensitive %	Simple Lithophilic Spawner %	TSS TIV
17MN217 7/19/2017	23.8	0.0	4.8	0.0	0.0	0.0	19.0	0.0	42.9	17.8
17MN217 9/20/2017	16.0	8.0	4.0	0.0	8.0	28.0	0.0	4.0	48.0	13.9
Statewide average for Class 3 Southern Headwater bio sites that are meeting the FIBI modified use threshold (33)	**31.4**	**1.0**	**10.8**	**0.5**	**4.9**	**12.4**	**22.6**	**6.0**	**30.1**	**16.9**
Expected response to **Suspended Solids** stress	↓	↓	↓	↓	↓	↓	↓	↓	↓	↑

Table 327. Suspended solids related invert metrics for reach 07020006-578

07020006-578 **Invert Class 5** **Modified Use**	Collector – filterer %	Plecoptera %	TSS TIV	TSS Intolerant Taxa %	TSS Tolerant Taxa %
17MN217 7/31/2017	0.6	0.0	21.9	0.0	61.3
Statewide average for Class 5 prairie stream rock riffle bio sites that are meeting the FIBI modified use threshold (24)	**22.1**	**0.1**	**16.1**	↓	↑
Expected response to **Suspended Solids** stress	↓	↓	↑		

TSS Monitoring Data

Table 328. Total suspended solids monitoring data for reach 07020006-578

07020001-578 TSS Sample Data	Range of Data (mg/L)	% of Monthly Samples > 65 mg/L [# of Samples]							% of Total Samples > 65 mg/L [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-363 (2017-2019)	2.4 – 8.8	-	-	-	0 [2]	-	0 [2]	-	0 [2]

Table 329. Transparency monitoring data for reach 07020006-578

07020001-578 Secchi Tube Data 10 cm target	Range of Data (cm)	% of Monthly Samples < 10 cm [# of Samples]							% of Total Samples < 10 cm [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-363 (2017-2019)	73 – 100+	-	-	-	0 [3]	0 [1]	0 [1]	-	0 [5]

Suspended Solids Summary

The suspended solids related fish metrics at bio site 17MN217 scored mostly poor when compared to the average of all other Class 3 southern headwater bio sites that meet the FIBI modified use threshold (Table 329). There were some benthic feeders and sensitive fish present though they were below the class average. The September visit scored better with above average percentages of centrarchids, long – lived species, perciformes, and lithophilic spawners. The TSS TIV score also scored well.

Invert metrics scored poorly. Not only did all of the metrics score poorly compared to the average, the scores were also generally worse. There were almost no collector – filterers and no Plecoptera or TSS intolerant species present while the percentage of TSS tolerant species was over 60%. The TSS TIV score was well above the class average (Table 327).

Only two samples were collected and analyzed for TSS from 2017 to 2019. No sample had a TSS concentration above 65 mg/L (Table 48).

Suspended solids are inconclusive as a stressor to aquatic life at this time. It is likely that other factors, such as altered hydrology or habitat are causing poor scores in the fish biological metrics. The invert metrics show a biological community that is likely affected by TSS but at this time is also inconclusive. It is recommended that more TSS data be collected during high flows in order to determine whether it is a biological stressor.

3.4.3.8 Nitrates

Nitrate Biological Metric Data

Table 330. Nitrate related invert metrics for reach 07020006-578

07020006-578 **Invert Class 5** Modified Use	Trichoptera Taxa %	Nitrogen TIV	Nitrate Intolerant Taxa %	Nitrogen Tolerant Taxa %
17MN217 7/31/2017	11.5	6.3	0.0	83.4
Statewide average for Class 5 prairie stream rock riffle bio sites that are meeting the FIBI modified use threshold (24)	**11.1**	**3.2**	↓	↑
Expected response to **nitrogen** stress	↓	↑		

Nitrate Monitoring Data

Table 331. Nitrate monitoring data for reach 07020006-578

07020001-578 Nitrate/Nitrite Sample Data	2x Highest Reach TIV Average	Range of Data (mg/L) [# of Samples]	Monthly Average [# of Samples]						
			April	May	June	July	August	Sept	Oct
S014-363 (2017-2019)	6.4	3.7 – 8.7 [4]	-	-	-	6.2 [2]	-	4.7 [2]	-
			Highest Value						
			-	-	-	8.7	-	4.7	-

Summary

The macroinvertebrate assemblage at site 17MN217 scored below average in all of the nitrate related metrics evaluated when compared to all other macroinvertebrate Class 5 streams bio sites that meet the MIBI modified use threshold (Table 330). The biological bio site did show a healthy amount of Trichoptera taxa, which tend to decrease in streams with excessive nitrate values. However, the species present was nectopsyche, which is considered very tolerant to nitrates. There was a high amount of nitrate tolerant invertebrates as well as complete lack of nitrate intolerant invertebrate species. The nitrogen TIV score also indicates a macroinvertebrate community that is generally tolerant to high levels of nitrates.

Only four samples were collected in reach 07020006-578 and analyzed for nitrate/nitrite (Table 331). Out of the limited number of samples there was one that was high at 8.7 mg/L. Due to the mixed biological response and low numbers of nitrate data, nitrates are inconclusive as a stressor to aquatic life in reach 07020006-578.

3.4.3.9   Reach Stressors

07020006-578	Hydrologic Alteration	Connectivity	Habitat	Dissolved Oxygen	Eutrophication	Suspended Solids	Nitrate
✓ = Stressor ✗ = Not a Stressor O = Inconclusive	✓	O	O	O	✓	O	O

3.5   Lower Redwood River

3.5.1 07020006-503   Redwood River
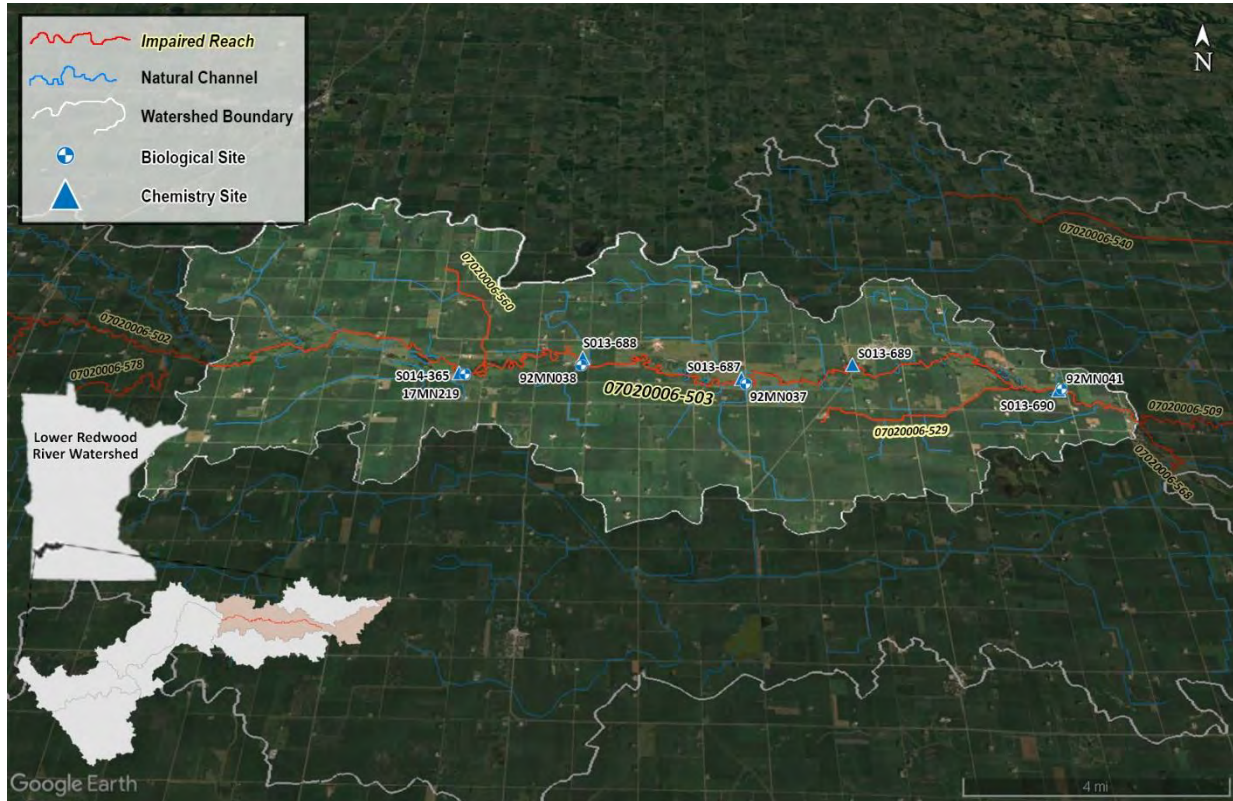
3.5.1.1   Biological Community

Reach 07020006-503 was sampled twice for fish in 2017. Bio sites 17MN219 and 92MN037 scored 29.2 and 41.0, both below the Fish Class 1 southern river general use threshold of 49 (Table 333). Spotfin shiners, channel catfish, and bluntnose minnows dominated the fish community, which are all detritivores and either considered generalists or pioneer species.

Invertebrate sampling in reach 07020006-503 was done twice in 2017 and once in 2010. Both the upstream and downstream bio sites that were sampled in 2017 scored below their class averages (Table

---

334) (Table 336). Bio site 92MN037 scored just above the class average but was sampled in 2010 (Table 335). The mayfly tricorythodes dominated the bio community throughout the reach and the caddisfly cheumatopsyche and the mayfly fallceon were a large percentage of the community as well, all of which are considered more tolerant mayflies and caddisflies.

Biological Metric Data

Table 333. Fish IBI score and threshold for reach 07020006-503

07020006-503 **Fish Class 1** General Use	Fish IBI Score	Class Threshold Score
17MN219 7/13/2017	29.2	49
92MN037 9/19/2017	41.0	

Table 334. Invert class 5 IBI score and threshold for reach 07020006-503

07020006-503 **Invert Class 5** General Use	Invert IBI Score	Class Threshold Score
17MN219 8/01/2017	23.7	37

Table 335. Invert class 7 IBI score and threshold for reach 07020006-503

07020006-503 **Invert Class 7** General Use	Invert IBI Score	Class Threshold Score
92MN037 8/01/2017	45.1	41

07020006-503 **Invert Class 2** General Use	Invert IBI Score	Class Threshold Score
92MN041 8/02/2017	23.2	31

3.5.1.2 Hydrologic Alteration

Hydrologic Alteration Biological Metric Data

07020006-503 **Fish Class 1** General Use	General %	Nesting Non Lithophilic Spawner %
17MN219 7/13/2017	28.7	31.1
92MN037 9/19/2017	14.2	28.4
Statewide average for Class 1 Southern River bio sites that are meeting the FIBI general use threshold (49)	**20.7**	**16.0**
Expected response to **Hydrologic** stress	↑	↑

Table 338. Hydrologic alteration related invert metrics for reach 07020006-503

07020006-503 **Invert Class 5** General Use	Clinger %	Collector – filterer %	Long – lived %		Percent Ditched Intolerant %	Percent Ditched Tolerant %
17MN219 8/01/2017	55.1	44.6	5.4		0.9	0.9
Statewide average for Class 5 prairie stream rock riffle bio sites that are meeting the FIBI general use threshold (37)	**49.5**	**26.9**	**9.0**		↓	↑
Expected response to **Hydrologic** stress	↓	↓	↓			

Table 339. Hydrologic alteration related invert metrics for reach 07020006-503

07020006-503 **Invert Class 7** General Use	Clinger %	Collector – filterer %	Long – lived %		Percent Ditched Intolerant %	Percent Ditched Tolerant %
92MN037 8/01/2017	36.8	15.5	17.6		1.5	0.9
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI general use threshold (41)	**38.5**	**19.1**	**8.0**		↓	↑
Expected response to **Hydrologic** stress	↓	↓	↓			

Table 340. Hydrologic alteration related invert metrics for reach 07020006-503

07020006-503 **Invert Class 2** General Use	Clinger %	Collector – filterer %	Long – lived %	Percent Ditched Intolerant %	Percent Ditched Tolerant %
92MN041 8/02/2017	53.1	39.8	14.6	6.5	1.0
Statewide average for Class 2 Prairie Forest River bio sites that are meeting the FIBI general use threshold (31)	**43.2**	**23.0**	**6.7**	↓	↑
Expected response to **Hydrologic** stress	↓	↓	↓		

HSPF Model Flow Data

Table 341. HSPF modeled flow data for reach 07020006-503

07020006-503 HSPF Reach 430 Min: 6.5 cfs Max: 7,470.8 cfs	<5 cfs % (# of values)	<1 cfs % (# of values)	<0.5 cfs % (# of values)
6,210 Total Daily Averages 1996 – 2012	**0%** (0)	**0%** (0)	**0%** (0)

Hydrologic Alteration Summary

The fish hydrologic alteration biological metrics were mostly poor when compared to the average of Class 1 stream southern river bio sites that meet the IBI general use threshold. Generalized fish species are correlated with channelization and are adaptable to different habitats through generalized food preferences. Generalist fish at bio site 17MN219 were 28.7% of the population. Bio site 92MN037 scored better with a generalist population of 14.2%. Nesting fish were well above the class average at both bio sites (Table 337).

Hydrologic alteration related invert metrics were mixed, though for the most part were pretty good. The caddisfly cheumatopsyche, considered a clinger and a collector – filterer, dominated the invert community at 17MN219 and made up the majority of the clingers and collector – filterers at that site (Table 338). Bio site 92MN037 scored below the class averages in both clingers and collector – filterers due to the dominance of the mayflies' fallceon and tricorythodes. Even so, the percentage of both clingers and collector – filterers were just below the class averages and the percentage of long – lived inverts scored well at 17.6% (Table 339). Bio site 92MN041 scored very well compared to the class

averages in all of the hydrologic alteration metrics. The ratio of ditched intolerant verses tolerant was also good (Table 340).

The biological metrics between fish and inverts seem to be showing different effects from hydrologic alteration, with the fish metrics showing a negative response. There were no extended low flow periods shown in the HSPF model, though this part of the Redwood River should have enough flow most years as it is considered a southern river and has sufficient drainage area to maintain flows most years. Hydrologic alteration appears to be a stressor to the fish community in this reach.

3.5.1.3 Connectivity

Connectivity Metric Data

Table 342. Connectivity related fish metrics for reach 07020006-503

07020006-503 **Fish Class 1** General Use	Mature Age >3 minus Tolerant Taxa %	Migrating Taxa %
17MN219 7/13/2017	23.5	29.4
92MN037 9/19/2017	35.7	28.6
Statewide average for Class 1 Southern River bio sites that are meeting the FIBI general use threshold (49)	**41.5**	**30.7**
Expected response to **Connectivity** stress	↓	↓

Connectivity Summary

Metrics for fish taxa whose females take greater than three years to mature were below the class average and the actual numbers of late maturing fish were low with the exception of channel catfish which were 22% of the fish caught at bio site 92MN037 (Table 342). Migrating taxa were present and close to the average for southern streams that meet the standard though very few numbers of migrating fish were caught.

There are no known barriers along this reach and since this reach is the main stem of the Redwood River, most of the road crossings are bridges that do not impede fish passage. Due to the presence of late maturing and migratory species it appears that connectivity is not a stressor at this time.

3.5.1.4 Habitat

Habitat Metric Data

Table 343. Habitat related fish metrics for reach 07020006-503

07020006-503 Fish Class 1 General Use	Benthic Insect minus Tolerant %	Darter Sculpin Sucker %	Lithophilic Spawner %	Pioneer %	Piscivore %	Riffle %	Simple Lithophilic Spawner %	Tolerant %
17MN219 7/13/2017	10.8	10.8	21.6	25.1	6.0	8.4	12.0	43.7
92MN037 9/19/2017	10.5	10.5	19.1	6.2	22.8	4.3	11.7	21.6
Statewide average for Class 1 Southern River bio sites that are meeting the FIBI general use threshold (49)	**20.6**	**18.5**	**29.2**	**5.2**	**15.2**	**14.0**	**25.0**	**22.1**
Expected response to **Habitat** stress	↓	↓	↓	↑	↓	↓	↓	↑

Table 344. Habitat related invert metrics for reach 07020006-503

07020006-503 Invert Class 5 General Use	Burrower %	Climber %	Clinger %	Ephemeroptera Plecoptera Trichoptera %	Legless %	Sprawler %
17MN219 8/01/2017	0.3	9.8	55.1	86.1	7.0	23.7
Statewide average for Class 5 prairie stream rock riffle bio sites that are meeting the FIBI general use threshold (37)	**7.5**	**14.7**	**49.5**	**43.9**	**36.0**	**16.8**
Expected response to **Habitat** stress	↑	↓	↓	↓	↑	↑

Table 345. Habitat related invert metrics for reach 07020006-503

07020006-503 **Invert Class 7** General Use	Burrower %	Climber %	Clinger %	Ephemeroptera Plecoptera Trichoptera %	Legless %	Sprawler %
92MN037 8/01/2017	0.6	8.1	36.8	75.5	3.7	25.7
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI general use threshold (41)	**7.5**	**21.6**	**38.5**	**38.5**	**39.8**	**20.9**
Expected response to **Habitat** stress	↑	↓	↓	↓	↑	↑

Table 346. Habitat related invert metrics for reach 07020006-503

07020006-503 **Invert Class 2** General Use	Burrower %	Climber %	Clinger %	Ephemeroptera Plecoptera Trichoptera %	Legless %	Sprawler %
92MN041 8/02/2017	1.9	5.8	53.1	76.7	7.1	18.1
Statewide average for Class 2 Prairie Forest River bio sites that are meeting the FIBI general use threshold (31)	**6.9**	**14.0**	**43.2**	**54.8**	**25.9**	**17.6**
Expected response to **Habitat** stress	↑	↓	↓	↓	↑	↑

MPCA Stream Habitat Assessment Score

Table 347. Habitat Assessment scores for reach 07020006-503

07020006-503	Land Use	Riparian	Substrate	Cover	Channel Morphology	Total Score
17MN219 7/13/2017	2.5	8.5	16.6	13	19	59.6
17MN219 8/01/2017	0	5	16.7	6	15	42.7
92MN038 8/31/2010	0	5	18	8	14	45
92MN037 8/01/2017	0	9	8	6	14	37

07020006-503	Land Use	Riparian	Substrate	Cover	Channel Morphology	Total Score
92MN037 9/19/2017	3.8	7	9	8	11	38.8
92MN041 8/31/2010	0	10.5	20.2	8	20	58.7
92MN041 8/02/2017	0	7.5	18	9	17	51.5
Maximum Attainable Habitat Score	**5**	**14**	**28**	**18**	**35**	**100**

Habitat Summary

The fish community in reach 07020006-503 scored poorly in almost all of the habitat related fish metrics at both sites when compared to all other Class 1 southern river bio sites that meet the FIBI general use threshold (Table 343). The percentage of benthic insectivores that were not tolerant species were low, as were darters. Lithophilic spawners scored a little better, though they were still below the class averages. Pioneer species were higher at the upstream bio site and piscivores scored above the class average at bio site 92MN037. Riffle dwelling fish were low as well as lithophilic spawning fish and tolerant fish were mixed at the two bio sites, with the downstream site scoring better.

Habitat related invertebrate metrics scored mostly well throughout the reach (Table 344, Table 345, Table 346). Burrowers and legless inverts were low at all of the bio sites, which is a good sign for habitat. There were good numbers of clingers throughout the reach due to Hydropsychidae caddisflies. The reach was dominated by caddisflies and mayflies that, and although they are more generally tolerant taxa, the dominate species were not necessarily tolerant of habitat metrics. There were some high numbers of the mayfly Fallceon and the caddisfly nectopsyche, which scored tolerant to fine sediments and embeddedness. The mayfly tricorythodes, which is a spawler, dominated the reach. This might indicate that excess sediment issues may exist and substrate may be affecting the invertebrate community.

Several MSHA scores were calculated throughout the reach. Both the upstream site and downstream site scored in the middle and the midstream site scored poorly. Moderate embeddedness and siltation were observed throughout the reach. Coarse sediment and such as sand, gravel and cobbles were observed at all the bio sites (Table 347).

Low numbers of benthic insectivores, lithophilic spawners, and riffle dwelling fish indicate habitat may be a stressor to the biological fish community in the reach, especially at the upstream bio site 17MN219, which had less geomorphic development as well. Invert metrics scored better than the fish. Habitat appears to be a stressor to the fish community in the reach, especially in the section near bio site 17MN219.

3.5.1.5   Dissolved Oxygen

Dissolved Oxygen Biological Metric Data

Table 348. Dissolved oxygen related fish metrics for reach 07020006-503

07020006-503 **Fish Class 1** General Use	Mature Age >3 %	Serial Spawner %	Taxa Count	DO TIV	DO Sensitive %	DO Tolerant %
17MN219 7/13/2017	16.8	73.7	17	8.6	0.0	13.8
92MN037 9/19/2017	34.0	55.6	14	8.5	0.0	15.4
Statewide average for Class 1 Southern River bio sites that are meeting the FIBI general use threshold (49)	**40.4**	**35.6**	**21.6**	**8.6**	↓	↑
Expected response to **DO** stress	↓	↑	↓	↓		

Table 349. Dissolved oxygen related invert metrics for reach 07020006-503

07020006-503 **Invert Class 5** General Use	DO TIV	HBI_MN	Low DO Intolerant Taxa %	Low DO Tolerant Taxa %
17MN219 8/01/2017	7.5	8.4	3.5	0.9
Statewide average for Class 5 prairie stream rock riffle bio sites that are meeting the FIBI general use threshold (37)	**7.1**	**7.0**	↓	↑
Expected response to **DO** stress	↓	↑		

Table 350. Dissolved oxygen related invert metrics for reach 07020006-503

07020006-503 **Invert Class 2** General Use	DO TIV	HBI_MN	Low DO Intolerant Taxa %	Low DO Tolerant Taxa %
92MN041 8/02/2017	7.5	8.3	10.4	1.9
Statewide average for Class 2 Prairie Forest River bio sites that are meeting the FIBI general use threshold (31)	**7.1**	**7.3**	↓	↑
Expected response to **DO** stress	↓	↑		

Table 351. Dissolved oxygen related invert metrics for reach 07020006-503

07020006-503 **Invert Class 7** General Use	DO TIV	HBI_MN	Low DO Intolerant Taxa %	Low DO Tolerant Taxa %
92MN037 8/01/2017	7.5	8.7	4.3	0.6
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI general use threshold (41)	**6.9**	**7.6**	↓	↑
Expected response to **DO** stress	↓	↑		

Dissolved Oxygen Monitoring Data

07020006-503 DO Data 5 mg/L target	Range of Data (mg/L)	% of Monthly Samples < 5 mg/L [# of Samples]							May - Sep <5 mg/L % [# of Samples]
		April	May	June	July	August	Sept	Oct	
S013-687 S013-688 S013-689 S013-690 S014-365 (2010-2017)	6.8 – 21.3	-	-	-	0% [1]	0% [9]	0% [1]	-	0% [11]
		Minimum Value							
		-	-	-	8.5	6.8	8.5	-	
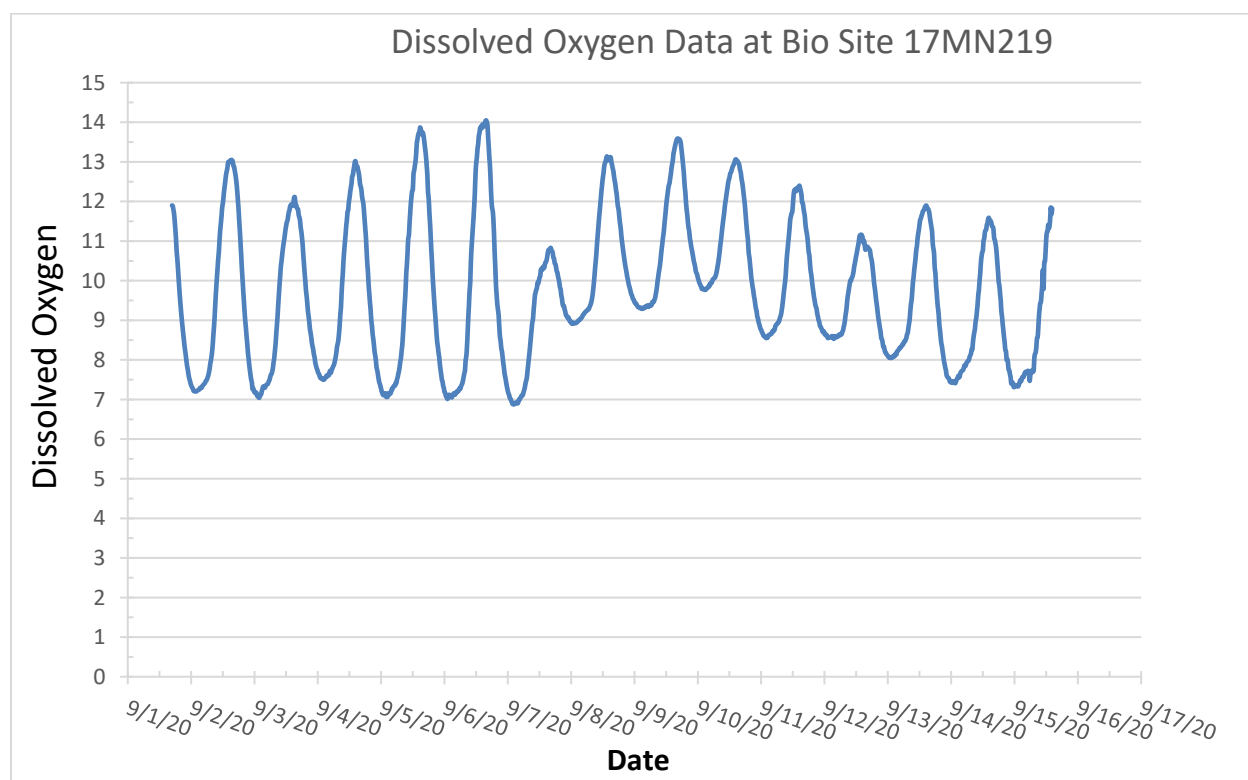
Figure 78. Continuous dissolved oxygen data at site 17MN219

Dissolved Oxygen Summary

The fish community in reach 07020006-503 scored below average in almost all DO related fish metrics when compared to the average of all other Class 2 southern stream bio sites that meet the FIBI general use threshold (Table 348). Species with females that take more than three years to mature comprised 16.8% and 34.0%, both below class average. Serial spawner percentages were higher than average and taxa counts were lower than average at both bio sites. No DO sensitive fish were caught. There were no

fish caught who are sensitive to low DO while low DO tolerant species comprised 13.8% and 15.4% of the fish population.

Invertebrate metrics related to low DO score better than the fish metrics, with only the HBI_MN score that was poor. At all of the bios sites the DO TIV number scored over the class average and there were low DO intolerant species present, while the low DO tolerant species were low.

Although no DO measurements taken during sampling were below the warmwater standard of 5 mg/L, none of those measurements were taken before 8:00 a.m., when values are usually the lowest. An YSI Sonde water meter measured continuous DO data from 9/1/2020 to 9/15/2020 (Figure 78). During this deployment, DO values were not measured below the standard of five mg/L.

Based on the mixed biological metric scores and the measured sonde values, DO is inconclusive as a stressor in this reach.

3.5.1.6   Eutrophication

Eutrophication Biological Metric Data

Table 353. Eutrophication related fish metrics for reach 07020006-503

07020006-503 **Fish Class 1** General Use	Darter %	Omnivore %	Sensitive %	Simple Lithophillic Spawner %	Tolerant %	Phosphorus Sensitive %	Phosphorus Tolerant %
17MN219 7/13/2017	4.8	7.8	3.0	12.0	43.7	0	59.3
92MN037 9/19/2017	1.9	10.5	1.9	11.7	21.6	0	82.7
Statewide average for Class 1 Southern River bio sites that are meeting the FIBI general use threshold (49)	**4.4**	**15.2**	**13.5**	**25.0**	**22.1**	↑	↓
Expected response to **Eutrophication** stress	↓	↑	↓	↓	↑		

Table 354. Eutrophication related invert metrics for reach 07020006-503

07020006-503 Invert Class 5 General Use	Crustacean and Mollusca %	Collector – Gatherer Taxa #	Ephemeroptera Plecoptera Trichoptera Taxa %	Intolerant Two Taxa %	Scraper %	Taxa Count All #	Tolerant Two Taxa %	Phosphorus Intolerant %	Phosphorus Tolerant %
17MN219 8/01/2017	0.0	8	48	0.0	4.7	25	84.0	0.6	38.6
Statewide average for Class 5 prairie stream rock riffle bio sites that are meeting the FIBI general use threshold (37)	**9.2**	**15.1**	**30.5**	**0.8**	**15.8**	**41.9**	**74.3**	↓	↑
Expected response to **Eutrophic** stress	↑	↓	↓	↓	↑	↓	↑		

Table 355. Eutrophication related invert metrics for reach 07020006-503

07020006-503 Invert Class 7 General Use	Crustacean and Mollusca %	Collector – Gatherer Taxa #	Ephemeroptera Plecoptera Trichoptera Taxa %	Intolerant Two Taxa %	Scraper %	Taxa Count All #	Tolerant Two Taxa %	Phosphorus Intolerant %	Phosphorus Tolerant %
92MN037 8/01/2017	0.0	7	44.8	0.0	12.7	29	79.3	0.9	59.4
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI general use threshold (41)	**11.8**	**13.3**	**28.8**	**0.2**	**16.1**	**37.0**	**81.9**	↓	↑
Expected response to **Eutrophic** stress	↑	↓	↓	↓	↑	↓	↑		

Table 356. Eutrophication related invert metrics for reach 07020006-503

07020006-503 Invert Class 2 General Use	Crustacean and Mollusca %	Collector – Gatherer Taxa #	Ephemeroptera Plecoptera Trichoptera Taxa %	Intolerant Two Taxa %	Scraper %	Taxa Count All #	Tolerant Two Taxa %	Phosphorus Intolerant %	Phosphorus Tolerant %
92MN041 8/02/2017	0.3	8	45.2	0.0	9.4	31	87.1	0.3	34.3
Statewide average for Class 2 Prairie Forest River bio sites that are meeting the FIBI general use threshold (31)	6.6	12.6	39.7	0.8	13.8	35.5	74.3	↓	↑
Expected response to **Eutrophic** stress	↑	↓	↓	↓	↑	↓	↑		

Eutrophication Monitoring Data

Table 357. Phosphorus monitoring data for reach 07020006-503

07020006-503 P Sample Data 0.15 mg/L target	Range of Data (mg/L)	Monthly Average of Samples (mg/L) [# of Samples]							June-Aug Average (mg/L) [# of Samples]
		April	May	June	July	August	Sept	Oct	
S013-687 S013-688 S013-690 S014-365 (2010-2017)	0.253 – 0.656	-	-	-	0.315 [1]	0.602 [2]	0.253 [1]	-	0.506 [3]
		Maximum Value							
		-	-	-	0.315	0.547	0.253	-	

Table 358. DO% Saturation monitoring data for reach 07020006-503

07020006-503 DO% Sat Data	Range of Data (%)	Monthly Average of Samples (%) [# of Samples]							June-Aug Average (%) [# of Samples]
		April	May	June	July	August	Sept	Oct	
S013-687 S013-690 S014-365 (2017)	94.1 – 121.3	-	-	-	102.7 [1]	110.6 [3]	99.2 [1]	-	108.7 [4]

Table 359. Total Phosphorus WPLMN monitoring and modeled data for site E27035001

E2703500 01 Total P WPLMN Sample & Model Data	Range (mg/L) [#]	Monthly Averages (mg/L) [# of Samples]												Jun - Aug Average (mg/L) [# of Samples]
		Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	
S013-687 S013-688 S013-690 S014-365 (2010-2017)	0.095 _ 2.63 [4,018]	1.011 [341]	1.115 [311]	0.833 [341]	0.400 [330]	0.310 [341]	0.346 [330]	0.357 [341]	0.379 [341]	0.401 [330]	0.564 [341]	0.691 [330]	0.758 [341]	0.361
		Highest Value (mg/L)												
		2.28	2.15	2.63	0.89	1.30	0.802	0.703	1.23	0.865	1.41	1.89	2.50	

Eutrophication Summary

The fish community in reach 07020006-503 was mostly poor in eutrophication related metrics when compared to the average of all other Class 1 southern river bio sites that meet the FIBI general use threshold (Table 353). The abundance of darter individuals was low at the downstream site and just above the class average at the upstream site. There were almost no sensitive species and tolerant species were mixed. Simple lithophilic spawners were low throughout the reach. Tolerant species scored poorly at the upstream site and just below the class average at the downstream bio site. There were no fish caught who are considered sensitive to phosphorus and the percentage of phosphorus tolerant fish were almost 60% to 82% of the total number of fish caught. The percentage of omnivores was generally low throughout the reach.

Invert metrics were mixed throughout the reach and the metrics that scored poorly were generally the same from upstream to downstream. There were almost no crustaceans and mollusks caught, EPT taxa percentages were high, and scraper percentages were low throughout the reach. There were no intolerant species caught and taxa counts were all poor. There were very few phosphorus tolerant species compared to phosphorus intolerant species.

Four samples were collected and analyzed for Phosphorus from 2011 through 2017. The summer average was twice the standard of 0.15 mg/L (Table 357). The watershed pollutant load monitoring network has a long term monitoring site just downstream of this reach on the Redwood River. This site is monitored several times a month throughout the year and includes modeled data in between samples, which provides a good indication of what phosphorus concentrations are on every day of the year. Data from 2010 through 2017 is shown in the table above (Table 359). Monthly averages were above the 0.150 mg/L for all 12 months and the summer average was 0.361 mg/L.

An YSI Sonde water meter measured continuous DO data from 9/1/2020 to 9/15/2020 (Figure 78). During this deployment, diel DO flux was measured at or above 5 mg/L several times, especially during the first half of the sonde deployment. The temperature dropped 20 to 30 degrees from the beginning to the end of the week and over an inch and a half of rainfall on the September 7 likely had an effect on

the DO flux the remainder of the deployment. It appears that DO flux is an issue in the reach when conditions are right as the excessive phosphorus concentrations in the water triggers DO diurnal fluctuations.

The biological community is showing the effects of the elevated phosphorus, phosphorus sampling showed elevated concentrations, and DO flux was measured at 5 mg/L or greater. Eutrophication is a stressor to the biological community in reach 07020006-503.

3.5.1.7   Suspended Solids

Suspended Solids Biological Metric Data

Table 360. Suspended solids related fish metrics for reach 07020006-503

07020006-503 Fish Class 1 General Use	Benthic Feeder %	Centrarchid - Tolerant %	Herbivore %	Intolerant %	Long – lived %	Perciformes - Tolerant %	Riffle %	Sensitive %	Simple Lithophilic Spawner %	TSS TIV
17MN219 7/13/2017	14.4	0.0	1.8	0.0	11.4	4.8	8.4	3.0	12.0	30.6
92MN037 9/19/2017	9.9	0.0	0.0	0.0	35.2	2.5	4.3	1.9	11.7	35.6
Statewide average for Class 1 Southern River bio sites that are meeting the FIBI general use threshold (49)	**21.4**	**4.1**	**1.0**	**4.6**	**43.6**	**18.0**	**13.9**	**13.5**	**25.0**	**34.1**
Expected response to **Suspended Solids** stress	↓	↓	↓	↓	↓	↓	↓	↓	↓	↑

Table 361. Eutrophication related invert metrics for reach 07020006-503

07020006-503 Invert Class 5 General Use	Collector – filterer %	Plecoptera %	TSS TIV	TSS Intolerant %	TSS Tolerant %
17MN219 8/01/2017	44.6	0.6	24.9	0.3	88.9
Statewide average for Class 5 prairie stream rock riffle bio sites that are meeting the FIBI general use threshold (37)	**26.9**	**0.5**	**15.9**	↓	↑
Expected response to **Suspended Solids** stress	↓	↓	↑		

Table 362. Eutrophication related invert metrics for reach 07020006-503

07020006-503 **Invert Class 7** **General Use**	Collector – filterer %	Plecoptera %	TSS TIV	TSS Intolerant %	TSS Tolerant %
92MN037 8/01/2017	15.5	0.9	30.0	0.6	92.3
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI general use threshold (41)	**19.1**	**0.2**	**17.8**	↓	↑
Expected response to **Suspended Solids** stress	↓	↓	↑		

Table 363. Suspended solids related invert metrics for reach 07020006-503

07020006-503 **Invert Class 2** **General Use**	Collector – filterer %	Plecoptera %	TSS TIV	TSS Intolerant Taxa %	TSS Tolerant Taxa %
92MN041 8/02/2017	39.8	0.3	25.6	0.0	91.3
Statewide average for Class 2 Prairie Forest River bio sites that are meeting the FIBI general use threshold (31)	**22.9**	**0.6**	**18.4**	↓	↑
Expected response to **Suspended Solids** stress	↓	↓	↑		

TSS Monitoring Data

Table 364. Total suspended solids monitoring data for reach 07020006-503

07020006-503 TSS Sample Data	Range of Data (mg/L)	% of Monthly Samples > 65 mg/L [# of Samples]							% of Total Samples > 65 mg/L [# of Samples]
		April	May	June	July	August	Sept	Oct	
S013-687 **S013-688** **S013-690** **S014-365** (2010-2017)	38 - 97	-	-	-	100 [1]	0 [2]	0 [1]	-	25 [4]

Table 365. Transparency monitoring data for reach 07020006-503

07020001-503 Secchi Tube Data 10 cm target	Range of Data (cm)	% of Monthly Samples < 10 cm [# of Samples]							% of Total Samples < 10 cm [# of Samples]
		April	May	June	July	August	Sept	Oct	
S013-687 **S013-688** **S013-689** **S013-690** **S014-365** (2009-2017)	14 – 42	-	-	-	0 [1]	0 [9]	0 [1]	-	0 [11]

Table 366. TSS WPLMN monitoring and modeled data for site E27035001

E27035001 TSS WPLMN Sample & Model Data	Range (mg/L) [#]	% Values Above 65mg/L [# of Samples]											
		Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
S013-687 **S013-688** **S013-690** **S014-365** (2010-2017)	1 – 576 [4,018]	0 [341]	2.3 [311]	19.6 [341]	32.1 [330]	45.7 [341]	70.0 [330]	41.6 [341]	26.7 [341]	20.6 [330]	17.3 [341]	2.1 [330]	0 [341]
		Highest Value (mg/L)											
		13.7	121	576	264	527	532	227	380	261	357	139	53.4

Suspended Solids Summary

The fish community in reach 07020006-503 scored below average in most suspended solids related fish metrics when compared to the average of all other Class 1 southern river bio sites that meet the FIBI general use threshold (Table 360). There were some benthic feeders, long – lived, riffle dwelling, perciformes, and simple lithophilic spawners present though they were below the class average. The TSS TIV was right near the average at both of the bio sites.

Most of the invert metrics over the three bio sites scored poorly. Collector – filterer numbers were decent, especially at the upper and lower bio site. This mostly due to the relative abundance of the caddisflies cheumatopsyche and hydropsyche, which are both tolerant to TSS. All three bio sites were dominated by invertebrate taxa that are considered tolerant to TSS. There were some plectoptera at all of the bio sites, with the two upstream sites scoring above the average percentage, though there were only five collected throughout the entire reach.

Only four samples were collected and analyzed for TSS from 2010 through 2017. The sample collected in July had a TSS concentration above 65 mg/L (Table 364). The watershed pollutant load monitoring network has a long term monitoring site just downstream of this reach on the Redwood River. This site is monitored several times a month throughout the year and includes modeled data in between samples, which provides a good indication of what nitrate concentrations are on every day of the year. Data from 2010 through 2017 is shown in the table above (Table 366). There was a high percentage of values above 65mg/L in 9 out of the 12 months, with percentages well above the 10% threshold of the TSS standard.

Suspended solids appear to be having an effect on aquatic life. Both fish and invertebrate metrics are showing signs of stress and the dominance of taxa that are tolerant to TSS indicate that the biology is being negatively affected by suspended solids. WPLMN monitoring and modeled data indicate that the river sees very high concentrations of TSS throughout most of the year. TSS are a stressor to the biology in reach 07020006-503.

3.5.1.8   Nitrates

Nitrate Biological Metric Data

Table 367. Nitrate related invert metrics for reach 07020006-503

07020006-503 Invert Class 5 General Use	Trichoptera Taxa %	Nitrogen TIV	Nitrate Intolerant Taxa	Nitrogen Tolerant Taxa %
17MN219 8/01/2017	20.0	4.6	0.3	83.5
Statewide average for Class 5 prairie stream rock riffle bio sites that are meeting the FIBI general use threshold (37)	**13.6**	**3.0**	↓	↑
Expected response to **nitrogen** stress	↓	↑		

Table 368. Nitrate related invert metrics for reach 07020006-503

07020006-503 **Invert Class 7** General Use	Trichoptera Taxa %	Nitrogen TIV	Nitrate Intolerant	Nitrogen Tolerant Taxa %
92MN037 8/01/2017	17.2	5.6	0.9	66.6
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI general use threshold (41)	**10.9**	**3.2**	↓	↑
Expected response to **nitrogen** stress	↓	↑		

Table 369. Nitrate related invert metrics for reach 07020006-503

07020006-503 **Invert Class 2** General Use	Trichoptera Taxa %	Nitrogen TIV	Nitrate Intolerant	Nitrogen Tolerant Taxa %
92MN041 8/02/2017	22.6	4.6	0.0	71.5
Statewide average for Class 2 Prairie Forest River bio sites that are meeting the FIBI general use threshold (31)	**15.8**	**2.9**	↓	↑
Expected response to **nitrogen** stress	↓	↑		

Nitrate Monitoring Data

Table 370. Nitrate monitoring data for reach 07020006-503

07020006-503 Nitrate/Nitrite WPLMN Sample & Model Data	2x Highest Reach TIV Average	Range of Data (mg/L) [# of Samples]	Monthly Average [# of Samples]						
			April	May	June	July	August	Sept	Oct
S013-687 **S013-688** **S013-690** **S014-365** (2010-2017)	6.4	1 – 576 [4,018]	-	-	-	2.9 [1]	0.9 [2]	2.9 [1]	-
			Highest Value						
			-	-	-	2.9	1.1	2.9	-

Table 371. Nitrate WPLMN monitoring and modeled data for site E27035001

E27035001 Nitrate/Nitrite Sample Data	2x Highest Reach TIV Average	Range (mg/L) [#]	Monthly Average [# of Samples]											
			Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
S013-687 S013-688 S013-690 S014-365 (2010-2017)	6.4	0.2 – 16.8 [1,712]	6.7 [248]	6.2 [226]	5.5 [248]	4.8 [240]	7.0 [248]	8.7 [240]	4.6 [248]	2.8 [248]	3.3 [240]	4.3 [248]	5.5 [240]	7.0 [248]
			Highest Value											
			13.2	10.8	9.9	14.2	16.4	16.8	13.4	16.4	16.4	15.9	16.2	16.2

Summary

The macroinvertebrate assemblage in reach 07020006-503 scored poorly in most of the nitrate related metrics evaluated when compared to all other macroinvertebrate bio sites that meet the MIBI general use threshold (Table 367) (Table 368) (Table 369). The reach did have a healthy amount of Trichoptera taxa, which tend to decrease in streams with excessive nitrate values, though the taxa that had the most individuals present, cheumatopsyche and noctopsyche, are both considered tolerant to high nitrates. There was a high amount of nitrate tolerant invertebrates as well as almost a complete lack of nitrate intolerant invertebrate species throughout the reach. The nitrogen TIV scores also indicate a macroinvertebrate community that is generally tolerant to high levels of nitrates.

Only four samples were collected in reach 07020001-541 and analyzed for nitrate/nitrite during the IWM monitoring (Table 263). None of the total nitrate samples had concentrations greater than 6.4 mg/L. The watershed pollutant load monitoring network has a long term monitoring site just downstream of this reach on the Redwood River. This site is monitored several times a month throughout the year and includes modeled data in between samples, which provides a good indication of what nitrate concentrations are on every day of the year. Data from 2010 through 2017 is shown in the table above (Table 371). High concentrations of nitrate/nitrites were found throughout the entire year, with December, January, May, and June having high monthly averages above the 2X TIV average. Due to the poor biological invert metrics and high concentrations of nitrate/nitrite shown in the river, nitrates are a stressor to aquatic life in reach 07020006-503.

3.5.1.9   Reach Stressors

07020006-503	Hydrologic Alteration	Connectivity	Habitat	Dissolved Oxygen	Eutrophication	Suspended Solids	Nitrate
✔ = Stressor ✘ = Not a Stressor O = Inconclusive	✔	✘	✔	O	✔	✔	✔

3.5.2 07020006-560   Judicial Ditch 3
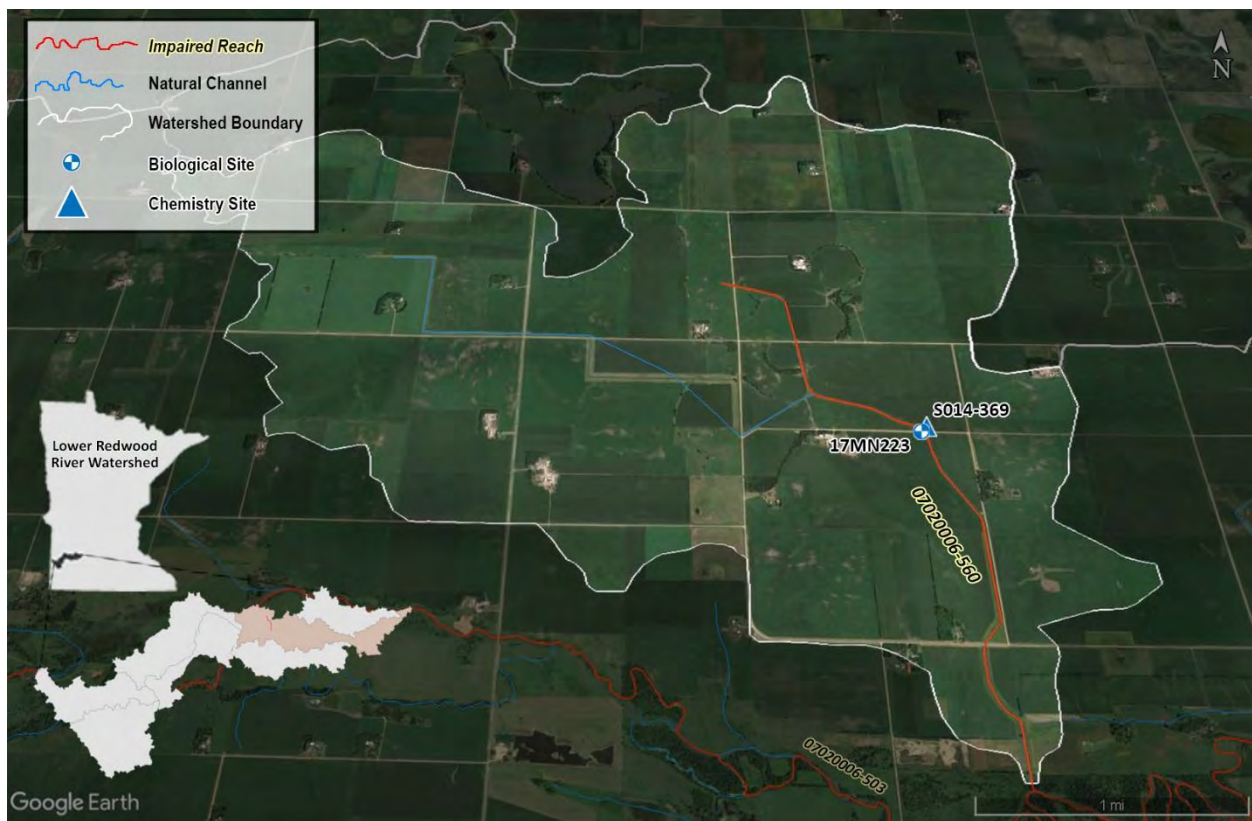
Figure 79. Satellite image of reach 07020006-560 and its watershed

3.5.2.1   Biological Community

Bio site 17MN223 was sampled once for inverts in 2017. The MIBI scores of 16.7 was below the invert class 7 southern prairie stream glide pool modified use threshold of 22 (Table 373). The midge dicrotendipes, the damselfly coenagrionidae, and physella snails dominated the bio community, all fairly tolerant species.

Biological Metric Data

Table 373. Invert IBI score and threshold for reach 07020006-560

07020006-560 **Invert Class 7** Modified Use	Invert IBI Score	Class Threshold Score
17MN223 8/01/2017	16.7	22

3.5.2.2   Hydrologic Alteration

Hydrologic Alteration Biological Metric Data

Table 374. Hydrologic alteration related invert metrics for reach 07020006-560

07020006-560 **Invert Class 7** Modified Use	Clinger %	Collector – filterer %	Long – lived %	Percent Ditched Intolerant %	Percent Ditched Tolerant %
17MN223 8/01/2017	13.8	7.4	0.3	0.0	72.6
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI modified use threshold (22)	**23.1**	**9.9**	**5.6**	↓	↑
Expected response to **Hydrologic** stress	↓	↓	↓		

HSPF Model Flow Data

Table 375. HSPF modeled flow data for reach 07020006-560

07020006-560 HSPF Reach 373 Min: 0.0 cfs Max: 248.6 cfs	<5 cfs % (# of values)	<1 cfs % (# of values)	<0.5 cfs % (# of values)
6,210 Total Daily Averages 1996 – 2012	**85.0%** (5,278)	**53.0%** (3,294)	**40.5%** (2,513)

Hydrologic Alteration Summary

The biological metrics all scored poorly when compared to the average of Class 7 streams bio sites that meet the MIBI modified use threshold (Table 374). There were some clingers present, though they were almost all midges. Collector – filterers were lower than average and there were very few long – lived invertebrates present. The percent of invertebrates that are considered tolerant to high percentage of ditching was very high and there were no invertebrates that are considered intolerant to ditching.

The HSPF model shows that 53% of the daily average flows from 1996 through 2012 are below 1 cfs while 85% of the flows are below 5 cfs (Table 375). It would appear that this reach has extensive low flow periods. It is likely that ditching and tiling within the watershed has caused the water to move through this system quickly, resulting in flashy hydrology and low flows.

Based on the very poor scores of the biological metrics, extended low flow periods shown in the HSPF model, Hydrologic Alteration is a stressor in this reach. The alteration of the stream channel itself, as well as drainage within the watershed, has changed the timing and delivery of water and nutrients, causing low flows during periods of low precipitation as well as eutrophication issues within the stream due to excess nutrients within the stream.

3.5.2.3   Connectivity

Connectivity Metric Data

Table 376. Connectivity related fish metrics for reach 07020006-560

07020006-560 **Fish Class 7** **Modified Use**	Mature Age >3 minus Tolerant Taxa %	Migrating Taxa %
17MN223 9/18/2017	11.1	11.1
Statewide average for Class 7 low gradient bio sites that are meeting the FIBI modified use threshold (15)	**8.7**	**13.4**
Expected response to **Connectivity** stress	↓	↓

Connectivity Summary

Metrics for fish taxa whose females take greater than three years to mature were above and migrating taxa were just below the class 7 average (Table 376). This was due to only one taxa present, the white sucker, and only one individual was actually caught.

The culvert near the bio site there is a culvert that is likely a fish barrier due to it being undersized, likely creating velocities that are barriers

Figure 80. Photo showing the undersized culvert near bio site 17MN223.

to fish migration upstream during high flows (Figure 80). Lateral, or side to side connectivity is likely a stressor as the channel is completely cut off from its flood plain and has very little depth variability throughout the ditch. Both lateral and longitudinal connectivity appear to be a stressor.

3.5.2.4   Habitat

Habitat Metric Data

Table 377. Habitat related invert metrics for reach 07020006-560

07020006-560 Invert Class 7 Modified Use	Burrower %	Climber %	Clinger %	Ephemeroptera Plecoptera Trichoptera %	Legless %	Sprawler %
17MN223 8/01/2017	43.6	36.5	13.8	1.3	67.6	4.8
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI modified use threshold (22)	**14.1**	**27.5**	**23.1**	**20.6**	**55.8**	**27.0**
Expected response to **Habitat** stress	↑	↓	↓	↓	↑	↑

MPCA Stream Habitat Assessment Score

Table 378. Habitat Assessment scores for reach 07020006-560

07020006-560	Land Use	Riparian	Substrate	Cover	Channel Morphology	Total Score
17MN223 8/1/2017	0	6	1	1	10	18
17MN223 9/18/2017	0	7	2	6	2	17
Maximum Attainable Habitat Score	**5**	**14**	**28**	**18**	**35**	**100**

Habitat Summary

The invert community in reach 07020006-560 scored below average in most of the habitat related invertebrate metrics when compared to all other Class 7 southern prairie stream glide pool bio sites that meet the MIBI general use threshold (Table 377). The percentage of burrowers was high as the midge

Figure 81. Photo taken in June, 2020 showing a ditched channel near bio site 17MN223.

dicrotendipes dominated the invertebrate community. Climbers scored decent due to the prevalence of the damselfly coenagrionidae, though there were some physella snails as well, which are also climbers. Almost all of the invertebrates present are considered tolerant to poor habitat metrics.

Both of the MSHA scores were very poor (Table 378). Severe embeddedness, heavy siltation, and muck were observed throughout the reach. There was very little coarse sediment present. Depth variability was low and channel morphology was very poor. The ditch was observed to be very deep and have very steep banks with muck up to the bio samplers' knees for most of the site (Figure 81).

Most of the habitat related invert metrics scored poorly and the majority of the invertebrates that were present are considered tolerant to most habitat metrics. The MSHA scores were very poor and the channel of the ditch has been highly modified and entrenched. Habitat is a stressor to the biological community.

3.5.2.5   Dissolved Oxygen

Dissolved Oxygen Biological Metric Data

07020006-560 Invert Class 7 Modified Use	DO TIV	HBI_MN	Low DO Intolerant Taxa %	Low DO Tolerant Taxa %
17MN223 8/01/2017	5.8	8.3	0.0	74.8
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI modified use threshold (22)	**6.2**	**8.0**	↓	↑
Expected response to **DO** stress	↓	↑		

Dissolved Oxygen Monitoring Data

07020006-560 DO Data 5 mg/L target	Range of Data (mg/L)	% of Monthly Samples < 5 mg/L [# of Samples]							May - Sep <5 mg/L % [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-369 (2017)	2.0 – 9.1	-	-	-	-	100% [1]	0% [1]	-	50% [2]
		Minimum Value							
		-	-	-	-	2.0	9.1	-	
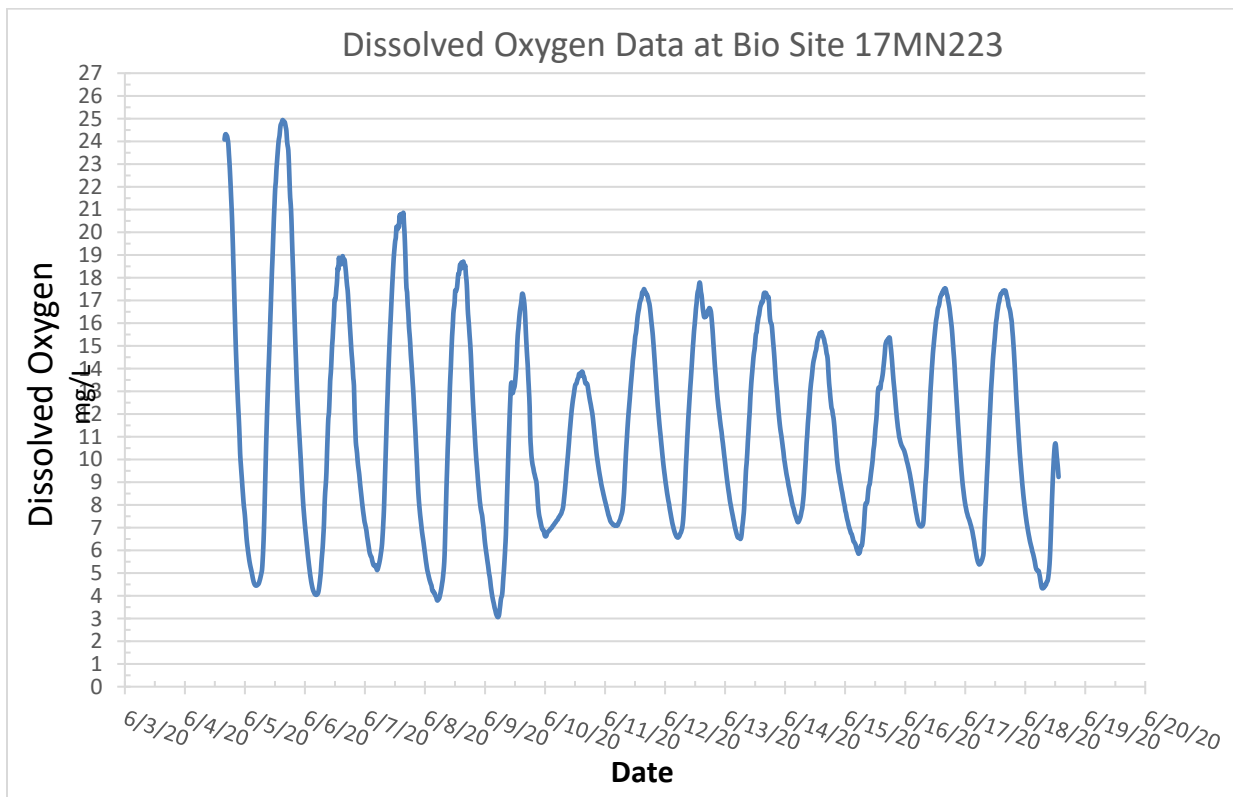
Figure 82. Continuous dissolved oxygen data at site 17MN223

Dissolved Oxygen Summary

The invert community at bio site 17MN223 scored poorly in all four DO related invert metrics (Table 379). There were no invert taxa present that are considered sensitive to low DO compared to 78% that are considered tolerant to low DO. The two most abundant inverts, the midge dicrotendipes and the damselfly coenagrionidae, made up over 64% of the total number of inverts caught and are both considered tolerant to DO.

Only two discreet DO measurements were taken during sampling in 2017 (Table 380). One was below the warmwater standard of 5 mg/L. An YSI Sonde water meter measured continuous DO data from 6/4/2020 to 6/18/2020 (Figure 82). During this deployment, DO values were measured below the standard 5 out of 15 days.

Based on the very poor invertebrate biological metric scores and the measured sonde values, DO is a stressor in this reach.

3.5.2.6   Eutrophication

Eutrophication Biological Metric Data

Table 381. Eutrophication related invert metrics for reach 07020006-560

07020006-560 **Invert Class 7** **Modified Use**	Crustacean and Mollusca %	Collector – Gatherer Taxa #	Ephemeroptera Plecoptera Trichoptera Taxa %	Intolerant Two Taxa %	Scraper %	Taxa Count All #	Tolerant Two Taxa %
17MN223 8/01/2017	13.5	7	12.5	0.0	8.3	24	95.8
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI modified use threshold (22)	**23.2**	**11.8**	**15.2**	**0.1**	**17.7**	**33.6**	**86.6**
Expected response to **Eutrophic** stress	↑	↓	↓	↓	↑	↓	↑

Eutrophication Monitoring Data

Table 382. Phosphorus monitoring data for reach 07020006-560

07020001-560 P Sample Data 0.15 mg/L target	Range of Data (mg/L)	Monthly Average of Samples (mg/L) [# of Samples]							June-Aug Average (mg/L) [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-369 (2017-2020)	0.163 - 0.192	-	-	0.163 [1]	-	-	0.117 [1]	-	0.163 [1]
		Maximum Value							
		-	-	0.163	-	-	0.192	-	

Table 383. DO% Saturation monitoring data for reach 07020006-560

07020006-560 DO% Sat Data	Range of Data (%)	Monthly Average of Samples (%) [# of Samples]							June-Aug Average (%) [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-369 (2017-2020)	22.3 – 103.5	-	-	159.2 [1]	-	22.3 [1]	105.3 [2]	-	90.8 [2]

Eutrophication Summary

The invertebrate community at bio site 17MN223 scored poorly in most of the eutrophication related invert metrics when compared to the average of all other Class 7 southern stream bio sites that meet the MIBI general use threshold. Collector – gatherer taxa and EPT taxa were low. There were no

Figure 83. Photo of bio site 17MN223 showing algae growth in June, 2020

intolerant species, taxa count was low, and almost all of the individuals present were tolerant species (Table 381).

Only three samples were collected and analyzed for Phosphorus from 2017-2020. The one summer value was above 0.15 mg/L (Table 372).

An YSI Sonde water meter measured continuous DO data from 7/6/2017 to 7/27/2017. During this deployment, diel DO flux was measured at or above 5 mg/L every night of deployment, and was actually around 20 mg/L the second night of deployment (Figure 82).

The biological community is showing the effects of the elevated phosphorus, phosphorus sampling showed elevated concentrations, and DO flux was very high. Algae growth was observed at the station (Figure 83). Eutrophication is a stressor in this reach.

3.5.2.7 Suspended Solids

Suspended Solids Biological Metric Data

Table 384. Suspended solids related invert metrics for reach 07020006-560

07020006-560 Invert Class 7 Modified Use	Collector – filterer %	Plecoptera %	TSS TIV	TSS Intolerant Taxa %	TSS Tolerant Taxa %
17MN223 8/01/2017	7.4	0.0	17.8	0.0	35.4
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI modified use threshold (22)	**9.9**	**0.0**	**16.2**	↓	↑
Expected response to **Suspended Solids** stress	↓	↓	↑		

TSS Monitoring Data

Table 385. Total suspended solids monitoring data for reach 07020006-560

07020006-560 TSS Sample Data	Range of Data (mg/L)	% of Monthly Samples > 65 mg/L [# of Samples]							% of Total Samples > 65 mg/L [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-369 (2017-2020)	18 - 20	-	-	0 [1]	-	-	0 [1]	-	0 [1]

Table 386. Transparency monitoring data for reach 07020006-560

07020001-560 Secchi Tube Data 10 cm target	Range of Data (cm)	% of Monthly Samples < 10 cm [# of Samples]							% of Total Samples < 10 cm [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-369 (2017-2020)	21 – 55	-	-	0 [1]	-	0 [1]	0 [1]	-	0 [3]

Suspended Solids Summary

The invertebrate community at bio site 17MN223 scored poorly in most of the suspended solids related invert metrics when compared to the average of all other Class 7 southern prairie stream glide pool bio sites that meet the MIBI modified use threshold (Table 384). Collector – filterers were low and were mostly the midge tanytarsus. There were no Plecoptera or TSS intolerant taxa present compared to a TSS tolerant taxa percentage of 35.4%. The TSS TIV score was also poor.

Only three samples were collected and analyzed for TSS from 2017 through 2020. No sample had a TSS concentration above 65 mg/L (Table 385). Transparency measurements were also relatively high (Table 386).

Suspended solids are inconclusive as a stressor to aquatic life at this time. It is likely that other factors, such as altered hydrology, habitat, and eutrophication are causing poor scores in the invertebrate biological metrics. It is recommended that more TSS data be collected during high flows in order to determine whether it is a biological stressor.

3.5.2.8   Nitrates

Nitrate Biological Metric Data

Table 387. Nitrate related invert metrics for reach 07020006-560

07020006-560 **Invert Class 7** Modified Use	Trichoptera Taxa %	Nitrogen TIV	Nitrate Intolerant	Nitrogen Tolerant Taxa %
17MN223 8/01/2017	4.2	3.7	0.0	55.1
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI modified use threshold (22)	**5.9**	**3.3**	↓	↑
Expected response to **nitrogen** stress	↓	↑		

Nitrate Monitoring Data

Table 388. Nitrate monitoring data for reach 07020006-560

07020006-560 Nitrate/Nitrite Sample Data	2x Highest Reach TIV Average	Range of Data (mg/L) [# of Samples]	Monthly Average [# of Samples]						
			April	May	June	July	August	Sept	Oct
S014-369 (2017-2020)	6.6	3.5 – 11 [4]	-	-	8.9 [2]	-	-	3.1 [2]	-
			Highest Value						
			-	-	11	-	-	3.5	-

Summary

The macroinvertebrate assemblage at site 17MN223 scored poorly in all of the nitrate related metrics evaluated when (Table 50). The biological bio site had very little Trichoptera taxa, which tend to decrease in streams with excessive nitrate values. The nitrogen TIV score was higher than the class average. There was a complete lack of nitrate intolerant invertebrate species and a relatively high amount of nitrate tolerant invertebrates. The most dominant invertebrate, the midge dicrotendipes, is considered tolerant to high nitrates.

Of the four nitrate/nitrite samples collected in reach 07020006-560, half of the total nitrate samples had concentrations greater than 6.6 mg/L (Table 388). The two higher sample values were in the month of June, which is when precipitation events can contribute to high levels of Nitrate/nitrite. Due to the biological response and relatively high nitrate concentrations, nitrates are a stressor to aquatic life in reach 07020006-560.

3.5.2.9   Reach Stressors

Table 389. Summary of stressors for reach 07020006-560

07020006-560	Hydrologic Alteration	Connectivity	Habitat	Dissolved Oxygen	Eutrophication	Suspended Solids	Nitrate
✔ = Stressor ✘ = Not a Stressor O = Inconclusive	✔	✔	O	✔	✔	O	✔

3.5.3 07020006-529   County Ditch 33
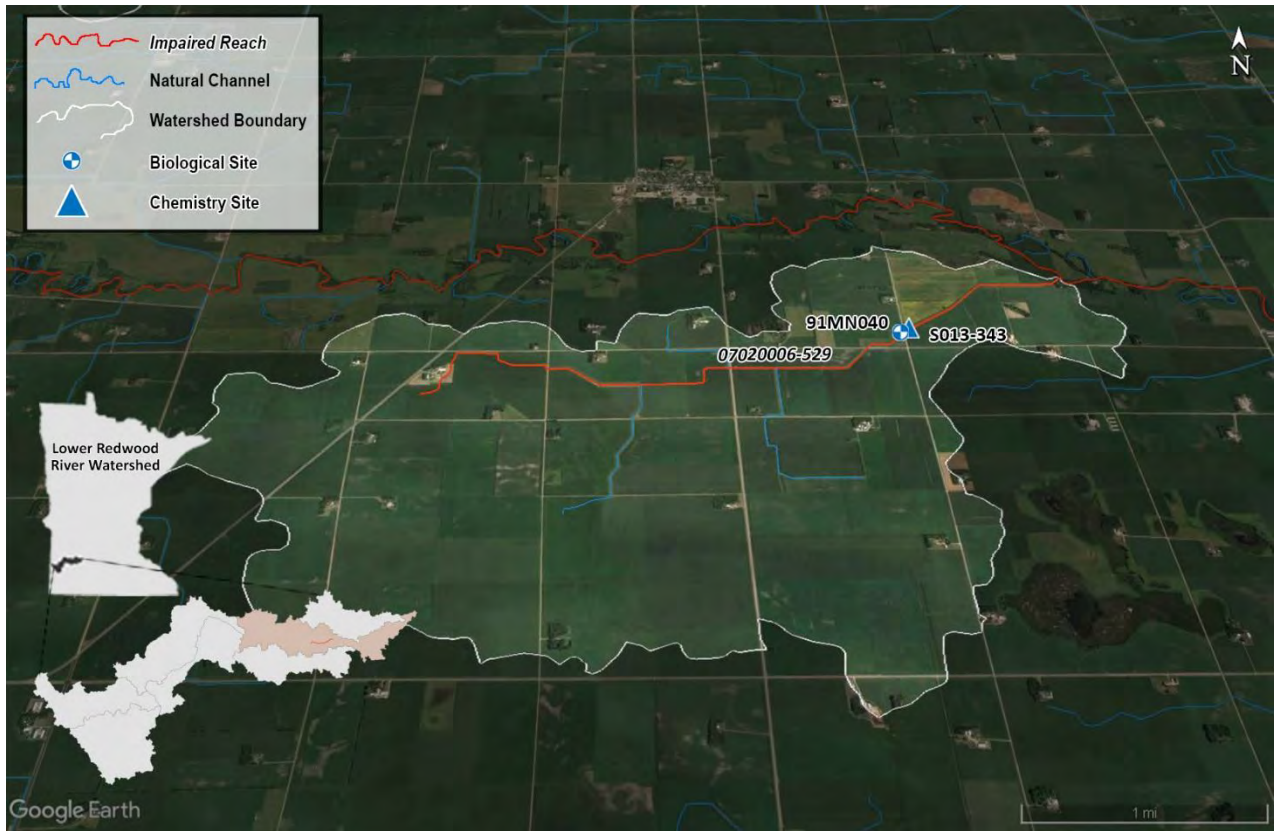
Figure 84. Satellite image of reach 07020006-529 and its watershed

3.5.3.1   Biological Community

Bio site 91MN040 was sampled once in 2017. The MIBI score of 22.3 was right at the modified use threshold of 22 and within the upper confidence interval (Table 390). The midges dicrotendipes, thienemannimyia, micropsectra, and zavrelimyia dominated the invert community as well as other short lived, legless, and tolerant taxa.

Biological Metric Data

Table 390. Invert IBI score and threshold for reach 07020006-529

07020006-529 **Invert Class 7** Modified Use	Invert IBI Score	Class Threshold Score
91MN040 8/01/2017	22.3	22

3.5.3.2   Hydrologic Alteration

Hydrologic Alteration Biological Metric Data

Table 391. Hydrologic alteration related invert metrics for reach 07020006-529

07020006-529 Invert Class 7 Modified Use	Clinger %	Collector – filterer %	Long – lived %	Percent Ditched Intolerant %	Percent Ditched Tolerant %
91MN040 8/01/2017	10.2	1.0	0.6	0.0	42.2
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI modified use threshold (22)	**23.1**	**9.9**	**5.6**	↓	↑
Expected response to **Hydrologic** stress	↓	↓	↓		

HSPF Model Flow Data

Table 392. HSPF modeled flow data for reach 07020006-529

07020006-529 HSPF Reach 411 Min: 0.0 cfs Max: 227.8 cfs	<5 cfs % (# of values)	<1 cfs % (# of values)	<0.5 cfs % (# of values)
6,210 Total Daily Averages 1996 – 2012	**82.9%** (5,149)	**48.3%** (2,997)	**29.3%** (1,819)

Hydrologic Alteration Summary

The biological metrics all scored poorly when compared to the average of Class 7 streams bio sites that meet the MIBI modified use threshold (Table 391). Clingers were low, with only thirteen paratanytarsus midges and nine hydoptila caddisflies caught. There were almost no

Figure 85. Photo showing ditched stream channel near bio site 91MN040

Collector – filterers or long – lived invertebrates caught. There were no invertebrates who are considered intolerant to ditching and ditch tolerant inverts comprised 42% of the total number of inverts caught, including the most dominant invert, dicrotendipes, which is considered very tolerant to ditched stream channels.

The HSPF shows that shows that more than 48% of the daily average flows from 1994 through 2012 were below 1 cfs (Table 392). Flows reduced beyond normal base flow will decrease habitat for aquatic organisms and increase competition for resources.

The channel itself has been extensively altered and shaped into a ditch. The ditch is very steep a deep, making for a very artificial stream channel shape.

Based on the very poor scores of the biological metrics, extended low flow periods shown in the HSPF model, and observations made during SID site visits, altered hydrology is a stressor in this reach. The alteration of the stream channel itself, as well as drainage within the watershed, has changed the timing and delivery of water and nutrients, causing low flows during periods of low precipitation as well as eutrophication issues within the stream due to excess nutrients within the stream.

3.5.3.3 Connectivity

Connectivity Metric Data

Table 393. Connectivity related fish metrics for reach 07020006-529

07020006-529 **Fish Class 3** Modified Use	Mature Age >3 minus Tolerant Taxa %	Migrating Taxa %
91MN040 9/20/2017	0.0	16.7
Statewide average for Class 3 prairie headwater bio sites that are meeting the FIBI modified use threshold (33)	**3.2**	**20.1**
Expected response to **Connectivity** stress	↓	↓

Connectivity Summary

Metrics for fish taxa whose females take greater than three years to mature were poor. There were no late maturing, nontolerant fish present. Migrating taxa were present and close to the class average, though there were only three white suckers and one Iowa darter that were caught.

Figure 86. Photo showing the culvert near bio site 91MN040

There culvert at the road crossing near bio site 91MN040 appears to be a fish barrier at low flows (Figure 86). This culvert is also relatively long and narrow, likely creating velocities that are barriers to fish migration upstream during high flows. Due to the poor metrics and very few migratory species present, it appears that connectivity is a stressor to reach 07020006-529.

3.5.3.4   Habitat

Habitat Metric Data

07020006-529 Invert Class 7 Modified Use	Burrower %	Climber %	Clinger %	Ephemeroptera Plecoptera Trichoptera %	Legless %	Sprawler %
91MN040 8/01/2017	35.1	16.6	10.2	3.8	77.0	21.7
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI modified use threshold (22)	**14.1**	**27.5**	**23.1**	**20.6**	**55.8**	**27.0**
Expected response to **Habitat** stress	↑	↓	↓	↓	↑	↑

MPCA Stream Habitat Assessment Score

07020006-529	Land Use	Riparian	Substrate	Cover	Channel Morphology	Total Score
91MN040 8/1/2017	0	4.5	1	11	6	22.5
91MN040 9/20/2017	0	11	13	12	6	42
Maximum Attainable Habitat Score	**5**	**14**	**28**	**18**	**35**	**100**

Habitat Summary

The invertebrate community in reach 07020006-529 scored poorly in most of the habitat related invert metrics when compared to all other Class 7 southern stream prairie glide pool bio sites that meet the MIBI modified use threshold (Table 394). Burrowing inverts were high and the most dominant invertebrate present was the midge dicrotendipes, which made up 33.5% of those burrowers. The percentage of climbers

Figure 87. Photo near bio site 91MN040 showing ditch and bank erosion just downstream of a culvert.

was low and most of those were the midge zavrelimyia. Clinger were also low, though there were a few hydroptila caddisflies present, though there were only nine caught. EPT percentage was low as well as there were only 12 individuals caught between the four caddisfly and mayfly taxa present. Legless inverts dominated the community and the third most abundant invert which had legs was the amphipod hyalella, generally considered a tolerant species that is also very tolerant to habitat specific metrics.

The MSHA scores were both poor (Table 395). The September assessment did score better than the August one, mostly due to differences in substrate and the riparian scores. During the September visit there were more substrate types observed, such as sand and clay, which brought the score up as well as a wider riparian width and low bank erosion.

Due to the poor biological metrics and MSHA scores, habitat is a stressor in this reach.

3.5.3.5   Dissolved Oxygen

Dissolved Oxygen Biological Metric Data

Table 396. Dissolved oxygen related invert metrics for reach 07020006-529

07020006-529 Invert Class 7 Modified Use	DO TIV	HBI_MN	Low DO Intolerant Taxa %	Low DO Tolerant Taxa %
91MN040 8/01/2017	6.3	7.9	0.0	55.2
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI modified use threshold (22)	**6.2**	**8.0**	↓	↑
Expected response to **DO** stress	↓	↑		

Dissolved Oxygen Monitoring Data

Table 397. Dissolved oxygen monitoring data for reach 07020006-529

07020006-529 DO Data 5 mg/L target	Range of Data (mg/L)	% of Monthly Samples < 5 mg/L [# of Samples]							May - Sep <5 mg/L % [# of Samples]
		April	May	June	July	August	Sept	Oct	
S013-643 (2009-2017)	2.2 – 12.0	-	-	-	-	100% [2]	0% [1]	-	67% [3]
		Minimum Value							
		-	-	-	-	2.2	12.0	-	

Dissolved Oxygen Summary

The DO related metrics at bio site 91MN040 were mixed, though both the TIV score and HBI_MN scores just barely scored above and below the class averages respectively (Table 396). There were no DO intolerant taxa caught and DO tolerant species comprised over 55% of the invert population and the most abundant invertebrate caught, dicrotendipes, is considered tolerant to low DO.

Of the three DO measurements taken during sampling, two of them were below the warmwater standard of 5 mg/L, none of those measurements were taken before 8:00 a.m., when values are usually the lowest.

Based on the related invertebrate biological metric scores and the measured DO values, DO is a stressor in this reach.

3.5.3.6   Eutrophication

Eutrophication Biological Metric Data

Table 398. Eutrophication related invert metrics for reach 07020006-529

07020006-529 **Invert Class 7** Modified Use	Crustacean and Mollusca %	Collector – Gatherer Taxa #	Ephemeroptera Plecoptera Trichoptera Taxa %	Intolerant Two Taxa %	Scraper %	Taxa Count All #	Tolerant Two Taxa %
91MN040 8/01/2017	16.9	10	3.8	0.0	2.6	21	95.2
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI modified use threshold (22)	**23.2**	**11.8**	**15.2**	**0.1**	**17.7**	**33.6**	**86.6**
Expected response to **Eutrophic** stress	↑	↓	↓	↓	↑	↓	↑

Eutrophication Monitoring Data

Table 399. Phosphorus monitoring data for reach 07020006-529

07020001-529 P Sample Data 0.150 mg/L target	Range of Data (mg/L)	Monthly Average of Samples (mg/L) [# of Samples]							June-Aug Average (mg/L) [# of Samples]
		April	May	June	July	August	Sept	Oct	
S013-643 (2017-2020)	0.095 – 0.158	-	-	0.158 [1]	-	-	0.098 [2]	-	0.158 [1]
		Maximum Value							
		-	-	0.158	-	-	0.095	-	

Table 400. DO% Saturation monitoring data for reach 07020006-529

07020006-529 DO% Sat Data	Range of Data (%)	Monthly Average of Samples (%) [# of Samples]							June-Aug Average (%) [# of Samples]
		April	May	June	July	August	Sept	Oct	
S013-643 (2017-2020)	25.8 – 137.7	-	-	89.7 [1]	-	25.8 [1]	137.7 [1]	-	57.8 [2]

Eutrophication Summary

The invertebrate community at bio site 91MN040 scored below average in all but two habitat related metric when compared to the average of all other Class 7 southern prairie stream glide pool bio sites that meet the MIBI modified use threshold (Table 398). Crustacean and Mollusca percentage and scraper percentage were the only metrics to score well. Collector – gatherer taxa count was just below the class average and EPT taxa were very low. There were no intolerant taxa present and total taxa count was only 21. The two most numerous tolerant taxa dominated the bio site with over 95% of the population.

Three samples were collected and analyzed for Phosphorus from 2017 through 2020. There was only one sample collected during the summer months and it was just above the standard of 0.15 mg/L (Table 399).

The biological community is showing the effects of the elevated phosphorus, the limited phosphorus sampling was mixed. Although the biological community appears to be stressed by eutrophication there is not enough data to call it a stressor. Eutrophication is inconclusive as a stressor in this reach.

3.5.3.7   Suspended Solids

Suspended Solids Biological Metric Data

Table 401. Suspended solids related invert metrics for reach 07020006-529

07020006-529 **Invert Class 7** **Modified Use**	Collector – filterer %	Plecoptera %	TSS TIV	TSS Intolerant Taxa %	TSS Tolerant Taxa %
91MN040 8/01/2017	1.0	0.0	14.1	0.0	4.1
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI modified use threshold (22)	**9.9**	**0.0**	**16.2**	↓	↑
Expected response to **Suspended Solids** stress	↓	↓	↑		

TSS Monitoring Data

Table 402. Total suspended solids monitoring data for reach 07020006-529

07020006-529 TSS Sample Data	Range of Data (mg/L)	% of Monthly Samples > 65 mg/L [# of Samples]							% of Total Samples > 65 mg/L [# of Samples]
		April	May	June	July	August	Sept	Oct	
S013-643 (2017)	4.4 – 5.2	-	-	-	-	-	0 [2]	-	0 [2]

Table 403. Transparency monitoring data for reach 07020006-529

07020001-529 Secchi Tube Data 10 cm target	Range of Data (mg/L)	% of Monthly Samples < 10 cm [# of Samples]							% of Total Samples < 10 cm [# of Samples]
		April	May	June	July	August	Sept	Oct	
S013-643 (2009-2017)	100+	-	-	-	-	0 [2]	0 [1]	-	0 [3]

Suspended Solids Summary

The suspended solids related invertebrate metrics at bio site 91MN040 were mixed when compared to the average of all other Class 7 southern prairie stream glide pool bio sites that meet the MIBI modified use threshold (Table 401). Collector – filterers were very low and no Plecoptera were present in the ditch. TSS specific metrics scored better; however, as the TSS TIV score was below the class average and although there were no TSS intolerant taxa present, TSS tolerant taxa were relatively low.

Only two samples were collected and analyzed for TSS in 2017. No sample had a TSS concentration above 65 mg/L (Table 402). Transparency data was also good (Table 403).

Suspended solids are inconclusive as a stressor to aquatic life at this time. It is likely that other factors, such as altered hydrology or habitat are causing poor scores in the fish biological metrics. It is recommended that more TSS data be collected during high flows in order to determine whether it is a biological stressor.

3.5.3.8   Nitrates

Nitrate Biological Metric Data

Table 404. Nitrate related invert metrics for reach 07020006-529

07020006-529 **Invert Class 7** Modified Use	Trichoptera Taxa %	Nitrogen TIV	Nitrate Intolerant	Nitrogen Tolerant Taxa %
91MN040 8/01/2017	9.5	4.0	0.0	81.0
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI modified use threshold (22)	**5.9**	**3.3**	↓	↑
Expected response to **nitrogen** stress	↓	↑		

Nitrate Monitoring Data

Table 405. Nitrate monitoring data for reach 07020006-529

07020001-529 Nitrate/Nitrite Sample Data	2x Highest Reach TIV Average	Range of Data (mg/L) [# of Samples]	Monthly Average [# of Samples]						
			April	May	June	July	August	Sept	Oct
S013-643 (2017)	6.6	9.0 – 11 [3]	-	-	11 [1]	-	-	9.1 [2]	-
			Highest Value						
			-	-	11	-	-	9.2	-

Summary

The macroinvertebrate assemblage at site 91MN040 scored below average in three of the four nitrate related metrics evaluated when compared to all other macroinvertebrate Class 7 bio sites that meet the MIBI modified use threshold (Table 404). The biological bio site did show a healthy amount of Trichoptera taxa, which tend to decrease in streams with excessive nitrate values; however, this was due to the nine Hydroptila caddislies caught, which is considered tolerant of nitrates. The majority of the invertebrates caught are considered very tolerant to nitrates and there were no nitrate intolerant invertebrate taxa present. The nitrogen TIV score also indicates a macroinvertebrate community that is generally tolerant to high levels of nitrates.

Three samples were collected in the reach and analyzed for nitrate/nitrite (Table 405). All of the nitrate samples had concentrations greater than 6.6 mg/L. Due to the biological response and relatively high nitrate concentrations, nitrates are a stressor to aquatic life in reach 0702006-529.

3.5.3.9   Reach Stressors

Table 406. Summary of stressors for reach 07020006-529

07020006-529	Hydrologic Alteration	Connectivity	Habitat	Dissolved Oxygen	Eutrophication	Suspended Solids	Nitrate
✔ = Stressor ✘ = Not a Stressor O = Inconclusive	✔	✔	✔	✔	O	O	✔

3.5.4 07020006-509   Redwood River
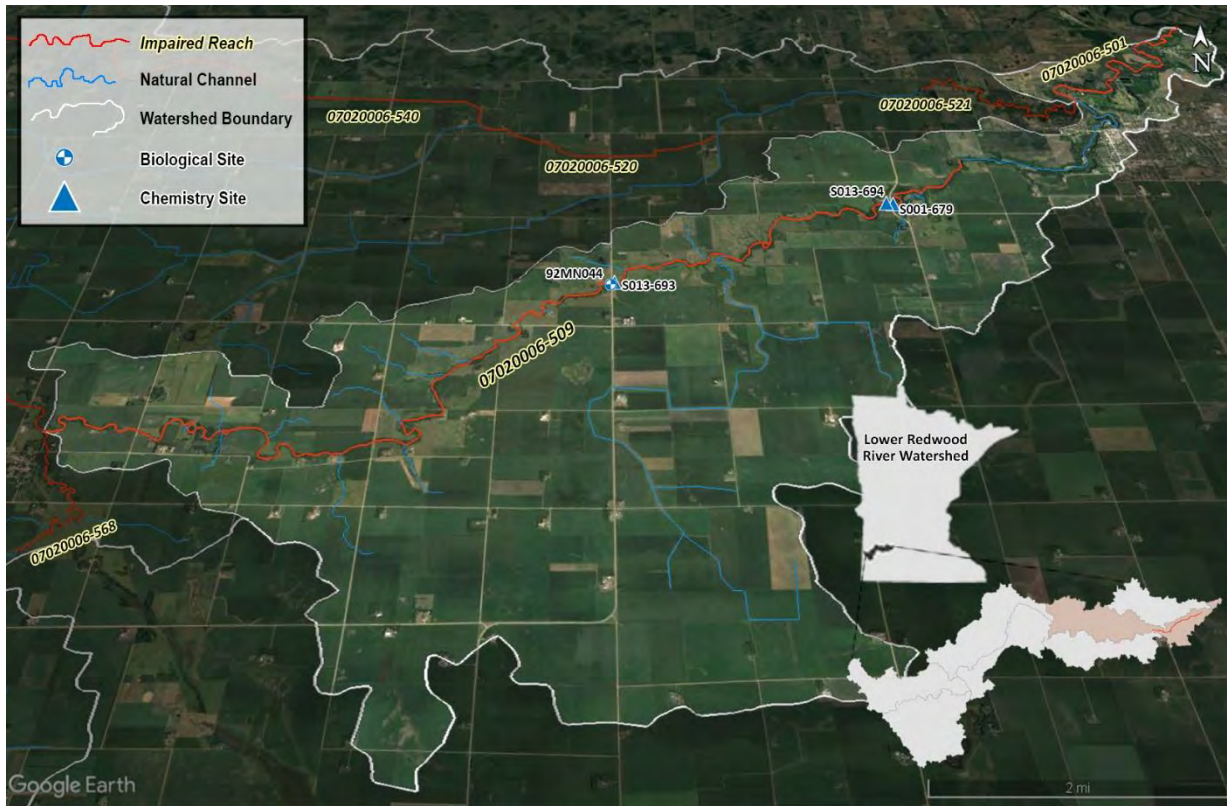
Figure 88. Satellite image of reach 07020006-509 and its watershed

3.5.4.1   Biological Community

Reach 07020006-509 is the main stem of the Redwood River and is impaired for fish from a site visit in 2010. The FIBI score of 28.8 was below the Fish Class 1 southern river general use threshold of 49 (Table 407). Sand shiners and bluntnose minnows dominated the fish community and comprised over 70% of the total number of fish caught. Both are tolerant, fast maturing taxa. There were also some common shiners and northern hogsuckers present, the latter being a sensitive species.

Biological Metric Data

Table 407. Fish IBI score and threshold for reach 07020006-509

07020006-509 Fish Class 1 General Use	Fish IBI Score	Class Threshold Score
92MN044 8/30/2010	28.8	49

3.5.4.2   Hydrologic Alteration

Hydrologic Alteration Biological Metric Data

Table 408. Hydrologic alteration related fish metrics for reach 07020006-509

07020006-509 **Fish Class 1** General Use	General %	Nesting Non Lithophilic Spawner %
92MN044 8/30/2010	37.6	32.5
Statewide average for Class 1 Southern River bio sites that are meeting the FIBI general use threshold (49)	**20.7**	**16.0**
Expected response to **Hydrologic** stress	↑	↑

HSPF Model Flow Data

Table 409. HSPF modeled flow data for reach 07020006-509

07020006-509 HSPF Reach 470 Min: 6.6 cfs Max: 8,676 cfs	<10 cfs % (# of values)	<5 cfs % (# of values)	<1 cfs % (# of values)
6,210 Total Daily Averages 1996 – 2012	**4.4%** (276)	**0.0%** (0)	**0.0%** (0)

Hydrologic Alteration Summary

Both altered hydrology biological metrics scored poorly when compared to the average of Class 1 bio sites that meet the FIBI general use threshold (Table 408). Generalized fish species are correlated with channelization and are adaptable to different habitats through generalized food preferences. Bio site 92MN044 had a generalist fish percentage of 37.6%, above the class average of 20.7%. The 32.5% of nesting fish was also about double the class average

The HSPF model shows none of the daily average flows from 1994 through 2012 are below 5 cfs, which is to be expected of a main stem river. The percentage of daily average flows below 10 cfs were only 4.4%.

Based on the mixed data sets and lack of recent biological or geomorphic data, hydrologic alteration is inconclusive as a stressor in this reach.

3.5.4.3 Connectivity

Connectivity Metric Data

Table 410. Connectivity related fish metrics for reach 07020006-509

07020006-509 **Fish Class 1** General Use	Mature Age >3 minus Tolerant Taxa %	Migrating Taxa %
92MN044 8/30/2010	23.8	28.6
Statewide average for Class 1 Southern River bio sites that are meeting the FIBI general use threshold (49)	**41.5**	**30.7**
Expected response to **Connectivity** stress	↓	↓

Connectivity Summary

Metrics for fish taxa whose females take greater than three years to mature were low, though there were 24 northern hogsuckers present, which are a sensitive late-maturing species. Migrating taxa percentage was close to the class average, though the numbers of migrating fish that were caught were only 7.3% of the total (Table 410).

The biological metrics scored poorly, though there were some migrating fish present. Connectivity is inconclusive to the biological community in reach 07020006-509.

3.5.4.4   Habitat

Habitat Metric Data

Table 411. Habitat related fish metrics for reach 07020006-509

07020006-509 **Fish Class 1** **General Use**	Benthic Insect minus Tolerant %	Darter Sculpin Sucker %	Lithophilic Spawner %	Pioneer %	Piscivore %	Riffle %	Simple Lithophilic Spawner %	Tolerant %
92MN044 8/30/2010	12.9	11.4	20.6	29.4	2.2	8.3	18.7	75.0
Statewide average for Class 1 Southern River bio sites that are meeting the FIBI general use threshold (49)	**20.6**	**18.5**	**29.2**	**5.2**	**15.2**	**14.0**	**25.0**	**22.1**
Expected response to Habitat stress	↓	↓	↓	↑	↓	↓	↓	↑

MPCA Stream Habitat Assessment Score

Table 412. Habitat Assessment scores for reach 07020006-509

07020006-509	Land Use	Riparian	Substrate	Cover	Channel Morphology	Total Score
92MN044 8/30/2010	0	9.5	19.1	12	33	73.6
Maximum Attainable Habitat Score	**5**	**15**	**27**	**17**	**36**	**100**

Habitat Summary

The fish community in reach 07020006-509 scored poorly in all eight habitat related fish metrics when compared to all other Class 1 southern river bio sites that meet the FIBI general use threshold (Table 411). There were; however some numbers of benthic insectivores, darters, lithophilic spawners, and riffle dwelling fish. There were very few piscivores present and tolerant fish percentage was very high as both sand shiners and bluntnose minnows, the two most abundant taxa present, dominated the fish community.

The MSHA score was good (Table 412). The river had little to moderate bank erosion at the bio site. The instream zone appears to have adequate habitat as several types and sizes of substrate were present and silt was low. Embeddedness of coarse substrates was low as well. The channel morphology was well developed with different types of habitat and depth variability present.

Every fish habitat related fish metric scored poorly compared to the average for Class 1 streams. The habitat score was pretty good, however. It would appear that there is adequate habitat for fish at the bio site and it is likely other stressors are having an effect on the bio community. Habitat is inconclusive as a stressor at this time.

3.5.4.5   Dissolved Oxygen

Dissolved Oxygen Biological Metric Data

Table 413. Dissolved oxygen related fish metrics for reach 07020006-509

07020006-509 Fish Class 1 General Use	Mature Age >3 %	Serial Spawner %	Taxa Count	DO TIV	DO Sensitive %	DO Tolerant %
92MN044 8/30/2010	11.2	75.5	21	8.8	0.0	3.4
Statewide average for Class 1 Southern River bio sites that are meeting the FIBI general use threshold (49)	**40.4**	**35.6**	**21.6**	**8.6**	↓	↑
Expected response to **DO** stress	↓	↑	↓	↓		

Dissolved Oxygen Monitoring Data

Table 414. Dissolved oxygen monitoring data for reach 07020006-509

07020006-509 DO Data 5 mg/L target	Range of Data (mg/L)	% of Monthly Samples < 5 mg/L [# of Samples]							May - Sep <5 mg/L % [# of Samples]
		April	May	June	July	August	Sept	Oct	
S001-679 **S013-693** **S013-694** (2009-2018)	4.9 – 18.7	0% [32]	0% [37]	0% [47]	3.1% [32]	0% [20]	0% [27]	0% [33]	0.4% [228]
		Minimum Value							
		8.9	7.1	5.2	4.9	6.6	7.0	7.7	

Dissolved Oxygen Summary

The fish community at bio site 92MN044 were mixed (Table 413). Species with females that take more than three years to mature comprised only 11.2%, well below class average. The two most abundant species, sand shiners and bluntnose minnows are both fast maturing and serial spawners. Taxa count was 21, right at the class average. The DO TIV was pretty good and was just above the class average,

there were no DO sensitive fish caught though the DO tolerant percentage was only 3.4%. Overall most of the fish caught are neither tolerant nor sensitive to low DO.

There were a few DO measurements taken during sampling that were below the warmwater standard of 5 mg/L (Table 414). Out of the 228 measurements only 0.4% were low. A sonde was deployed in the adjacent upstream reach, 07020006-503 in September of 2020 (Figure 78). It is likely that the conditions just upstream are similar to the conditions in reach 07020006-509. During the deployment the measured DO values did not fall below 5 mg/L.

Due to the mixed related fish biological metric scores and relatively good measured values, DO is inconclusive as a stressor in this reach.

3.5.4.6   Eutrophication

Eutrophication Biological Metric Data

Table 415. Eutrophication related fish metrics for reach 07020006-509

07020006-509 **Fish Class 1** General Use	Darter %	Omnivore %	Sensitive %	Simple Lithophillic Spawner %	Tolerant %
92MN044 8/30/2010	2.4	1.7	5.8	18.7	75.0
Statewide average for Class 1 Southern River bio sites that are meeting the FIBI general use threshold (49)	**4.4**	**15.2**	**13.5**	**25.0**	**22.1**
Expected response to **Eutrophication** stress	↓	↑	↓	↓	↑

Eutrophication Monitoring Data

Table 416. Phosphorus monitoring data for reach 07020006-509

07020001-509 P Sample Data 0.150 mg/L target	Range of Data (mg/L)	Monthly Average of Samples (mg/L) [# of Samples]							June-Aug Average (mg/L) [# of Samples]
		April	May	June	July	August	Sept	Oct	
S001-679 (2009-2019)	0.051 – 1.280	0.373 [37]	0.348 [47]	0.409 [63]	0.371 [40]	0.392 [33]	0.384 [46]	0.625 [31]	0.394 [136]
		Maximum Value							
		0.917	1.280	0.802	0.702	0.780	0.796	1.280	

Table 417. DO% Saturation monitoring data for reach 07020006-509

07020006-509 DO% Sat Data	Range of Data (%)	Monthly Average of Samples (%) [# of Samples]							June-Aug Average (%) [# of Samples]
		April	May	June	July	August	Sept	Oct	
S001-679 **S013-694** (2015-2018)	83.6 – 186.2	134.9 [2]	-	-	89.6 [2]	113.0 [1]		94.8 [2]	97.4 [3]

Eutrophication Summary

The fish community at bio site 92MN044 scored poorly in most eutrophication related fish metrics when compared to the average of all other Class 1 southern river bio sites that meet the FIBI general use threshold (Table 415). The abundance of darter individuals was low, sensitive fish were only 5.8% of the population, simple lithophilic spawning fish were below the class average. Tolerant fish made up 75% of the total number of fish caught as the two most abundant species, the sand shiner and bluntnose minnow, are both considered tolerant. The percentage of omnivorous fish was very low; however, and only comprised 1.7% of the population.

One hundred thirty-six samples were collected and analyzed for Phosphorus from 2009 through 2019. The summer average was over twice the standard of 0.15 mg/L (Table 416). During site visits from 2015 to 2018 the percent saturation of oxygen was high during both April and August visits as all three of the measurements were above 100% (Table 417).

A sonde was deployed in the adjacent upstream reach, 07020006-503 in September of 2020 (Figure 78). It is likely that the conditions just upstream are similar to the conditions in reach 07020006-509. During this deployment, diel DO flux was measured at or above 5 mg/L several times, especially during the first half of the sonde deployment. The temperature dropped 20 to 30 degrees from the beginning to the end of the week and over an inch and a half of rainfall on the September 7 likely had an effect on the DO flux the remainder of the deployment. It appears that DO flux is an issue in the reach when conditions are right as the excessive phosphorus concentrations in the water triggers DO diurnal fluctuations.

The biological community is showing the effects of the elevated phosphorus, phosphorus sampling showed elevated concentrations, and DO flux in the upstream reach was 5 mg/L or greater. Eutrophication is likely a stressor in this reach though at this time it is inconclusive.

3.5.4.7   Suspended Solids

Suspended Solids Biological Metric Data

Table 418. Suspended solids related fish metrics for reach 07020006-509

07020006-509 Fish Class 1 General Use	Benthic Feeder %	Centrarchid - Tolerant %	Herbivore %	Intolerant %	Long – lived %	Perciformes - Tolerant %	Riffle %	Sensitive %	Simple Lithophilic Spawner %	TSS TIV
92MN044 8/30/2010	11.9	0.2	1.9	0.0	10.4	2.7	8.3	5.8	18.7	26.5
Statewide average for Class 1 Southern River bio sites that are meeting the FIBI general use threshold (49)	**21.4**	**4.1**	**1.0**	**4.6**	**43.6**	**18.0**	**13.9**	**13.5**	**25.0**	**34.1**
Expected response to **Suspended Solids** stress	↓	↓	↓	↓	↓	↓	↓	↓	↓	↑

TSS Monitoring Data

Table 419. Total suspended solids monitoring data for reach 07020006-509

07020006-509 TSS Sample Data	Range of Data (mg/L)	% of Monthly Samples > 65 mg/L [# of Samples]							% of Total Samples > 65 mg/L [# of Samples]
		April	May	June	July	August	Sept	Oct	
S001-679 S013-693 (2001-2019)	9 – 532	33.3 [39]	14.3 [49]	84.4 [64]	62.0 [42]	45.7 [35]	47.8 [46]	33.3 [33]	54.2 [308]

Table 420. Transparency monitoring data for reach 07020006-509

07020001-509 Secchi Tube Data 10 cm target	Range of Data (mg/L)	% of Monthly Samples < 10 cm [# of Samples]							% of Total Samples < 10 cm [# of Samples]
		April	May	June	July	August	Sept	Oct	
S001-679 S013-693 S013-694 (2001-2019)	3 – 86	7.7 [39]	14.3 [49]	38.1 [63]	11.6 [43]	11.8 [34]	15.4 [39]	9.7 [31]	17.4 [298]

Table 421. TSS WPLMN monitoring and modeled data for site E27035001

E27035001 TSS WPLMN Sample & Model Data	Range (mg/L) [#]	% Values Above 65mg/L [# of Samples]											
		Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
S013-687 **S013-688** **S013-690** **S014-365** (2010-2017)	1 – 576 [4,018]	0 [341]	2.3 [311]	19.6 [341]	32.1 [330]	45.7 [341]	70.0 [330]	41.6 [341]	26.7 [341]	20.6 [330]	17.3 [341]	2.1 [330]	0 [341]
		Highest Value (mg/L)											
		13.7	121	576	264	527	532	227	380	261	357	139	53.4

Suspended Solids Summary

The fish community at bio site 92MN044 scored below average in 8 of the 10 suspended solids related fish metrics when compared to the average of all other Class 1 southern river bio sites that meet the FIBI general use threshold (Table 418). There were some benthic feeders, though the percentage was half the class average. Centrarchids were very low and there were no intolerant fish caught. Long – lived fish and perciformes were well below the class average. Riffle dwelling fish, sensitive fish, and riffle dwelling fish were present though they were below the class average. The two metrics that scored well were herbivores and the TSS tolerance index value, though herbivore was only about 1% above the class average.

TSS data was poor. Three hundred-eight samples were collected and analyzed for TSS from 2001 through 2019. Fifty-four percent of the total samples were above the TSS concentration standard of 65 mg/L and every month also had a relatively high percentage exceedance (Table 419). Transparency data was also poor as 17% of the total number of readings taken were below 10cm (Table 420). May through June's percentages of readings below 10cm was also relatively high. The watershed pollutant load monitoring network has a long term monitoring site just downstream of this reach on the Redwood River. This site is monitored several times a month throughout the year and includes modeled data in between samples, which provides a good indication of what nitrate concentrations are on every day of the year. Data from 2010 through 2017 is shown in the table above (Table 421). There was a high percentage of values above 65mg/L in 9 out of the 12 months, with percentages well above the 10% threshold of the TSS standard.

The bio metrics, TSS data, transparency data, and WPLMN data are all poor. Suspended solids appear to be a stressor to the biological community in reach 07020006-509.

3.5.4.8   Nitrates

Nitrate Biological Metric Data

Table 422. Nitrate related invert metrics for reach 07020006-509

07020006-509 **Invert Class 2** General Use	Nitrate Intolerant Taxa %	Nitrogen Tolerant Taxa %	Trichoptera Taxa %	Nitrogen TIV
92MN044 8/02/2010	0.0	84.3	12.5	3.8
92MN045 8/08/2017	0.0	56.9	20.0	3.5
Statewide average for Class 2 Prairie Forest River bio sites that are meeting the MIBI general use threshold (31)	**4.4**	**46.8**	**15.8**	**2.9**
Expected response to **nitrogen** stress	↓	↑	↓	↑

Nitrate Monitoring Data

Table 423. Nitrate monitoring data for reach 07020006-509

07020001-509 Nitrate/Nitrite Sample Data	2x Highest Reach TIV Average	Range of Data (mg/L) [# of Samples]	Monthly Average [# of Samples]						
			April	May	June	July	August	Sept	Oct
S013-643 (2001-2019)	5.8	0.2 – 16.9 [276]	6.0 [36]	6.9 [46]	6.9 [64]	4.9 [38]	3.8 [28]	4.8 [34]	5.3 [30]
			Highest Value						
			13.6	16.1	16.2	13.4	16.9	16.4	15.9

Summary

The macroinvertebrate assemblage in reach 07020006-509 scored below average in most of the four nitrate related metrics evaluated when compared to all other macroinvertebrate Class 2 streams bio sites that meet the MIBI general use threshold (Table 422). Bio site 92MN044 was sampled in 2010 and every metric scored poorly and the two dominant inverts, the mayfly tricorythodes and the midge polypedilum are both considered very tolerant to nitrates. Bio site 92MN045 was sampled more recently in 2017. The metrics were mostly poor as there were some ceratopsyche caddisflies present, though the site was dominated by the midge polypedilum.

Two hundred seventy-six samples were collected in reach 07020006-509 and analyzed for nitrate/nitrite (Table 423). Very high concentrations were measured in every month from April to October. The monthly averages of April, May, and June were high.

Due to the biological response and relatively high nitrate concentrations, nitrates are a stressor to aquatic life in reach 07020006-509.

3.5.4.9   Reach Stressors

Table 424. Summary of stressors for reach 07020006-509

07020006-509 ✔ = Stressor ✗ = Not a Stressor O = Inconclusive	Hydrologic Alteration	Connectivity	Habitat	Dissolved Oxygen	Eutrophication	Suspended Solids	Nitrate
	O	O	O	O	O	✔	✔

3.5.5   07020006-501   Redwood River
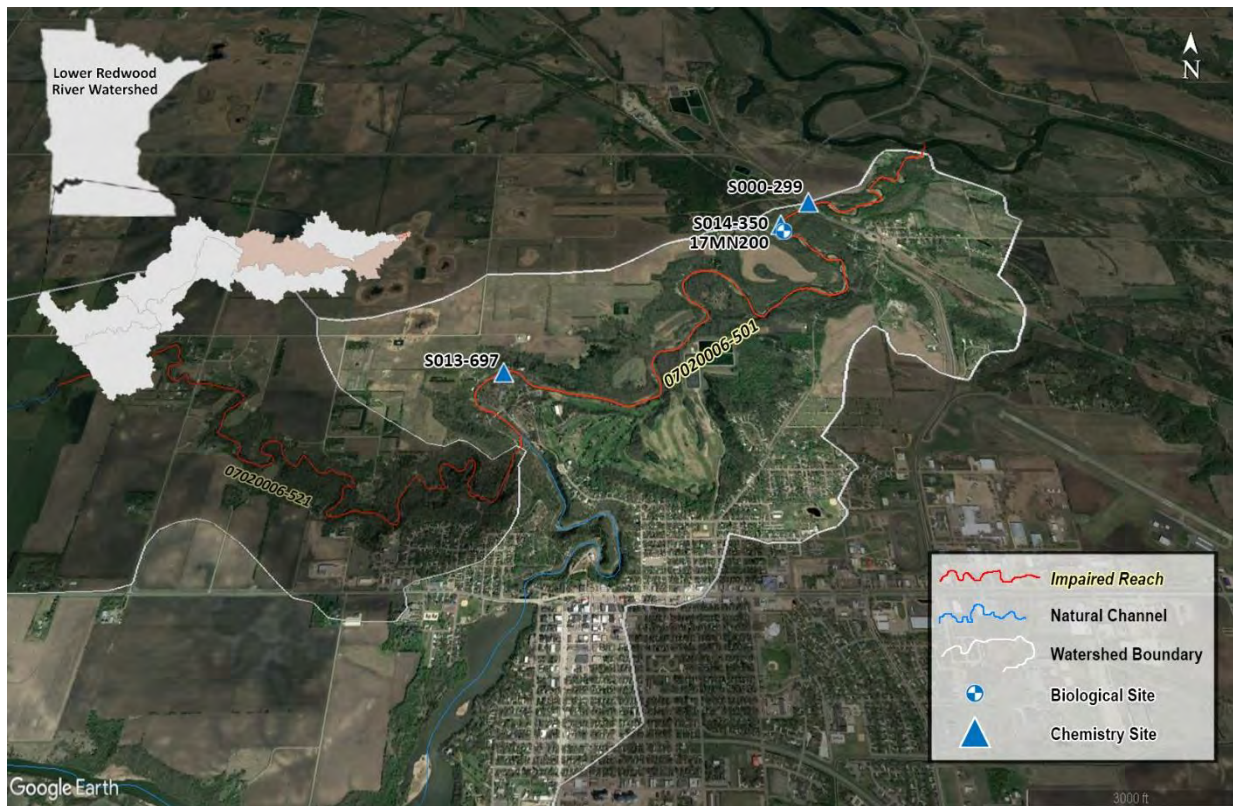
Figure 89. Satellite image of reach 07020006-501 and its watershed

3.5.5.1   Biological Community

Reach 07020006-501 is the furthest downstream section of the main stem Redwood River after the confluence with Ramsey Creek. The reach has two bio sites that were sampled for invertebrates in both 2010 and 2017. MIBI scores of 24.9 and 25.2 are below the Invert Class 2 prairie and southern forest river general use threshold of 31 (Table 425). Both visits had both mayflies and caddisflies present in relatively high amounts, though they were mostly more tolerant ones, such as the mayflies fallceon and

tricorythodes, as well as the caddisfly cheumatopsyche. There were also high numbers of the black fly simulium at the 2017 site visit. There were relatively high numbers of the mayfly baetis, which is not nearly as tolerant.

Biological Metric Data

Table 425. Invert IBI score and threshold for reach 07020006-501

07020006-501 **Invert Class 2** General Use	Invert IBI Score	Class Threshold Score
92MN049 8/02/2010	24.9	31
17MN200 8/08/2017	25.2	

3.5.5.2   Hydrologic Alteration

Hydrologic Alteration Biological Metric Data

Table 426. Hydrologic alteration related invert metrics for reach 07020006-501

07020006-501 **Invert Class 2** General Use	Clinger %	Collector – filterer %	Long – lived %	Percent Ditched Intolerant %	Percent Ditched Tolerant %
92MN049 8/02/2010	26.4	10.7	5.9	0.6	6.7
17MN200 8/08/2017	59.0	26.1	13.0	18.9	0.3
Statewide average for Class 2 Prairie Forest River bio sites that are meeting the FIBI general use threshold (31)	**43.2**	**23.0**	**6.7**	↓	↑
Expected response to **Hydrologic** stress	↓	↓	↓		

HSPF Model Flow Data

Table 427. HSPF modeled flow data for reach 07020006-501

07020006-501 HSPF Reach 510 Min: 6.9 cfs Max: 9,153.6 cfs	<10 cfs % (# of values)	<5 cfs % (# of values)	<1 cfs % (# of values)
6,210 Total Daily Averages 1996 – 2012	**5.0%** (313)	**0.0%** (0)	**0.0%** (0)

Hydrologic Alteration Summary

The biological metrics were mixed from the 2010 to 2017 datasets (Table 426). The 2010 data scored poorly in all the hydrologic alteration metrics, though the water level during the time of sampling was high and the bio sample may not be representative. The 2017 data was the opposite and scored well in all metrics. Clingers, collector – filterers, and long – lived invertebrates were al above the class average and there were more ditch intolerant invertebrates than tolerant. The two most prevalent inverts, fallceon and simulium are both neither tolerant nor intolerant of ditching. Then next four most abundant inverts, baetis intercalaris, tricorythodes, cheumatopsyche, and stenelmis are considered either intolerant or very intolerant to low depth variability and baetis is intolerant to ditching. This would indicate that the natural stream channel has the habitat to support some invertebrates, even those that are intolerant of low depth variability.

The HSPF model shows that none of the daily average flows from 1994 through 2012 are below 1 cfs and only 5% are below 10 cfs, which is to be expected of a main stem river.

This section of the Redwood River is downstream of the impoundment Lake Redwood caused by dam just upstream of the confluence of the Redwood and Minnesota Rivers. Being downstream from a dam has effects on both the biological communities, fish migration, and the geomorphology of the channel. Parts of the reach flow through a relatively steep gradient as the river falls into the Minnesota River Valley.

There are likely geomorphic effects from upstream drainage that is affecting the reach but based on the mixed scores of the biological metrics, lack of geomorphic data, and lack of extended low flow periods shown in the HSPF model, hydrologic alteration is inconclusive as a stressor in this reach.

3.5.5.3   Connectivity

Connectivity Metric Data

Table 428. Connectivity related fish metrics for reach 07020006-501

07020006-501 **Fish Class 1** General Use	Mature Age >3 minus Tolerant Taxa %	Mature Age >3 minus Tolerant %	Migrating Taxa %	Migrating %
92MN049 8/26/2010	45.5	25.4	31.8	19.8
Statewide average for Class 3 prairie headwater bio sites that are meeting the FIBI modified use threshold (33)	**41.5**	**9.0**	**30.7**	**23.0**
Expected response to **Connectivity** stress	↓	↓	↓	↓

Connectivity Summary

Connectivity related fish metrics both scored well (Table 428). Metrics for fish taxa whose females take greater than three years to mature higher than the class average, as were migrating taxa. The northern hogsucker, which is both, was the most prevalent late maturing and migrating species, though there were only 14 of them out of 197 total fish caught. The percentage of late maturing individuals was well above the class average and the percentage of migrating individuals was just below the class average.

Due to the presence of migratory and late maturing species, it appears that connectivity is not a stressor in this reach.

3.5.5.4   Habitat

Habitat Metric Data

07020006-501 **Invert Class 2** **General Use**	Burrower %	Climber %	Clinger %	Ephemeroptera Plecoptera Trichoptera %	Legless %	Sprawler %
92MN049 8/02/2010	3.6	8.8	26.4	81.4	9.1	40.1
17MN200 8/08/2017	1.0	2.9	58.9	66.1	6.8	16.0
Statewide average for Class 2 Prairie Forest River bio sites that are meeting the FIBI general use threshold (31)	**6.9**	**14.0**	**43.2**	**54.8**	**25.9**	**17.6**
Expected response to **Habitat** stress	↑	↓	↓	↓	↑	↑

MPCA Stream Habitat Assessment Score

07020006-501	Land Use	Riparian	Substrate	Cover	Channel Morphology	Total Score
92MN049 8/26/2010	5	8.5	22.3	11	31	77.8
17MN200 8/08/2017	0	11	19.2	9	32	71.2
Maximum Attainable Habitat Score	**5**	**14**	**28**	**18**	**35**	**100**

Habitat Summary

The fish community in reach 07020001-501 were mixed in habitat related fish metrics when compared to all other Class 1 southern river bio sites that meet the FIBI general use threshold (Table 429). The reach was sampled in both 2010 and 2017. Several of the metrics improved in the 2017 visit except for climbers and EPT percentage. Climbers were poor and EPT percentage scored well for both visits, though the percentage of EPT individuals went down in the 2017 visit. The top four most numerous taxa in the 2010 visit were mayflies and caddisflies and the site was dominated by the two mayflies *tricorythodes* and *baetis*. There were also the caddisflies *hydroptila, ceratopsyche, and mayatrichia*, which are all intolerant to several habitat metrics, such as percent fines, low MSHA scores, and poor substrate. The

2017 visit was dominated by the mayfly fallceon and the black fly simulium, as well as the mayfly's *baetis* intercalaris and *tricorythodes*. The mayfly *fallceon* is considered tolerant to many habitat metrics and most of the other mayflies and caddisflies present are also tolerant to low percentage of cover and low flows. There were very few invert taxa that are considered intolerant to many of the poor habitat metrics that were present in the 2010 site visit. The 2010 site visit was dominated by tricorythodes, which caused the sprawler percentage to be very high. In 2017 tricorythodes was present, but not to the extent that it was in 2010. Clinger percentage also improved, though there were many clinger taxa present in 2010, the total percentage was low due to the dominance of tricorythodes and baetis, which are sprawlers and swimmers respectively. In 2017 there were a lot of clinger taxa as well and their numbers were much better.

Both MSHA scores were good, with both scores in the 70s (Table 430). The 2017 score was slightly lower due to a change in the surrounding land use to row crops, as well as slightly lower scores in substrate and cover due to more silt and less overall cover.

The invert habitat related fish metrics were mixed but were better in the 2017 metrics and the MSHA scores were good. Due to the fact that several of the most dominant inverts in the 2017 sample are considered tolerant to both cover and low flows habitat cannot be completely ruled out and is inconclusive as a stressor at this time.

3.5.5.5   Dissolved Oxygen

Dissolved Oxygen Biological Metric Data

Table 431. Dissolved oxygen related invert metrics for reach 07020006-501

07020006-501 **Invert Class 2** General Use	DO TIV	HBI_MN	Low DO Intolerant Taxa %	Low DO Tolerant Taxa %
92MN049 8/02/2010	7.5	7.9	30.3	0.3
17MN200 8/08/2017	7.5	7.8	20.2	0.3
Statewide average for Class 2 Prairie Forest River bio sites that are meeting the FIBI general use threshold (31)	**7.1**	**7.3**	↓	↑
Expected response to **DO** stress	↓	↑		

Dissolved Oxygen Monitoring Data

Table 432. Dissolved oxygen monitoring data for reach 07020006-501

07020006-501 DO Data 5 mg/L target	Range of Data (mg/L)	% of Monthly Samples < 5 mg/L [# of Samples]							May - Sep <5 mg/L % [# of Samples]
		April	May	June	July	August	Sept	Oct	
S000-299 **S013-697** **S014-350** (2009-2018)	4.5 – 11.5	0% [1]	0% [3]	0% [6]	0% [7]	0% [9]	0% [4]	-	0% [30]
		Minimum Value							
		8.5	7.8	5.8	6.9	6.4	5.5	-	

Dissolved Oxygen Summary

The fish community at in reach 07020006-501 scored well in most of the DO related fish metrics when compared to the average of all other Class 1 southern river bio sites that meet the MIBI general use threshold (Table 431). The DO TIV score was better than the class average and the ratio of low DO intolerant to tolerant taxa was very good for both site visits.

There were 30 DO measurements taken during sampling and none were below the warmwater standard of 5 mg/L.

Based on the related fish biological metric scores and the measured DO values, DO is not a stressor in this reach.

3.5.5.6   Eutrophication

Eutrophication Biological Metric Data

07020006-501 **Invert Class 2** **General Use**	Crustacean and Mollusca %	Collector – Gatherer Taxa #	Ephemeroptera Plecoptera Trichoptera Taxa %	Intolerant Two Taxa %	Scraper %	Taxa Count All #	Tolerant Two Taxa %
92MN049 8/02/2010	0.3	7	37.5	0.0	7.2	24	83.3
17MN200 8/08/2017	0.0	4	50.0	0.0	10.1	20	75.0
Statewide average for Class 2 Prairie Forest River bio sites that are meeting the FIBI general use threshold (31)	**6.6**	**12.6**	**39.7**	**0.8**	**13.8**	**35.5**	**74.3**
Expected response to **Eutrophic** stress	↑	↓	↓	↓	↑	↓	↑

Eutrophication Monitoring Data

07020001-501 P Sample Data 0.150 mg/L target	Range of Data (mg/L)	Monthly Average of Samples (mg/L) [# of Samples]							June-Aug Average (mg/L) [# of Samples]
		April	May	June	July	August	Sept	Oct	
S000-299 **S013-697** (2009-2018)	0.129 – 0.655	0.262 [1]	0.228 [3]	0.272 [5]	0.323 [6]	0.356 [6]	0.260 [4]	-	0.320 [17]
		Maximum Value							
		0.262	0.328	0.512	0.547	0.655	0.424	-	

Table 435. Chlorophyll-a monitoring data for reach 07020006-501

07020001-501 Chl-a Sample Data 40 µg/L target	Range of Data (µg/L)	Monthly Average of Samples (µg/L) [# of Samples]							June-Aug Average (µg/L) [# of Samples]
		April	May	June	July	August	Sept	Oct	
S000-299 (2009-2018)	1 – 57.6	-	-	15.2 [5]	20.3 [5]	22.8 [5]	21.9 [4]	-	19.4 [17]
		Maximum Value							
		-	-	45.8	52.3	57.6	33.5	-	

Eutrophication Summary

The eutrophication related invert metrics were mixed in reach 07020006-501 when compared to the average of all other Class 2 southern prairie and southern river bio sites that meet the MIBI general use threshold (Table 433). There were very few or no crustacean or mollusks caught. EPT taxa were above the average in the 2017 visit and scrapers were relatively low. Collector – gatherer taxa were low, though the third and fourth most abundant taxa present were collector – gatherers and actual numbers were high. There were no taxa that are considered intolerant and taxa count was relatively low. The two most tolerant taxa comprised 75% of the total number of inverts caught.

25 samples were collected and analyzed for Phosphorus from 200 through 2018. The summer average was over twice the standard of 0.15 mg/L (Table 434). Chl-*a* data was decent as the summer average was well below 40 µg/L (Table 435). There were some relatively high samples but for the most part, Chl-*a* was not excessively high.

The biological community is mixed and although phosphorus sampling showed elevated concentrations, Chl-*a* data was not excessively high. Eutrophication is inconclusive as a stressor in this reach.

3.5.5.7   Suspended Solids

Suspended Solids Biological Metric Data

Table 436. Suspended solids related invert metrics for reach 07020006-501

07020006-501 **Invert Class 2** **General Use**	Collector – filterer %	Plecoptera %	TSS TIV	TSS Intolerant %	TSS Tolerant %
92MN049 8/02/2010	35.2	0.0	21.9	0.0	57.0
17MN200 8/08/2017	26.1	1.0	24.1	1.0	58.3
Statewide average for Class 2 Prairie Forest River bio sites that are meeting the FIBI general use threshold (31)	**22.9**	**0.6**	**18.4**	↓	↑
Expected response to **Suspended Solids** stress	↓	↓	↑		

TSS Monitoring Data

Table 437. Total suspended solids monitoring data for reach 07020006-501

07020006-501 TSS Sample Data	Range of Data (mg/L)	% of Monthly Samples > 65 mg/L [# of Samples]							% of Total Samples > 65 mg/L [# of Samples]
		April	May	June	July	August	Sept	Oct	
S000-299 S013-697 (2009-2017)	25 – 121	0.0 [1]	33.3 [3]	0.0 [3]	25.0 [4]	50.0 [4]	0.0 [3]	-	22.2 [18]

Suspended Solids Summary

The invert community in reach 07020006-501 scored below average in all but one suspended solids related invert metrics when compared to the average of all other Class 2 prairie and southern forest river bio sites that meet the MIBI general use threshold (Table 436). Collector – filterers scored well, thought it was mostly due to the prevalence of the black fly simulium. There were decent numbers of the caddisfly cheumatopsyche, which is also a collector - filterer. There were almost no Plecoptera present or TSS intolerant taxa. TSS tolerant taxa percent was high at 58.3%, including the mayfly

fallceon, the most dominant invert present. The TSS tolerance value index score is higher than the class average and indicates an invert community that is generally tolerant to TSS.

Eighteen samples were collected and analyzed for TSS from 2009 through 2017. Several samples had a TSS concentration above 65 mg/L (Table 437).

TSS biological metrics are mostly poor and there are some high TSS values that were measured in the reach. TSS appears to be a stressor to the invert community in reach 07020006-501.

3.5.5.8   Nitrates

Nitrate Biological Metric Data

Table 438. Nitrate related invert metrics for reach 07020006-501

07020006-501 **Invert Class 2** General Use	Trichoptera Taxa %	Nitrogen TIV	Nitrate Intolerant %	Nitrogen Tolerant Taxa %
92MN049 8/02/2010	20.8	3.3	0.0	74.3
17MN200 8/08/2017	14.3	4.9	1.0	61.6
Statewide average for Class 2 Prairie Forest River bio sites that are meeting the FIBI general use threshold (31)	**15.8**	**2.9**	↓	↑
Expected response to **nitrogen** stress	↓	↑		

Nitrate Monitoring Data

Table 439. Nitrate monitoring data for reach 07020006-501

07020001-501 Nitrate/Nitrite Sample Data	2x Highest Reach TIV Average	Range of Data (mg/L) [# of Samples]	Monthly Average [# of Samples]						
			April	May	June	July	August	Sept	Oct
S000-299 **S013-697** (2009-2010)	5.8	<0.05 – 5.2 [7]	5.1 [1]	5.2 [1]	2.1 [1]	1.7 [1]	0.7 [2]	0.0 [1]	-
			Highest Value						
			5.1	5.2	2.1	1.7	1.3	<0.05	-

Summary

The macroinvertebrate assemblage in reach 07020001-501 scored poorly in almost all of the nitrate related metrics evaluated when compared to all other macroinvertebrate Class 2 prairie and southern river bio sites that meet the MIBI general use threshold (Table 438). The biological bio site did have

---

some Trichoptera taxa, which tend to decrease in streams with excessive nitrate values. The three caddisflies present; however, are considered either tolerant or very tolerant to nitrates. There was a high amount of nitrate tolerant invertebrates as well as complete lack of nitrate intolerant invertebrate species. The nitrogen TIV score also indicates a macroinvertebrate community that is generally tolerant to high levels of nitrates. In all, five of the top seven most numerous inverts are considered tolerant or very tolerant to nitrates.

Seven samples were collected in reach 07020001-501 and analyzed for nitrate/nitrite (Table 439). None of the total nitrate samples had concentrations greater than 5.8 mg/L.

Even though the chemistry data is not showing high concentrations, the data set is limited. The poor biological response indicates that nitrates are a stressor to the invert community though at this time it is inconclusive in reach 07020006-501.

3.5.5.9   Reach Stressors

Table 440. Summary of stressors for reach 07020006-501

07020006-501	Hydrologic Alteration	Connectivity	Habitat	Dissolved Oxygen	Eutrophication	Suspended Solids	Nitrate
✔ = Stressor ✘ = Not a Stressor O = Inconclusive	O	✘	O	✘	O	✔	O

3.6   Clear Creek

3.6.1 07020006-568   Clear Creek
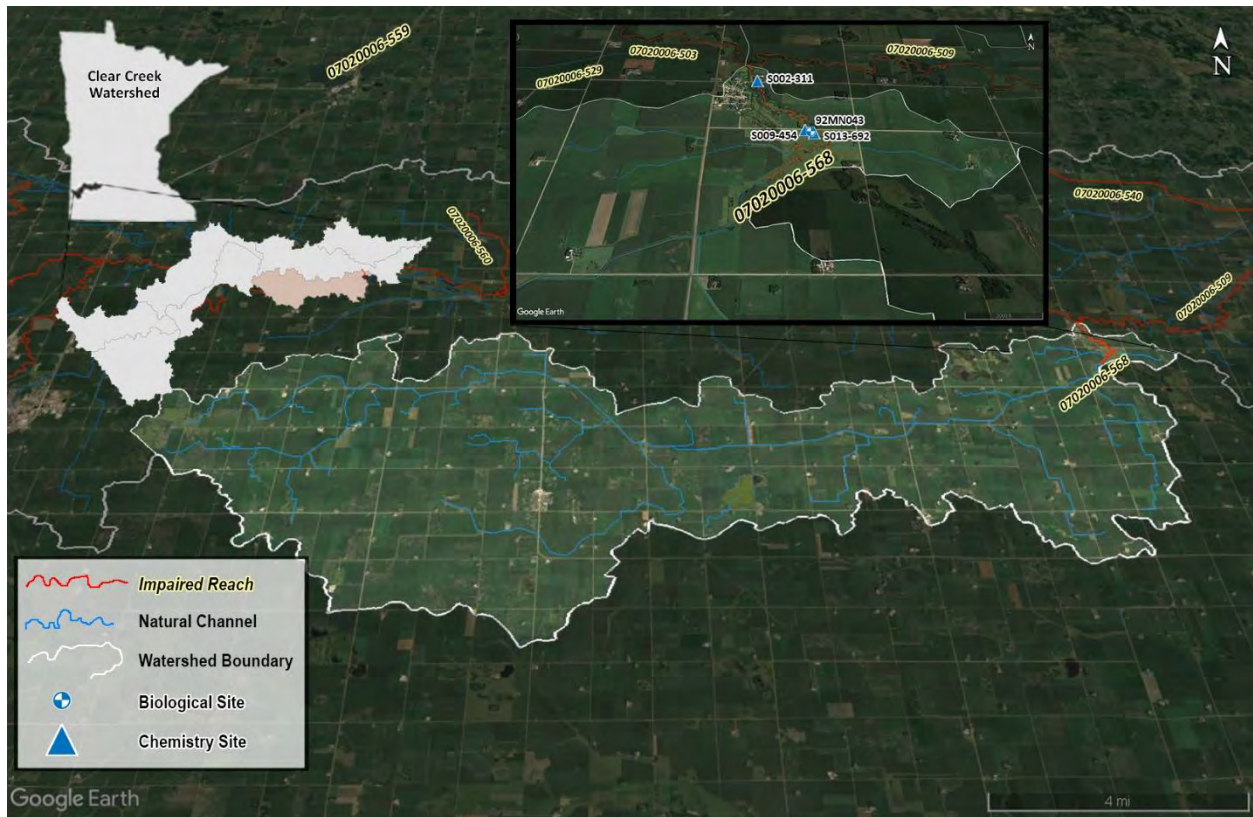
Figure 90. Satellite image of reach 07020006-568 and its watershed

3.6.1.1   Biological Community

Bio site 92MN043 was sampled once for invertebrates in 2017. The MIBI score of 10.7 is well below the Invert Class 5 southern streams rock riffle general use threshold of 37 (Table 441). The site was dominated by the caddisfly ceratopsyche, comprising over 63% of the total number of inverts, which is considered intolerant to a lot of habitat metrics and low DO.

Biological Metric Data

Table 441. Invert IBI score and threshold for reach 07020006-568

07020006-568 **Invert Class 5** General Use	Invert IBI Score	Class Threshold Score
92MN043 8/02/2017	10.7	37

3.6.1.2   Hydrologic Alteration

Hydrologic Alteration Biological Metric Data

Table 442. Hydrologic alteration related invert metrics for reach 07020006-568

07020006-568 **Invert Class 5** General Use	Clinger %	Collector – filterer %	Long – lived %		Percent Ditched Tolerant %	Percent Ditched Intolerant %
92MN043 8/02/2017	76.4	67.8	6.7		5.4	2.5
Statewide average for Class 5 prairie stream rock riffle bio sites that are meeting the FIBI general use threshold (37)	**49.5**	**26.9**	**9.0**		↑	↓
Expected response to **Hydrologic** stress	↓	↓	↓			

HSPF Model Flow Data

Table 443. HSPF modeled flow data for reach 07020006-568

07020006-568 HSPF Reach 443 Min: 0.1 cfs Max: 2,994.6 cfs	**<5 cfs %** (# of values)	**<1 cfs %** (# of values)	**<0.5 cfs %** (# of values)
6,210 Total Daily Averages 1996 – 2012	**34.4%** (2,139)	**7.5%** (464)	**4.0%** (249)

Hydrologic Alteration Summary

The biological metrics scored mostly well when compared to the average of Class 5 southern stream rock riffle bio sites that meet the MIBI general use threshold. The net-spinning caddisfly, *ceratopsyche morosa*, dominated the invert community and comprised 55% of the total number of inverts caught. There were 24 more ceratopsyche identified to the genus level. *Ceratopsyche* is both a clinger and a collector-filterer, which caused those metrics to score very well. It is intolerant to several habitat metrics and is considered very intolerant to poor depth variability. There were also several other inverts present that are considered either intolerant or very intolerant to low depth variability. This section of the stream is considered natural and the percent ditched tolerant to intolerant individuals was relatively low, which indicates that both geomorphic features and substrate appear to be present. Long – lived inverts were lower than average. The next most numerous invert caught were 15 physella snails, 14 riffle beetles, and 13 midges.

The HSPF model shows that 7.5% of the daily average flows from 1996 through 2012 are below 1 cfs, which represents about 466 days out of the 17 years' worth of data represented within the model.

Based on the mostly good scores of the biological metrics and the act that the most dominant invertebrate present is ceratopsyche, as well as relatively low amounts of low flow periods shown in the HSPF model, hydrologic alteration is likely not a stressor in this reach.

3.6.1.3   Connectivity

Connectivity Metric Data

Table 444. Connectivity related fish metrics for reach 07020006-568

07020006-568 Fish Class 2 General Use	Mature Age >3 minus Tolerant Taxa %	Migrating Taxa %
92MN043 6/27/2017	25.0	37.5
Statewide average for Class 2 prairie stream bio sites that are meeting the FIBI general use threshold (50)	**21.8**	**24.3**
Expected response to **Connectivity** stress	↓	↓

Connectivity Summary

Metrics for fish taxa whose females take greater than three years to mature scored above the class average. Migrating taxa were also above the average for southern streams that meet the standard, though the majority were the tolerant white sucker (Table 444). There were 10 golden and 4 silver redhorses caught, which are both late maturing and migrating.

Due to the presence of late-maturing and migratory species it appears that connectivity is not a stressor at the bio site at this time.

3.6.1.4   Habitat

Habitat Metric Data

Table 445. Habitat related invert metrics for reach 07020006-568

07020006-568 **Invert Class 5** General Use	Burrower %	Climber %	Clinger %	Ephemeroptera Plecoptera Trichoptera %	Legless %	Sprawler %
92MN043 8/02/2017	0.3	11.1	76.4	78.0	14.0	6.1
Statewide average for Class 5 prairie stream rock riffle bio sites that are meeting the FIBI general use threshold (37)	**7.5**	**14.7**	**49.5**	**43.9**	**36.0**	**16.8**
Expected response to **Habitat** stress	↑	↓	↓	↓	↑	↑

MPCA Stream Habitat Assessment Score

Table 446. Habitat Assessment scores for reach 07020006-568

07020006-568	Land Use	Riparian	Substrate	Cover	Channel Morphology	Total Score
92MN043 6/27/2017	1.5	10.5	16.3	7	19	54.3
92MN043 8/02/2017	0	8.5	19.9	10	23	61.4
Maximum Attainable Habitat Score	**5**	**14**	**28**	**18**	**35**	**100**

Habitat Summary

The invert community in reach 07020006-568 scored well in five out of the six habitat related metrics when compared to all other Class 5 southern stream rock riffle bio sites that meet the MIBI general use threshold (Table 445). Burrowers, legless, and sprawler invertebrates were low. There were good numbers of EPT and clingers due to the caddisfly ceratopsyche dominating the invert community.

The MSHA scores were fair during both visits in 2017. The riparian zone scored well with an extensive width and little to moderate bank erosion. The substrate scores were also decent and

Figure 91. Photo of Bio site 92MN043 showing a natural channel and vegetation along banks.

there were a lot of cobble, gravel, and sand present with only light siltation and embeddedness (Table 446).

Most of the invertebrate habitat related metrics scored well and the MSHA scores all indicate that habitat is decent. Habitat does not appear to be a stressor in reach 07020006-568.

3.6.1.5   Dissolved Oxygen

Dissolved Oxygen Biological Metric Data

Table 447. Dissolved oxygen related invert metrics for reach 07020006-568

07020006-568 **Invert Class 5** General Use	DO TIV	HBI_MN	Low DO Intolerant Taxa %	Low DO Tolerant Taxa %
92MN043 8/02/2017	7.9	7.2	66.2	0.0
Statewide average for Class 5 prairie stream rock riffle bio sites that are meeting the FIBI general use threshold (37)	**7.1**	**7.0**	↓	↑
Expected response to **DO** stress	↓	↑		

Dissolved Oxygen Monitoring Data

Table 448. Dissolved oxygen monitoring data for reach 07020006-568

07020006-568 DO Data 5 mg/L target	Range of Data (mg/L)	% of Monthly Samples < 5 mg/L [# of Samples]							May - Sep <5 mg/L % [# of Samples]
		April	May	June	July	August	Sept	Oct	
S002-311 **S009-454** (2009-2020)	4.9 – 14.3	0% [8]	0% [11]	0% [13]	0% [11]	7.8% [13]	0% [13]	-	0% [61]
		Minimum Value							
		8.4	7.0	5.9	5.3	4.9	5.5	-	
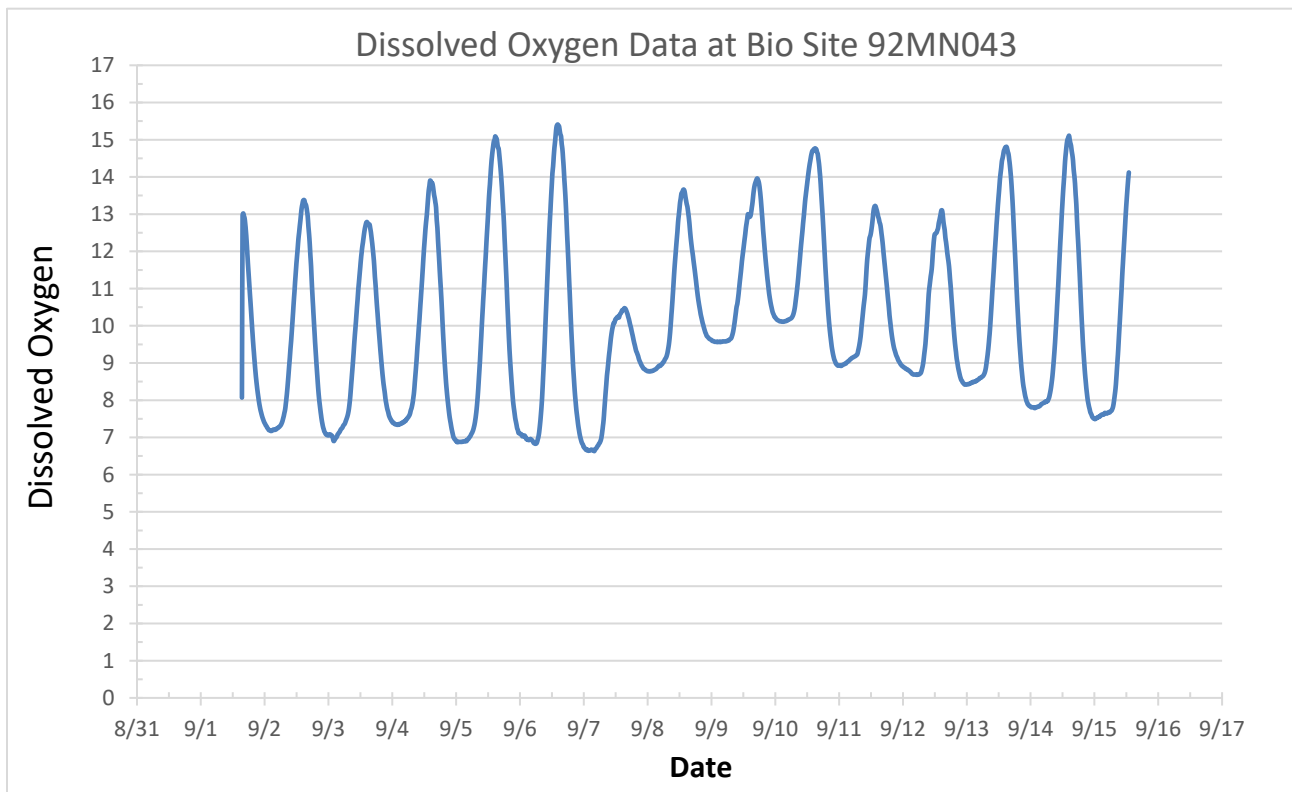
Figure 92. Continuous dissolved oxygen data at site 92MN043

Dissolved Oxygen Summary

The fish community at bio site 92MN043 scored well in three out of four DO related fish metrics when compared to the average of all other Class 5 southern stream rock riffle bio sites that meet the MIBI general use threshold (Table 447). The DO TIV was above the class average, indicating an invertebrate community that is not tolerant to low DO conditions. The percent of low DO intolerant individuals was high at 66.2%. The invert Ceratopsyche is considered very intolerant to low DO conditions and was almost 64% of the total number of inverts caught. There were also a few beatis mayflies as well as the fly atherix, which both are very intolerant to low DO as well. There were no low DO tolerant species present.

There were 68 discreet DO measurements taken during sampling from 2009 through 2018. Only one was below the warmwater standard of 5 mg/L (Table 448). An YSI Sonde water meter measured continuous DO data from 9/1/2020 to 9/15/2020. During this deployment, DO values were not measured below 5mg/L.

Based on the related invertebrate biological metric scores and the measured sonde values, DO is inconclusive as a stressor in this reach.

3.6.1.6 Eutrophication

Eutrophication Biological Metric Data

07020006-568 Invert Class 5 General Use	Crustacean and Mollusca %	Collector – Gatherer Taxa #	Ephemeroptera Plecoptera Trichoptera Taxa %	Intolerant Two Taxa %	Scraper %	Taxa Count All #	Tolerant Two Taxa %
92MN043 8/02/2017	6.1	5	36.4	0.0	6.7	22	86.4
Statewide average for Class 5 prairie stream rock riffle bio sites that are meeting the FIBI general use threshold (37)	**9.2**	**15.1**	**30.5**	**0.8**	**15.8**	**41.9**	**74.3**
Expected response to **Eutrophic** stress	↑	↓	↓	↓	↑	↓	↑

Eutrophication Monitoring Data

07020001-568 P Sample Data 0.150 mg/L target	Range of Data (mg/L)	Monthly Average of Samples (mg/L) [# of Samples]							June-Aug Average (mg/L) [# of Samples]
		April	May	June	July	August	Sept	Oct	
S002-311 **S009-454** **S013-692** (2009-2017)	0.019 – 0.668	0.101 [8]	0.200 [11]	0.153 [14]	0.106 [11]	0.138 [10]	0.177 [15]	-	0.134 [38]
		Maximum Value							
		0.246	0.668	0.586	0.189	0.244	0.374	-	

Table 451. DO% Saturation monitoring data for reach 07020006-568

07020006-568 DO% Sat Data	Range of Data (%)	Monthly Average of Samples (%) [# of Samples]							June-Aug Average (%) [# of Samples]
		April	May	June	July	August	Sept	Oct	
S013-692 (2017-2020)	131.4 – 163.2	-	-	131.4 [1]	-	135.9 [1]	163.2 [1]	-	133.7 [2]

Eutrophication Summary

The eutrophication related invert metrics at bio site 92MN043 were mixed compared to the average of all other Class 5 southern stream rock riffle bio sites that meet the MIBI general use threshold (Table 449). Two-hundred *ceratopsyche* caddisflies were caught, comprising almost 64% of the total number of inverts. *Physella* snails were the next most numerous invert; however, there were only 15 present, which brought the percentage of crustaceans and mollusks down. EPT taxa were above and scraper percentage was below the class average, which were good scores. Collector – gatherer taxa, intolerant two taxa, total taxa count, and the tolerant two taxa metrics all scored poorly.

There were 69 samples collected and analyzed for TP from 2009 through 2017. The summer average was below the standard of 0.15 mg/L (Table 450). However, there were some very high values in all of the months sampled as well as some high monthly averages outside of the summer months.

An YSI Sonde water meter measured continuous DO data from 9/1/2020 to 9/15/2020. During this deployment, diel DO flux was measured at or above 5 mg/L for most of the deployment, with a couple days after a rain event where DO flux was a little below 5mg/L.

The biological community is showing the effects of the elevated phosphorus, phosphorus sampling showed elevated concentrations, and DO flux was 5 mg/L or greater. Eutrophication appears to be a stressor in this reach.

3.6.1.7   Suspended Solids

Suspended Solids Biological Metric Data

Table 452. Suspended solids related invert metrics for reach 07020006-568

07020006-568 **Invert Class 5** General Use	Collector – filterer %	Plecoptera %	TSS TIV	TSS Intolerant %	TSS Tolerant %
92MN043 8/02/2017	67.8	0.0	17.0	0.0	23.6
Statewide average for Class 5 prairie stream rock riffle bio sites that are meeting the FIBI general use threshold (37)	**26.9**	**0.5**	**15.9**	↓	↑
Expected response to **Suspended Solids** stress	↓	↓	↑		

TSS Monitoring Data

Table 453. Total suspended solids monitoring data for reach 07020006-568

07020006-568 TSS Sample Data	Range of Data (mg/L)	% of Monthly Samples > 65 mg/L [# of Samples]							% of Total Samples > 65 mg/L [# of Samples]
		April	May	June	July	August	Sept	Oct	
S002-311 S009-454 S013-692 (2009-2018)	6 – 100+	0.0 [8]	27.3 [11]	7.2 [14]	0.0 [11]	10.0 [10]	14.3 [14]	0.0 [1]	10.2 [69]

Table 454. Transparency monitoring data for reach 07020006-568

07020001-568 Secchi Tube Data 10 cm target	Range of Data (mg/L)	% of Monthly Samples < 10 cm [# of Samples]							% of Total Samples < 10 cm [# of Samples]
		April	May	June	July	August	Sept	Oct	
S002-311 S009-454 S013-692 (2009-2018)	6 – 100+	0.0 [8]	18.2 [11]	5.6 [18]	0.0 [13]	0.0 [15]	0.0 [14]	0.0 [1]	3.8 [80]

Suspended Solids Summary

The invertebrate community at bio site 92MN043 scored poorly in four out of five suspended solids related invert metrics when compared to the average of all other Class 5 southern stream rock riffle bio sites that meet the MIBI general use threshold (Table 452). Collector-filterer percentage was high due to the prevalence of the caddisfly ceratopsyche, which dominated the community. There were no Plecoptera caught at all and the TSS TIV was higher than the class average. There were no TSS intolerant invertebrates and TSS tolerant ones comprised 23.6% of the total number of inverts caught.

There were 69 samples were collected and analyzed for TSS from 2009 through 2018. Of those, 10.2% had a TSS concentration above 65 mg/L (Table 453). Secchi tube data also had some poor transparency in the month of May (Table 454), which correlates with the TSS data. The MSHA data indicates that there is some moderate to heavy bank erosion as well as some siltation and moderate embeddedness of coarse sediment.

The TSS related invert metrics are mostly poor and no TSS intolerant taxa were caught. TSS sampling indicate high concentrations. Suspended solids appear to be at least a minor stressor to aquatic life at this time.

3.6.1.8   Nitrates

Nitrate Biological Metric Data

Table 455. Nitrate related invert metrics for reach 07020006-568

07020006-568 **Invert Class 5** General Use	Trichoptera Taxa %	Nitrogen TIV	Nitrate Intolerant	Nitrogen Tolerant Taxa %
92MN043 8/02/2017	18.2	3.2	0.0	30.9
Statewide average for Class 5 prairie stream rock riffle bio sites that are meeting the FIBI general use threshold (37)	**13.6**	**3.0**	↓	↑
Expected response to **nitrogen** stress	↓	↑		

Nitrate Monitoring Data

Table 456. Nitrate monitoring data for reach 07020006-568

07020001-568 Nitrate/Nitrite Sample Data	2x Highest Reach TIV Average	Range of Data (mg/L) [# of Samples]	Monthly Average [# of Samples]						
			April	May	June	July	August	Sept	Oct
S002-311 (2009-2012)	6.0	<0.05 – 18.4 [58]	8.9 [8]	13.1 [9]	13.1 [12]	7.4 [8]	2.1 [8]	6.1 [12]	11.2 [1]
			Highest Value						
			13.6	18.4	18.2	14.2	11.0	14.6	11.2

Summary

The macroinvertebrate assemblage at site 92MNN043 scored below average in three of the four nitrate related metrics evaluated when compared to all other macroinvertebrate Class 5 southern stream rock riffle bio sites that meet the MIBI general use threshold (Table 455). The bio site did show a healthy amount of Trichoptera taxa, which tend to decrease in streams with excessive nitrate values. The most dominant invertebrate present, the caddisfly ceratopsyche, is neither tolerant nor intolerant to nitrogen. The next eight most numerous inverts are considered either tolerant or very tolerant to nitrogen. The nitrogen TIV score was just above the class average. There was a high amount of nitrate tolerant invertebrates as well as complete lack of nitrate intolerant invertebrates.

Fifty-eight samples were collected in reach 07020006-568 and analyzed for nitrate/nitrite (Table 456). Every month listed except August had monthly average concentrations greater than 6.0 mg/L and there were high values observed in all of the months. Due to the biological response and relatively high nitrate concentrations, nitrates are a stressor to aquatic life in reach 07020006-568.

3.6.1.9   Reach Stressors

Table 457. Summary of stressors for reach 07020006-568

07020006-568	Hydrologic Alteration	Connectivity	Habitat	Dissolved Oxygen	Eutrophication	Suspended Solids	Nitrate
✔ = Stressor ✖ = Not a Stressor O = Inconclusive	✖	✖	✖	O	✔	✔	✔

3.7   Ramsey Creek

3.7.1 07020006-540   Judicial Ditch 32
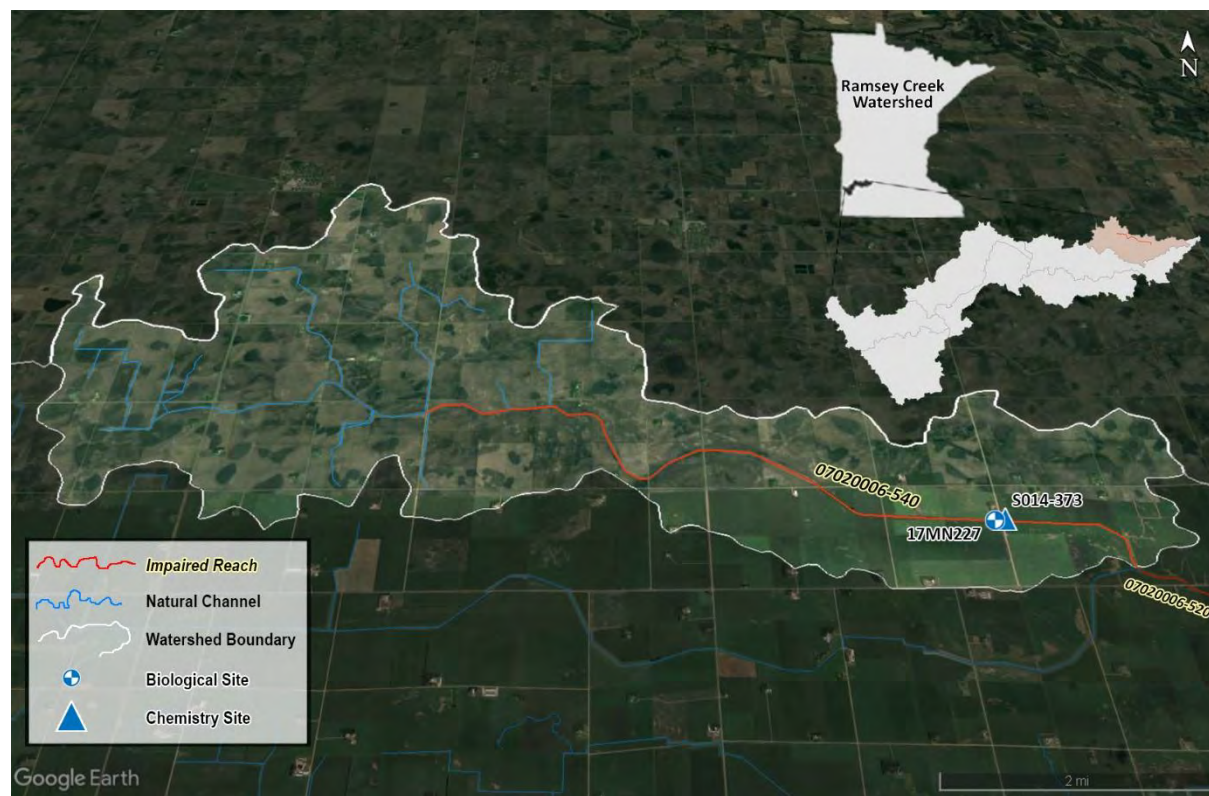
Figure 93. Satellite image of reach 07020006-540 and its watershed

3.7.1.1   Biological Community

Bio site 17MN227 was sampled once for invertebrates in 2017. The MIBI scores of 19.9 is below the Invert Class 7 southern prairie stream glide pool modified use threshold of 22 (Table 458). The bio site was dominated by the damselfly coenagrionidae, several types of midges, as well as the amphipod hyalella, which are all generally tolerant species.

Biological Metric Data

Table 458. Invert IBI score and threshold for reach 07020006-540

07020006-540 **Invert Class 7** Modified Use	Invert IBI Score	Class Threshold Score
17MN227 8/02/2017	19.9	22

3.7.1.2   Hydrologic Alteration

Hydrologic Alteration Biological Metric Data

Table 459. Hydrologic alteration related invert metrics for reach 07020006-540

07020006-540 **Invert Class 7** Modified Use	Clinger %	Collector – filterer %	Long – lived %	Percent Ditched Tolerant %	Percent Ditched Intolerant %
17MN227 8/02/2017	22.7	2.3	0.6	60.8	0.0
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI modified use threshold (22)	**23.1**	**9.9**	**5.6**	↑	↓
Expected response to **Hydrologic** stress	↓	↓	↓		

HSPF Model Flow Data

Table 460. HSPF modeled flow data for reach 07020006-540

07020006-540 HSPF Reach 491 Min: 0.1 cfs Max: 477.0 cfs	<5 cfs % (# of values)	<1 cfs % (# of values)	<0.5 cfs % (# of values)
6,210 Total Daily Averages 1996 – 2012	**61.8%** (3,836)	**22.0%** (1,369)	**8.1%** (503)

Hydrologic Alteration Summary

The biological metrics all scored poorly when compared to the average of Class 7 southern prairie stream glide pool bio sites that meet the MIBI modified use threshold (Table 459). Clingers were just below the class average at 22.7%, though that was mainly due to the midge *paratanytarsus*, which is tolerant to both ditching and lack of depth variability. The four most numerous inverts present are considered tolerant to poor depth variability and three of the four invertebrates are considered either tolerant or very tolerant to ditching as over 60% of the total number of inverts caught are considered tolerant to ditching. Those same invertebrates are also considered tolerant or very tolerant to several habitat related metrics as well.

The HSPF model shows that 22% of the daily average flows from 1996 through 2012 are below 1 cfs (Table 460). Flows reduced beyond normal base flow will decrease habitat for aquatic organisms and increase competition for resources.

According to the DNR Watershed Characterization Report, the stream channel is has been completely altered and exhibits the shape and dimensions of a type G stream, which is often called a "gully" channel due to an entrenched, narrow, and deep, step/pool channel with a low to moderate sinuosity. "The upper Ramsey Creek channel does not act like a typical naturally formed G5 channel, however. Because the ditched

Figure 94. Photo showing the ditched stream channel near bio site 17MN227 just downstream of the road crossing.

manmade channel does not act like a typical G channel, the description of that channel type will not be elaborated on. It is the mere pattern, profile, and dimensions of the manmade channel that best matches those of G classification. The manmade channel in this instance does not have the excess sediment and erosion problem typically found in a natural G channel" (DNR 2020). The manmade channel is deeply incised and entrenched and is effectively cut off from its floodplain.

Based on the very poor scores of the biological metrics, the biological community that is tolerant to metrics related to ditching, and the extended low flow periods shown in the HSPF model, hydrologic alteration is a stressor in this reach. The primary impact in this reach from Hydrologic Alteration is the ditching of the stream itself, which affects biology in several ways. Ditching destroys the natural geomorphology of the stream, which reduces the riffle, run, glide, and pool environments needed to support a diverse invertebrate community. It cuts the stream off from its floodplain, which provides habitat and cover and dissipates some of the streams power during high flows. Ditching and tiling of the tributaries and surrounding landscape contributes to low base flows during times of low precipitation, contributing to the stagnation of the water within the ditch and eutrophication of the water causing excessive algae growth from the nutrient overloading of phosphorus, nitrogen.

3.7.1.3   Connectivity

Connectivity Metric Data

Table 461. Connectivity related fish metrics for reach 07020006-540

07020006-540 **Fish Class 3** Modified Use	Mature Age >3 minus Tolerant Taxa %	Migrating Taxa %
17MN227 9/27/2017	0.0	14.3
Statewide average for Class 3 prairie headwater bio sites that are meeting the FIBI modified use threshold (33)	**3.2**	**20.1**
Expected response to **Connectivity** stress	↓	↓

Connectivity Summary

There were no nontolerant fish taxa whose females take greater than three years to mature. Migrating taxa were present though they were below the class average and they were entirely white suckers, a tolerant species.

The road crossing near bio site 17MN227 appears to have an artificial riffle that was likely created to reduce erosion of the bank
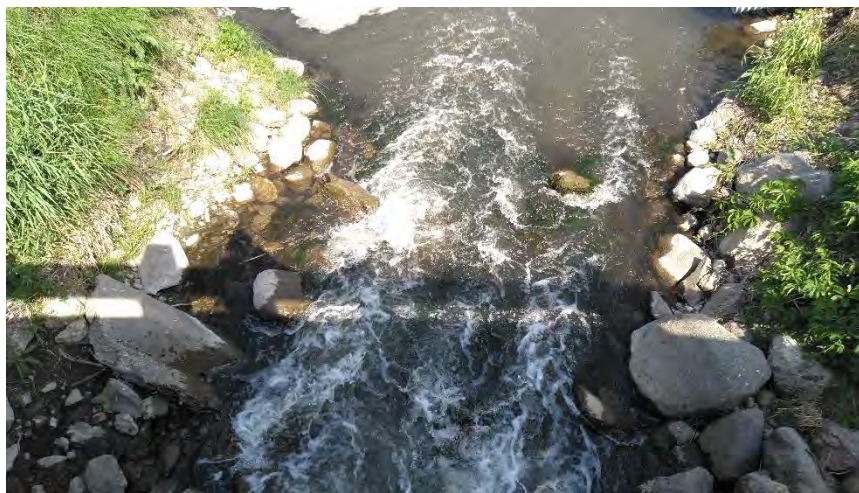
Figure 95. Photo showing the artificial riffle created underneath the road crossing near bio site 17MN227.

underneath the bridge (Figure 95). There are chunks of concrete placed in the channel and the riffle itself is very steep, short, and had relatively high flows during the site visit in 2020 and is likely a fish barrier.

Lateral, or side to side connectivity is likely a stressor as the channel is completely cut off from its flood plain and has very little depth variability throughout the ditch. Due to the poor connectivity related fish metrics and the evidence of a fish migration barrier both lateral and longitudinal connectivity appear to be a stressor to the biological community in reach 07020006-540.

3.7.1.4   Habitat

Habitat Metric Data

Table 462. Habitat related invert metrics for reach 07020006-540

07020006-540 Invert Class 7 Modified Use	Burrower %	Climber %	Clinger %	Ephemeroptera Plecoptera Trichoptera %	Legless %	Sprawler %
17MN227 8/02/2017	16.2	39.8	22.7	4.2	56.0	19.1
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI modified use threshold (22)	**14.1**	**27.5**	**23.1**	**20.6**	**55.8**	**27.0**
Expected response to **Habitat** stress	↑	↓	↓	↓	↑	↑

MPCA Stream Habitat Assessment Score

Table 463. Habitat Assessment scores for reach 07020006-540

07020006-540	Land Use	Riparian	Substrate	Cover	Channel Morphology	Total Score
17MN227 8/2/2017	0	5	6	5	3	19
17MN227 9/27/2017	0	7	8	9	2	26
Maximum Attainable Habitat Score	**5**	**14**	**28**	**18**	**35**	**100**

Habitat Summary

The habitat related invertebrate metrics in reach 07020006-540 were mostly poor compared to the Class 7 southern prairie stream glide pool bio sites that meet the MIBI modified use threshold (Table 462). Burrowers were higher than average as there were high numbers of the midge *dicrotendipes*.

Figure 96. Photo showing upstream of road crossing near bio site 17MN227 showing a straightened ditch with unstable banks.

Clingers were just below the class average, though that was from the high numbers of the midge *paratanytarsus*. EPT taxa were very low as only 11 *caenis* and one *callibaetis* mayflies were observed. The top four most abundant taxa present were legless midges, limpets, and snails. Those same legless individuals are considered climbers; however, as that metric scored above the class average. Sprawlers were also low at just over 19%.

Both MSHA scores were very poor (Table 463). Sand and silt were observed with moderate to severe embeddedness and siltation on the channel bottom. Depth variability and stream morphology was very poor as well. Three out of the top four most numerous inverts caught are either tolerant or very tolerant to ditching and the top four are either tolerant or very tolerant to low depth variability.

Most of the habitat related invert metrics scored poorly and the climbers that were present were mostly tolerant midges, limpets, and snails. The MSHA scores were very poor and the stream itself is a straightened ditch with poor depth variability and unstable banks (Figure 96). Habitat is a stressor in reach 07020006-540.

3.7.1.5   Dissolved Oxygen

Dissolved Oxygen Biological Metric Data

Table 464. Dissolved oxygen related invert metrics for reach 07020006-540

07020006-540 **Invert Class 7** **Modified Use**	DO TIV	HBI_MN	Low DO Intolerant Taxa %	Low DO Tolerant Taxa %
17MN227 8/02/2017	6.0	8.5	0.0	71.8
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI modified use threshold (22)	**6.2**	**8.0**	↓	↑
Expected response to **DO** stress	↓	↑		

Dissolved Oxygen Monitoring Data

Table 465. Dissolved oxygen monitoring data for reach 07020006-540

07020006-540 DO Data 5 mg/L target	Range of Data (mg/L)	% of Monthly Samples < 5 mg/L [# of Samples]							May - Sep <5 mg/L % [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-373 (2017-2020)	3.7 – 11.57	-	-	0% [2]	-	100% [1]	0% [1]	-	25% [4]
		Minimum Value							
		-	-	8.1	-	3.7	8.1	-	
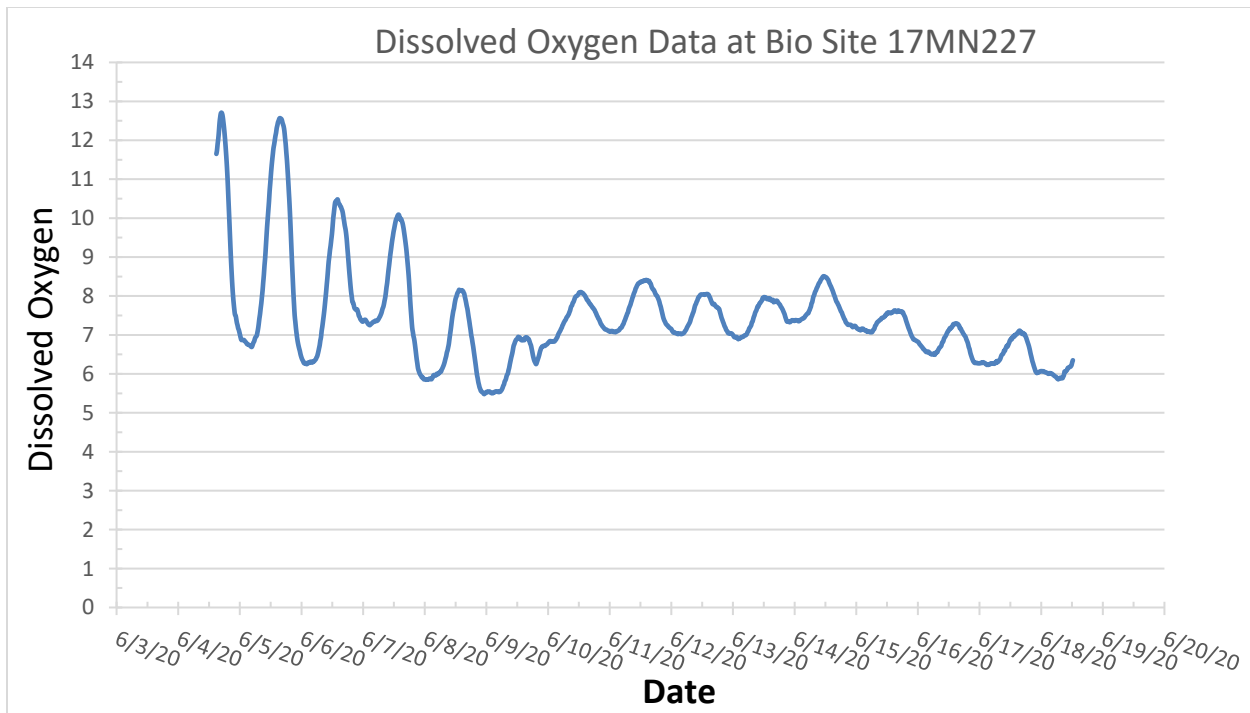
Figure 97. Continuous dissolved oxygen data at site 17MN227

Dissolved Oxygen Summary

The invertebrate community at bio site 17MN227 scored below average in all four DO related invertebrate metrics when compared to the average of all other Class 7 southern prairie stream glide pool bio sites that meet the MIBI modified use threshold (Table 464). The DO tolerance index value was just below the class average and the HBI_MN index score was above the class average. There were no invertebrates caught that are considered intolerant to low DO and over 71% of the taxa caught are considered tolerant to low DO. The top four most numerous taxa present, the damselfly Coenagrionidae, the midges paratanytarsus and dicrotendipes, as well as the amphipod hyalella, are either tolerant or very tolerant to low DO. Those four taxa comprised over 67% of the total number of inverts caught.

Only four discreet DO measurements were taken from 2017-2020 in reach 07020006-540. Out of the four, one was below the DO standard of 5 mg/L (Table 465). An YSI Sonde water meter measured continuous DO data from 6/4/2020 to 6/18/2020 (Figure 97). During this deployment, DO values were not measured below the standard.

Based on the related fish biological metric scores and the measured sonde values, DO is inconclusive as a stressor in this reach.

3.7.1.6   Eutrophication

Eutrophication Biological Metric Data

Table 466. Eutrophication related invert metrics for reach 07020006-540

07020006-540 Invert Class 7 Modified Use	Crustacean and Mollusca %	Collector – Gatherer Taxa #	Ephemeroptera Plecoptera Trichoptera Taxa %	Intolerant Two Taxa %	Scraper %	Taxa Count All #	Tolerant Two Taxa %
17MN227 8/02/2017	22.0	8	11.5	0.0	9.1	26	96.2
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI modified use threshold (22)	**23.2**	**11.8**	**15.2**	**0.1**	**17.7**	**33.6**	**86.6**
Expected response to **Eutrophic** stress	↑	↓	↓	↓	↑	↓	↑

Eutrophication Monitoring Data

Table 467. Phosphorus monitoring data for reach 07020006-540

07020001-540 P Sample Data 0.150 mg/L target	Range of Data (mg/L)	Monthly Average of Samples (mg/L) [# of Samples]							June-Aug Average (mg/L) [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-373 (2017-2020)	0.055 – 0.260	-	-	0.175 [3]	-	-	0.148 [2]	-	0.170 [3]
		Maximum Value							
		-	-	0.260	-	-	0.150	-	

Table 468. DO% Saturation monitoring data for reach 07020006-540

07020006-540 DO% Sat Data	Range of Data (%)	Monthly Average of Samples (%) [# of Samples]							June-Aug Average (%) [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-373 (2017-2020)	43.1 – 76.8	-	-	116.2 [2]	-	43.1 [1]	76.8 [1]	-	43.7 [2]

Eutrophication Summary

The invertebrate community at bio site 17MN227 scored mostly poor in eutrophication related invert metrics when compared to the average of all other Class 7 southern prairie stream glide pool bio sites that meet the MIBI modified use threshold (Table 466).

Five samples were collected and analyzed for Phosphorus from 2017 to 2020. The summer average was 0.170 mg/L, above the standard of 0.15 mg/L (Table 466).

An YSI Sonde water meter measured continuous DO data from 6/4/2020 to 6/18/2020 (Figure 97). During this deployment, diel DO flux was measured at or above 5 mg/L several times at the beginning of the deployment. DO flux was lower after 6/9/20 after two rain events.

Figure 98. Photo showing the rock riffle underneath the road crossing. Algae growth is shown growing on the rocks on 6/26/2020.

The biological community is showing the effects of the elevated phosphorus, phosphorus sampling showed elevated concentrations, and DO flux was 5 mg/L or greater. Algae growth was observed at the station (Figure 11). Eutrophication is a stressor in this reach.

3.7.1.7 Suspended Solids

Suspended Solids Biological Metric Data

Table 469. Suspended solids related invert metrics for reach 07020006-540

07020006-540 **Invert Class 7** **Modified Use**	Collector – filterer %	Plecoptera %	TSS TIV	TSS Intolerant %	TSS Tolerant %
17MN227 8/02/2017	2.3	0.0	16.5	0.0	35.6
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI modified use threshold (22)	**9.9**	**0.0**	**16.2**	↓	↑
Expected response to **Suspended Solids** stress	↓	↓	↑		

TSS Monitoring Data

Table 470. Total suspended solids monitoring data for reach 07020006-540

07020006-540 TSS Sample Data	Range of Data (mg/L)	% of Monthly Samples > 65 mg/L [# of Samples]							% of Total Samples > 65 mg/L [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-373 (2017-2020)	25 – 120	-	-	66.6 [3]	-	-	0 [2]	-	40 [5]

Suspended Solids Summary

The invertebrate community at bio site 17MN227 scored below average in four of the five suspended solids related invert metrics when compared to the average of all other Class 7 southern prairie stream glide pool bio sites that meet the MIBI modified use threshold (Table 469). Collector-filterers were low and the only ones present were the midges' tanytarsus and rheotanytarsus. There were no Plecoptera present and the TSS TIV score was just above the class average. There were no TSS intolerant species caught and the percentage of TSS tolerant species was 35.6%, including the most dominant invertebrate present, the damselfly coenagrionidae.

Five samples were collected and analyzed for TSS from 2017 to 2020. Two of the five samples had a TSS concentration above 65 mg/L (Table 470).

Due to the poor TSS related biological metrics and several high TSS samples, TSS appears to be a stressor to the biological community in reach 07020006-540.

3.7.1.8   Nitrates

Nitrate Biological Metric Data

Table 471. Nitrate related invert metrics for reach 07020006-540

07020006-540 **Invert Class 7** Modified Use	Trichoptera Taxa %	Nitrogen TIV	Nitrate Intolerant	Nitrogen Tolerant Taxa %
17MN227 8/02/2017	3.8	3.4	0.0	53.4
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI modified use threshold (22)	**5.9**	**3.3**	↓	↑
Expected response to **nitrogen** stress	↓	↑		

Nitrate Monitoring Data

Table 472. Nitrate monitoring data for reach 07020006-540

07020001-540 Nitrate/Nitrite Sample Data	2x Highest Reach TIV Average	Range of Data (mg/L) [# of Samples]	Monthly Average [# of Samples]						
			April	May	June	July	August	Sept	Oct
S014-373 (2017-2020)	6.6	0.2 – 11.0 [4]	-	-	9.8 [2]	-	-	3.6 [2]	-
			Highest Value						
			-	-	11	-	-	7.0	-

Summary

The macroinvertebrate assemblage at site 17MN227 scored poorly in all four nitrate related metrics evaluated when compared to all other macroinvertebrate Class 7 southern prairie stream glide pool sites (Table 471). Trichoptera taxa were pretty low and their actual numbers were very low as only one nectopsyche, which tend to decrease in streams with excessive nitrate values. There were a high amount of nitrate tolerant invertebrates as well as complete lack of nitrate intolerant invertebrate species. The nitrogen TIV score was just above the class average.

Four samples were collected in reach 07020006-540 and analyzed for nitrate/nitrite (Table 472). Seventy-nine percent of the total nitrate samples had concentrations greater than 6.6 mg/L. Due to the

biological response and relatively high nitrate concentrations, nitrates are a stressor to aquatic life in reach 07020006-540.

3.7.1.9   Reach Stressors

07020006-540	Hydrologic Alteration	Connectivity	Habitat	Dissolved Oxygen	Eutrophication	Suspended Solids	Nitrate
✔ = Stressor ✗ = Not a Stressor O = Inconclusive	✔	✔	✔	O	✔	✔	✔

3.7.2 07020006-520   Judicial Ditch 33
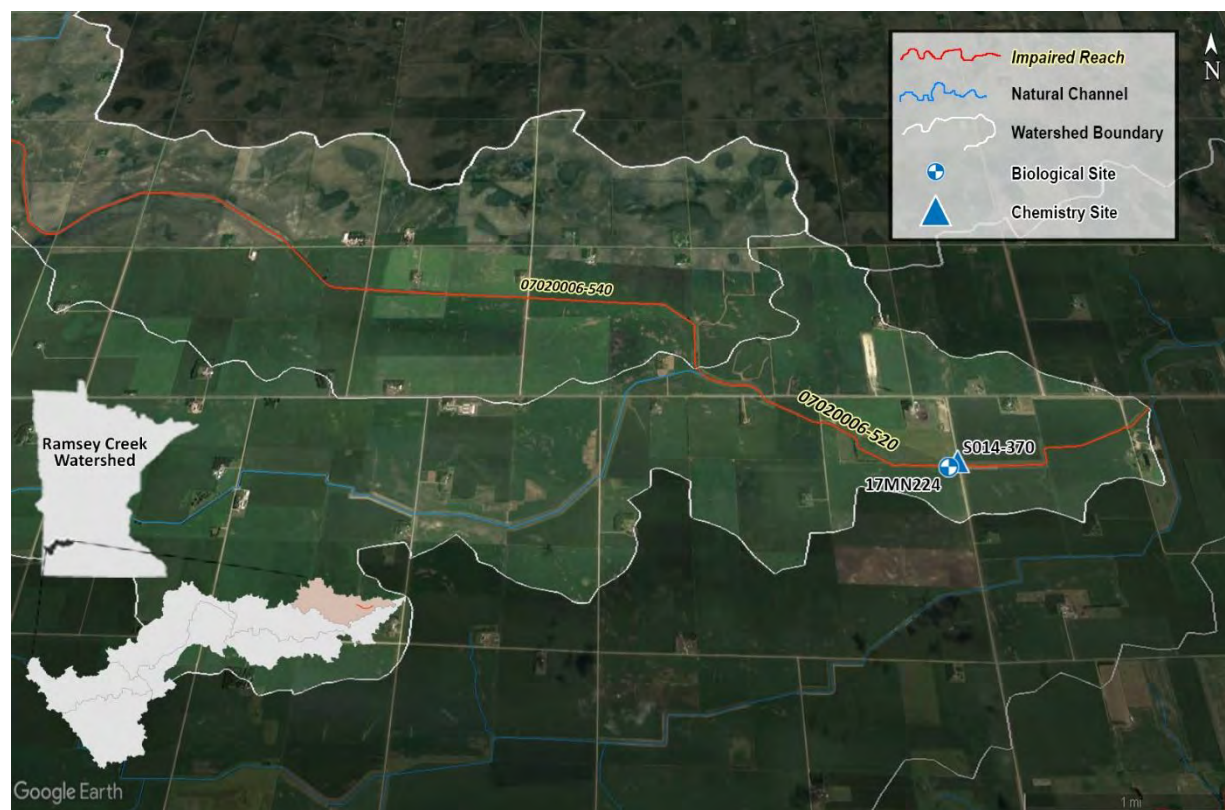
Figure 99. Satellite image of reach 07020006-520 and its watershed

3.7.2.1   Biological Community

Bio site 17MN224 was sampled twice for fish in 2015. The FIBI scores of 0.4 and 7.4 are well below the Fish Class 2 southern streams modified use threshold of 35 (Table 474). Blacknose dace and creek chubs dominated the fish community as well as other tolerant and very tolerant taxa resulting in poor metric scores.

Biological Metric Data

Table 474. Fish IBI score and threshold for reach 07020006-520

07020006-520 **Fish Class 2** **Modified Use**	Fish IBI Score	Class Threshold Score
17MN224 6/13/2017	0.4	35
17MN224 9/26/2017	7.4	

3.7.2.2   Hydrologic Alteration

Hydrologic Alteration Biological Metric Data

Table 475. Hydrologic alteration related fish metrics for reach 07020006-520

07020006-520 **Fish Class 2** **Modified Use**	General %	Nesting Non Lithophilic Spawner %
17MN224 6/13/2017	85.3	0.0
17MN224 9/26/2017	88.2	3.1
Statewide average for Class 2 southern stream bio sites that are meeting the FIBI modified use threshold (35)	**43.9**	**39.2**
Expected response to **Hydrologic** stress	↑	↑

HSPF Model Flow Data

Table 476. HSPF modeled flow data for reach 07020006-520

07020006-520 HSPF Reach 493 Min: 0.1 cfs Max: 747.7 cfs	**<5 cfs %** (# of values)	**<1 cfs %** (# of values)	**<0.5 cfs %** (# of values)
6,210 Total Daily Averages 1996 – 2012	**47.0%** (2,921)	**8.4%** (524)	**3.4%** (212)

Hydrologic Alteration Summary

The hydrologic alteration related biological metrics were mixed. Generalized fish species are correlated with channelization and are adaptable to different habitats through generalized food preferences. Bio site 17MN224 had a population of generalist fish ranging from 85-88% of the population (Table 475). Nesting fish; however, were very low at the bio site. The three or four most numerous taxa present are lithophilic spawning fish.

Figure 100. Photo showing a ditched stream channel at bio site 17MN224. Tile lines on the left side of the photo have been exposed due to erosion of the stream bank.

The HSPF model (Table 476) shows that 8.4% of the daily average flows from 1996 through 2012 are below 1 cfs, which is a relatively low percentage. Flows reduced beyond normal base flow will decrease habitat for aquatic organisms and increase competition for resources.

The HSPF model shows that 22% of the daily average flows from 1996 through 2012 are below 1 cfs (Table 460). Flows reduced beyond normal base flow will decrease habitat for aquatic organisms and increase competition for resources.

Bio site 17MN224 is roughly three miles downstream of 17MN227, where the DNR watershed characterization report conducted geomorphic analysis of the stream. Another ditched tributary enters the stream in between the two bios sites. It is likely similar enough to bio site 17MN227 that some of the same concepts and analysis apply to this bio site. It has been completely altered and exhibits the shape and dimensions of a type G stream. The

Figure 101. Photo showing the ditched stream channel near bio site 17MN227.

manmade channel is deeply incised and entrenched and is effectively cut off from its floodplain.

Based on the mixed scores of the biological metrics, relatively low percentage of low flow periods shown in the HSPF model, hydrologic alteration is inconclusive as a stressor in this reach.

3.7.2.3   Connectivity

Connectivity Metric Data

Table 477. Connectivity related fish metrics for reach 07020006-520

07020006-520 **Fish Class 2** Modified Use	Mature Age >3 minus Tolerant Taxa %	Migrating Taxa %
17MN224 6/13/2017	0.0	25.0
17MN224 9/26/2017	0.0	14.3
Statewide average for Class 2 southern stream bio sites that are meeting the FIBI modified use threshold (35)	**17.1**	**20.6**
Expected response to **Connectivity** stress	↓	↓

Connectivity Summary

Connectivity related metrics were mostly poor (Table 477). There were no fish taxa whose females take greater than three years to mature. Migrating taxa percentage during the June visit was actually above the class average. Only four taxa were present at the June visit and white suckers were the only migrating taxa present. There were seven total taxa caught during the September visit with white suckers being the only migrating taxa present again. Lateral or side to side connectivity is likely a stressor as the channel is completely cut off from its flood plain and has very little depth variability throughout the ditch. "Overall, the channel at the upper Ramsey Creek – Judicial Ditch #33 survey location has no habitat and holds virtually no aquatic resource value. The stream has historically been channelized, thus destroying any and all habitat that may have once existed" (DNR 2020).

Due to the poor connectivity related fish metrics and evidence of channelization, lateral connectivity appears to be a stressor to the biological community in reach 07020006-520.

3.7.2.4　Habitat

Habitat Metric Data

Table 478. Habitat related fish metrics for reach 07020006-520

07020006-520 **Fish Class 2** Modified Use	Benthic Insect minus Tolerant %	Darter Sculpin Sucker %	Lithophilic Spawner %	Pioneer %	Piscivore %	Riffle %	Simple Lithophilic Spawner %	Tolerant %
17MN224 6/13/2017	0.0	0.0	85.3	26.5	0.0	4.4	58.8	100.0
17MN224 9/26/2017	0.0	0.0	85.5	36.8	0.0	11.3	51.4	100.0
Statewide average for Class 2 southern stream bio sites that are meeting the FIBI modified use threshold (35)	**19.1**	**16.5**	**35.6**	**23.6**	**8.0**	**19.5**	**26.2**	**46.4**
Expected response to Habitat stress	↓	↓	↓	↑	↓	↓	↓	↑

MPCA Stream Habitat Assessment Score

Table 479. Habitat Assessment scores for reach 07020006-520

07020006-520	Land Use	Riparian	Substrate	Cover	Channel Morphology	Total Score
17MN224 6/13/2017	0	9	17	6	8	40
17MN224 8/02/2017	0	6.5	13.3	11	17	47.8
17MN224 9/26/2017	0	8.5	10	10	3	31.5
Maximum Attainable Habitat Score	**5**	**14**	**28**	**18**	**35**	**100**

Habitat Summary

The fish community in reach 07020006-520 scored below average in most of the habitat related fish metrics when compared to all other Class 2 southern stream bio sites that meet the FIBI modified use threshold (Table 478). There were no benthic insectivores that are not

Figure 102. Photo of Bio site 17MN224. The stream channel is a straightened ditch that appears to be incised. There is very little depth variability in the stream channel.

considered tolerant and no darters, sculpins, or round-bodied suckers present. There were lithophilic spawners present, though they were blacknose dace, creek chubs, and white suckers, which are all considered tolerant species. The high percentage of creek chubs, being the second most numerous taxa present, caused the pioneer percentage to be higher than the class average. There were no Piscivores caught and riffle dwelling fish were low as white suckers were the only riffle dwelling fish caught. All of the fish taxa present are considered either tolerant or very tolerant.

All three MSHA scores done in 2017 were poor (Table 479). There was some sand and other coarse sediments present, though silt and embeddedness were observed. During a site visit in 2020 the stream bottom had some sand but the bottom was very soft. There were no riffles present in the stream channel.

It appears that the substrate may not be an issue and that lack of both geomorphic structures and depth variability are what is causing the stress on the biological community. Due to the lack of nontolerant benthic insectivores, darters, and riffle dwelling fish, as well as the only lithophilic spawning fish being tolerant generalists, habitat is a stressor in reach 07020006-520.

3.7.2.5   Dissolved Oxygen

Dissolved Oxygen Biological Metric Data

Table 480. Dissolved oxygen related fish metrics for reach 07020006-520

07020006-520 **Fish Class 2** Modified Use	Mature Age >3 %	Serial Spawner %	Taxa Count	DO TIV	DO Sensitive %	DO Tolerant %
17MN224 6/13/2017	4.4	14.7	4	8.7	0.0	0.0
17MN224 9/26/2017	11.3	10.0	7	8.5	0.0	7.3
Statewide average for Class 2 southern stream bio sites that are meeting the FIBI modified use threshold (35)	**28.0**	**25.3**	**15.2**	**8.3**	↓	↑
Expected response to **DO** stress	↓	↑	↓	↓		

Dissolved Oxygen Monitoring Data

Table 481. Dissolved oxygen monitoring data for reach 07020006-520

07020006-520 DO Data 5 mg/L target	Range of Data (mg/L)	% of Monthly Samples < 5 mg/L [# of Samples]							May - Sep <5 mg/L % [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-370 (2017-2020)	2.0 – 16.0	-	-	25 [4]	-	100 [2]	-	-	50 [6]
		Minimum Value							
		-	-	2.0	-	2.4	-	-	

Dissolved Oxygen Summary

The DO related fish metrics at bio site 17MN224 were mixed (Table 480). There were no fish caught who are sensitive to low DO, though there were very few fish caught that are tolerant to low DO. Species with females that take more than three years to mature comprised 4.4% and 11.3%, both well below class average. Overall taxa count was well below average. Serial spawners were relatively low and the DO tolerance index value scored well. All of the taxa caught are considered either tolerant or very tolerant.

Out of the six DO measurements taken from 2017 through 2020, three of them were below the standard value of 5 mg/L (Table 481).

Based on the related fish biological metric scores and the measured DO values, DO is a likely a stressor in this reach, though at this time it is inconclusive.

3.7.2.6 Eutrophication

Eutrophication Biological Metric Data

Table 482. Eutrophication related fish metrics for reach 07020006-520

07020006-520 Fish Class 2 Modified Use	Darter %	Omnivore %	Sensitive %	Simple Lithophillic Spawner %	Tolerant %
17MN224 6/13/2017	0.0	4.4	0.0	58.8	100.0
17MN224 9/26/2017	0.0	14.0	0.0	51.4	100.0
Statewide average for Class 2 southern stream bio sites that are meeting the FIBI modified use threshold (35)	**13.6**	**25.5**	**8.4**	**26.2**	**46.4**
Expected response to **Eutrophication** stress	↓	↑	↓	↓	↑

Eutrophication Monitoring Data

Table 483. Phosphorus monitoring data for reach 07020006-520

07020001-520 P Sample Data 0.150 mg/L target	Range of Data (mg/L)	Monthly Average of Samples (mg/L) [# of Samples]							June-Aug Average (mg/L) [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-370 (2017 - 2020)	0.041 – 0.366	-	-	0.204 [2]	-	-	0.083 [3]	-	0.285 [2]
		Maximum Value							
		-	-	0.366	-	-	0.096	-	

Table 484. DO% Saturation monitoring data for reach 07020006-520

07020006-520 DO% Sat Data	Range of Data (%)	Monthly Average of Samples (%) [# of Samples]							June-Aug Average (%) [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-370 (2017-2020)	83.5 – 191.4	-	-	143.1 [4]		116.2 [1]	119.2 [1]	-	138.3 [5]

Eutrophication HSPF Model Data

Eutrophication Summary

The fish community at bio site 17MN224 scored below average in all three out of five eutrophication related fish metrics when compared to the average of all other Class 2 southern stream bio sites that meet the FIBI modified use threshold (Table 482). There were no darters or generally sensitive fish caught. Every fish taxa present is considered generally tolerant. Omnivorous fish were low as the two most abundant taxa, blacknose dace and creek chubs, are an invertivore and carnivore respectively.

Five samples were collected and analyzed for Phosphorus from 2017 through 2020. The summer average was over twice the standard of 0.15 mg/L (Table 483).

Five discreet DO measurements were taken from 2017 to 2020 (Table 484). The monthly averages for percent saturation were all very high, well above 100%.

The biological community is showing the effects of the elevated phosphorus, phosphorus sampling showed elevated concentrations, and DO percent saturation was very high. Eutrophication is a stressor in reach 07020006-520.

3.7.2.7   Suspended Solids

Suspended Solids Biological Metric Data

Table 485. Suspended solids related fish metrics for reach 07020006-520

07020006-520 Fish Class 2 Modified Use	Benthic Feeder %	Centrarchid - Tolerant %	Herbivore %	Intolerant %	Long – lived %	Perciformes - Tolerant %	Riffle %	Sensitive %	Simple Lithophilic Spawner %	TSS TIV
17MN224 6/13/2017	4.4	0.0	0.0	0.0	0.0	0.0	4.4	0.0	58.8	13.4
17MN224 9/26/2017	11.3	0.0	4.1	0.0	0.0	0.0	11.3	0.0	51.4	14.7
Statewide average for Class 2 southern stream bio sites that are meeting the FIBI modified use threshold (35)	**30.1**	**6.2**	**2.9**	**0.9**	**21.3**	**28.7**	**19.5**	**8.4**	**26.2**	**20.7**
Expected response to **Suspended Solids** stress	↓	↓	↓	↓	↓	↓	↓	↓	↓	↑

TSS Monitoring Data

Table 486. Total suspended solids monitoring data for reach 07020006-520

07020006-520 TSS Sample Data	Range of Data (mg/L)	% of Monthly Samples > 65 mg/L [# of Samples]							% of Total Samples > 65 mg/L [# of Samples]
		April	May	June	July	August	Sept	Oct	
S014-370 (2017 - 2020)	6.4 – 190	-	-	50 [2]	-	-	0 [2]	-	25 [4]

Suspended Solids Summary

The fish community at bio site 17MN224 scored below average in most of the suspended solids related fish metrics when compared to the average of all other Class 2 southern stream bio sites that meet the FIBI modified use threshold (Table 485). There were some herbivores and simple lithophillic spawners present. The TSS tolerance index values were also below the class average. None of the fish caught are considered tolerant to TSS. The rest of the metrics were very poor.

Only four samples were collected and analyzed for TSS from 2009 through 2020. Of those four, one sample had a TSS concentration of 190 mg/l (Table 486).

Suspended solids could be stressing the biological community but are inconclusive as a stressor at this time. It is likely that other factors, such as altered hydrology or habitat are causing such poor scores in the fish biological metrics. It is recommended that more TSS data be collected during high flows in order to determine whether it is a biological stressor.

3.7.2.8   Nitrates

Nitrate Biological Metric Data

Table 487. Nitrate related invert metrics for reach 07020006-520

07020006-520 Invert Class 7 Modified Use	Trichoptera Taxa %	Nitrogen TIV	Nitrate Intolerant %	Nitrogen Tolerant Taxa %
17MN224 8/02/2017	8.7	4.5	0.0	84.0
17MN224 8/02/2017	9.1	4.1	0.0	86.5
Statewide average for Class 7 prairie stream glide pool bio sites that are meeting the FIBI modified use threshold (22)	**5.9**	**3.3**	↓	↑
Expected response to **nitrogen** stress	↓	↑		

Nitrate Monitoring Data

Table 488. Nitrate monitoring data for reach 07020006-520

| 07020001-520 Nitrate/Nitrite Sample Data | 2x Highest Reach TIV Average | Range of Data (mg/L) [# of Samples] | Monthly Average [# of Samples] | | | | | | |
			April	May	June	July	August	Sept	Oct
S014-370 (2017 - 2020)	6.6	6.9 – 14 [4]	-	-	11.9 [2]	-	-	7.1 [2]	-
			Highest Value						
			-	-	14.0	-	-	7.3	-

Summary

The macroinvertebrate assemblage at site 17MN224 scored poorly in most of the nitrate related invert metrics (Table 487). The biological bio site did show a healthy amount of Trichoptera taxa, which tend to decrease in streams with excessive nitrate values, though the majority of species caught are considered very tolerant to nitrates. There was a high amount of nitrate tolerant invertebrates as well as complete lack of nitrate intolerant invertebrate species. The nitrogen TIV score also indicates a macroinvertebrate community that is generally tolerant to high levels of nitrates.

Four samples were collected in reach 07020006-520 and analyzed for nitrate/nitrite (Table 488). All four samples had a nitrate/nitrite concentration above the 2x TIV value of 6.6 mg/L. Due to the biological response and relatively high nitrate concentrations, nitrates are a stressor to aquatic life in reach 07020006-520.

3.7.2.9   Reach Stressors

Table 489. Summary of stressors for reach 07020006-520

07020006-520	Hydrologic Alteration	Connectivity	Habitat	Dissolved Oxygen	Eutrophication	Suspended Solids	Nitrate
✔ = Stressor ✘ = Not a Stressor O = Inconclusive	O	✔	✔	O	✔	O	✔

3.7.3 07020006-521   Ramsey Creek

Figure 103. Satellite image of reach 07020006-521 and its watershed

3.7.3.1   Biological Community

Bio site 92MN047 was sampled once for fish in 2017. The FIBI score of 20.1 is well below the Fish Class 2 Southern Streams general use threshold of 50 (Table 490). Blacknose dace, white suckers, and creek chubs dominated the fish community as well as other tolerant taxa resulting in a poor metric score. All three of those fish are considered generalist taxa. There were also high numbers of bigmouth shiners present, which is a very tolerant, short-lived, seriel spawner.

The invertebrate community was also sampled in 2017 and had a scored a 9.7, well below the invert class 5 general use threshold of 37 (Table 491). The site was dominated by the net spinning caddisfly ceratopsyche, with lower numbers of the snail physella and the mayfly baetis intercalaris.

Biological Metric Data

Table 490. Fish IBI score and threshold for reach 07020006-521

07020006-521 **Fish Class 2** General Use	Fish IBI Score	Class Threshold Score
92MN047 6/26/2017	20.1	50

Table 491. Invert IBI score and threshold for reach 07020006-521

07020006-521 **Invert Class 5** General Use	Invert IBI Score	Class Threshold Score
92MN047 8/08/2017	9.7	37

3.7.3.2   Hydrologic Alteration

Hydrologic Alteration Biological Metric Data

Table 492. Hydrologic alteration related fish metrics for reach 07020006-521

07020006-521 **Fish Class 2** General Use	General %	Nesting Non Lithophilic Spawner %
92MN047 6/26/2017	88.0	3.5
Statewide average for Class 2 Southern Stream bio sites that are meeting the FIBI general use threshold (50)	**42.4**	**19.1**
Expected response to **Hydrologic** stress	↑	↑

Table 493. Hydrologic alteration related invert metrics for reach 07020006-521

07020006-521 **Invert Class 5** General Use	Clinger %	Collector – filterer %	Long – lived %		Percent Ditched Intolerant %	Percent Ditched Tolerant %
92MN047 8/08/2017	63.8	60.5	5.5		7.4	2.9
Statewide average for Class 5 prairie stream rock riffle bio sites that are meeting the FIBI general use threshold (37)	**49.5**	**26.9**	**9.0**		↓	↑
Expected response to **Hydrologic** stress	↓	↓	↓			

HSPF Model Flow Data

Table 494. HSPF modeled flow data for reach 07020006-521

07020006-521 HSPF Reach 495 Min: 0.2 cfs Max: 1,664.2 cfs	<5 cfs % (# of values)	<1 cfs % (# of values)	<0.5 cfs % (# of values)
6,210 Total Daily Averages 1996 – 2012	**36.8%** (2,286)	**4.6%** (283)	**1.8%** (110)

Hydrologic Alteration Summary

The hydrologic alteration related fish metrics were mixed (Table 492). Generalized fish species are correlated with channelization and are adaptable to different habitats through generalized food preferences. Bio site 92MN047 had a generalist fish population of 88 %. Nesting fish; however, were very low at only 3.5% as the majority of fish present were lithophilic spawners. Almost all of the species caught were either tolerant or very tolerant.

Hydrologic alteration related invert metrics scored mostly well (Table 493). The most dominant invert, the net spinning caddisfly *ceratopsyche*, made up over 58% of the total number of inverts caught and is both a clinger and collector filterer. 183 ceratopsyche were caught, followed by 45 of a different net spinning caddisfly, *cheumatopsyche*. Both caddisflies are considered very intolerant to poor depth variability, indicating that there are enough pools, riffles, and other geomorphic features present in this section of the reach to support a species that are sensitive to direct channel alterations. Ceratopsyche is considered intolerant to several habitat metrics as well, also indicating that the hydrologic alteration of the stream channel itself, like in the upstream sections of the watershed, is not stressing the biological community in the same way. These two caddisflies are actually tolerant to low flows, indicating that

variability of the stream flow could be affecting the biological community in this stream section. The next most numerous invert caught were 17 physella snails and 12 baetis mayflies. There were also a few species that are intolerant to ditching and very few ditch tolerant ones present.

The HSPF model (Table 494) shows that 4.6% of the daily average flows from 1996 through 2012 are below 1 cfs, and flows below 5 cfs were 36.8%

The site was also dominated by flow tolerant invertebrates as well as tolerant and very tolerant fish. Hydrologic alteration appears to be having some effect on the biological community, likely from stream alterations and drainage upstream that cause water to move more quickly off the landscape, causing an increase in peak flows, which can cause changes to the structures of the stream channel that had developed through geomorphic processes. Lower Ramsey Creek was classified as a B3c. "Measurements at the riffle cross section determined the BHR to be 2.23. A BHR of 2.23 is considered to be deeply incised. The entrenchment ratio was measured to be 1.4 at the same location. An entrenchment of 1.4 is considered to be moderately entrenched, as the channel is roughly 0.75 feet below having good floodplain access over its left bank. Sinuosity at the Lower Ramsey Creek site was also low; however, the low sinuosity is due to the steep grade of the valley and stream type rather than historical channelization. Sinuosity was measured to be 1.17, just below the typical range found for B channels. Several banks showed signs of mass failure along the incised channel and a study bank was established." (DNR 2020). The biological metrics were mixed, geomorphic measurements indicate that the channel is incised, and there were some low flow periods shown in the HSPF model. Hydrologic alteration is stressing the biological community in reach 07020006-521.

3.7.3.3   Connectivity

Connectivity Metric Data

Table 495. Connectivity related fish metrics for reach 07020006-521

07020006-521 Fish Class 2 General Use	Mature Age >3 minus Tolerant Taxa %	Migrating Taxa %
92MN047 6/26/2017	14.3	28.6
Statewide average for Class 2 Southern Stream bio sites that are meeting the FIBI general use threshold (50)	**21.8**	**24.3**
Expected response to **Connectivity** stress	↓	↓

Connectivity Summary

Metrics for fish taxa whose females take greater than three years to mature were low (Table 495). The only nontolerant late-maturing taxa present was the brown trout, which is a sensitive but also an invasive fish in Minnesota. Migrating taxa were present and were over the class average for southern streams that meet the standard, though the majority were white suckers, a tolerant species.

Figure 104. Photo of the artificial rapids and rip rap placed to help protect the bridge crossing near bio site 92MN047.

Although there were late-maturing and migratory species, the majority were white suckers, a tolerant species. This part of Ramsey Creek is relatively natural though the bridge crossing near the bio site appears to have an artificial rapids that has been created to protect the streambank and bridge foundation (Figure 104). The rapids appears to be a fish barrier as the rocks placed there and the shape of the bank has created a much narrower channel and faster moving water than the other parts of the stream. There is also a waterfall downstream of the bio site several meters high that is a natural fish barrier and would prevent fish from moving upstream at all times of the year. Connectivity is a stressor to the biological community in Ramsey Creek, though the waterfall is a natural barrier.

3.7.3.4   Habitat

Habitat Metric Data

Table 496. Habitat related fish metrics for reach 07020006-521

07020006-521 **Fish Class 2** General Use	Benthic Insect minus Tolerant %	Darter Sculpin Sucker %	Lithophilic Spawner %	Pioneer %	Piscivore %	Riffle %	Simple Lithophilic Spawner %	Tolerant %
92MN047 6/26/2017	0.0	0.0	85.7	25.7	1.2	26.1	62.2	98.8
Statewide average for Class 2 Southern Stream bio sites that are meeting the FIBI general use threshold (50)	**20.4**	**18.2**	**58.3**	**19.0**	**5.2**	**32.5**	**39.4**	**44.9**
Expected response to **Habitat** stress	↓	↓	↓	↑	↓	↓	↓	↑

Table 497. Habitat related invert metrics for reach 07020006-521

07020006-521 **Invert Class 5** General Use	Burrower %	Climber %	Clinger %	Ephemeroptera Plecoptera Trichoptera %	Legless %	Sprawler %
92MN047 8/08/2017	1.0	5.8	63.8	83.5	12.3	5.5
Statewide average for Class 5 prairie stream rock riffle bio sites that are meeting the FIBI general use threshold (37)	**7.5**	**14.7**	**49.5**	**43.9**	**36.0**	**16.8**
Expected response to **Habitat** stress	↑	↓	↓	↓	↑	↑

MPCA Stream Habitat Assessment Score

Table 498. Habitat Assessment scores for reach 07020006-521

07020006-521	Land Use	Riparian	Substrate	Cover	Channel Morphology	Total Score
92MN047 6/26/2017	1	7.5	16.9	15	24	64.4
92MN047 8/08/2017	0	8	16.6	12	25	61.6
Maximum Attainable Habitat Score	**5**	**14**	**28**	**18**	**35**	**100**

Habitat Summary

The fish community in reach 07020006-521 scored below average in six out of eight habitat related fish metrics when compared to all other Class 2 southern stream bio sites that meet the FIBI general use threshold (Table 496). There were no nontolerant benthic insectivores or darters, sculpins, or

Figure 105. Photo near bio site 92MN047 just upstream of the bridge at the road crossing showing the natural stream channel and a small riffle.

round-bodied suckers present. The most dominant fish present, the blacknose dace, is a tolerant invertivore. The lithophilic spawning percentage scored well as the top three most numerous fish present are all lithophilic spawners. Pioneer fish percentage was high as there creek chubs were the third most numerous fish caught. Piscivore percentage was low, as were riffle dwelling fish. Tolerant fish made up over 98% of the total number caught.

The habitat related invert metrics scored mostly well as the only metric to score poorly was the percentage of climbers. The only climbers caught were 17 physella snails as well as one of each of a hydroptilidae caddisfly and the midge polypedilum. The percentage of both legless and sprawler inverts was low. Burrowers were low and the two most dominant invertebrates present, the caddisflies ceratopsyche and cheumatopsyche, are both clingers and between the two of them, are over 73% of the total number of inverts caught.

The MSHA scores were moderate, the riparian zone had good shade and riparian width, though bank erosion was an issue. Several types and sizes of substrates, including cobble, gravel, and sand were observed at the bio sites during both site visits in 2017. There was also good cover observed at the site, including deep pools, undercut banks, logs and woody debris, and boulders. The channel morphology score was good as depth variability, sinuosity, channel stability and channel development scored well.

The bio metrics were mixed as the fish metrics are mostly poor; however, lithophilic spawners were very high, indicating that substrate is likely not the issue. It is likely that other factors, such as connectivity, is having an effect on the remaining fish metrics that scored poorly. Invertebrate metrics scored mostly well with high amounts of clinger and EPT individuals present. The most numerous invert caught is also considered intolerant to several habitat related metrics. Because of the mixed metrics and decent MSHA score, habitat is inconclusive as a stressor in reach 07020006-521.

3.7.3.5   Dissolved Oxygen

Dissolved Oxygen Biological Metric Data

Table 499. Dissolved oxygen related fish metrics for reach 07020006-521

07020006-521 **Fish Class 2** General Use	Mature Age >3 %	Serial Spawner %	Taxa Count	DO TIV	DO Sensitive %	DO Tolerant %
92MN047 6/26/2017	27.4	13.9	7	8.6	1.2	3.9
Statewide average for Class 2 Southern Stream bio sites that are meeting the FIBI general use threshold (50)	**23.9**	**28.7**	**19.9**	**8.4**	↓	↑
Expected response to **DO** stress	↓	↑	↓	↓		

Table 500. Dissolved oxygen related invert metrics for reach 07020006-521

07020006-521 **Invert Class 5** General Use	DO TIV	HBI_MN	Low DO Intolerant Taxa %	Low DO Tolerant Taxa %
92MN047 8/08/2017	7.9	7.0	66.2	1.6
Statewide average for Class 5 prairie stream rock riffle bio sites that are meeting the FIBI general use threshold (37)	**7.1**	**7.0**	↓	↑
Expected response to **DO** stress	↓	↑		

Dissolved Oxygen Monitoring Data

Table 501. Dissolved oxygen monitoring data for reach 07020006-521

07020006-521 DO Data 5 mg/L target	Range of Data (mg/L)	% of Monthly Samples < 5 mg/L [# of Samples]							May - Sep <5 mg/L % [# of Samples]
		April	May	June	July	August	Sept	Oct	
S004-387 **S013-696** (2009-2018)	5.4 – 11.8	-	0.0 [2]	0.0 [6]	0.0 [6]	0.0 [8]	0.0 [3]	-	0 [25]
		Minimum Value							
		-	10.4	7.8	5.4	7.7	8.7	-	
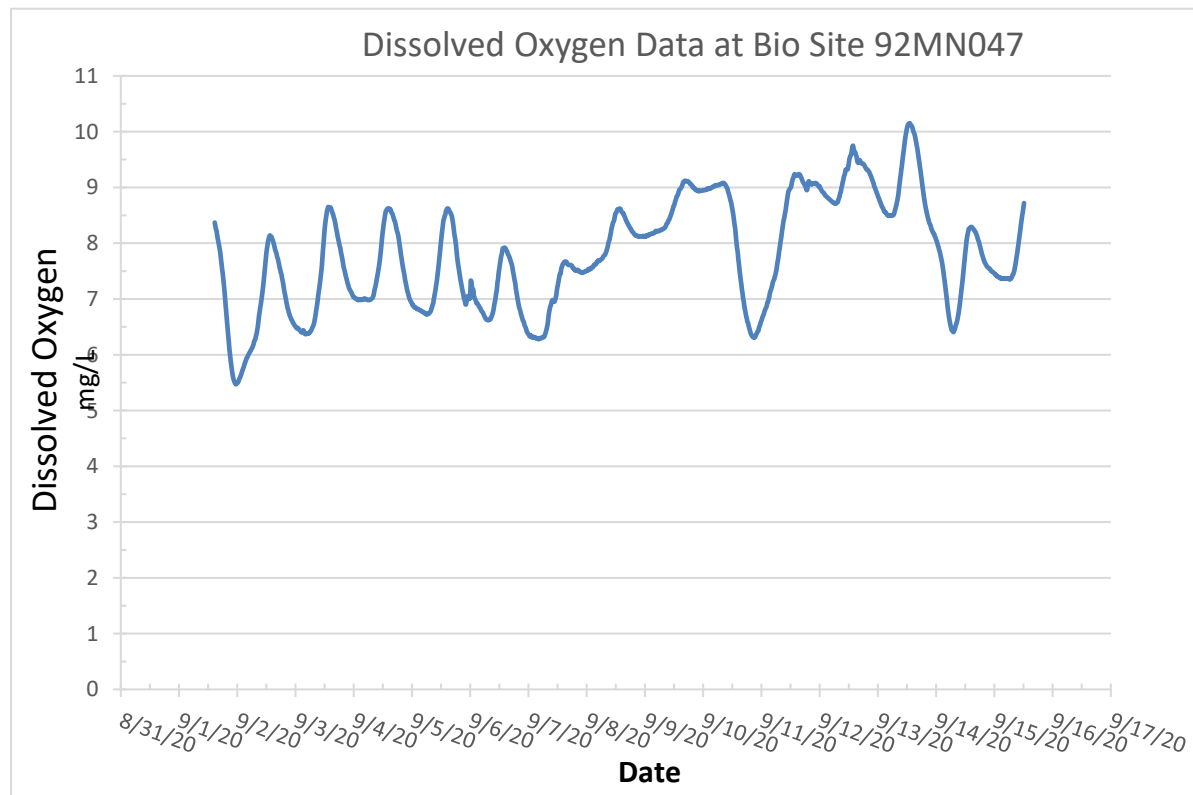
Figure 106. Continuous dissolved oxygen data at site 92MN047

Dissolved Oxygen Summary

The fish community at bio site 92MN047 scored mostly well in DO related fish metrics when compared to the average of all other Class 2 southern stream bio sites that meet the FIBI general use threshold (Table 499). Species with females that take more than three years to mature comprised 27.4%, above the class 2 average. Serial spawners were low and the DO tolerance value index scored higher than the class average. DO tolerant species comprised only 3.9% of the fish population. Taxa count was low; however, and only 1.2% of DO sensitive fish were caught.

Invertebrate DO related metrics all scored well (Table 500). The DO tolerance index value scored above average and the HBI_MN score was right at the class average. The low DO intolerant taxa was very high at 66.2% and low DO tolerant taxa were very low. Also, the most abundant invertebrate present, the caddisfly ceratopsyche, is considered intolerant to low DO.

Although no DO measurements taken during sampling were below the warmwater standard of 5 mg/L, none of those measurements were taken before 8:00 a.m., when values are usually the lowest (Table 501). An YSI Sonde water meter measured continuous DO data from 9/1/2020 to 9/15/2020 (Figure 106). During this deployment, DO values were not measured below 5mg/L.

Based on the related fish and invertebrate biological metric scores and the measured sonde values, DO does not appear to be a stressor in this reach.

3.7.3.6   Eutrophication

Eutrophication Biological Metric Data

Table 502. Eutrophication related fish metrics for reach 07020006-521

07020006-521 Fish Class 2 General Use	Darter %	Omnivore %	Sensitive %	Simple Lithophillic Spawner %	Tolerant %
92MN047 6/26/2017	0.0	29.7	1.2	62.2	98.8
Statewide average for Class 2 Southern Stream bio sites that are meeting the FIBI general use threshold (50)	**11.7**	**16.5**	**18.7**	**39.4**	**44.9**
Expected response to **Eutrophication** stress	↓	↑	↓	↓	↑

Table 503. Eutrophication related invert metrics for reach 07020006-521

07020006-521 Invert Class 5 General Use	Crustacean and Mollusca %	Collector – Gatherer Taxa #	Ephemeroptera Plecoptera Trichoptera Taxa %	Intolerant Two Taxa %	Scraper %	Taxa Count All #	Tolerant Two Taxa %
92MN047 8/08/2017	6.5	6	30.0	0.0	8.4	20	85.0
Statewide average for Class 5 prairie stream rock riffle bio sites that are meeting the FIBI general use threshold (37)	**9.2**	**15.1**	**30.5**	**0.8**	**15.8**	**41.9**	**74.3**
Expected response to **Eutrophic** stress	↑	↓	↓	↓	↑	↓	↑

Eutrophication Monitoring Data

Table 504. Phosphorus monitoring data for reach 07020006-521

07020001-521 P Sample Data 0.150 mg/L target	Range of Data (mg/L)	Monthly Average of Samples (mg/L) [# of Samples]							June-Aug Average (mg/L) [# of Samples]
		April	May	June	July	August	Sept	Oct	
S004-387 (2017-2020)	0.039 – 0.427	-	0.088 [2]	0.165 [4]	0.196 [4]	0.133 [3]	0.100 [3]	-	0.167 [11]
		Maximum Value							
		-	0.136	0.427	0.396	0.141	0.153	-	

Table 505. DO% Saturation monitoring data for reach 07020006-521

07020006-521 DO% Sat Data	Range of Data (%)	Monthly Average of Samples (%) [# of Samples]							June-Aug Average (%) [# of Samples]
		April	May	June	July	August	Sept	Oct	
S013-696 (2017-2020)	95.1 – 159.3	-	-	143.4 [2]	-	95.1 [1]	-	-	127.3 [3]

Eutrophication Summary

The fish community at bio site 92MN047 scored below average in four out of five eutrophication related fish metrics when compared to the average of all other Class 2 southern stream bio sites that meet the FIBI general use threshold (Table 502). There were no darter individuals and omnivorous fish comprised around 29.7% of the population. There were almost no sensitive species and 98.8% of individuals present were tolerant species. Lithophilic spawners were very high, however.

Eutrophication related invertebrate metrics were also mostly poor (Table 503). Collector-gatherer taxa count was low and EPT taxa percentage was just below the class average. There were no taxa considered intolerant and overall taxa count was low. The two most abundant tolerant species comprised 85% of the total number taxa caught. Crustaceans and Mollusca percentage was low as was the scraper percentage.

Eleven samples were collected and analyzed for Phosphorus from 2017 through 2020. The summer average was twice the standard of 0.15 mg/L (Table 504).

An YSI Sonde water meter measured continuous DO data from 9/1/2020 to 9/15/2020 (Figure 106). During this deployment, diel DO flux was not measured at or above 5 mg/L.

The biological community may be showing the effects of the elevated phosphorus, phosphorus sampling showed elevated concentrations, though DO flux was not 5 mg/L or greater. Eutrophication is inconclusive as a stressor in this reach.

3.7.3.7 Suspended Solids

Suspended Solids Biological Metric Data

Table 506. Suspended solids related fish metrics for reach 07020006-521

07020006-521 **Fish Class 2** General Use	Benthic Feeder %	Centrarchid - Tolerant %	Herbivore %	Intolerant %	Long – lived %	Perciformes - Tolerant %	Riffle %	Sensitive %	Simple Lithophilic Spawner %	TSS TIV
92MN047 6/26/2017	26.1	0.0	0.4	0.0	1.2	0.0	26.1	1.2	62.2	14.4
Statewide average for Class 2 Southern Stream bio sites that are meeting the FIBI general use threshold (50)	**37.4**	**4.9**	**9.6**	**5.0**	**11.7**	**18.7**	**32.5**	**18.6**	**39.4**	**17.9**
Expected response to **Suspended Solids** stress	↓	↓	↓	↓	↓	↓	↓	↓	↓	↑

07020006-521 Invert Class 5 General Use	Collector – filterer %	Plecoptera %	TSS TIV	TSS Intolerant %	TSS Tolerant %
92MN047 8/08/2017	60.5	0.0	15.8	0.0	24.8
Statewide average for Class 5 prairie stream rock riffle bio sites that are meeting the FIBI general use threshold (37)	**26.9**	**0.5**	**15.9**	↓	↑
Expected response to **Suspended Solids** stress	↓	↓	↑		

TSS Monitoring Data

Table 508. Total suspended solids monitoring data for reach 07020006-521

07020006-521 TSS Sample Data	Range of Data (mg/L)	% of Monthly Samples > 65 mg/L [# of Samples]							% of Total Samples > 65 mg/L [# of Samples]
		April	May	June	July	August	Sept	Oct	
S004-378 (2017-2020)	6 - 320	-	0 [2]	16.7 [6]	0 [6]	0 [5]	0 [3]	-	4.5 [22]

Table 509. Transparency monitoring data for reach 07020006-521

07020001-521 Secchi Tube Data 10 cm target	Range of Data (mg/L)	% of Monthly Samples < 10 cm [# of Samples]							% of Total Samples < 10 cm [# of Samples]
		April	May	June	July	August	Sept	Oct	
S004-387 **S013-644** **S013-696** (2009-2020)	7 – 100+	-	0 [3]	12.5 [8]	0 [8]	0 [9]	0 [4]	-	3.1 [32]

Suspended Solids Summary

The fish community at bio site 92MN047 scored below average in eight of the 10 suspended solids related fish metrics when compared to the average of all other Class 2 southern stream bio sites that meet the FIBI general use threshold (Table 506). There were some benthic feeders and riffle dwelling

fish present, though they were below the class average. There were no Centrarchids, intolerant fish, or perciformes that were caught. Herbivores, long-lived, and sensitive fish were all very low. Simple lithophilic spawners score well above the class average and the TSS TIV score was relatively low.

Suspended solids related invertebrate metrics were mostly poor (Table 507). There were no Plecoptera or invertebrates considered intolerant to TSS. TSS tolerant invertebrates were 24.8% of the total number caught. Collector-filterers scored well; however, and the TSS tolerance index value was just below the class average.

Twenty-two samples were collected and analyzed for TSS from 2017-2020. Of the June samples, 16.7% had a TSS concentration above 65 mg/L (Table 508). There were also some transparency readings in June that were below 10cm.

Due to the mostly poor biological metrics as well as the TSS and transparency data, suspended solids appears to be a stressor to the biological community in reach 07020006-521.

3.7.3.8   Nitrates

Nitrate Biological Metric Data

Table 510. Nitrate related invert metrics for reach 07020006-521

07020006-521 **Invert Class 5** General Use	Trichoptera Taxa %	Nitrogen TIV	Nitrate Intolerant	Nitrogen Tolerant Taxa %
92MN047 8/08/2017	15.0	3.1	0.0	31.5
Statewide average for Class 5 prairie stream rock riffle bio sites that are meeting the FIBI general use threshold (37)	**13.6**	**3.0**	↓	↑
Expected response to **nitrogen** stress	↓	↑		

Nitrate Monitoring Data

Table 511. Nitrate monitoring data for reach 07020006-521

07020001-521 Nitrate/Nitrite Sample Data	2x Highest Reach TIV Average	Range of Data (mg/L) [# of Samples]	Monthly Average [# of Samples]						
			April	May	June	July	August	Sept	Oct
S004-387 (2017-2020)	6.0	1.5 – 18.8 [12]	-	17.2 [2]	13.0 [3]	6.0 [3]	6.2 [2]	6.4 [2]	-
			Highest Value						
			-	18.8	15.5	9.9	10.8	7.3	-

Summary

The macroinvertebrate assemblage at site 92MN047 scored below average in two of the four nitrate related metrics evaluated when compared to all other macroinvertebrate Class 5 streams bio sites that meet the MIBI general use threshold (Table 510). The biological bio site did show a healthy amount of Trichoptera taxa, the most dominant invert present, the caddisfly ceratopsyche is neither tolerant nor intolerant to nitrates. The second most dominant invert present, the caddisfly cheumatopsyche, is considered very tolerant to high nitrates. There was a high amount of nitrate tolerant taxa as well as complete lack of nitrate intolerant invertebrate species. The nitrogen TIV score was right at the class average.

Twelve samples were collected in reach 07020006-521 and analyzed for nitrate/nitrite (Table 511). Many of the values were excessively high. The average concentration of the two May values was above 17.2 mg/L. Due to the biological response and relatively high nitrate concentrations, nitrates are a stressor to aquatic life in reach 07020006-521.

3.7.3.9   Reach Stressors

Table 512. Summary of stressors for reach 07020006-521

07020006-521	Hydrologic Alteration	Connectivity	Habitat	Dissolved Oxygen	Eutrophication	Suspended Solids	Nitrate
✔ = Stressor ✘ = Not a Stressor O = Inconclusive	✘	✔	O	✘	O	O	✔

4 References

Allan, J. (1995). Stream Ecology: structure and function of running waters. Dordrecht, Netherlands: Kluwer Academic Publishers. 388 pp.

Blann, Kristen, L.; Anderson, J, L.; Sands, Gary, R.; Vondracek, Bruce. Effects of Agricultural Drainage on Aquatic Ecosystems: A Review. https://conservancy.umn.edu/bitstream/handle/11299/183566/Blann-et-al-2009-CREST.pdf?sequence=1&isAllowed=y

Balon, E.K. 1975. Reproductive guilds of fishes: a proposal and definition. Journal of the Fisheries Research Board of Canada 32: 821-864.

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid bioassessment protocols for use in streams and wadeable rivers: periphyton, benthic macroinvertebrates, and fish. U.S. Environmental Protection Agency, EPA 841-B-99-002. Washington, D.C.

Becker, G.C. 1983. Fishes of Wisconsin. University of Wisconsin Press, Madison, WI. 1052 p.

Bruton, M. N. (1985). The effects of suspensoids on fish. Hydrobiologica 125, 221-242.

Camargo J. A. and Alonso A. 2006. Ecological and toxicological effects of inorganic nitrogen pollution in aquatic ecosystems; A global assessment. Environmental International. 32. 831- 849.

Chirhart, J., 2003. Development of a macroinvertebrate index of biological integrity for rivers and streams of the St. Croix River Basin in Minnesota, in Minnesota Pollution Control Agency. St. Paul, MN.

Cormier S., S. Norton, G. Suter and D. Reed-Judkins. 2000. Stressor Identification Guidance Document. U.S. Environmental Protection Agency, Washington D.C., EPA/822/B-00/025.

Davis, J. (1975). Minimal Dissolved Oxygen Requirements of Aquatic Life with Emphasis on Canadian Species: A Review. *Journal of the Fisheries Reasearch Board of Canada*, 2295-2331.

Doudoroff, P. and C. E. Warren. 1965. Dissolved oxygen requirements of fishes. Biological Problems in Water Pollution: Transactions of the 1962 seminar. Cincinatti, Ohio. Robert A. Taft Sanitary Engineering Center, U.S. Public Health Service, Health Service Publication, 999-WP-25 http://water.epa.gov/scitech/swguidance/standards/criteria/aqlife/biocriteria/upload/stressorid.pdf

Echols, B. S., Currie, R. J., & Cherry, D.S. (2009). Influence of Conductivity Dissipation on Benthic Macroinvertebrates in the North Fork Holston River, Virginia Downstream of a Point Source Brine Discharge during Severe Low-Flow Conditions. *Human and Ecological Risk Assessment: An International Journal 15*(1), 170-184.

Engstrom, D. J. (2009). Historical changes in sediment and phosphorus loading to the upper Mississippi River:Mass-balance reconstructions from the sediments of Lake Pepin. Journal of Paleolimnology 41(4), 563-588.

Erman, D. C. & Ligon, F.K. (1988). Effects of discharge fluctuation and the addition of fine sediment on stream fish and macroinvertebrates below a water-filtration facility. Environmental Management 12, 85-97.

Etnier,D.A. and W.C. Starnes. 1999. The Fishes of Tennessee. University of Tennessee Press, Knoxville, TN. 681 p.

Frey, D. G. (1977). Biological integrity of water—an historical approach. In The integrity of water. Proceedings of a symposium. US Environmental Protection Agency. Washington, DC, USA, 1977. Washington: US Environmental Protection Agency.

Frimpong, E.A. and P.L. Angermeier. 2009. FishTraits: A database of ecological and life-history traits of freshwater fishes of the United States. Fisheries 34: 143-144.

Goldstein, R.M. and M.R. Meador. 2004. Comparisons of fish species traits from small streams to large rivers. Transactions of the American Fisheries Society 133: 971-983.

Grabda, E., Einszporn-Orecka, T., Felinska, C., & Zbanysek, R. (1974). Experimental methemoglobinemia in trout. Acta Ichtyol., 4,43.

Gray, L.J. & Ward, J.V. (1982). Effects of sediment releases from a reservoir on stream macroinvertebrates. Hydrobiologia 96 (2), 177-184.

Griffith, M. B., Rashleigh, B., & Schofield, K. (2010). Physical Habitat.In USEPA Causal Analysis/ Diagnosis Decision Information System (CADDIS). Retrieved 02 10, 2014, from
http://www.epa.gov/caddis/ssr_phab_int_html.

Heiskary, e. (2013). *Minnesota Nutrient Criteria Development for Rivers.* St. Paul: Minnesota Pollution Control Agency.

Karr, J. and E.W. Chu. 1999. Restoring Life in Running Waters: Better Biological Monitoring. Island Press, Washington D.C. 206 p.

Karr, J.R., K.D. Fausch, P.L. Angermeier, P.R. Yant, and I.J. Schlosser. 1986. Assessing biological integrity in running waters: a method and its rationale. Illinois Natural History Survey Special Publication 5. 28 p.

Kostick, D.S. 1993. The Material Flow of Salt. Information Circular 9343. Washington, D.C.: U.S. Department of the Interior, Bureau of Mines. 31 pp.

Landwehr, K., & Rhoads, B. (2003). Depositional response of a headwater stream to channelization, East Central Illinois, USA. River Research and Applications, Vol. 19, p. 77-100.

Lau, J.K., Lauer, T.E., and M.L. Weinman. 2006. Impacts of Channelization on Stream Habitats and Associated Fish Assemblages in East Central Indiana. American Midland Naturalist 156:319-330.

Lyons, J. 1992. Using the Index of Biological Integrity (IBI) to measure environmental quality in warmwater streams of Wisconsin. U.S. Department of Agriculture, Forest Service, North Central Experiment Bio site Gen. Tech. Rep. NC-149. St. Paul, MN. 51 p.

Meador, M.R. and D.M. Carlisle. 2007. Quantifying tolerance indicator values for common fish species of the United States. Ecological Indicators 7: 329-338.

Minnesota Department of Natural Resources (DNR). 2020. Redwood River Watershed Characterization Report. Division of Ecological and Water Resources, Minnesota Department of Natural Resources, St Paul, Minnesota.

Minnesota Pollution Control Agency (MPCA). 2017a. Fish Data Collection Protocols for Lotic Waters in Minnesota. Minnesota Pollution Control Agency, St. Paul, MN.
https://www.pca.state.mn.us/sites/default/files/wq-bsm3-12b.pdf

Minnesota Pollution Control Agency (MPCA). 2017b. Macroinvertebrate Data Collection Protocols for Lotic Waters in Minnesota. Minnesota Pollution Control Agency, St. Paul, MN.
https://www.pca.state.mn.us/sites/default/files/wq-bsm3-12a.pdf

Minnesota Pollution Control Agency (MPCA). 2017c. Stressors to Biological Communities in Minnesota's Rivers and Streams. Minnesota Pollution Control Agency, St. Paul, MN.
https://www.pca.state.mn.us/sites/default/files/wq-ws1-27.pdf

Minnesota Pollution Control Agency (MPCA). 2014a. Development of a Macroinvertebrate Based Index of Biological Integrity for Minnesota's Rivers and Streams. Minnesota Pollution Control Agency, St. Paul, MN. https://www.pca.state.mn.us/sites/default/files/wq-bsm2-03.pdf

Minnesota Pollution Control Agency (MPCA). 2014b. Development of a Macroinvertebrate Based Index of Biological Integrity for Minnesota's Rivers and Streams. Minnesota Pollution Control Agency, St. Paul, MN. https://www.pca.state.mn.us/sites/default/files/wq-bsm4-01.pdf

Minnesota Pollution Control Agency (MPCA). 2008. Draft Biota TMDL Protocols and Submittal Requirements. Minnesota Pollution Control Agency, St. Paul, MN. http://www.pca.state.mn.us/index.php/view-document.html?gid=8524

Nebeker, A. D. (1991). Effects of low dissolved oxygen on survival, growth and reproduction of Daphnia, Hyallella and Gammarus. *Environmental Toxicology and Chemistry*, 373-379.

Newcombe, C. P., and D. D. MacDonald. "Effects of suspended sediments on aquatic ecosystems." *North American Journal of Fisheries Management 11:72-82*, 1991: 11:72-82.

Pekarsky, B.L. (1984) Predator-prey interactions among aquatic insects. In V.H. Resch and D.M.

Pflieger, W.L. 1975. Fishes of Missouri. Missouri Department of Conservation, Jefferson City, MO. 343 p.

Piscart, C. Moreteau J.C. & Beisel, J. C. (2005). Biodiversity and Structure of Macroinvertebrate Communities along a small permanent salinity gradient. *Hydrobiologia 551*, 227-236.

Poff, N. a. (1997). The Natural Flow Regime: A paradigm for river conservation and restoration. BioScience 47(11), 769-784.

Raleigh, R.F., L.D. Zuckerman, and P.C. Nelson. 1986. Habitat suitability index models and instream flow suitability curves: brown trout. Biological Report 82 (10.124). U.S. Fish and Wildlife Service. 65 pp.

Rankin, E. 1989. The Qualitative Habitat Evaluation Index (QHEI): Rationale, Methods, and Application. Ohio EPA, Division of Water Quality Planning and Assessment, Ecological Analysis Section, Columbus, Ohio.

Rosenberg (Eds.), the Ecology of Aquatic Insects (pp. 196-254). NY: Praeger Scientific.

Rosgen, D. L. 1994. A classification of natural rivers. Elsevier, Catena. 22:169-199

Rosgen, D. L. 1996. Applied river morphology. Pagosa Springs, CO. Wildland Hydrology Books.

Rhoads, B. L., and K. D. Massey. "Flow Structure and Channel Change in a Sinuous Grass-Lined Stream within an Agricultural Drainage Ditch: Implications for Ditch Stability and Aquatic Habitat." *River Research and Applications*, vol. 28, no. 1, Apr. 2010, pp. 39–52

Rosenberg, D. & Wiens, A. (1978). Effect of sediment addition on macrobenthic invertebrates in a

Northern Canadian river. Water Research 12, 753 - 763.

Sandberg, J. (2013, 09 01). Tolerance values for fish in Minnesota.

Santucci V.A., e. (2005). Effects of Multiple Low-Head Dams on Fish, Macroinvertebrates, Habitat, and Water Quality in the Fox River, Illinois. North American Journal of Fisheries Management, 25:975-992.

Schlosser, I. (1990). Environmental variation, life history attributes, and community structure in stream fishes: implications for environmental management and assessment. Environmental Management 14, 621-628.

SETAC (Society of Environmental Toxicology and Chemistry). (2004). Whole effluent toxicity testing: Ion imbalance. Pensacola, FL, USA: Technical issue paper.

Tiemann, J., Gillette, D., Wildhaber, M., & Edds, D. (2004). Effects of lowhead dams on riff dwelling fishes and macroinvertebrates in a midwestern river. *Transactions of the American Fisheries Society, 133*, 705-717.

Triplet, L. D. (2009). A whole-basin stratigraphic record of sediment and phosphorus loading to the St. Croix River, USA. Journal of Paleolimnology 41(4), 659-677.

Urban, M., & Rhoads, B. (2003). Catastrophic Human-Induced Change in Stream-Channel Planform and Geometry in an Agricultural Watershed, Illinois, USA. Annals of the Association of American Geographers, Vol. 93, pp 783-796.

U.S. EPA. 2010. Causal Analysis/Diagnosis Decision Information System (CADDIS). Environmental Protection Agency. Office of Research and Development, Washington, DC. Available online at http://www.epa.gov/caddis.

U.S.EPA. (2012). CADDIS Volume 2 Sources, Stressors & Responses. Retrieved 02 11, 2014, from CADDIS Volume 2 Sources, Stressors & Responses: http://www.epa.gov/caddis/ssr_flow_int.html

Warren, M.L., Jr. and M.G. Pardew. 1998. Road Crossings as Barriers to Small-Stream Fish Movement. Transactions of the American Fisheries Society 127(4):637-644.

Waters, T. 1995. *Sediment in Streams: Sources, Biological Effects, and Control.* Bethesda, Maryland: American Fisheries Society.

Wilcox, R. a. (2001). Effects of aquatic macrophytes on physico-chemical conditions of three contrasting lowland streams: a conseauence of diffuse pollution from agriculture. *Water Science and Technology 43(5)*, 163-168.

Winston, M. C. (1991). Upstream exterpation of four minnow species due to damming of a prairie stream. Transactions of the American Fisheries Society, 120:98-105.