City of River Falls
North Kinnickinnic River Monitoring Project

2006 Technical Review

<u>Project Introduction:</u>

The Kinnickinnic River is one of the premier, naturally sustaining trout fisheries in the Upper Midwest, primarily producing brown trout. There has been a lot of concern about how new development in River Falls may affect the river, especially due to storm water runoff from impervious surfaces in these urbanizing areas. Not only can storm water runoff contribute chemicals from lawns, cars, etc., but the thermal impacts of untreated storm water are also a concern, as described on the North Kinnickinnic River Monitoring Project website (see "The Thermal Impacts of Storm Water"). In 2002, the City adopted a new Storm Water Management Ordinance, which is designed to protect the Kinnickinnic River from the negative impacts of storm water runoff associated with new development. For new development and re-development projects, the City of River Falls Storm Water Management Ordinance requires that, for a 1.5-inch, 24-hour rainfall event, the post-development runoff volume and peak flow rate must not exceed the pre-development runoff volume and peak flow rate. To achieve this requirement, developers must provide on-site infiltration of storm water.

To take an active role in the river's health and well-being, the City has implemented a monitoring program aimed at evaluating the effectiveness of our Storm Water Management Ordinance for preventing degradation of the Kinnickinnic River due to new City development.

Project Scope:

- Temperature Monitoring
- Water Quality Monitoring
- Base Flow Surveys
- Macroinvertebrate Monitoring

The City will examine the long-term results of each of these four monitoring elements to determine whether the new storm water ordinance is protecting the river as new development occurs. The project will use an "upstream/downstream" approach to determine if storm water management practices in the Sterling Ponds subdivision protect downstream river conditions. We will also take a focused look at the performance of the on-site storm water management practices that are incorporated into new developments. Our hope is that due to the ordinance requirements, the water quality and thermal impacts of new development will be undetectable or greatly reduced.

River Falls Precipitation:

Due to the major influence of precipitation on river flow, temperature, and water quality, an analysis of seasonal precipitation is conducted as a part of this project. During the April-September 2006 monitoring period, hourly precipitation was measured in 0.01-inch increments with an electronic tipping-bucket rain gauge. The rain gauge, provided by the Wisconsin Department of Natural Resources (WDNR), is located in the Sterling Ponds subdivision at the northwest corner of the City of River Falls. This location places the rain gauge in very close proximity to all six North Kinnickinnic River monitoring stations. A weather station at Rocky Branch Elementary School, on the south side of River Falls, serves as an alternate source of daily rainfall data. This station is part of an extensive network of local weather stations supported by KSTP-TV in Minneapolis, MN, via the Automated Weather Source. The Rocky Branch Weather Station also serves as a source of daily mean, minimum, and maximum air temperatures. In addition, daily precipitation data are available from the United States Geological Survey (USGS) Kinnickinnic River monitoring station at County Highway F, near Kinnickinnic State Park, approximately five miles west of River Falls.

A total of 17.16 inches of precipitation was recorded in River Falls during the April-September 2006 period, 3.5 inches less than the normal total of 20.67 inches for the April -September time period. Rain fell on 61 days, or 33% of the April-September 2006 period. In comparison, a near-normal total of 19.82 inches of precipitation was recorded in River Falls during the April-September 2004 monitoring period, and an above-normal total of 36.45 inches was measured during the April-September 2005 period. "Normal" monthly and seasonal rainfall amounts are based upon measurements made by the National Weather Service at the Twin Cites International Airport during the "climate normal period" of 1971-2000.

Daily rainfall amounts during the April-September 2006 period are presented in Figure 1. Monthly rainfall amounts during the April-September 2006 period, with a comparison to normal monthly rainfall amounts, are presented in Figure 2. Except for April and August, all months during the April-September 2006 period were drier than normal, with monthly rainfall deficits ranging from 0.4 inch to 3.6 inches. The greatest rainfall deficits occurred in June and July, with the lowest monthly rainfall amount (0.73 inch) recorded in June. August was the wettest month (6.68 inches), exceeding the normal monthly rainfall amount by 2.6 inches.

Besides being drier than normal, the April-September 2006 monitoring period was warmer than normal. The mean air temperature in River Falls during the April-September 2006 period was 64.8º Fahrenheit (F), 1.6º F higher than the normal mean of 63.2º F for the April-September period, as measured at the Twin Cities International Airport. Monthly mean air temperatures during the April-September 2006 period, with a comparison to normal monthly mean temperatures during the "climate normal period" of 1971-2000, are presented in Figure 3. With the exception of September, all months during the April-September 2006 monitoring period were warmer than normal. The month of April was nearly 7º F warmer than normal, while the month of July was 4º F warmer than normal. The month of September was 3º F colder than normal.

The distribution of River Falls daily rainfall amounts during the April-September 2006 period is presented in Figure 4. Although the 2006 monitoring season was drier than normal, it was characterized by numerous (51) days with rainfall amounts of 0.50 inch or less. On 43 (70%) of the 61 days with measurable precipitation, rainfall amounts were 0.25 inch or less. These 43 days contributed only 17% of the total April-September 2006 precipitation. The majority of these 43 days occurred in the cooler months of April, May, June, and September (Figure 5). On 8 (13%) of the 61 days with measurable precipitation, rainfall amounts ranged from 0.26-0.50 inch. These 8 days contributed an additional 17% of the total April-September 2006 precipitation. Six of these 8 days occurred in April, May, and September (Figure 5), the coolest months. On 4 (7%) of the 61 days with measurable precipitation, rainfall amounts ranged from 0.51-0.75 inch. These 4 days contributed 15% of the total April-September 2006 precipitation, with the majority of these 4 days occurring in July, August, and September (Figure 5). Only one (2%) of the 61 days with measurable precipitation had a rainfall amount in the 0.76-1.00 inch range (Figure 5), contributing 6% of the total April-September 2006 precipitation. On 5 (8%) of the 61 days with measurable precipitation, rainfall amounts exceeded 1.00 inch. These 5 days with the largest rainfall events contributed 45% of the total April-September 2006 precipitation. Rainfall amounts in excess of 1 inch occurred on April 2, July 24, and August 1, 2, and 24 (Figures 1 and 5). On 2 of the 5 days, rainfall amounts ranged from 1.01-1.25 inches. On 3 of the 5 days, rainfall amounts exceeded 1.50 inches. Four of the 5 largest rainfall events occurred in July and August, and were produced by convective thunderstorm activity during a warmer than normal summer.

To achieve the requirements of the City's storm water ordinance, developers must provide on-site infiltration of post-development storm water runoff from 24-hour rainfall events of 1.5 inches or less. Of the 61 days with measurable precipitation during the April-September 2006 period, 58 days (95%) had rainfall amounts less than 1.5 inches in 24 hours (a midnight-to-midnight total). Based on that data, only rainfall amounts on July 24 (1.80 inches), August 2 (2.26 inches), and August 24 (1.63 inches) exceeded this criterion. Even so, some infiltration would have occurred under the requirements of the storm water ordinance, thereby accounting for infiltration of approximately 93% (15.97 inches) of the total rainfall (17.16 inches) that occurred during the April-September 2006 period. Figure 6 depicts the annual effectiveness of the River Falls Storm Water Ordinance for infiltrating storm water runoff generated by rainfall during the April-September period. This figure was prepared for illustrative purposes only, and was created with the assumption that the entire 1.5-inch event is infiltrated. This scenario essentially assumes zero pre-development runoff, which may not necessarily be the case.

Kinnickinnic River Flow:

The flow of the Kinnickinnic River is a reflection of strong ground water (spring) contributions, as well as precipitation-induced storm water runoff from predominantly agricultural and urban land uses throughout the 165-square mile Kinnickinnic River Watershed. The United States Geological Survey (USGS) operates a Kinnickinnic River monitoring station (number 05342000) at County Highway F, near Kinnickinnic State Park, approximately five miles west of River Falls. The station measures river stage (water height) and flow at 15-minute intervals, and precipitation in 0.01-inch increments. Because accurate monitoring of river stage and flow entails a significant investment in equipment and labor, no continuous measurement of river flow is currently being conducted within the North Kinnickinnic River Monitoring Project Area. For this reason, the Kinnickinnic River flow information provided by the USGS monitoring station is particularly valuable, as it clearly documents when runoff events are occurring and storm water impacts may be apparent. The City of River Falls, Kinnickinnic River Land Trust, and Trout Unlimited provide annual cost-share funding for this USGS monitoring station.

The daily mean (average) flow of the Kinnickinnic River at County Highway F during the April-September 2006 period is presented in Figure 7. Due to a brief equipment malfunction, the daily mean flow is not available for September 7. Daily rainfall, as measured in River Falls at Sterling Ponds, is also presented in Figure 7.

The precipitation pattern during the April-September 2006 period helps explain the changes in the Kinnickinnic River hydrograph, due to runoff events in the watershed. High river flows of 673 cubic feet per second (cfs) on March 30, 323 cfs on April 3, and 312 cfs on April 7 occurred as a result of spring snowmelt and rain in late March, in combination with 1.11-inch and 0.60-inch rainfall events on April 2 and 6, respectively. Numerous small rain events (less than 0.50 inch) in April, May, June, and September had little influence on the Kinnickinnic River hydrograph.

During the July-August period, rainfall amounts in excess of 1 inch generally had the greatest influence on the Kinnickinnic River hydrograph. A large rainfall event on July 24 (1.80 inches) resulted in only a moderate increase in the Kinnickinnic River hydrograph, with a peak daily mean flow of 117 cfs. This moderate runoff event, in spite of heavy rainfall, can be attributed to very dry antecedent conditions in June and July, and full canopy closure in the agricultural and forested areas of the watershed. Large, back-to-back rainfall events on August 1 (1.04 inches) and August 2 (2.26 inches) produced a significant increase in the Kinnickinnic River hydrograph, with a peak daily mean flow of 232 cfs. Similarly, large, back-to-back rainfall events on August 23 (0.71 inch) and August 24 (1.63 inches) also produced a significant increase in the Kinnickinnic River hydrograph, with a peak daily mean flow of 342 cfs.

The Kinnickinnic River hydrograph suggests that five significant runoff events occurred during the April-September 2006 period. Two of these five significant runoff events occurred in April (1-5 and 6-9), due to early spring rains on April 2 and April 6. With cool air and water temperatures in early April, thermal impacts of storm water runoff are generally not a concern, but water quality impacts can be problematic, due to frozen soils and a lack of vegetative cover in the watershed. Three of the five significant runoff events occurred in July and August, during the warmest time of the year (Figure 3), when thermal impacts of storm water runoff can be a considerable concern. On July 24, one of the heaviest rainfalls of the year (1.80 inches) resulted in a 3-day runoff event (July 24-26), with a peak daily mean flow of 117 cfs. On August 1 and 2, back-to-back rainfall events totaling 3.30 inches resulted in a 5-day runoff event (August 1-5), with a peak daily mean flow of 232 cfs. On August 23 and 24, back-to-back rainfall events totaling 2.34 inches resulted in a 6-day runoff event (August 23-28), with a peak daily mean flow of 342 cfs. These three runoff events in July and August should be the focus for evaluating possible storm water impacts in the North Kinnickinnic River Monitoring Project Area in 2006, and are further analyzed in this report. See Appendix A for reasons why smaller rainfall and runoff events were not analyzed in 2006.

During dry periods between runoff events, the Kinnickinnic River maintained a base flow condition of approximately 85-95 cfs at County Highway F.

Temperature Monitoring:

In 2006, temperature monitoring was conducted at five of the six City of River Falls monitoring stations (Sites 1-6, except Site 2) in the North Kinnickinnic River Monitoring Project Area. To evaluate the thermal performance of the storm water management practices at Site 5, temperature monitoring was conducted at three locations: the wet detention pond (Site 5P), the wet detention pond outlet to the infiltration basin (Site 5IB), and the wet detention pond outfall to Sumner Creek (Site 5MHW).

The local Kiap-TU-Wish Chapter of Trout Unlimited (TU) also conducted temperature monitoring at one Kinnickinnic River station (Site 1A) within the project area, between Sites 1 and 2. The TU monitoring station is located along Quarry Road on the northeast edge of River Falls, just east of the WI Highway 35 bypass, and just upstream of the Sumner Creek confluence. The TU station has been in service during all summer periods (May-September) since 1992. In 2005, as an additional contribution to the North Kinni Project, TU established a temperature monitoring station in Sumner Creek (Site 4A), approximately 100 feet upstream of the creek confluence with the Kinnickinnic River. This station was in service during the summer periods (May-September) of 2005 and 2006. The thermal impacts of Sumner Creek on the Kinnickinnic River, including any storm water contributions from Sterling Ponds, can be evaluated at this location.

Onset Computer Corporation's® HOBO Water Temp Pro Loggers are used to measure water temperature at all City of River Falls monitoring stations (Sites 1-6). A Ryan Instruments® RTM 2000 Temperature Logger is used to measure water temperature at the TU monitoring station at Quarry Road (Site 1A). Onset Computer Corporation's® Optic StowAway Templogger is used at the TU monitoring station in Sumner Creek (Site 4A). All Onset and Ryan temperature loggers are programmed to record temperatures at 10-minute intervals. Date and time stamps and the 10-minute temperature data are electronically recorded by each logger; and all recorded information is downloaded as necessary. The brief 10-minute time interval was selected so that any rapid temperature increases associated with warm storm water runoff could be documented. With the exception of Site 2, Site 5MHW, and Site 6, all temperature loggers were deployed throughout the May-September (summer) period. These loggers malfunctioned this year. The thermal impacts of storm water runoff are most likely to occur during this summer period, when air temperatures are highest. The summer 2006 deployment periods (and locations) for the temperature loggers at the ten monitoring stations were as follows:

Site:	Deployment Period:	Location:
Site 1:	May 1-September 30, 2006	Kinnickinnic River
Site 1A:	May 1-September 30, 2006	Kinnickinnic River
Site 2:	No Deployment	Kinnickinnic River
Site 3:	May 1-September 30, 2006	Kinnickinnic River
Site 4:	May 1-September 30, 2006	Sumner Creek: Wet Pool in Culvert
Site 4A:	May 1-September 30, 2006	Sumner Creek: Mouth
Site 5P:	May 1-September 30, 2006	Sterling Ponds: Wet Pond
Site 5IB:	May 1-September 30, 2006	Sterling Ponds: Infiltration Basin
Site 5MHW:	May 1-July 25, 2006	Sterling Ponds: Wet Pond Outlet
Site 6:	May 1-July 25, 2006	Sumner Creek: Dry Box Culvert

Due to instrumentation problems, the temperature logger at Site 2 was not deployed during the summer of 2006, and the loggers at Site 5MHW and Site 6 were only deployed through July 25. In conversations with Onset, this model of the logger is prone to such errors; therefore the City is looking into upgrading to the newest model of the Hobo Water Temp Pro to reduce the risk of future complications and gaps in data.

Kinnickinnic River Temperature Monitoring Results:

The May-September (summer) 2006 temperature monitoring data obtained for the Kinnickinnic River at Sites 1, 1A, and 3 are presented as thermographs in Figures 8-10, respectively. Of immediate note in these thermographs is the strong diurnal (daily) temperature pattern in the river. Although cold groundwater continually feeds the river via springs along the entire riverway, the temperature of the Kinnickinnic River is greatly influenced by ambient air temperature. During the daylight hours, the river gradually warms and generally reaches a daily maximum temperature in the late afternoon or early evening (4:30-6:30 PM). At night, the river gradually cools and typically reaches a daily minimum temperature just after sunrise (7:30-9:30 AM). These diurnal temperature fluct uations in the river are natural, and the river's residents, including macroinvertebrates and trout, have become accustomed to a constantly but slowly changing temperature regime.

Also of note in the 2006 Kinnickinnic River thermographs are the relatively frequent changes in the daily minimum and maximum river temperatures and daily temperature ranges that are influenced by local weather patterns (cold fronts and warm fronts) and seasonal climate changes. During the summer 2006 period, for example, the monthly mean river temperature in the North Kinnickinnic River Project Area (Sites 1, 1A, and 3) was coolest in May (12.7 degrees Celsius (°C)) and warmest in July (17.1° C).

At Sites 1, 1A, and 3, river temperatures averaged 14.6° C and ranged from 5.9-23.1° C over the course of the summer. Monthly and summer mean temperatures at each of these three monitoring sites are presented in Figure 11. These monthly and summer mean temperatures were nearly identical at Sites 1 and 1A, but slightly cooler at Site 3, especially during the July-September period.

For the second consecutive year, slightly higher-than-normal river temperatures probably prevailed in the North Kinnickinnic River Project Area during the summer of 2006, since the 2006 summer average air temperature of 19.4º C (67.0º F) was slightly higher than the normal summer average air temperature of 19.2° C (66.5° F). A comparison of 2004-2006 summer average air temperatures and river temperatures (at Sites 1, 1A, and 2) can be found in the North Kinnickinnic River Monitoring Project Indicators.

The most direct way to determine if any thermal impacts occurred in the Kinnickinnic River as a result of the Sterling Ponds subdivision is to compare the temperature monitoring data at Site 1, located immediately downstream from Sumner Creek, to the temperature monitoring data at Sites 1A and 2, located immediately upstream from Sumner Creek. These two upstream sites serve as control or reference sites, which are not impacted by Sterling Ponds storm water discharges. The 2006 temperature data were compared at Sites 1 and 1A, as no data were obtained at Site 2.

A comparison of all upstream summer temperature data at Site 1A to all downstream summer temperature data at Site 1 is presented in Figure 12. This comparison indicates that summer temperatures were nearly identical at these two locations. The temperature similarity at Sites 1 and 1A is even more evident in the monthly thermographs for May, June, July, August, and September 2006 (Figures 13-17, respectively). Figures 12-17 indicate that daily maximum and minimum temperatures tended to be slightly higher at Site 1A, due to less canopy cover and shading at this location. Figure 11 shows that the monthly and summer mean temperatures at Sites 1 and 1A were also nearly identical. The following should be noted concerning aquatic life in the Kinnickinnic River:

1. Approximately 81% of all temperatures recorded at Sites 1 and 1A during the May-September 2006 period were less than or equal to (≤) 17° C, which is considered to be the top of the optimum temperature range for a healthy coldwater macroinvertebrate community (Galli, 1990). A temperature of 17° C is considered to be the physiological optimum for brown trout survival (Armour, 1994).

2. Approximately 95% of all temperatures recorded at Sites 1 and 1A during the May-September 2006 period were ≤ 19° C, which is considered to be the top of the optimum temperature range for brown trout growth (Armour, 1994).

3. Approximately 98% of all temperatures recorded at Sites 1 and 1A during the May-September 2006 period were ≤ 20° C, which is considered to be the top of the optimum temperature range for brown trout survival (Armour, 1994). River temperatures exceeding 20º C were only recorded on two dates in late May and eight dates in mid-to-late July, when air temperatures ranged from 32-37º C (90-99° F).

During three significant rainfall and runoff events in July and August 2006, thermographs at Sites 1 and 1A can be compared to determine if rapid temperature increases (thermal spikes), which are characteristic of warm storm water discharges, were apparent at Site 1. In spite of a major rainfall event on July 24 (1.80 inches), no thermal spike was evident at Site 1 in July (Figure 15). A closer examination of the thermographs for Sites 1 and 1A during the 1.80-inch rainfall event on July 24 (Figure 18) indicates that no thermal spike occurred at Site 1, downstream from Sumner Creek and the Sterling Ponds subdivision. During the same rain event, however, the thermograph for the Trout Unlimited temperature monitoring site at Division Street (Figure 18) shows three very prominent thermal spikes, due to the thermal impacts of direct storm water discharges from the downtown area of River Falls. Thermographs for Sites 1, 1A, and Division Street can be similarly compared during the two large back-to-back rainfall events on August 1-2 (Figure 19) and August 23-24 (Figure 20). During the August 1-2 and August 23-24 rainfall events, no thermal spikes were evident at Site 1, while prominent thermal spikes were evident at Division Street. During the July and August rainfall events, the thermal spikes at Division Street ranged in magnitude from 0.4-3.6 degrees Celsius. While the presence of thermal spikes at Division Street is attributed to the thermal impacts of untreated storm water discharges to the Kinnickinnic River, the lack of thermal spikes at Site 1 could be attributed to several factors, including effective storm water management at the Sterling Ponds subdivision, or simply a lack of Sterling Ponds storm water discharges and/or storm water conveyance down Sumner Creek, even during the largest runoff events.

Sumner Creek and Sterling Ponds Temperature Monitoring Results:

<u>*Sumner Creek*</u>

Sumner Creek is a low-gradient tributary of the Kinnickinnic River that exhibits only intermittent flow for the majority of its length. Permanent flow begins in the vicinity of the WI Highway 35 bypass, near the creek confluence with the Kinnickinnic River (Site 4A). From this location, the creek drainage way extends upstream to Radio Road on the far northwest corner of River Falls. This upper portion of the Sumner Creek drainage way, including Sites 4 and 6, conveys no flow for the majority of the year. The headwaters area near Site 6 is a dry run; however, rather extensive wetland areas are apparent in the Sumner Creek drainage way through the Sterling Ponds subdivision, and for an appreciable distance downstream of Site 4. Anecdotal evidence suggests that flow may occur during the spring snowmelt period and perhaps during large summer rain events. During large summer rain events, however, the wetland areas and dry portions of the Sumner Creek channel likely provide considerable water storage, making it very difficult to determine if and when any upstream flow is conveyed all the way downstream to the Kinnickinnic River.

The May-September (summer) 2006 temperature monitoring data obtained for Sumner Creek at Site 4A are presented as a thermograph in Figure 21. Site 4A near the creek mouth was the only Sumner Creek monitoring location with permanent flow throughout the summer. At Site 4A, Sumner Creek temperatures averaged 12.4° C and ranged from

7.6-22.0° C during the May-September 2006 period. The summer mean temperature of Sumner Creek (12.4º C) was notably colder than the summer mean temperature of the Kinnickinnic River (14.6º C) at Sites 1, 1A, and 3, reflecting strong spring activity. Approximately 99% of all temperatures recorded at Site 4A during the May-September 2006 period were ≤ 17° C, and approximately 99.5% of all temperatures were ≤ 20° C. Temperatures exceeding 20º C were only recorded during the large back-to-back rainfall events on August 1-2.

Based upon the 2005 and 2006 temperature data, lower Sumner Creek may have potential as a brook trout stream, and is regardless an important contributor of cold water to the Kinnickinnic River. Of significant concern, however, are several prominent thermal spikes that occurred at Site 4A after the large rain events in July and August (Figure 21). The thermal spikes in lower Sumner Creek ranged from 4.1-7.1 degrees Celsius, and were of even greater magnitude than those observed at the Division Street monitoring site. In spite of their magnitude, none of these thermal spikes had a discernible impact on Kinnickinnic River temperatures at Site 1, downstream from Sumner Creek. However, thermal spikes of this magnitude and frequency may have detrimental impacts on aquatic life in lower Sumner Creek, especially macroinvertebrates. Numerous thermal spikes were also apparent in lower Sumner Creek (Site 4A) during the summer of 2005. Possible sources contributing to thermal spikes in Sumner Creek may include: storm water runoff from WI Highway 35, located immediately upstream from Site 4A; warm water from natural wetland areas in the upper Sumner Creek drainage way; and storm water discharges from the Sterling Ponds subdivision.

Sterling Ponds

The May-September (summer) 2006 temperature monitoring data obtained for the Sterling Ponds wet detention pond at Site 5P are presented as a thermograph in Figure 22. At Site 5P, wet detention pond temperatures averaged 21.4° C and ranged from 10.4-30.4° C during the summer period. Approximately 68% of all summer temperatures exceeded 20° C. With the exception of a short time period from June 10-13, wet pond temperatures remained above 20° C from May 24 until September 8. Substantial warming of small, shallow ponds such as this can be expected, especially with no shading or canopy cover. The summer mean temperature of the Sterling Ponds wet detention pond (21.4° C) was substantially higher than the summer mean temperature of Sumner Creek at Site 4A (12.4º C), clearly demonstrating the potential for thermal impact when the pond discharges to the creek, and emphasizing the importance of the River Falls Storm Water Management Ordinance, which requires storm water infiltration.

Assessment of Sterling Ponds Storm Water Infiltration and Discharge to Sumner Creek

Temperature data from the three Sterling Ponds monitoring stations (Sites 5P, 5IB, and Site MHW) and the two downstream Sumner Creek monitoring stations (Sites 4 and 4A) can be used to evaluate the effectiveness of the Sterling Ponds storm water management practices for infiltrating storm water and minimizing warm storm water discharges to Sumner Creek. Given the warm and relatively stable thermal regime (Figure 22) in the

Sterling Ponds wet detention pond (measured at Site 5P), pond discharges to the infiltration basin can be readily identified when the temperature at Site 5IB closely matches that at Site 5P. Similarly, pond discharges to Sumner Creek can be readily identified when the temperature at Site 5MHW closely matches that at Site 5P. Warm storm water discharges to Sumner Creek may be detectable as thermal spikes at Sites 4 and 4A.

During the summer of 2006, the thermal performance of Sterling Ponds stormwater management practices can be evaluated monthly by comparing the Sterling Ponds and Sumner Creek thermographs. Performance of these stormwater management practices during the three significant rainfall and runoff events in July and August is of particular interest, and may help explain the possible causes of the thermal impacts observed in lower Sumner Creek (Site 4A). These July and August events were characterized by rainfall amounts in excess of 1.5 inches, beyond the infiltration requirement of the River Falls Storm Water Management Ordinance.

May

The comparative Sterling Ponds and Sumner Creek thermographs for May 2006 are presented in Figure 23. As indicated by the nearly identical temperatures at Sites 5P and 5IB, the Sterling Ponds wet detention pond was already discharging to the infiltration basin on May 1, due to rainfall events on April 29 (0.46 inch) and April 30 (0.25 inch). With numerous smaller rainfall events during the May 1-19 period, the wet pond continued discharging to the infiltration basin until May 21. No further discharges to the infiltration basin occurred through the end of May, in spite of two small rainfall events on May 25 (0.08 inch) and May 29 (0.03 inch). No wet pond discharges to Sumner Creek occurred in May, and no thermal spikes were apparent in Sumner Creek (Sites 4 and 4A), downstream from Sterling Ponds. The entire May rainfall amount of 2.10 inches (11 small events ranging from 0.01-0.39 inch and 1 moderate event of 0.97 inch) (Figure 5) was infiltrated.

June

The comparative Sterling Ponds and Sumner Creek thermographs for June 2006 are presented in Figure 24. As indicated by the nearly identical temperatures at Sites 5P and 5IB, the Sterling Ponds wet detention pond discharged to the infiltration basin during the June 6-8 period (Figure 25), due to small rainfall events on June 5 (0.08 inch) and June 6 (0.25 inch). No wet pond discharges to Sumner Creek occurred during the June 6-8 period, and no thermal spikes were apparent in Sumner Creek (Sites 4 and 4A), downstream from Sterling Ponds (Figure 25). The remainder of June was very dry, and no further discharges to the infiltration basin occurred through the end of the month (Figure 24). The entire June rainfall amount of 0.73 inch (11 small events ranging from 0.01-0.25 inch) (Figure 5) was infiltrated.

July

The comparative Sterling Ponds and Sumner Creek thermographs for July 2006 are presented in Figure 26. The July 1-23 period was hot and dry, with small rainfall events recorded on only three dates. During this time period, no wet pond discharges occurred to either the infiltration basin or Sumner Creek, and no thermal spikes were apparent in Sumner Creek (Sites 4 and 4A), downstream from Sterling Ponds. The three small rain events, totaling 0.77 inch, were likely stored in the wet pond and/or evaporated from the pond, given the high ambient air and pond temperatures.

The comparative Sterling Ponds and Sumner Creek thermographs for the large July 24 rain event (1.80 inches) are presented in Figure 27. As indicated by the nearly identical temperatures at Sites 5P and 5IB, the Sterling Ponds wet detention pond began discharging to the infiltration basin at 18:30 CDT (6:30 PM) on July 24, shortly after the onset of heavy rainfall at 18:00 CDT (6:00 PM). Wet pond discharge to the infiltration basin, due to the July 24 rainfall event, continued for four days, until 19:00 CDT (7:00 PM) on July 28. As indicated by the nearly identical temperatures at Sites 5P and 5MHW, the Sterling Ponds wet detention pond began discharging to the Sumner Creek drainage way at 18:40 CDT (6:40 PM) on July 24 and continued discharging until 22:40 CDT (10:40 PM). During this 4-hour period, the wet pond discharge temperature averaged 24.5º C and ranged from 23.4-26.5º C. Some storage of this storm water discharge likely occurred in the wetland that comprises the creek drainage way upstream from Site 4. A marked temperature increase (2.3º C) was apparent downstream at Site 4 in Sumner Creek by 23:30 CDT (11:30 PM) on July 24, and is likely due to the release of warm water (including storm water) from the upstream wetland. The thermal spike (5.3º C) evident near the mouth of Sumner Creek (Site 4A) at 19:50 CDT (7:50 PM) on July 24 cannot be attributed to the Sterling Ponds storm water discharge, since the spike at Site 4A, located 1.5 miles downstream, occurred shortly after the storm water discharge, but well before the thermal spike was evident at Site 4. It seems apparent that the thermal spike at Site 4A had a more “local” cause, perhaps including storm water runoff from WI Highway 35 and/or warm water flowing from natural wetland or storage areas in the upstream Sumner Creek drainage way.

During the July 24 rain event, the wet pond began discharging to Sumner Creek shortly (10 minutes) after it began discharging to the infiltration basin. However, the duration of discharge to Sumner Creek (4 hours) was relatively short, compared to the duration of discharge to the infiltration basin (96 hours). It seems likely that most of this rain event was infiltrated, but a brief discharge of warm storm water occurred, with a downstream impact in Sumner Creek at Site 4.

August

The comparative Sterling Ponds and Sumner Creek thermographs for August 2006 are presented in Figure 28. August was the wettest month of the summer 2006 monitoring season, with 6.68 inches of rain. As indicated by the nearly identical temperatures at Sites 5P and 5IB, the Sterling Ponds wet detention pond discharged to the infiltration basin during the August 1-8, August 13-14, and August 23-31 periods, after large back-to -back rainfall events on August 1-2 (1.04 and 2.26 inches), a smaller rainfall event on

August 13 (0.48 inch), and large back-to-back rainfall events on August 23-24 (0.71 and 1.63 inches). Unfortunately, the temperature logger at Site 5MHW malfunctioned after July 26, making it impossible to directly determine if the wet pond was discharging to Sumner Creek after rainfall events in August and September. However, no thermal spikes were apparent in Sumner Creek (Sites 4 and 4A), downstream from Sterling Ponds, after the August 13 rain event (0.48 inch), suggesting that this entire event was infiltrated. Similarly, smaller rainfall events on August 6 (0.28 inch) and August 25 (0.11 inch) were likely infiltrated, while the smaller event on August 17 (0.13 inch) was likely stored in the wet detention pond.

The comparative Sterling Ponds and Sumner Creek thermographs for the large back-to-back rainfall events on August 1-2 (1.04 and 2.26 inches) are presented in Figure 29. As indicated by the nearly identical temperatures at Sites 5P and 5IB, the Sterling Ponds wet detention pond began discharging to the infiltration basin at 04:30 CDT (4:30 AM) on August 1, shortly after the onset of rainfall at 03:00 CDT (3:00 AM). Wet pond discharge to the infiltration basin, due to the August 1-2 rainfall events, continued for nearly seven days, until 03:00 CDT (3:00 AM) on August 8. Since no temperature data are available at Site 5MHW, it is not possible to directly determine if the wet pond discharged to Sumner Creek. However, after heavy rainfall commenced again at 23:00 CDT (11:00 PM) on August 1, a marked temperature increase (2.8º C) was apparent downstream at Site 4 in Sumner Creek by 06:00 CDT (6:00 AM) on August 2, and is likely due to the discharge of Sterling Ponds storm water and release of warm water from the upstream wetland. At Site 4A near the mouth of Sumner Creek, a series of three thermal spikes occurred on August 1 and 2. The large (primary) thermal spike (5.3º C) at 22:30 CDT (10:30 PM) on August 1 and a smaller secondary spike (1.5º C) at 04:00 CDT (4:00 AM) on August 2 cannot be attributed to a Sterling Ponds storm water discharge, since both spikes occurred prior to the thermal spike at Site 4 upstream (06:00 CDT). The first two thermal spikes had a more local cause (see the discussion of the July 24 rain event, above). However, the “plug” of warm water passing through Site 4 (at 06:00 CDT on August 2) may have contributed to the third thermal spike (3.6º C) downstream at Site 4A (at 15:30 CDT on August 2). The time-of-travel (9.5 hours) and speed of travel (0.2 miles per hour) for water flowing between Sites 4 and 4A in Sumner Creek seem plausible for this low-gradient stream with extensive wetland areas. Furthermore, the peak temperature at Site 4 (24.0º C) was sufficiently high enough to create the peak temperature at Site 4A (22.0º C).

The comparative Sterling Ponds and Sumner Creek thermographs for the large back-to-back rainfall events on August 23-24 (0.71 and 1.63 inches) are presented in Figure 30. As indicated by the nearly identical temperatures at Sites 5P and 5IB, the Sterling Ponds wet detention pond began discharging to the infiltration basin at 05:30 CDT (5:30 AM) on August 23, shortly after the onset of rainfall at 05:00 CDT (5:00 AM). Wet pond discharge to the infiltration basin, due to the August 23-24 rainfall events, continued for eight and one-half days, until 17:30 CDT (5:30 PM) on August 31. Since no temperature data are available at Site 5MHW, it is not possible to directly determine if the wet pond discharged to Sumner Creek. After the August 23 rainfall event (0.71 inch), no thermal spike was apparent downstream at Site 4 in Sumner Creek, suggesting that no discharge of Sterling Ponds storm water occurred. However, after heavy rainfall commenced again at 17:00 CDT (5:00 PM) on August 24, a marked temperature increase (2.1º C) was apparent downstream at Site 4 in Sumner Creek by 22:40 CDT (10:40 PM), and is likely due to the discharge of Sterling Ponds storm water and release of warm water from the upstream wetland. At Site 4A near the mouth of Sumner Creek, no thermal spike was apparent after the August 23 rain event, but two thermal spikes occurred on August 24 and 25, after the August 24 rain event. The large (primary) thermal spike (4.1º C) at 21:00 CDT (9:00 PM) on August 24 cannot be attributed to a Sterling Ponds storm water discharge, since the spike occurred prior to the thermal spike at Site 4 upstream (22:40 CDT). The first thermal spike had a more local cause (see the discussion of the July 24 rain event, above). However, the "plug" of warm water passing through Site 4 (at 22:40 CDT on August 24) may have contributed to the smaller (secondary) thermal spike (1.8º C) downstream at Site 4A (at 07:00 CDT on August 25). The time-of-travel (8.5 hours) and speed of travel (0.2 miles per hour) for water flowing between Sites 4 and 4A in Sumner Creek seem plausible for this low-gradient stream with extensive wetland areas. Furthermore, the peak temperature at Site 4 (19.8º C) was sufficiently high enough to create the peak temperature at Site 4A (17.8º C).

September

The comparative Sterling Ponds and Sumner Creek thermographs for September 2006 are presented in Figure 31. Like May and June, September was characterized by numerous smaller rainfall events (14 events less than 0.50 inch) and a moderate event (0.66 inch) on September 3 (Figure 5), resulting in below-normal precipitation for the month. As indicated by the nearly identical temperatures at Sites 5P and 5IB, the Sterling Ponds wet detention pond discharged to the infiltration basin during the September 3-9, September 16-18, and September 22-30 periods.

During the moderate rainfall event (0.66 inch) on September 3, the Sterling Ponds wet detention pond began discharging to the infiltration basin at 16:40 CDT (4:40 PM) on September 3, shortly after the onset of rainfall at 16:00 CDT (4:00 PM) (Figure 32). Wet pond discharge to the infiltration basin continued for six days, until 16:30 CDT (4:30 PM) on September 9. Since no temperature data are available at Site 5MHW, it is not possible to directly determine if the wet pond discharged to Sumner Creek. However, after the September 3 rainfall event, no thermal spike was apparent downstream at Site 4 in Sumner Creek, suggesting that no discharge of Sterling Ponds storm water occurred. In addition, no thermal spike was evident at Site 4A, near the mouth of Sumner Creek.

Small, back-to-back rainfall events occurred on September 16 (0.28 inch) and September 17 (0.10 inch). After the September 16 event, the Sterling Ponds wet detention pond began discharging to the infiltration basin at 20:30 CDT (8:30 PM) on September 16 and continued discharging until 10:40 CDT (10:40 AM) on September 18 (Figure 33). During this time period, no thermal spikes were apparent downstream at Site 4 in Sumner Creek, suggesting that no discharges of Sterling Ponds storm water occurred. In addition, no thermal spikes were evident at Site 4A, near the mouth of Sumner Creek.

Three consecutive days of rainfall occurred on September 21 (0.38 inch), September 22 (0.24 inch), and September 23 (0.37 inch). During the September 21 event, the Sterling Ponds wet detention pond began discharging to the infiltration basin at 21:50 CDT (9:50 PM) on September 21 and continued discharging through the end of September (Figure 34). During the September 21-30 period, no thermal spikes were apparent downstream at Site 4 in Sumner Creek, suggesting that no discharges of Sterling Ponds storm water occurred. In addition, no thermal spikes were evident at Site 4A, near the mouth of Sumner Creek.

Based upon the Sterling Ponds and Sumner Creek temperature data, it appears that the entire September rainfall amount of 2.30 inches (15 small-to-moderate events ranging from 0.01-0.66 inch) (Figure 5) was infiltrated.

Effectiveness of Sterling Ponds Storm Water Management Practices:

During the May-September (summer) 2006 period, the extent of storm water discharge to the Sterling Ponds infiltration basin could be readily determined, as temperature monitoring of the basin (Site 5IB) was conducted throughout the summer. The extent of storm water discharge to Sumner Creek could be directly determined via temperature monitoring at the wet pond outlet (Site 5MHW) and/or indirectly determined by the presence of thermal spikes in Sumner Creek (Sites 4 and 4A). Due to equipment malfunction at Site 5MHW, discharges to Sumner Creek could not be directly determined after July 26.

The available temperature data for Site 5P, Site 5IB, and Site 5MHW suggest that the performance of the Sterling Ponds storm water management practices (wet detention pond and infiltration basin) was excellent during 49 summer rain events, ranging in magnitude from 0.01-1.04 inches, representing 8.72 inches of precipitation, or 60% of the total summer rainfall amount (14.41 inches). All runoff from these events was infiltrated. All 38 rainfall events in May, June, and September were infiltrated. These events ranged from 0.01-0.97 inch in magnitude and represented monthly totals of 2.10, 0.73, and 2.30 inches, respectively, or 36% of the total summer rainfall amount. Four small-to-moderate rain events in July, ranging from 0.03-0.52 inch and totaling 0.80 inch, were either infiltrated or stored in the wet detention pond. Seven small-to-moderate rain events in August, ranging from 0.11-1.04 inches and totaling 2.79 inches, were largely infiltrated.

With the exception of the three largest rain events in July and August (1.80 inches on July 24, 2.26 inches on August 2 and 1.63 inches on August 24), all summer (May-September) rainfall events were fully infiltrated. The discharges to Sumner Creek due to these three large events were directly measured at Site 5MHW during the July event, and indirectly measured as thermal spikes at Site 4 during the two August events. Although the magnitude of all three events exceeded the River Falls Storm Water Management Ordinance requirement (to infiltrate additional runoff of a 1.5-inch, 24-hour rainfall compared to pre-development conditions), it seems likely that substantial infiltration of these events occurred. The duration of the storm water discharges to Sumner Creek was relatively short (4 hours), compared with lengthy discharges of storm water to the infiltration basin (4-8.5 days), suggesting that the majority of storm water from these three rain events was infiltrated rather than discharged. Since the storm water volumes discharged to the infiltration basin and Sumner Creek were not measured, it is not possible to precisely determine the amount of water infiltrated. Although the magnitude of these rain events clearly exceeded the 1.5-inch infiltration requirement of the storm water management ordinance, the events nonetheless resulted in warm storm water discharges that produced pronounced thermal spikes in Sumner Creek (2.1-2.8 ºC at Site 4 and 3.6 ºC at Site 4A).

During the July 24 rain event (1.80 inches), the wet pond began discharging to the Sumner Creek drainage way shortly (10 minutes) after it began discharging to the infiltration basin. Although the intensity of this rain event was high (1.5 inches in two hours), it is desirable to infiltrate as much of the first 1.5 inches of rainfall as possible, prior to discharging any excess amount. At a minimum, it is especially desirable to capture the "first-flush" component of storm water runoff, which generally conveys the greatest thermal impact and highest concentrations of pollutants. Very warm water (23.4-26.5º C) from the wet detention pond was almost immediately conveyed to Sumner Creek during the July 24 event, in spite of very dry antecedent conditions and potential storage capacity in the wet detention pond. The two large rain events in August (2.26 and 1.63 inches) may also have caused early discharges of warm storm water to Sumner Creek. Although temperature data at Site 5MHW are not available for direct comparison of wet pond discharge time to the onset of rainfall, thermal spikes were evident at Site 4 within five hours after the onset of rainfall, suggesting a release of warm storm water at the wet pond outlet. Compared to the early wet pond discharges to Sumner Creek during the July and August rain events, wet pond discharges to the infiltration basin occurred for extended periods, ranging from 4-8.5 days.

The pipe leading from the wet pond to the infiltration pond is inverted to provide a skimming device, so that oils and other debris floating in the wet pond are not transferred to the infiltration basin. Due to the hydraulics of an inverted pipe, water will continue to trickle into the infiltration basin for an extended time period following a rain event. More rapid delivery of storm water to the infiltration basin may be desirable. During the summer of 2006, rather lengthy infiltration times (1.5-8.5 days) were evident for a variety of rainfall events (0.33-2.26 inches). An extended infiltration time may be desirable when there is adequate time between rain events, as it also maximizes total suspended solids (TSS) and total phosphorus (TP) removal in the wet pond. However, it certainly limits the available storage volume in the wet pond when the next rain event occurs, possibly causing a premature discharge of storm water to the creek drainage way. This is particularly true for larger, back-to-back rainfall events, such as those that occurred on August 1-2 and August 23-24. During both of these back-to-back August events, wet pond discharge to the infiltration basin was already underway due to the first rain event, but was not yet complete when the second rain event began. A moderate rain event on August 1 (1.04 inches) caused a discharge to the infiltration basin at 04:30 CDT, but the large event on August 2 (2.26 inches) began at 24:00 CDT (midnight) on August 1, with infiltration of the first event not yet complete. Similarly, a moderate rain event on August 23 (0.71 inch) caused a discharge to the infiltration basin at 05:30 CDT, but the large event on August 24 (1.63 inches) began at 14:00 CDT, with infiltration of the first event not yet complete. The August 1-2 events were only separated by a 13-hour period, but the August 23-24 events were separated by a 31-hour period. The current ordinance requires water to be infiltrated within 48 hours. Therefore, these events did not violate the ordinance, but perhaps some provisions should be made for back-to-back events.

The relatively small diameter of the pipe (8 inches) leading to the infiltration basin may be limiting the ability of the wet detention pond to deliver the appropriate storm water volume to the infiltration basin before the pond discharges to the creek. As stated above, the ordinance requires infiltration within 48 hours; however the inverted pipe extends that timeline greatly. Modeling of the Sterling Ponds storm water management practices was conducted in 2006 to further investigate performance and determine if any corrective action is necessary. The current pond configurations were put into a HydroCAD model. The outlet structure of the pond to Sumner Creek is controlled by a weir in the structure, which allows storage of water to be diverted to the infiltration basin, but anything above the weir discharges to the creek. By adjusting the height of that weir we are able to hold back additional water for infiltration and provide added storage to the basin. However rate control requirements must still be complied with. It was determined through modeling that the weir could be raised from 922.5 to 923.0 and still meet rate control requirements. This adjustment will be made by City maintenance staff prior to the deployment of the temperature monitors in the spring of 2007. Results will be monitored and examined with data gathered throughout the 2007 monitoring season.

While this project is primarily focused on evaluating long-term trends, annual information is important as well. The storm water management practices at Sterling Ponds caused no major thermal impacts on the Kinnickinnic River during the May-September (summer) 2006 period. The following should be noted:

- The summer temperature regime in the Kinnickinnic River at Sites 1A and 1 (above and below the Sumner Creek confluence) was generally excellent for coldwater macroinvertebrate and brown trout communities.
- The performance of the Sterling Ponds storm water management practices (wet detention pond and infiltration basin) was excellent during 49 summer rain events, ranging in magnitude from 0.01-1.04 inches and totaling 8.72 inches (60% of the total summer precipitation). All storm water runoff from these events was infiltrated, as required by the River Falls Storm Water Management Ordinance.
- During the three largest summer rain events (in excess of 1.5 inches), the Sterling Ponds wet detention pond discharged very warm water (23.4-26.5º C) to the Sumner Creek drainage way, often for extended periods (4 hours). These warm storm water discharges produced pronounced thermal spikes (2.1-2.8 ºC) in Sumner Creek at Site 4. After the largest rain event of the summer on August 2 (2.26 inches), a "plug" of warm water (including Sterling Ponds storm water) moved downstream from Site 4, also causing a thermal spike (3.6 ºC) at Site 4A, near the mouth of Sumner Creek. However, no thermal spike was apparent downstream in the Kinnickinnic River, at Site 1. We will watch for these

thermal spikes in the years to come and monitor their intensity and frequency.

- The very prominent "first-flush" thermal spikes (4.1-7.1 °C) observed in lower Sumner Creek (Site 4A) during the three largest summer rain events appear unrelated to the storm water discharges at Sterling Ponds, and seem to have a more local cause.

Water Quality Monitoring:

No runoff event-based water quality monitoring was conducted in 2006. With below-normal precipitation during the April-September period (Figure 2), very few significant runoff events occurred in the North Kinnickinnic River Monitoring Project Area. Numerous small rain events (less than 0.50 inch) in April, May, June, and September had little influence on the Kinnickinnic River hydrograph (Figure 7). A large rainfall event on July 24 (1.80 inches) resulted in only a moderate increase in the Kinnickinnic River hydrograph, due to very dry antecedent conditions. Large back-to-back rainfall events on August 1-2 (3.30 inches) and August 23-24 (2.34 inches) produced significant increases in the Kinnickinnic River hydrograph, but no water quality samples were obtained during these two events. Given more normal precipitation and runoff conditions, the water quality monitoring component of the North Kinnickinnic River Monitoring Project will be initiated in 2007.

Base Flow Surveys:

The USGS stream flow gauge located at County Highway F, as described earlier in this report, was used to determine when a base flow condition existed in the Kinnickinnic River. When 3-4 days of "flat-line" flow was observed at this station, the river was assumed to be at a base flow condition. During dry periods between runoff events, the Kinnickinnic River maintained a base flow of approximately 85-95 cfs at County Highway F. Real-time and recent (31-day) stage, flow, and precipitation data for this monitoring station are web-accessible at:

http://waterdata.usgs.gov/wi/nwis/uv?dd_cd=02&format=gif&period=7&site_no=05342000

In the spring and autumn of 2006, instantaneous measurements of base flow were obtained at Sites 1-3 in the Kinnickinnic River and at the mouth of Sumner Creek (Site 4A) within the North Kinnickinnic River Monitoring Project Area. The 2006 base flow surveys were conducted using a SonTek® FlowTracker handheld acoustic doppler velocimeter (ADV).

The spring 2006 survey was conducted on May 24 & 25. Kinnickinnic River base flows were lowest at Site 3 (54 cfs) and nearly identical at Sites 1 (64 cfs) and 2 (65 cfs). Sumner Creek provided a small contribution (1 cfs) to the Kinnickinnic River, just upstream of Site 1. An additional 52% increase in Kinnickinnic River base flow occurred between Site 1 and County Highway F (97 cfs), including contributions from the South Fork of the Kinnickinnic River (unmeasured), Mann Valley Creek (unmeasured), and Rocky Branch Creek (6 cfs).

The fall 2006 survey was conducted on October 10. These autumn 2006 survey results are presented in Figure 35, with a comparison to the autumn 2005 survey results. In autumn 2006, Kinnickinnic River base flows were nearly identical at Sites 2 and 3 (52 cfs). The base flow at Site 1 (55 cfs) was only slightly higher, with Sumner Creek providing a small contribution (1 cfs) upstream of Site 1. An additional 84% increase in Kinnickinnic River base flow occurred between Site 1 and County Highway F (101 cfs), including contributions from the South Fork of the Kinnickinnic River (unmeasured), Mann Valley Creek (unmeasured), and Rocky Branch Creek (6 cfs). The autumn 2006 Kinnickinnic River base flows in the project area (Sites 1-3) were reduced, compared to autumn 2005, likely due to below-normal precipitation during the summer of 2006. A reduction was especially apparent at Site 1. The autumn 2005 and 2006 Sumner Creek base flows were essentially identical. In autumn 2006, slight base flow increases were apparent in Rocky Branch Creek, and in the Kinnickinnic River at County Highway F.

One goal of the River Falls Storm Water Management Ordinance is to maintain strong base flow conditions in the Kinnickinnic River by requiring storm water management practices that promote infiltration of rainfall, thereby maintaining shallow aquifer levels, as well as the springs that provide cold water for the river. The initial base flow surveys in 2005 and 2006 will provide a baseline for determining if base flow conditions will be sustained in the future as development progresses in the North Kinnickinnic River Monitoring Project Area.

Macroinvertebrate Monitoring:

Biotic indicators such as macroinvertebrates (aquatic insects) are often used to complement physical and chemical measurements in stream monitoring programs. Biological data add a significant dimension to monitoring procedures because they provide an analysis that measures long-term phenomena. Because many aquatic organisms live in the stream environment for a year or more, they are excellent indicators of past as well as present water quality conditions. Annual macroinvertebrate samples are collected at Sites 1-3 within the North Kinnickinnic River Monitoring Project Area. Organisms are identified and counted in the laboratory, and various biological indices can then be calculated for each monitoring site. The index values are indicative of water quality, depending upon the pollution tolerances of the macroinvertebrates collected at the monitoring sites.

The use of benthic macroinvertebrates (bottom-dwelling aquatic insects and crustaceans) was initiated in Wisconsin with the work of W. L. Hilsenhoff at the University of Wisconsin-Madison, and has been modified and refined (Hilsenhoff 1982, 1987). The Hilsenhoff Biotic Index (HBI) is particularly useful for determining the influence of organic pollution on macroinvertebrates. The Wisconsin Department of Natural Resources has used this index for many years in long-term stream monitoring efforts.

Macroinvertebrate HBI determinations follow a sequence of field collection, laboratory sorting, identification, and index calculation. Each macroinvertebrate taxon has been assigned a specific tolerance value at the genus or species level. These values range from 0 (extremely intolerant of organic pollution) to 10 (extremely tolerant of organic pollution). Because the HBI calculation is based on multiplying the count of a given taxon (number of individuals in the sample) by its specific tolerance value, the more intolerant taxa that are present, the lower the biotic index, indicating better water quality, as follows:

HBI Value	Water Quality	Degree of Organic Pollution
0.00-3.50	Excellent	No apparent organic pollution
3.51-4.50	Very Good	Slight organic pollution
4.51-5.50	Good	Some organic pollution
5.51-6.50	Fair	Fairly significant organic pollution
6.51-7.50	Fairly Poor	Significant organic pollution
7.51-8.50	Poor	Very significant organic pollution
8.51-10.00	Very Poor	Severe organic pollution

HBI values provide the observer with quantitative data that can be used for comparing water quality at various river sites. Additionally, the work yields supplementary metrics useful for further analysis. These include: taxa richness, numerical dominance, and proportions of sensitive groups (Ephemeroptera, Plecoptera, Trichoptera, i.e., EPT index).

The following HBI values represent North Kinnickinnic River Monitoring Project samples (three replicates each) collected at Sites 1-3 in 2004 and 2005. All sampling was conducted in late May of the respective years.

Sampling Site	Sampling Location	2004 HBI Values	2005 HBI Values
Site 1: North Main	50 yards upstream from North Main Street Bridge, River Falls, WI Lat. 44°52'32.1", Long. 92°37'15.6"	2.77 2.86 2.99	3.17 3.04 2.79
	Mean of 3 reps:	2.87	3.00
Site 2: Swinging	Approx. 1.1 mile upstream from North Main Street Bridge, River Falls, WI	4.20 3.99	4.30 4.67

Gate (STH 65)	Lat. 44°53'12.9", Long. 92°36'40.9"	3.85	4.45
	Mean of 3 reps:	4.01	4.48
Site 3: Hebert (Hebert-Hagen)	Approx. 0.4 mile downstream from Quarry Rd. Lat. 44°53'22.2", Long. 92°36'19.5"	3.37 4.04 3.60	3.65 3.55 3.13
	Mean of 3 reps:	3.67	3.44

The 2004-2005 macroinvertebrate HBI values are also presented in Figure 36. These data were generated to establish a macroinvertebrate-based water quality baseline at the start of this monitoring project. In 2004 and 2005, mean HBI values at Site 1 were indicative of excellent water quality, mean HBI values at Site 2 were indicative of very good water quality, and mean HBI values at Site 3 were indicative of very good-excellent water quality. Macroinvertebrate monitoring was again conducted in May 2006, but the taxonomic analysis has not yet been completed by the University of Wisconsin-Stevens Point laboratory. Annual HBI values and site comparisons will continue to be posted as they become available.

Appendix A

Reasons why small rainfall events (less than one inch) were not analyzed in 2006

While smaller rainfall and runoff events can cause significant storm water impacts on the Kinnickinnic River, it seems unlikely that storm water runoff from the Sterling Ponds subdivision caused any impacts on the river during these smaller rainfall events (less than 1 inch) in 2006, due to several factors:

1. Building progress remained somewhat limited in the Sterling Ponds subdivision in 2006, and has largely occurred in the southeast quadrant of the subdivision. In the southeast quadrant, only 3 single-family housing units were built by year-end 2003, 19 single-family housing units were built by year-end 2004, 33 single-family housing units were built by year-end 2005, and 36 single-family housing units were built by year-end 2006. In the northeast quadrant, 2 duplex units were complete by year-end 2005, and 2 multi-family (8-plex) units were under construction. By year-end 2006, 1 single-family unit, 2 duplex units, 3 multi-family 8-plex units, and 2 multi-family 10-plex units were complete. A build-out total of 600 units are projected for Sterling Ponds. Maps of Sterling Ponds build-out progress in 2003, 2004, 2005, and 2006 are available on the project website ("What We Monitored"). With only 36 of approximately 150 single family units (24%) complete in the southeast quadrant by year-end 2006, impervious surfaces (rooftops, sidewalks, driveways, and streets) still accounted for only a relatively small proportion (??%) of the overall subdivision area.

2. Four wet storm water detention ponds were already in place, with some capacity for storing storm water runoff from the existing impervious areas, especially during smaller rain events. Three of the four infiltration basins paired with the wet storm water detention ponds were not yet functional in 2006. However, the fourth infiltration basin serving the southeast quadrant of Sterling Ponds was functional throughout the April-September 2006 period (see 2006 build-out map). These infiltration basins were designed and constructed to meet the current River Falls Storm Water Management Ordinance infiltration requirements. The Sterling Ponds infiltration basins remained off-line throughout 2004, so that percolation testing could be conducted and native vegetation had an opportunity to become established. The southeast wet detention pond and infiltration basin should have provided effective storm water treatment for the southeast quadrant of Sterling Ponds in 2006, as required by the ordinance. Indeed, monitoring of these southeast storm water management practices in 2006 demonstrated excellent infiltration for 49 summer rain events, ranging in magnitude from 0.01-1.04 inches and totaling 8.72 inches (60% of the total summer precipitation) (see ***Effectiveness of Sterling Ponds Storm Water Management Practices***).

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3. The Sterling Ponds subdivision is approximately 1.5 miles from the Kinnickinnic River, with a connection via Sumner Creek. Sumner Creek is a low-gradient tributary that typically exhibits only intermittent flow during larger rain events. Downstream wetland areas that are part of the Sumner Creek drainage way and the Sumner Creek channel itself likely provide some storage of any Sterling Ponds storm water discharges, especially during larger rain events that may exceed the capacity of the wet detention ponds and the functional infiltration basin.

Monitoring at Sterling Ponds in 2006 capably evaluated ordinance effectiveness and identified the storm water impacts related to several rainfall events in excess of 1.5 inch (see ***Effectiveness of Sterling Ponds Storm Water Management Practices***). Ongoing annual monitoring and evaluation will be especially important as the Sterling Ponds subdivision continues to develop and impervious area increases.