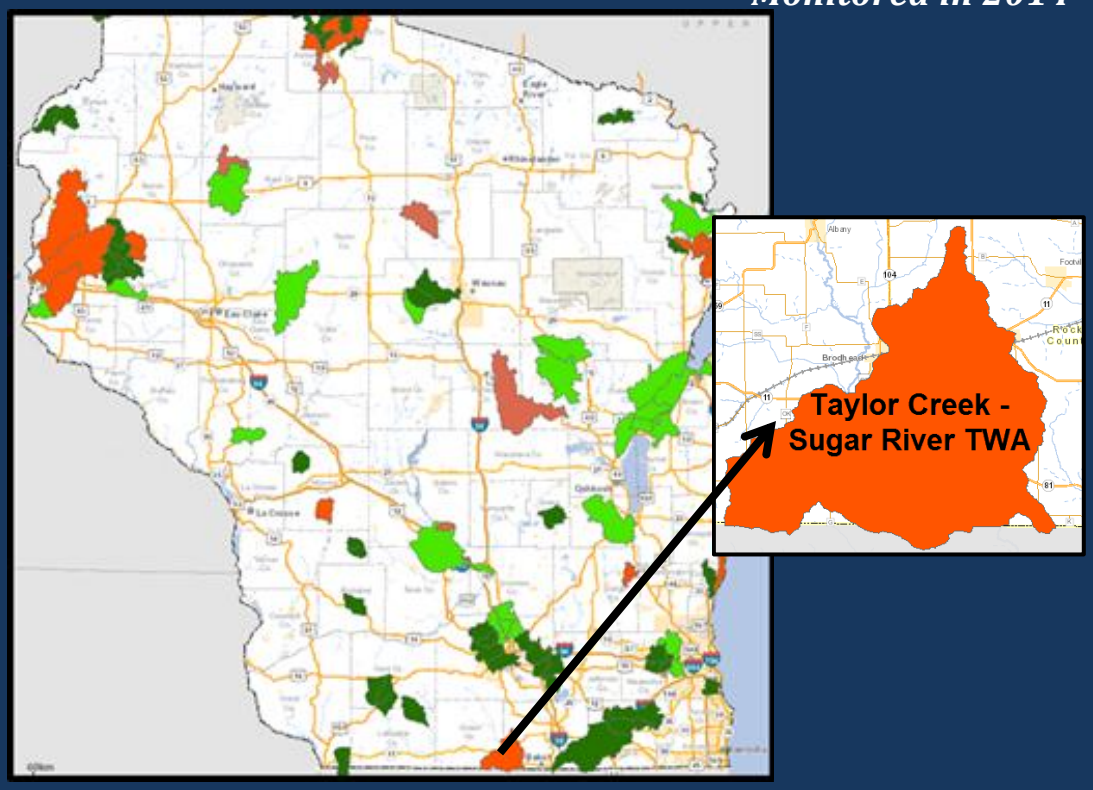
Willow Creek at Lee Rd
Photo by Jim Amrhein, DNR

A Watershed Report created by the Bureau of Water Quality in support of the Clean Water Act.

TAYLOR CREEK – SUGAR RIVER TWA WQM PLAN 2017

Lower Sugar River (SP11)
HUC: 0709000407
Monitored in 2014



WISCONSIN
DEPT. OF NATURAL RESOURCES

EGAD # 3200-2017-05
Water Quality Bureau,
Wisconsin DNR

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Wisconsin Water Quality Monitoring and Planning

This Water Quality Management Plan was created under the state's Water Quality Management Planning and Water Resources Monitoring Programs. The plan reflects Water Quality Bureau and Water Resources Monitoring Strategy 2015-2020 goals and priorities and fulfills Areawide Water Quality Management Planning milestones under the Clean Water Act, Section 208. Condition information and resource management recommendations support and guide program priorities for the plan area.

This plan is hereby approved by the Wisconsin DNR Water Quality Program and is a formal update to the Sugar – Pecatonica Areawide Water Quality Management Plan and Wisconsin's Statewide Areawide Water Quality Management Plan. This plan will be forwarded to USEPA for certification as a formal plan update.

Greg Searle — 2/6/18
Water Resources Field Supervisor — Date

Greg Searle — 2/6/18
Greg Searle, Water Quality Bureau Field Operations Director — Date

Timothy R. Asplund — 2/6/18
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Report Acknowledgements

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WISCONSIN DEPT. OF NATURAL RESOURCES

Abbreviations

BMP: **Best Management Practice**. A practice that is determined effective and practicable (including technological, economic, and institutional considerations) in preventing or reducing pollution generated from nonpoint sources to a level compatible with water quality goals.

DNR: **Department of Natural Resources.** Wisconsin Department of Natural Resources is an agency of the State of Wisconsin created to preserve, protect, manage, and maintain natural resources.

FIBI: **Fish Index of biological integrity (Fish IBI).** An Index of Biological Integrity (IBI) is a scientific tool used to identify and classify water pollution problems. An IBI associates anthropogenic influences on a water body with biological activity in the water and is formulated using data developed from biosurveys. In Wisconsin, Fish IBIs are created for each type of natural community in the state's stream system.

HUC: **Hydrologic Unit Code.** A code or sequence of numbers that identify one of a number of nested and interlocked hydrologic catchments delineated by a consortium of agencies including USGS, USFS, and Wisconsin DNR.

MIBI: **Macroinvertebrate Index of biological integrity.** In Wisconsin, the MIBI, or macroinvertebrate Index of biological integrity, was developed specifically to assess Wisconsin's macroinvertebrate community (see also Fish IBI).

Natural Community. A system of categorizing waterbodies based on their inherent physical, hydrologic, and biological assemblages. Both Streams and Lakes are categorized using an array of "natural community" types.

Monitoring Seq. No. Monitoring Sequence Number refers to a unique identification code generated by the Surface Water Integrated Monitoring System (SWIMS), which holds much of the state's water quality monitoring data.

SWIMS ID. Surface Water Integrated Monitoring System (SWIMS) Identification Code is the unique monitoring station identification number for the location where monitoring data was gathered.

TWA: **Targeted Watershed Assessment.** A statewide study design a rotating watershed approach to gathering of baseline monitoring data with specialized targeted assessments for unique and site-specific concerns, such as effectiveness monitoring of management actions.

WATERS ID: The Waterbody Assessment, Tracking and Electronic Reporting System Identification Code (WATERS ID) is a unique numerical sequence number assigned by the WATERS system, also known as "Assessment Unit ID code".

WBIC: **Water Body Identification Code.** WDNR's unique identification codes assigned to water features in the state. The lines and information allow the user to execute spatial and tabular queries about the data, make maps, and perform flow analysis and network traces.

Watershed Discussion & Management Recommendations

Watershed Goals

The overall goal of this plan is to improve and protect water quality in the basin. This Targeted Watershed Assessment monitoring project provided substantial data to analyze current conditions and to make recommendations for future management actions in the area. This plan is designed to present monitoring study results, identify issues or concerns in the area found during the project and to make recommendations to improve or protect water quality consistent with Clean Water Act guidelines and state water quality standards.

Watershed Overview

Figure 1: Taylor Creek – Sugar River TWA.

The Lower Sugar River watershed lies in southeast Green and southwest Rock Counties. It contains an 18.4 mile stretch of the Sugar River from the dam at Decatur Lake downstream to the Wisconsin-Illinois state line. The watershed is intensively agricultural with scattered grasslands and woodlots. Two municipalities, Brodhead and Orfordville, discharge to the Sugar River and Swan Creek, respectively. The Juda wastewater treatment facility discharges to groundwater. One industrial facility, Grande Cheese-Juda, discharges to the North Fork Juda Branch. Polluted runoff is the primary cause of water quality and in-stream habitat problems. Point source pollution is also a problem on the North Fork Juda Branch. The North Fork Juda Branch and Spring Creek are on the state's list of impaired (303d) waters, mainly due to habitat impairments caused by non-point source pollution. Many of the streams in this watershed have not been monitored in the last 10 years.

Population, Land Use, Site Characteristics

Land use in the Sugar River Watershed (the larger catchment) is dominated to a great extent by agricultural use. This intensive land use places a toll on the condition of resources in the area; yet, management actions are available to maintain and improve the conditions of streams in the area. This largely pastoral landscape is prototypically “rural Wisconsin” with working fields sprinkled with wind-rows and somewhat controlled and heavily used tributaries and receiving streams of the Sugar River Basin.

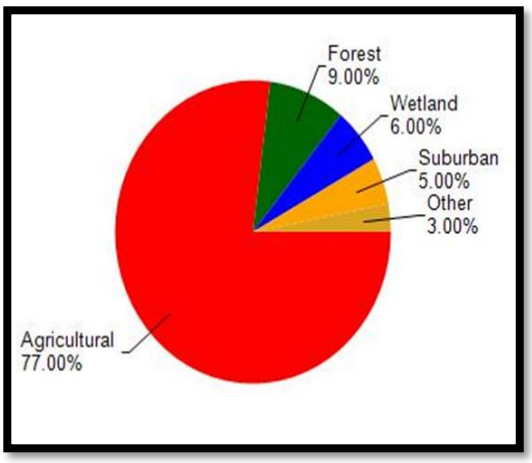


Figure 2: Land use percentages in the Sugar River Watershed.

Ecological Landscapes

The Southeast Glacial Plains Ecological Landscape makes up the bulk of the non-coastal land area in southeast Wisconsin. This Ecological Landscape is made up of glacial till plains and moraines. Most of this Ecological Landscape is composed of glacial materials deposited during the Wisconsin Ice Age, but the southwest portion consists of older, pre-Wisconsin till with a more dissected topography. Soils are lime-rich tills overlain in most areas by a silt-loam loess cap. Agricultural and residential interests throughout the landscape have significantly altered the historical vegetation. Most of the rare natural communities that remain are associated with large moraines or in areas where the Niagara Escarpment occurs close to the surface.

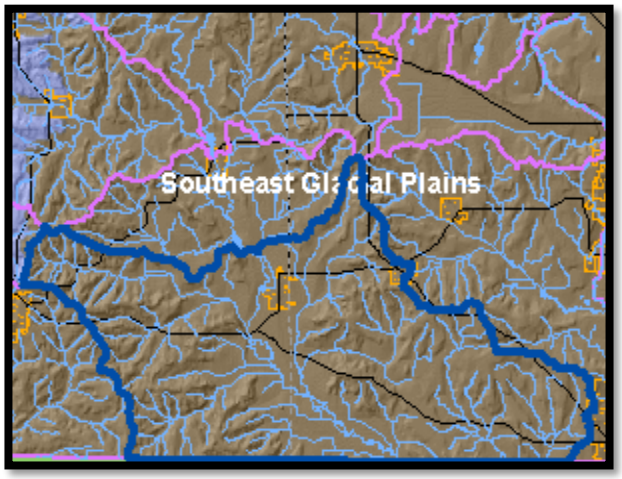


Figure 3: Ecological Landscapes in the Sugar River Watershed.

Historically, vegetation in the Southeast Glacial Plains consisted of a mix of prairie, oak forests and savanna, and maple-basswood forests. Wet-mesic prairies, southern sedge meadows, emergent marshes, and calcareous fens were found in lower portions of the landscape. End moraines and drumlins supported savannas and forests. Agricultural and urban land use practices have drastically changed the land cover of the Southeast Glacial Plains since Euro-American settlement. The current vegetation is primarily agricultural cropland. Remaining forests occupy only about 10% of the land area and consist of maple-basswood, lowland hardwoods, and oak. No large mesic forests exist today except on the Kettle Interlobate Moraine which has topography too rugged for agriculture. Some existing forest patches that were formerly savannas have succeeded to hardwood forest due to fire suppression.

Hydrology

The entire basin is characterized by the lack of natural lakes and wetlands; wetland complexes are few in the driftless region and there are only 13 named lakes in the basin – most of them impoundments on streams. The water quality of these lakes is marginal due to heavy siltation from upland runoff. This siltation usually leads to shallow, mucky ponds with a low diversity of aquatic macrophytes and fish.

Eastern Green County and the Rock County part of the basin are in the Southeast Glacial Plains ecological landscape. The Southeast Glacial Plains landscape is underlain by dolomite with some limestone and shale. The topography is rolling glacial till and outwash plains dissected by numerous streams. Valleys tend to be broader and streams in this part of the basin do not have the higher gradients of those in the driftless part. The original vegetation of this part of the basin was a mixture of prairie, oak savanna, and mixed hardwood forests. The most significant wetland complexes are located along the Sugar River.

Study Summary

Streams of the Lower Sugar River watershed tend to contain fish resembling a cool-warm thermal regime. The streams typically have 10 to 15 species, many of them transitional or warmwater species. And while there are multiple intolerant species found in certain locations, the majority of the total numbers of fish are tolerant to environmental degradation. The streams themselves have many sections that have been straightened to enhance drainage from agricultural fields. This lends itself to

degraded habitat within the individual streams and advanced sediment delivery to larger systems like the Sugar River.

As one attempts to think of ways to improve these streams, it is unrealistic to think that re-meandering of the stream channels is cost-effective or practical, especially in the contemporary agricultural economy. Therefore, it is imperative to work with landowners in the watershed to encourage management of woody vegetation to prevent overgrowth along banks, to control regrowth and use management practices that avoid destabilization of banks (i.e. cutting and grubbing of the shoreline with no shaping, sloping or mulching). This would allow for stabilization in grasses, embrace natural "re-meandering" within the channel footprint, and strive to keep some buffers in place. Where possible, encourage landowners to slope banks 3:1 to prevent erosion. It is also important to leave some in-stream woody debris in place to act as natural cover for fish. Control nutrient loading through development and implementation of nutrient management plans and proper manure management.

Management Recommendations

- The department should work with watershed organizations such as the Lower Sugar River Watershed Association on outreach efforts with landowners in the watershed, environmental programs in the Juda and Brodhead school districts, and research opportunities for harvestable buffers to provide economic incentives for maintaining buffers along streams.
- The entire length of OK Creek should be added to the state's 303(d) list of impaired waters due to habitat degradation caused by excessive sediment deposition and channel straightening. It should also be added for total phosphorus as concentrations exceed the WisCALM (WDNR, 2013) guidance. The department should review land use and nutrient management efforts in this sub-watershed to determine if any improvements can be made to reduce phosphorus delivery to the stream.
- Swan Creek should be added to the 303(d) list of impaired waters for total phosphorus that exceeds the criteria.
- Taylor Creek, from Swan Creek downstream to the Sugar River, and Willow Creek should be added as a watch water since total phosphorus concentrations are near the criteria for listing.
- Monitoring of phosphorus and nitrate concentrations in the streams of the Lower Sugar River should continue as funding and volunteer efforts allow.

Ecological, Aquatic Resources

Outstanding and Exceptional Resource Waters

Wisconsin has designated many of the state's highest quality waters as Outstanding Resource Waters (ORWs) or Exceptional Resource Waters (ERWs). Waters designated as ORW or ERW are surface waters which provide outstanding recreational opportunities, support valuable fisheries and wildlife habitat, have good water quality, and are not significantly impacted by human activities. ORW and ERW status identifies waters that the State of Wisconsin has determined warrant additional protection from the effects of pollution.

Most of the entire 81-mile length of the Sugar River within the state's boundary is designated as Exceptional Resource Water (ERW), save for the area downstream of the Green/Rock county border. Several rare species have been reported in the Sugar River mainstem including the gravel chub, silver chub, pallid shiner, redfin shiner and river redhorse. Wetlands are rare in the basin, but significant and regionally important wetland complexes do occur along the Sugar River.

Table 1: ERW listed in the Sugar River Watershed.

Waterbody Name	WBIC	Start Mile	End Mile
Sugar River	875300	11	81

Impaired Waters

Every two years, Section 303(d) of the Clean Water Act requires states to publish a list of all waters that do not meet water quality standards. The list, also known as the Impaired Waters List, is updated to reflect waters that are newly added or removed based on new information or changes in water quality status.

Table 2: Watershed Impaired Waters

Waterbody Name	WBIC	Start Mile	End Mile	Pollutant	Impairment
Sugar River	875300	0	56	Phosphorus	Unknown
Spring Creek	877000	0	10.3	Sediment	Habitat

Species of Special Concern

Gravel chub, silver chub, pallid shiner, redfin shiner and river redhorse have been reported in the mainstem of the Sugar River. Least darters were found in Willow Creek.

Monitoring Project Discussion

Purpose of Project

Monitor the contemporary status for this watershed (HUC 10) in the Lower Sugar River watershed. The department needs current fish, habitat, macroinvertebrate and water chemistry data for streams in this watershed. The data will be used to determine whether these streams are achieving their attainable use in order to update the watershed tables, list waters that are not meeting their attainable use, and assess the overall health of the watersheds as required by Section 305(b) of the Clean Water Act. The data, used in conjunction with observations about watershed health, will be used to guide planning for improvements where needed.

Site Selection and Study Design

The 2014 watershed survey was conducted by water resources biologists on 22 sites in the watershed. Sites were selected to cover named streams or major unnamed tributaries in the HUC 10.

Methods, Equipment and Quality Assurance

The fisheries assemblage was determined by electroshocking a section of stream with a minimum station length of 35 times the mean stream width (Lyons, 1992). A stream tow barge with a generator and two probes was used at most sites. A backpack shocker with a single probe was used at sites generally less than 2 meters wide. All fish were collected, identified, and counted. All gamefish were measured for length. At each site, qualitative notes on average stream width and depth, riparian buffers and land use, evidence of sedimentation, fish cover and potential management options were also recorded. A qualitative habitat survey (Simonson, et. al., 1994) was also performed at each site. Macroinvertebrate samples were obtained by kick sampling and collecting using a D-frame net at these same sites in the watershed in fall, 2014 and sent to the University of Wisconsin-Stevens Point for analysis.

Additionally, water samples were collected once per month throughout the growing season (May through October) by volunteer monitors in 2013 and/or 2014 and 2015 at 6 sites in the watershed. Three of these sites (Spring Creek, Taylor Creek at Smith Road and Willow Creek) are at the pour point of the HUC 12s which make up the HUC 10 because it was practical to do so. Two sites – on Swan and OK creeks - were near the pour point of these major tributaries. An additional site was collected in 2014 on Taylor Creek at W. Keesey Road for comparison with upstream/downstream of the confluence with Swan Creek. These samples were analyzed for total phosphorus.

Continuous water temperature loggers were also placed at sites on Swan, Taylor, and Willow creeks and programmed to take hourly water temperatures throughout the "summer" (June – August) period.

Project Results

Data Tables

Table 3: Fish Taxonomy Count

	Oakley Branch	O.K. Creek			Unnamed Trib (877300)	Spring Creek			Unnamed Trib (5042398)	Swan Creek			Taylor Creek				Willow Creek			Unnamed Trib (876500)		Unnamed Trib (876600)
Species	CTH K	Preston Rd	CTH G	Mt. Hope Rd	Giese Rd	CTH OK	Town Center Rd	Mt. Hope Rd	Gerber Rd	Potter Rd	S. Dickey Rd	W. Keesey Rd	W. Gempler Rd	W. Footville-Brodhead Rd	W. Keesey Rd[5]	W. Smith Rd	W. Avon N. Townline Rd	Lee Rd	STH 81	W. Skinner Rd (east)	W. Skinner Rd (west)	W. Avon N. Townline Rd
American Brook Lamprey												1							4			
Banded Darter							4	1								10		8	7			
Bigmouth Shiner							2					2							11			
Black Bullhead												*1*				*1*					*5*	
Blackside Darter			1	1				2				2				3		1	3			
Blackstripe Topminnow																			3			
Bluntnose Minnow			13	81	40		3	61			5	6				380		55	133		108	
Brassy Minnow								4			1			1				11			246	
Brook Stickleback	3	28	18	10	8	7	18		20	4	2	5	10	6		9	14	24	7	38	110	11
Brown Trout (size)				1 (3.0)																		
Central Mudminnow										1	3	1		1	3	10	65	13	3	4	121	13
Central Stoneroller	11		13	28	10	53	159	13			92	2		8	5	3		6	36		156	
Creek Chub	79		22	120	32	81	66	65	24	23	113	78	8	26	10	60	30	55	10	2	100	11
Common Shiner	3		4		1	4	93	56								5						
Fantail Darter	1					5	60						27	11				36	5			
Fathead Minnow	2	6	12		8			1			15	1		1		16	26	26		16	112	27
Golden Shiner	1										1					28		1				
Grass Pickerel				1																		
Green Sunfish	1			1			2				4	6				10	13	8	3	1	19	1
Hornyhead Chub				1		1	23	19														
Iowa Darter	1							2			18	5		18	3	15	26	23	6	18	44	2
Johnny Darter	5		48	18	33	18	27	28		29	19	12	30	33	1	49	4	116	45	13	61	15
Largemouth Bass (size)	1 (11.0)																					
Least Darter																		12			9	
Northern Hog Sucker																2						
Northern Pike (size)			1 (7.1)					1 (7.5)								1 (13.2)						
Rainbow Darter								2								13			21			
Rock Bass (size)								2 (6.3-6.5)														
Sand Shiner				42			11	105								5			9			
Smallmouth Bass (size)																1 (12.3)						
Shorthead Redhorse								1								2						
Southern Redbelly Dace	3			6	6	4	75	9									8	32			216	
Spotfin Shiner								9								99			4			
Suckermouth Minnow								2														
(Western) Blacknose Dace						3	17			1	22	20	3	3	1		2	12	1			
White Sucker	47		9	16	6	75	99	38			40	64		1	6	90		11	52		71	
Common Shiner x Creek Chub	1																					
Green Sunfish x Bluegill											1											
Modelled Natural Community[1]	CCHW	CCHW	CCHW	CCHW	CCHW	CCHW	CCHW	CCMS	CCHW	Cold	CCHW	CCHW	CCHW	CCHW	CCHW	CWMS	CCHW	CCHW	CWMS	CCHW	CWHW	CCHW
Verified?	Yes	Yes	Yes	No	No	No	No	No	Yes	No	No	Yes	No	No	No	Yes	No	No	Yes	No	Yes	No
Verified Natural Community[2]				CWMS[6]	CWHW	CWHW	CWHW	CWMS[6]		CCHW	CWHW		CWHW	CWHW	CWHW		CWHW	CWHW		CWHW		CWHW
Cold-Cool/Cool-Warm IBI[3]	**60** / 60	20 / 20	**45**/50[7]	60 / **70**	**60** / 50	60 / **60**	90 / **90**	90 / **90**	10 / 20	**60** / 40	70 / **70**	**70** / 70	70 / **60**	80 / **80**	70 / **60**	80 / **70**	70 / **60**	90 / **90**	90 / **80**	80 / **50**	90 / **90**	70 / 40
Other IBI (where appropriate)		20 (Poor)[4]			90 (Excellent)[4]				20 (Poor)[4]											90 (Excellent)[4]		90 (Excellent)[4]
% Tolerants	84	100	72	58	65	66	31	39	100	50	61	88	27	51	68	74	80	46	59	66	47	79

Stenothermal Coldwater Species
Tolerant Species
Intolerant Species
Species names in italics indicate warmwater species

1) Lyons, John. 2013. DRAFT Methodology for Using Field Data to Identify and Correrct Wisconsin Stream "Natural Community" Misclassifications. Version 4. May 16, 2013.
2) Natural Community suggested by the methodology cited above.
3) Coolwater IBI: Poor < 20 ; Fair 21-40 ; Good 41-60 ; Excellent 61-100
4) Small and Intermitent Stream IBI (Lyons, 2006)
5) Station length truncated at 86 meters due to numerous blowdowns
6) Fits neither headwater or mainstem, but closer to a mainstem
7) Average of two sections

Table 4: Habitat Data by Station

Station Name	Date Time	Flow CMS	Flow CFS	Ave Width (m)	Ave Depth (m)	Riparian Buffer Score	Bank Erosion Score	Pool Area Score	Width Depth Score	Riffle Riffle Score	Fine Sediments Score	Fish Cover Score	Total Hab Score	Hab Rating
OAKLEY BR AT CTH K	09-Jun-14	0.02	0.71	3	0.4	10	5	7	10	15	10	10	67	Good
OK CREEK UPSTREAM OF CTY G	09-Jul-14	0.058	2.059	3	0.3	15	5	0	10	0	0	5	35	Fair
OK CREEK UPSTREAM OF CTY G	09-Jul-14			4	0.1	15	0	0	5	5	0	0	25	Fair
OK CREEK AT MT HOPE RD	16-Jul-14	0.073	2.5915	3	0.2	10	15	0	10	0	0	5	40	Fair
OK CREEK AT PRESTON RD	05-Jun-14	-		2	0.3	15	5	3	10	10	10	5	58	Good
SPRING CREEK AT MOUNT HOPE RD	16-Jul-14	0.265	9.4075	6.5	0.25	15	0	3	0	0	5	15	38	Fair
SPRING CREEK AT TOWN CENTER RD	18-Jul-14	0.207	7.3485	6	0.4	0	0	0	10	10	10	5	35	Fair
SPRING CREEK AT CTH OK	09-Jul-14	0.025	0.8875	6	0.2	15	0	3	0	5	10	10	43	Fair
SWAN CREEK - DICKEY ROAD	08-Jul-14	0.119	4.2245	3.5	0.2	10	10	3	5	10	10	10	58	Good
SWAN CREEK, KEESEY ROAD BRIDGE	08-Jul-14	0.215	7.6325	5	0.2	15	10	0	5	0	5	5	40	Fair
SWAN CREEK - Upstrm Potter Rd (Above Orfordville Wastewater Ditch)	27-May-14	-		1.5	0.1	15	10	0	10	0	5	5	45	Fair
TAYLOR CREEK- DOWNSTREAM OF FOOTVILLE-BRODHEAD RD	27-May-14	0.039	1.3845	2	0.2	15	10	0	10	5	10	5	55	Good
TAYLOR CREEK AT W. GEMPLER RD	27-May-14	0.032	1.136	2.5	0.2	10	5	0	10	5	5	5	40	Fair
TAYLOR CREEK AT SMITH RD	21-Jul-14	0.598	21.229	7.5	0.25	15	15	0	5	5	0	10	50	Good
TAYLOR CREEK AT W. KEESEY ROAD	08-Jul-14	Brush Inhibited		3	0.3	15	10	0	15	0	0	10	50	Good
UNNAMED TRIB (876600) TO WILLOW CR AT W. AVON-N. TOWNLINE RD	04-Jun-14	0.059	2.0945	2.5	0.2	15	15	0	10	0	5	5	50	Good
UNNAMED TRIB (876500) TO WILLOW CR AT W. SKINNER RD (EAST CROSSING)	04-Jun-14	Stagnant		2	0.2	10	15	0	10	0	5	5	45	Fair
UNNAMED TRIB (876500) TO WILLOW CR AT W. SKINNER RD (WEST CROSSING)	30-Jul-14	0.038	1.349	2.5	0.25	15	15	0	10	0	0	5	45	Fair
UNNAMED TRIB (877300) TO OK CREEK AT GIESE RD	05-Jun-14	0.029	1.0295	3	0.25	5	10	0	10	0	5	5	35	Fair
UNNAMED TRIB (5042398) TO SPRING CREEK AT GERBER RD	05-Jun-14	-		2	0.2	0	15	0	10	5	5	5	40	Fair
WILLOW CREEK AT LEE RD	21-Jul-14	0.12	4.26	5.5	0.1	15	5	0	0	0	0	5	25	Fair
WILLOW CREEK - AVON NORTH TOWN LINE ROAD	04-Jun-14	0.049	1.7395	2	0.25	15	15	0	10	0	5	5	50	Good
WILLOW CREEK - UPSTREAM OF STH 81	18-Jul-14	0.218	7.739	4	0.4	15	15	3	10	10	0	10	63	Good

Station Name	Comments
OAKLEY BR AT CTH K	STREAM DEPTH VARIES FROM 0.05 M TO 0.8 M DEEP. SPRING POND FEEDS INTO THIS STATION ABOUT 80M UPSTREAM OF CTH K.
OK CREEK UPSTREAM OF CTY G	SECOND HALF OF STATION.
OK CREEK UPSTREAM OF CTY G	FIRST HALF OF STATION. NUMEROUS BLOWDOWNS. SMALL STREAM THAT IS WIDE/SHALLOW, WITH LOTS OF SOFT SEDIMENT.
OK CREEK AT MT HOPE RD	DEEPLY ENTRENCHED CHANNELIZED SYSTEM WITH A MODERATE TO HIGH AMOUNT OF SOFT SEDIMENT.
OK CREEK AT PRESTON RD	LOTS OF SPRING SEEPS ALONG EDGE OF CREEK. COLD WATER. HIGH GRADIENT.
SPRING CREEK AT MOUNT HOPE RD	ENTRENCHED, CHANNELIZED, BANK EROSION. W/D RATIO POOR BUT MANY BLOWDOWNS PROVIDE COVER BY CREATING POOLS, HOLES.
SPRING CREEK AT TOWN CENTER RD	NICE RIFFLE-RUN COMPLEXES. GOOD GRADIENT.
SPRING CREEK AT CTH OK	STREAM WIDE AND SHALLOW. STEEP RAW BANKS.
SWAN CREEK - IMMEDIATELY DOWNSTREAM FROM DICKEYROAD	-
SWAN CREEK, KEESEY ROAD BRIDGE	HIGH WIDTH/DEPTH RATIO, BUT DID CONTAIN A FEW AREAS UP TO 0.7 METERS DEEP.
SWAN CREEK - ABOVE ORFORDVILLE STP	-
TAYLOR CREEK-DS 141M OF FOOTVILLE-BRODHEAD RD	-
TAYLOR CREEK AT W. GEMPLER RD	-
TAYLOR CREEK AT SMITH RD	-
TAYLOR CREEK AT W. KEESEY ROAD	STREAM IS LINED WITH DOGWOOD, MAKING SAMPLING VERY DIFFICULT.
UNNAMED TRIB (876600) TO WILLOW CR AT W. AVON-N. TOWNLINE RD	-
UNNAMED TRIB (876500) TO WILLOW CR AT W. SKINNER RD (EAST CROSSING)	1ST 40 M SILT (INDUCED BY CULVERT), THEN SAND.
UNNAMED TRIB (876500) TO WILLOW CR AT W. SKINNER RD (WEST CROSSING)	CHANNELIZED SYSTEM; LIKELY COOL-COLD BECAUSE OF WETLAND. LOTS OF SILT, BUT TONS OF FISH WITH GOOD DIVERSITY.
UNNAMED TRIB (877300) TO OK CR AT GIESE RD	CHANNELIZED AND DEEPLY ENTRENCHED.
UNNAMED TRIB (5042398) TO SPRING CR AT GERBER RD	GOOD AMOUNT OF FILAMENTOUS. AERIAL PHOTOS SHOW TWO POTENTIAL SOURCE FARMS UPSTREAM ALONG SHANGHAI RD.
WILLOW CREEK AT LEE RD	HABITAT POOR. PUT IN CONTEXT WITH OTHER SITES ON WILLOW TO DETERMINE IF IMPAIRED.
WILLOW CREEK - AVON NORTH TOWN LINE ROAD	-
WILLOW CREEK - UPSTREAM OF STH 81	-

Table 5: Macroinvertebrate and Fish IBI Values

Station Name	MIBI (Rating)	HBI (Rating)
Oakley Br - CTH K	4.4 (Fair)	5.0 (Good)
OK Creek - Preston Rd	4.7 (Fair)	3.7 (V. Good)
Ok Creek - Cty G	3.7 (Fair)	4.4 (V. Good)
OK Creek - Mt Hope Rd	4.5 (Fair)	4.3 (V. Good)
Unnamed Trib (877300) to OK Cr - Giese Rd	4.0 (Fair)	4.9 (Good)
Spring Creek - CTH OK	3.3 (Fair)	4.8 (Good)
Spring Creek - Town Center Rd	5.8 (Good)	5.3 (Good)
Spring Creek - Mount Hope Rd	4.6 (Fair)	4.5 (V. Good)
Unnamed Trib (5042398) to Spring Cr - Gerber Rd	4.0 (Fair)	4.7 (Good)
Swan Creek - Potter Rd - Upstrm Orfordville WWTP discharge	3.9 (Fair)	4.3 (V. Good)
Swan Creek - Dickey Road	3.7 (Fair)	5.2 (Good)
Swan Creek Keesey Road Bridge	3.3 (Fair)	4.6 (Good)
Unnamed Trib (5040595) to Swan Cr at Lang Rd	5.4 (Good)	4.0 (V. Good)
Taylor Creek - W. Gempler Rd	3.1 (Fair)	4.0 (V. Good)
Taylor Creek - Footville-Brodhead Rd	2.8 (Fair)	4.1 (V. Good)
Taylor Creek - W. Keesey Road	3. 1 (Fair)	4.7 (Good)
Taylor Creek - Smith Rd	4.3 (Fair)	5.3 (Good)
Willow Creek - Avon North Town Line Road	4.6 (Fair)	4.2 (V. Good)
Willow Creek - Lee Rd	4.8 (Fair)	4.3 (V. Good)
Willow Creek STH 81	5.7 (Good)	4.6 (Good)
Unnamed Trib (876500) to Willow Cr - W. Skinner Rd (east crossing)	5.3 (Good)	9.1 (V. Poor)
Unnamed Trib (876500) to Willow Cr - W. Skinner Rd (west crossing)	1.8 (Poor)	5.8 (Fair)
Unnamed Trib (876600) to Willow Cr - W. Avon-N. Townline Rd	4.2 (Fair)	4.0 (V. Good)

Table 6: Total Phosphorus by Station

Site (Years of data)	**Total Phosphorus (mg/l)**	
	Median	**Mean**
OK Creek - Mt. Hope Road (3)	0.160	0.172
Spring Creek - Mt. Hope Road (3)	0.075	0.079
Swan Creek - W. Keesey Road (1)	0.186	0.168
Taylor Creek - W. Keesey Road (1)	0.045	0.042
Taylor Creek - Smith Road (3)	0.089	0.096
Willow Creek - STH 81 (2)	0.068	0.072

Table 7: Summary values for physical, chemical, and biological measures from Yellow River stream sampling sites.

	Detection Limit	WI Criteria or Guidance	Sample Count	% Non-detect	% Exceed Criteria	Min.*	Max.*	Mean*	SD*	Median*
Physical Measures										
Drainage Area (mi^2)			60			0.10	212.60	29.90	54.81	4.71
Flow volume (m^3/s)			47			0.00	2.10	0.21	0.45	0.02
Stream gradient (ft/mi)			60			2.33	26.30	11.83	6.49	11.18
Water temperature (° C)			343			6.00	27.70	15.96	5.08	15.20
pH			344			5.92	9.52	7.56	0.46	7.59
Conductivity (µS/cm)			331			27.90	1665.00	235.37	179.90	198.45
Transparency (cm)			335			8.00	120.00	83.34	30.58	90.00
Dissolved O_2 conc (mg/L)		5	344		17%	0.06	16.98	7.63	2.83	7.69
QHEI			60			22.50	91.00	56.87	18.42	54.75
WI Qualitative habitat			60			5.00	87.00	51.78	18.43	53.00
Water Column Chemistry Measures										
TP (mg/L)	0.005	0.075	262	0%	90%	0.0	27.7	0.4	1.8	0.2
TKN (mg/L)	0.014		262	0%		0.2	8.6	1.3	0.8	1.1
NH3 (mg/L)	0.015	19.89	262	8%	0%	0.0	1.5	0.1	0.2	0.0
NO_3NO_2-N (mg\L)	0.019		262	16%		0.0	5.2	0.5	0.7	0.2
BOD (mg\L)	no data		262	n/a		0.05	19.90	1.72	2.32	0.97
TSS (mg/L)	2.0		262	4%		1.00	152.00	10.61	17.40	5.00
TDS (mg\L)	50		262	0%		52.00	970.00	176.76	123.59	146.00
SSC (mg\L)	2.0		262	7%		1.00	159.00	11.62	21.69	5.00
Chloride (mg\L)	1.0	757	262	0%	0%	1.40	308.00	31.48	42.77	20.95
Chlorophyll-a (µg/L)	0.26		60	5%		0.13	104.00	10.25	18.73	3.31
Biological Measures										
Hilsenhoff' s Biotic Index			59			3.67	8.45	6.42	1.22	6.76
Macroinvertebrate IBI			59			1.53	8.10	3.83	1.41	3.80
Percent EPT			59			0.00	73.00	20.07	21.37	12.00
Fish Index of Biotic Integrity			56			0.00	100.00	65.91	29.13	71.00
E. coli (colonies/100mL)			59			2.00	2400.00	542.05	557.04	280.00

Discussion

River/Stream Health

Most of the streams in this HUC 10 are modelled to be cool-cold transitional headwaters or mainstems (Lyons, 2008). The department has recently developed a draft method to determine whether or not the modeled natural community is accurate based on the fishery assemblage and climate conditions (Lyons, 2013). In most cases, the thermal composition of species (cold, warm, or transitional) indicated these streams resemble cool-warm systems rather than cool-cold systems. There is a fair amount of diversity of nongame species in most of the streams and coldwater species are absent for all intents and purposes.

Environmental degradation can sometimes explain the discrepancy between the modelled and actual community where there is a lack of intolerant species and a dominance of tolerant ones (Ibid). For most systems in this HUC 10, the percentage of tolerant fish fall with expected ranges for cool-cold transitional systems, and therefore a degraded community is not the principle reason for the discrepancy.

Actual water temperature data collected in the watershed shows summer temperatures to be within the realm of cold to cool-cold transitional systems (Lyons et. al., 2009). The discrepancy between the temperature data and the fishery community can happen for several reasons: either the year of the thermal measurement wasn't representative of the long-term average, the modeled thermal values were inaccurate, or both (Lyons, personal communication). In this case, air temperatures during the 2014 "summer" season over which the thermistors were deployed were not considered abnormal save for a one-week period at the end of July and beginning of August when temperatures were considered abnormally cool. However, it is unlikely this weather affected the fish assemblage because the species found favored transitional and warm water systems despite the cool temperatures. The fishery assemblage encountered in 2014 is similar to that found in other years dating back to 2001 (WDNR, unpublished data), and therefore can also be considered representative of the stream. The fishery is a long-term gauge of conditions in the stream and is therefore most important for bioassessment. That's not to say measured water temperatures aren't useful, but for natural community determination and IBI purposes, and in the absence of moderate to severe environmental perturbation, the fishery assemblage trumps water temperature data (Lyons, personal communication).

Compared to streams in the northwest portion of the Lower Sugar watershed and the Lower Middle Sugar watershed which were sampled in 2013 (WDNR, 2015), these streams had a greater diversity of darters, and in particular Iowa and rainbow darters. There were also a greater number of intolerant species, but the percentage of tolerant species was similar.

The great majority of the transitional species (brook stickleback, creek chubs, and white sucker) found in these streams are tolerant to low dissolved oxygen and/or disturbed habitat. These particular species tend to be more widespread throughout the state, including south central Wisconsin, as opposed to other more intermediate or low tolerance species which are not found in this area (Becker, 1983).

One interesting occurrence from this study was the discovery that Iowa darters, an intolerant warmwater species, were quite prevalent in the 2014 sampling and found at 13 of the 23 sites. When looking back at historic fisheries data back to 1875, there are scant reports of an individual or two being found in Willow Creek and OK Creek. They have historically been reported in this area of the Sugar River

(Ibid). Iowa darters do well in sandy bottomed streams. They prefer submerged fibrous roots or filamentous algae for spawning and will only occasionally spawn on gravel. Their population size tends to be dependent the territorial society in that males can fertilize and care for only a limited number of eggs. Under crowded conditions, territories are not maintained and spawning is usually not successful (Ibid). The reason for the increase in incidence of Iowa darters in the 2014 surveys is unknown. Southern Wisconsin is near the southern edge of the species range. It is likely the Sugar River always harbors small populations of them. It can be surmised that weather conditions over the past several years just happened to be favorable for increased populations and expansion of their range into the Taylor Creek system.

Gamefish and/or panfish were virtually absent despite the proximity of several of the sites to the Sugar River. One could hypothesize the cool water temperatures limit the number of these species which generally inhabit the warmer waters of the Sugar River. However, there was a number of other (nongame) warmwater species present in these systems. The size of the streams may have been a limiting factor, but it is likely the general lack of fish cover and deeper pools that these species prefer plays a greater role.

Iowa Darter Photo by John Lyons

The cool water IBIs (Lyons, 2012), when applied to the natural community indicated by the fishery assemblage, rates the fishery of most of these systems to be “good” to “excellent”, despite the prevalence of species that are tolerant to habitat disturbance and lower water quality. This prevalence of transitional tolerant species may be a factor of water temperature and/or environmental disturbance, but likely influenced by both. The fishery is only one environmental indicator and for this reason, the quality of the resources should be looked at in the context of overall conditions including habitat and macroinvertebrates.

Given the land use, hydrologic modifications, and biologists’ observations of conditions in this watershed, there are suggestions of environmental disturbance. Overall habitat scores were fair to good but were buoyed by several metrics that were favorable in this watershed. The buffer width was favorable at many sites although it must be acknowledged that some of this is coincidental with the streams being deeply entrenched with steep banks, making farming up to the stream edge impractical if not impossible. There is also very limited grazing along the banks of the streams. There are sites with a riparian wooded corridor, which acts as a buffer, but also exacerbates bank erosion. The width-to-depth ratio of these channelized systems was also generally good. Conversely, many of the stream sites contained a predominance of silt and sand on the bottom which inhibited the percent fines metric. This was very dependent on the gradient at a particular site. Fish cover was variable, but 70% of sites had only “poor” to “fair” fish cover. Because of the straightening and dredging of the stream channels to augment drainage from agricultural fields, the pool area and riffle/bend ratio were depressed. OK Creek and Spring Creek had the lowest overall scores, followed by Swan Creek and Taylor Creek. Willow Creek was good save for the site at Lee Road. The overall scores for the unnamed tributaries ranged from 35 (fair) to 50 (good).

For streams that feed into the Sugar River from the west (Spring and OK Creeks), their gradients are good on the western (headwaters) areas and tend to have more gradual slopes as they near the Sugar River. These lower gradient areas are also most likely to be channelized to promote drainage from fields. These streams tend to be wider and shallower than a natural condition. However, numerous blowdowns have created small holes, narrowing, and scouring to create some habitat for non-game fish. In spring, 2014, several severe storms hit the area and created fresh blowdowns across some of the streams. This decreased sampling efficiency at several sites and even forced biologists to truncate station length at a few of the sites. While blowdowns can create habitat for fish, they also exacerbate bank erosion, and cause further widening of the stream channel. Not surprisingly, species diversity increased at sites closer to the Sugar River.

Streams that lie to the east of Sugar River (Swan, Taylor, and Willow) have fairly low gradients. Many sections have been channelized to augment drainage of the wet meadows which they flow through. In contrast to streams on the west side of the Sugar River, these streams tend to have more channelization in the mid to upper portion of their thread, with more meandering occurring closer to the Sugar River. Sand dominates the bottom composition with a few areas of gravel, particularly toward the headwaters. Similar to other streams in the area, species diversity gradually increases as one goes from the headwaters downstream toward the Sugar River.

The macroinvertebrate data was very consistent throughout the watershed, with macroinvertebrate IBIs generally in the “fair” range. The macroinvertebrate IBI has shown the combination of watershed land cover and local riparian and instream conditions strongly influence one another (Weigel, 2003). While watershed and local variables explain a significant portion of variance among sites, Weigel found that in the driftless region, localized stressors were of greater importance to explain the IBI than in other parts of the state. The similarity amongst scores in this watershed as well as the adjacent watershed (WDNR, 2015) reflects the overall condition of the watershed in that these streams are highly modified systems flowing through an intensive agricultural landscape. The HBIs indicate there is little organic loading to these streams.

Growing season phosphorus concentrations varied amongst the streams and the sites. The department’s listing methodology for impaired waters (WDNR, 2013) recommends listing sites where the median phosphorus concentration exceeds 0.075 mg/l on wadable streams and 0.1 mg/l on rivers. The impairment listing protocol uses a 95% confidence interval about the median for listing streams and rivers. This guidance was exceeded on Swan Creek at Keesey Road and OK Creek at Mt. Hope Road. For all intents and purposes, the criteria was also exceeded at Taylor Creek at Smith Road but was not exceeded upstream at W. Keesey Road. It is likely the phosphorus concentrations on Swan Creek and Taylor Creek at Smith Road are influenced by the wastewater discharge from Orfordville. OK Creek had a median concentration which was over double the criteria and all but 1 of the 18 samples taken over 3 years exceeded 0.075 mg/l. These concentrations are similar to Swan Creek, which receives a wastewater discharge. It is unknown why the phosphorus concentrations of OK Creek are almost double that of other streams in the area. A review of land use and nutrient management plans is warranted. The median concentration did not exceed the criteria nor data exceed the 95% confidence interval on Spring Creek and Willow Creek, but each of these systems had individual samples which exceeded the criteria and bare further monitoring.

It is interesting to note that the yearly median concentration increased at most sites in successive years from 2013 to 2015 at those sites where multiple years of data were available. The exception was on

Taylor Creek at Smith Road, where it decreased in successive years (Figure 2). When compared to the long-term trend site on the Sugar River, the 3-year median also increased, indicating a more basin-wide phenomenon.

It is unknown what caused this trend. The precipitation was not considered extreme - below 10th percentile or above 90th percentile – for the sample dates over this period (WDNR, 2013). This 3-year trend may be short-term as the 10 year median growing season phosphorus concentration on the Sugar River decreased (WDNR, unpublished data).

Management Actions

Management Priorities and Goals

The ideal scenario would focus on the facilitation of the re-meandering of stream channels in the watershed. However, this may not be cost-effective or practical, especially in the contemporary agricultural economy. Therefore, DNR staff and partners must work with landowners in the watershed to encourage management of woody vegetation to prevent overgrowth along banks and control regrowth and encourage landowners to use management practices that avoid destabilization of banks (i.e. cutting and grubbing of the shoreline with no shaping, sloping or mulching). Overall, the management goals include:

- Stream stabilization
- Enhancement/restoration of aquatic habitat
- Reduction of sediment and nutrient runoff and erosion from streams in agriculturally dominated landscapes
- Encourage and facilitate partnership and educational efforts to provide sustainable improvements that provide long-term management results

Recommendations

Monitoring and Assessment Recommendations

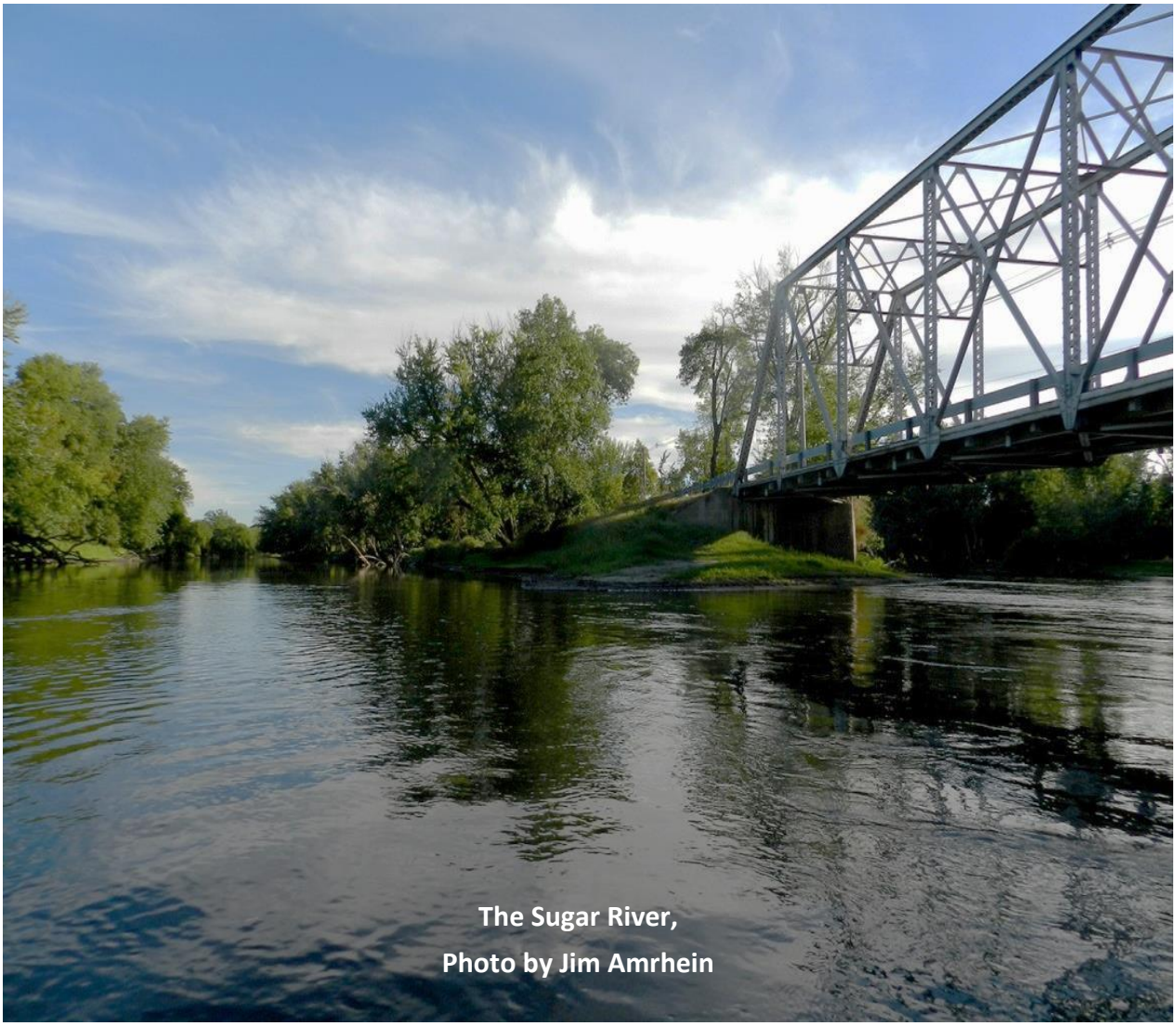
- The entire length of OK Creek should be added to the state's 303(d) list of impaired waters due to habitat degradation caused by excessive sediment deposition and channel straightening. OK Creek should also be added to the impaired waters list for total phosphorus as concentrations exceed the WisCALM (WDNR, 2018) guidance.
- The department should review land use and nutrient management efforts in this sub-watershed to determine if any improvements can be made to reduce phosphorus delivery to the stream.
- Swan Creek should be added to the 303(d) list of impaired waters for phosphorus that exceeds the criteria.
- Taylor Creek, from Swan Creek downstream to the Sugar River and Willow Creek should be added as a watch water since total phosphorus concentrations are near the criteria for listing.
- Monitoring of phosphorus and nitrate concentrations in the streams of the Lower Sugar River should continue as funding and volunteer efforts allow.

Management Recommendations for DNR

- The department should work with watershed organizations such as the Lower Sugar River Watershed Association on outreach efforts with landowners in the watershed, environmental programs in the Juda and Brodhead school districts, and research opportunities for harvestable buffers to provide economic incentives for maintaining buffers along streams.

Management Recommendations for External Parties

- The Lower Sugar River Watershed Association should apply for DNR grants to engage with local landowners and interested parties in projects that research the effectiveness of harvestable buffers in providing economic incentives for maintaining buffers along streams.
- Local partners should apply for funds to create educational programs that encourage landowners to leave some woody debris in Spring Creek as habitat for fish.



The Sugar River,
Photo by Jim Amrhein

Appendix A: References

Becker, George C. 1983. Fishes of Wisconsin. The University of Wisconsin Press. 1051 pp.

Hilsenhoff, William L. 1987. An Improved Biotic Index of Organic Stream Pollution. The Great Lakes Entomologist. 20: 31-39.

Lyons, John. 1992. Using the Index of Biotic Integrity (IBI) to Measure Environmental Quality in Warmwater Streams of Wisconsin. United States Department of Agriculture. General Technical Report NC-149.

Lyons, John. 2006. A Fish-based Index of Biotic Integrity to Assess Intermittent Headwater Streams in Wisconsin, USA. Environmental Monitoring and Assessment 122: 239-258.

Lyons, John. 2008. Using the Wisconsin Stream Model to Estimate the Potential Natural Community of Wisconsin Streams (DRAFT). Wisconsin Department of Natural Resources Fish and Aquatic Life Research Section. November 2008.

Lyons, John. T. Zorn, J. Stewart, P Seelbach, K Wehrly, and L. Wang. 2009. Defining and Characterizing Coolwater Streams and Their Fish Assemblages in Michigan and Wisconsin, USA. North American Journal of Fisheries Management. 29:1130-1151.

Lyons, John. 2012. Development and Validation of Two Fish-based Indices of Biotic Integrity for Assessing Perennial Coolwater Streams In Wisconsin, USA. Ecological Indicators 23 (2012) 402-412.

Lyons, John. 2013. Methodology for Using Field Data to Identify and Correct Wisconsin Stream "Natural Community" Misclassifications. Version 4. May 16, 2013. IN DRAFT.

Simonson, Timothy D., J. Lyons, and P.D. Kanehl. 1994. Guidelines for Evaluating Fish Habitat in Wisconsin Streams. U.S. Department of Agriculture. Forest Service. General Technical Report NC-164.

WDNR. 1980. Surface Water Resources of Green County. By D. Bush, R. Cornelius, D. Engel, C. Brynildson. Wisconsin Department of Natural Resources. Madison, WI.

WDNR. 2003. The State of the Sugar and Pecatonica River Basins. Wisconsin Department of Natural Resources.

WDNR. 2013. Wisconsin 2014 Consolidated Assessment and Listing Methodology (WisCALM). Clean Water Act Section 305(b), 314, and 303(d) Integrated Reporting. Wisconsin Department of Natural Resources. Bureau of Water Quality Program Guidance. September 2013.

WDNR. 2015. An Assessment of Water Quality in the Lower Middle and Lower Sugar River Watershed (HUC 0709000406). 2013. Project SCR_20_CMP13. February 2015. By James Amrhein, Water Quality Biologist – South District. http://prodoasint.dnr.wi.gov/wadrs/viewWatershedDetail.do?id=924722

Weigel, Brian. 2003. Development of Stream Macroinvertebrate Models That Predict Watershed and Local Stressors in Wisconsin. Journal of the North American Benthological Society. 22(1): 123-142.

Appendix B: Stream Narratives

Oakley Branch

This small, 2-mile long stream has its source near the Illinois border and flows northward and converges with Spring Creek near the unincorporated community of Oakley. It historically flowed entirely through pasture and experienced the severe bank erosion associated with heavy grazing (WDNR, 1980). Near Oakley, a 0.5-acre spring pond discharges a small flow to the stream.

Very little monitoring data exists for this stream. It harbors about a dozen non-game species, predominately creek chubs and white sucker. In the 2014 survey, 1 Iowa darter, an intolerant warmwater species was found along with 1 largemouth bass – most likely a stray from the spring pond – were also found. The stream has good gradient which scours down to the gravel and rubble cobble bottom. However, there is 6-8 inches of silt in the small pools. The moderate bank erosion is testament to its flashy nature. Much of the upper half of the stream runs through fields, while the middle portion is now more wooded. The stream is adjacent to several barnyards and feed lots which may contribute sediment and nutrients to the stream. Despite this, the fishery community represents a good, cold-cool transitional community.

OK Creek

Several springs in a small upland area form the headwaters of OK Creek. It flows 5 miles easterly until it joins the Sugar River. Like many streams in the area, the western headwaters area has higher gradient, but then gives way to lower gradient as it nears the Sugar River. Most of the lower half of OK Creek has been ditched to drain the large wetland complexes of the lower Sugar River (WDNR, 1980).

Three sites were sampled in 2014. At Preston Road, near the headwaters, only brook stickleback and fathead minnows were found. Historic sampling showed a more diverse fishery with creek chubs, stoneroller, johnny darters, and white sucker present. This site scored “poor” from a fishery IBI standpoint even though the habitat was good.

Further down at CTH G, diversity increased with creek chubs being most prevalent, followed by johnny darter, stoneroller, bluntnose minnow, and fathead minnow also common. Here the stream flows through a wooded corridor which exacerbates bank erosion, contributing to a shallow, wide stream with a silty bottom. Habitat scores were modest. Tree blowdowns from recent storms in the area made shocking difficult.

At Mount Hope Road, the stream is channelized and highly entrenched. Several tile lines drain the fields and add cold water to the stream. The monotypic habitat of this site is typical of the channelized sections of this stream. Still, species diversity was good with 15 species being represented. This may be due in part to the closer proximity with the Sugar River. Creek chubs and bluntnose minnows, both species tolerant of habitat disturbance were the most prevalent. This section is modelled to be a cold-cool mainstem, but the fishery assemblage more closely resembles a cool-warm mainstem that is excellent. Habitat was considered “fair” at this site, although the metrics of pool area, riffle/bend ratio and fine sediments were “poor”. Water samples were also collected from 2013 through 2015 and analyzed for phosphorus. The median concentration was 0.17 mg/l, which exceeds the state’s water quality criteria of 0.075 mg/l.

OK Creek should be added to the state's list of impaired waters for phosphorus as well as habitat degradation due to sedimentation and channelization. The department should review land use and nutrient management efforts (plans) in this sub-watershed to determine if any improvements can be made to reduce phosphorus delivery to the stream.

Spring Creek

Spring Creek flows 10 miles in southeastern Green County and drains into the Sugar River. Much of its length has been ditched to drain cropland. The lower ten miles of the stream are on the state's 303(d) list of impaired waters for degraded habitat due to sedimentation (WDNR, 2003).

It is modelled to be a cold-cool transitional stream, but the fishery assemblage more closely resembles that of a cool-warm system. Species diversity increases as one moves from the headwaters downstream toward the Sugar River. The variety of species found at Mt. Hope Road may be in part due to its proximity to the river. Creek chubs and white suckers are the predominant species at all sites sampled in 2014. Historic fishery surveys have shown similar species presence. The balance of the fishery is made up of a variety of species ranging from spotfin shiners to shorthead redhorse, suckermouth minnows to rock bass and northern pike and present in modest amounts. Most of these are warmwater species. Cool-warm IBI's range from 60 to 90 and are considered excellent. However, the habitat surveys showed a system that is only of moderate habitat quality, with qualitative habitat ratings of 35 to 43 or "fair". The stream suffers from severe bank erosion, lack of pools and lack of fish cover.

More specifically, the site at Town Center Road was unique in that it flowed through pastureland. It had many trampled banks, but the good gradient helped scour the bottom and create nice riffle/run complexes. Biologists noted that this portion of the stream, "reminded them a lot of the pastured streams of Lafayette and Grant counties". The other two stations sampled, at CTH OK, near the headwaters, and at Mt. Hope Road near the bottom end, were both in wooded corridors. As such, they both had raw eroding banks. Flow and temperature at the CTH OK site was influenced by springs in the area and the good gradient allowed the stream to scour to a rubble/cobble bottom in riffle areas. However, many areas also had silt over the hard substrate, likely from bank erosion. The lower site at Mt. Hope Road there was more silt, sand and clay. However, species diversity was greater, with 5 darter species being found during the survey. Biologists noted lots of blowdowns at both sites. While providing habitat for fish, these blowdowns also enhance bank erosion and increase the width- to-depth ratio.

In fall and winter of 2014/2015, a project was conducted on the stream at Mt. Hope Road that removed all the trees along the stream and sloped and stabilized the banks. Unfortunately, all the woody debris that was the only habitat in the stream was removed. However, the stream was narrowed this improved (lowered) the width/depth ratio. This type of project will also reduce the amount of bank erosion (and sediment delivery to the Sugar River) that had occurred in the past.

Phosphorus concentrations from 2013 through 2015 showed the median concentration to be 0.0749. This is just below the 0.075 mg/l criteria, however there were several samples that exceeded the criteria and therefore qualify Spring Creek as a "watch water" in the future.

Spring Creek should remain on the impaired waters list as certain aspects of the habitat measure are still poor. The stream would benefit from harvest of nuisance species like box elder along the shoreline and then bank stabilization. Landowners should be encouraged to leave some woody debris in the stream as

habitat for fish. While species diversity is good, enhanced stream management to improve the corridor could result in the lower portion of Spring Creek to be a refuge for some species like northern pike and smallmouth bass at certain times of the year. The department should monitor the stream at Mt. Hope Road to determine the effect of the recent management actions on the fishery and habitat indices.

Swan Creek

This stream originates near Orfordville and flows west, then south a total of 9 miles where it empties into Taylor Creek. The stream receives effluent from the Orfordville sewerage treatment plant through a ditch that parallels Potter Road and joins the creek just upstream of the bridge. The stream is modelled to be a coldwater system from its headwaters downstream 2.5 miles to just upstream of Dickey Road. From there, down to its confluence with Taylor Creek, it is purported to be a cold-cool headwater. Much of the stream has been channelized.

The stream is small, with limited flow upstream of Potter Road. This section contains the typical pioneer species you'd expect from a headwaters system, including creek chubs, brook stickleback, and johnny darter. Between Potter Road and Dickey Road, the stream picks up considerable flow as it meanders through spring-fed wetlands in this section. The Dickey Road site contains a higher diversity and number of fish and probably the best habitat of the system owing to the fact it is one of the few areas not channelized. While this portion is dominated by white sucker and creek chubs, central stonerollers, were also prevalent and a healthy number of the intolerant species, Iowa darter were reported. The fishery assemblage at W. Keesey Road is very similar, picking up several more species present in low numbers.

While the stream is modelled to be cold or cold-cool, and several brown trout have occasionally been reported in surveys conducted on the creek, there are no other stenothermal coldwater species present and the fishery assemblage more closely resembles a cold-cool to cool-warm system. Cool IBI's range from 60-70, or good to excellent.

Phosphorus sampling conducted at W. Keesey Road in 2014 showed an exceedance of the criteria. The median phosphorus concentration was 0.186 mg/l and all samples exceeded the 0.075 mg/l criteria. This is not unexpected given that the stream receives effluent from the Orfordville wastewater treatment plant.

Swan Creek should be added to the state's 303(d) list of impaired waters for phosphorus concentrations that exceed the listing criteria.

Taylor Creek

Taylor Creek is a 13-mile stream that drains southward in western Rock County and empties into the Sugar River. The lower ¾ mile flows through the Avon Bottoms Wildlife Area. At its headwaters, the upper mile of Taylor Creek is modelled to be a warm headwater. It then transitions into a cold-cool headwater until its confluence with Swan Creek where it becomes a cold-cool mainstem. It remains that way until it is joined by Willow Creek where it then is modelled to be a cool-warm mainstem. The fishery community has been monitored at the various road crossings over the past 10 years. The fishery community suggests the stream more closely resembles a cool-warm system for most of its length. Several species of gamefish are typically found in the lower 1/3 of the stream, likely owing to the proximity with the Sugar River. Four sites were surveyed in 2014.

As expected, the uppermost site at W. Gempler Road contained typical pioneer species such as brook stickleback creek chubs, and johnny darter. Species diversity increases as one moves downstream. The site at W. Keesey Road was difficult to sample because of shrub overgrowth. At W. Smith Road, 22 species were found, including a couple of gamefish species and 4 intolerant species, but tolerant species made up 74% of the assemblage.

In a survey conducted in 2007, biologists noted that the bridge at STH 11 seemed to be backing up water, and as a result, silt upstream of the bridge. The species diversity "is skewed towards the tolerant species". Indeed, the sites sampled upstream and downstream of STH 11 (W. Keesey Road and W. Smith Road) likewise contained a great majority of tolerant species, particularly bluntnose minnow, creek chub, and white sucker.

The bottom substrate of Taylor Creek has some gravel, but sand becomes more predominant as one moves downstream. The lower ½ of the stream is buffered to some extent by the wet shrub meadows that it meanders through. Fish cover is generally limited to overhanging vegetation along the banks. Overall habitat scores are around 50, or good.

Phosphorus was sampled at 2 locations: W. Keesey Road in 2014 and at W. Smith Road in 2013 through 2015. The median phosphorus concentration at W. Keesey Road was 0.04 mg/l and ranged from 0.01 to 0.07 mg/l. At W. Smith Road, the median phosphorus concentration was 0.09 mg/l. Thirteen of the eighteen samples collected from 2013 to 2015 exceeded the 0.075 mg/l criteria. The input from Swan Creek likely has some effect on the concentrations seen at W. Smith Road.

Taylor Creek should be added to the list of watch waters from Swan Creek downstream to the confluence with the Sugar River for phosphorus concentrations that may exceed the listing criteria.

Willow Creek

Willow Creek is a seepage fed stream originating south of Orfordville and flowing generally southwest to enter Taylor Creek. The upper three-fourths of the stream has been ditched. The stream is generally home to a variety of non-game species although a few game species (northern pike, large and smallmouth bass and rock bass) may occur in the lower portions near Taylor Creek. The lower portion of Willow Creek – downstream of Lee Road - adjoins fresh meadow and shallow marsh wetland.

Species diversity is as good as any stream in the watershed, with 20+ species found in the creek. In the 2014 surveys, good numbers of Iowa darter, an intolerant warm water species, were found. Previous investigations yielded only 1 or 2 individuals whereas the contemporary surveys showed a couple dozen specimens.

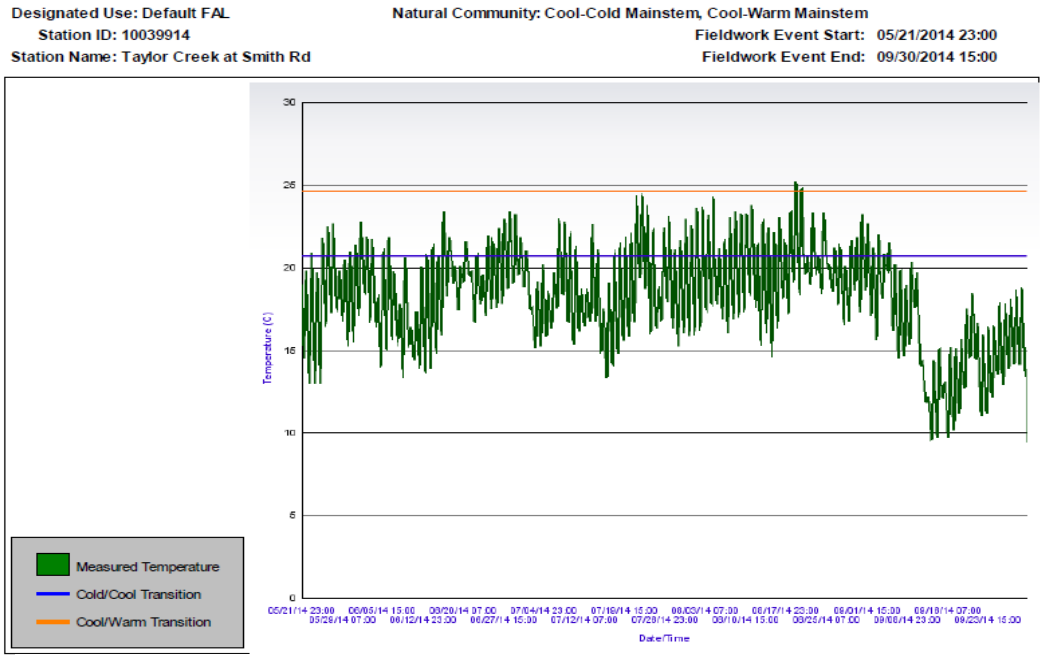
Habitat scores ranged from 25 (fair) at Lee Road to 63 (good) at STH 81. The overall score was buoyed by the wetland corridor which provides a good de facto buffer as well as low bank erosion. The site at Lee Road was different than the other two sites in that it flowed through a wooded corridor which enhanced bank erosion, was wide and shallow, and had little fish cover, save for woody debris. Despite this, there were a variety for species present in good numbers, and the cool-warm IBI for the stream was 90, or excellent.

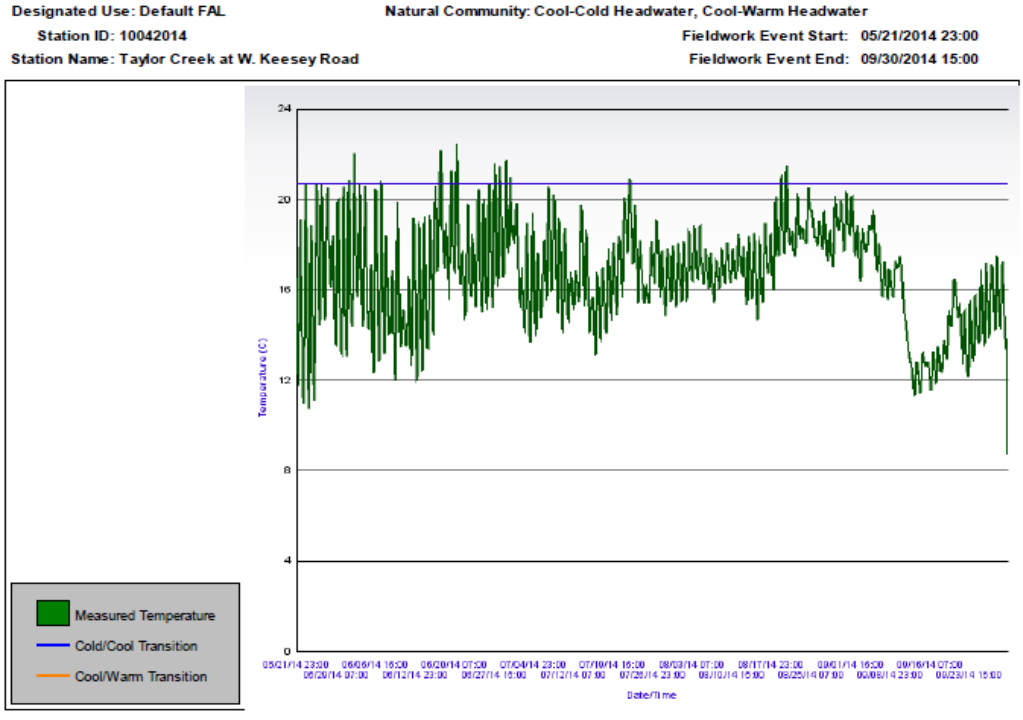
Phosphorus sampling was conducted 6 times during the growing season in 2014 and 2015 by volunteers at STH 81. While the median concentration was 0.068 mg/l – below the 0.075 mg/l phosphorus criteria,

nearly half the samples exceed the criteria; therefore, Willow Creek should be added to the list of watch waters.

The macroinvertebrate assemblage in Willow Creek was typical for the watershed with IBIs ranging from 4.6 (fair) to 5.7 (good). An unnamed tributary (WBIC = 876500) to Willow Creek had a good and poor IBI and very poor and fair HBI. At the lower crossing, overhanging vegetation was the only available cover sampled and was dominated by hemipteran species (water striders, giant water bugs, water boatman, and water scorpions) which depressed the IBI. Conversely, the upper portion was dominated by chironomids, which depressed the HBI. This tributary is a low gradient, channelized system that runs through a large wetland complex. The macroinvertebrate community appears to reflect these aspects.

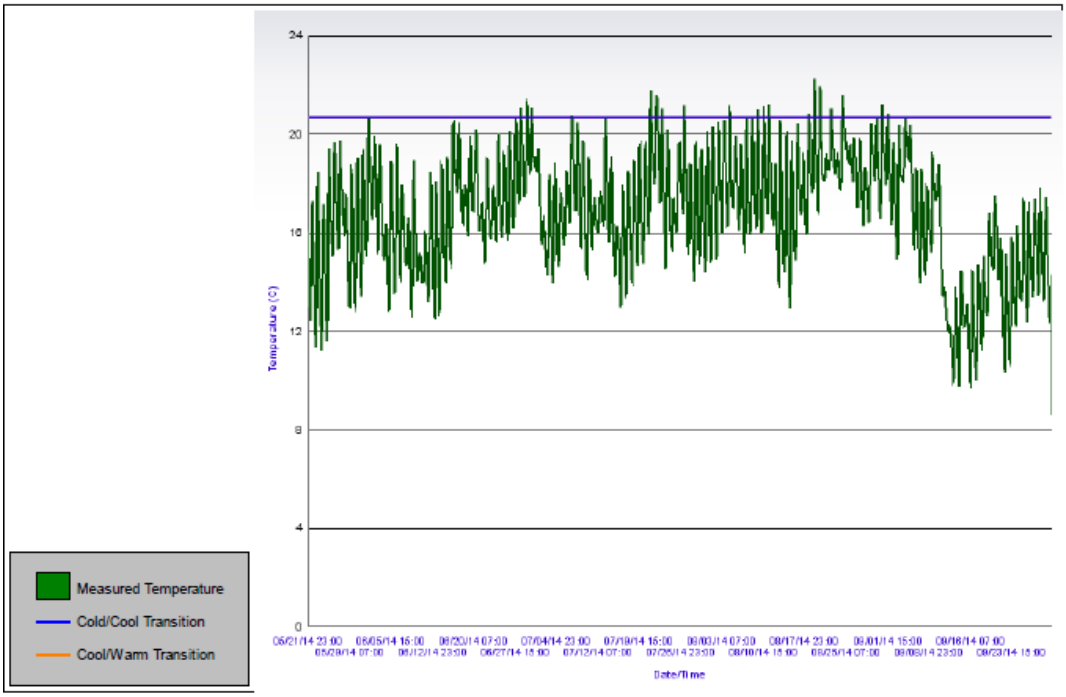
Appendix C: Temperature Graphs





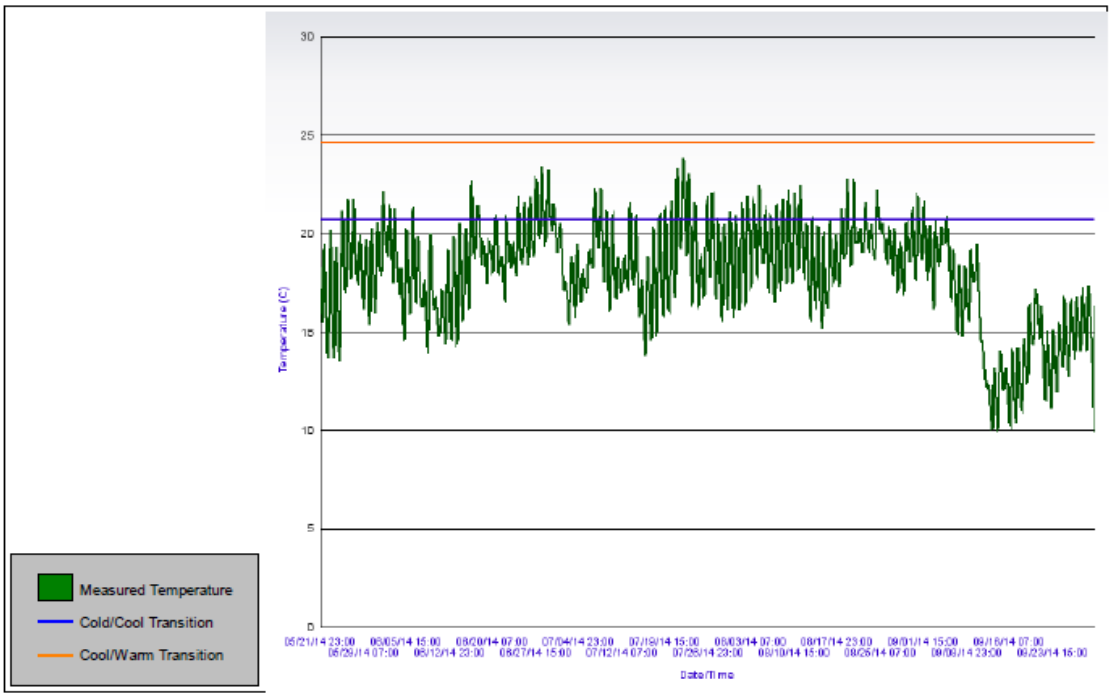
SWIMS: Temperature for a Selected Fieldwork Event

Designated Use: Default FAL
Natural Community: Coldwater, Cool-Cold Headwater, Cool-Warm Headwater
Station ID: 10013324
Fieldwork Event Start: 05/21/2014 23:00
Station Name: Swan Creek Keesey Road Bridge
Fieldwork Event End: 09/30/2014 15:00



SWIMS: Temperature for a Selected Fieldwork Event

Designated Use: Default FAL
Natural Community: Cool-Warm Mainstem
Station ID: 10012063
Fieldwork Event Start: 05/21/2014 23:00
Station Name: Willow Creek - Upstream Of Sth 81
Fieldwork Event End: 09/30/2014 16:00



SWIMS: Temperature for a Selected Fieldwork Event

Appendix D: Monitored Waters

WBIC	Waterbody Name	Station Id	Station Name	Earliest Fieldwork Date	Latest Fieldwork Date
875300	Sugar River	233001	Sugar River at Ten Eyck Rd Near Brodhead WI	07/26/1988	09/22/2016
877400	Sylvester Creek	10038073	Sylvester Creek at CTH OK	08/20/2012	09/17/2016
877400	Sylvester Creek	10010908	Sylvester Creek - Sylvester Creek at Ten Eyck Rd	11/07/2006	09/17/2016
877500	Juda Br	10014241	Juda Branch-US of CTH OK	10/28/1987	09/17/2016
877500	Juda Br	10044726	Juda Branch at Hwy KS	08/12/2012	09/09/2016
877600	Riley School Br	10020957	Riley School Br at Bagley Rd	08/12/2012	09/09/2016
877700	North Fork Juda Br	10007870	Juda Branch N Fork at CTH S	04/10/1989	09/09/2016
877700	North Fork Juda Br	10037204	North Fork Juda Branch in Juda Park 20m US of discharge	05/10/2012	09/09/2016
875300	Sugar River	10010767	Sugar River at Nelson Rd Boat Launch	05/25/2010	09/06/2016
874000	Raccoon Creek	10031035	Beckman Mill Pond (Raccoon Creek) County Park Canoe Launch	05/25/2010	08/01/2016
877000	Spring Creek	10037514	Spring Creek at Union Road	06/12/2012	07/10/2016
877000	Spring Creek	10044735	Spring Creek at Mill Road	05/10/2016	07/10/2016
877000	Spring Creek	10014328	Spring Creek -Us Cth G 226 M to End Gps	05/10/2016	07/10/2016
877000	Spring Creek	10037929	Spring Creek at Mount Hope Rd	09/10/2010	07/10/2016
879400	Decatur Lake	10002694	Decatur Lake - Sugar River	07/19/2005	07/08/2016
877700	North Fork Juda Br	10037206	North Fork Juda Branch at Balls Mills Rd	05/10/2012	07/07/2016
874100	East Fork Raccoon Creek	10009956	East Fork Raccoon Creek at Beloit Newark Rd	10/23/1987	06/29/2016
874000	Raccoon Creek	10013075	Raccoon Creek - Hwy 81 Bridge	10/28/1987	06/29/2016
877200	Ok Creek	10039915	OK Creek at Mt Hope Rd	05/21/2013	10/31/2015
876300	Taylor Creek	10039914	Taylor Creek at Smith Rd	05/21/2013	10/31/2015
876400	Willow Creek	10013320	Willow Creek Hwy 81 Bridge	05/10/2014	10/19/2015
878400	Sugar River - East Channel	10039969	Sugar River at Mill Race	05/18/2013	10/17/2015
874000	Raccoon Creek	10016373	Raccoon Creek - St Lawrence Rd	05/23/1994	09/28/2015
877100	Oakley Br	10042243	Oakley Br at CTH K	06/09/2014	07/21/2015
876700	Swan Creek	10013324	Swan Creek Keesey Road Bridge	05/10/2014	10/11/2014
876300	Taylor Creek	10042014	Taylor Creek at W. Keesey Road	05/10/2014	10/11/2014

WBIC	Waterbody Name	Station Id	Station Name	Earliest Fieldwork Date	Latest Fieldwork Date
877200	Ok Creek	10042232	OK Creek at Preston Rd	06/05/2014	10/09/2014
877000	Spring Creek	10042419	Spring Creek at CTH OK	10/09/2014	10/09/2014
5042398	Unnamed	10042233	Unnamed Trib (5042398) to Spring Cr at Gerber Rd	06/05/2014	10/09/2014
877000	Spring Creek	10042453	Spring Creek at Town Center Rd	07/18/2014	10/09/2014
877300	Unnamed	10042234	Unnamed Trib (877300) to OK Cr at Giese Rd	06/05/2014	10/09/2014
877200	Ok Creek	10009520	Ok Creek Upstream of Cty G	11/15/2002	10/09/2014
876400	Willow Creek	10013322	Willow Creek - Avon North Town Line Road	06/04/2014	10/01/2014
876700	Swan Creek	543079	Swan Creek - Above Orfordville Stp	04/15/1975	10/01/2014
876300	Taylor Creek	10042220	Taylor Creek at W. Gempler Rd	05/23/2014	10/01/2014
876600	Unnamed	10042236	Unnamed Trib (876600) to Willow Cr at W. Avon-N. Townline Rd	06/04/2014	10/01/2014
876500	Unnamed	10042508	Unnamed Trib (876500) to Willow Cr at W. Skinner Rd (west crossing)	07/30/2014	10/01/2014
876500	Unnamed	10042235	Unnamed Trib (876500) to Willow Cr at W. Skinner Rd (east crossing)	06/04/2014	10/01/2014
5040595	Unnamed	10042775	Unnamed Trib (5040595) to Swan Cr at Lang Rd	10/01/2014	10/01/2014
876400	Willow Creek	10042454	Willow Creek at Lee Rd	07/21/2014	10/01/2014
876300	Taylor Creek	10014327	Taylor Creek-Ds 141m of Footville-Brodhead Rd	05/22/2014	10/01/2014
876700	Swan Creek	10016727	Swan Creek - Immediately Downstream from Dickey Road	10/21/2002	09/30/2014
876400	Willow Creek	10012063	Willow Creek - Upstream of STH 81	10/29/2004	07/18/2014
877700	North Fork Juda Br	10040530	Juda Branch at N Fork in Juda Park 10 m DS	04/20/2008	10/15/2013
877400	Sylvester Creek	10040782	Sylvester Creek at STH 59	10/09/2013	10/09/2013
877400	Sylvester Creek	10014325	Sylvester Creek-Upstream Cth S 161 M To End	10/14/2004	10/09/2013
877400	Sylvester Creek	10014324	Sylvester Creek -Upstream Balls Mill Rd 191 M To End	03/09/2006	10/09/2013
877400	Sylvester Creek	10040850	Sylvester Creek at Greenbush Road	10/09/2013	10/09/2013
876000	Unnamed	10040739	Unnamed Trib (876000) Sugar R. at Hopkins Rd	07/11/2013	10/08/2013
877500	Juda Br	10014240	Juda Br Upstream Bagley Rd	10/08/2013	10/08/2013
877700	North Fork Juda Br	10040731	North Fork Juda Br at STH 11 (furthest DS crossing)	10/08/2013	10/08/2013

WBIC	Waterbody Name	Station Id	Station Name	Earliest Fieldwork Date	Latest Fieldwork Date
876300	Taylor Creek	10021931	Taylor Creek at Avon North Townline Rd.	05/24/2007	10/08/2013
877600	Riley School Br	10040073	Riley School Br at Giese Rd	10/08/2013	10/08/2013
875300	Sugar River	10018566	Sugar River – Access	09/30/2013	09/30/2013
875300	Sugar River	10042642	Sugar River at CTH F	09/30/2013	09/30/2013
874100	East Fork Raccoon Creek	10009953	East Fork Raccoon Creek - N. of Hwy 81	05/30/2012	05/30/2012
874000	Raccoon Creek	10012055	Raccoon Creek at Beloit Newark Rd	10/29/2004	10/14/2011
874100	East Fork Raccoon Creek	10009952	E. Fork Raccoon Creek at Lawrence St.	10/28/1987	10/14/2011
874000	Raccoon Creek	10013074	Raccoon Creek - Upstream of CTH 'H' Bridge	10/28/1987	09/29/2011
877400	Sylvester Creek	233046	Juda Branch - Drain Ditch Health Val a Juda Br	08/31/2011	08/31/2011
874100	East Fork Raccoon Creek	10009957	East Fork Raccoon Creek - East Raccoon West Cleophas Road	01/01/1994	07/25/2011
5580135	Unnamed	10041378	Unnamed Open Water	07/04/2011	07/04/2011
876400	Willow Creek	10013323	Willow Creek US of Avon Store Rd	05/24/2007	09/24/2009
875900	Unnamed	10021223	Unnamed to Sugar River at Nelson Rd	08/02/2007	11/01/2007
876300	Taylor Creek	10021080	Taylor Creek at STH 11	07/01/2007	11/01/2007
875300	Sugar River	543282	Sugar River at Nelson Road	07/14/2005	09/21/2006
877400	Sylvester Creek	10012119	Sylvester Creek - Upstream of Prien Rd	03/09/2006	03/09/2006
876300	Taylor Creek	10012061	Taylor Creek - Upstream of STH 81	10/29/2004	10/29/2004

Appendix E: Watershed Table[1]

WBIC	Waterbody Name	Start Mile	End Mile	Current Use	Attainable Use	Supporting Attainable Use	Designated Use	Impairments	Assessment	Impaired Water Status
879400	Decatur Lake	0	109.24	Impounded Flowing Water	FAL	Not Supporting	Default FAL	Impairment Unknown	Monitored	303d Listed
874100	E. Fork Raccoon Creek	1.25	6.64	Class III Trout	FAL	Fully Supporting	Default FAL	NA	Monitored	NA
874100	E. Fork Raccoon Creek	6.64	10.5	FAL	Cold	Fully Supporting	Default FAL	NA	Monitored	NA
875500	Green Drainage System	0	8.5	FAL	WWSF	Fully Supporting	Default FAL	NA	No Assessment on File	NA
877500	Juda Branch	0	4.43	FAL	WWSF	Not Supporting	Default FAL	Degraded Habitat, Unknown	Monitored	303d Listed
877500	Juda Branch	4.43	8.22	FAL	FAL	Not Assessed	Default FAL	NA	Not Assessed	NA
877700	N. Fork Juda Branch	0	1.68	FAL	FAL	Not Supporting	LFF	Low DO, Degraded Biological Community	Monitored	303d Listed
877700	N. Fork Juda Branch	1.68	3.8	FAL	FAL	Not Supporting	LFF	Low DO, Degraded Biological Community	Monitored	303d Listed
877100	Oakley Branch	0	2	WWFF	WWFF	Supporting	Default FAL	NA	No Assessment on File	NA
877200	Ok Creek	0	6.82	WWFF	WWFF	Not Supporting	Default FAL	Degraded Biological Community, Degraded Habitat	Monitored	303d Listed
874000	Raccoon Creek	0	13.01	FAL	WWFF	Fully Supporting	Default FAL	NA	Monitored	NA
877600	Riley School Branch	0	4	FAL	FAL	Not Supporting	Default FAL	Degraded Biological Community, Degraded Habitat	Monitored	303d Listed

WBIC	Waterbody Name	Start Mile	End Mile	Current Use	Attainable Use	Supporting Attainable Use	Designated Use	Impairments	Assessment	Impaired Water Status
877000	Spring Creek	0	10.31	WWFF	WWSF	Not Supporting	WWSF	Degraded Habitat	Monitored	TMDL Approved
875300	Sugar River	0	10.99	FAL	FAL	Not Supporting	Default FAL	Impairment Unknown	Monitored	303d Listed
875300	Sugar River	10.99	56.14	FAL	FAL	Not Supporting	Default FAL	Impairment Unknown	Monitored	303d Listed
878400	Sugar River East Channel	0	3.19	FAL	FAL	Not Supporting	Default FAL	Impairment Unknown	Monitored	303d Listed
873000	Sugar River - Oxbow	0	4.86	Small	FAL	Not Assessed	Default FAL	NA	No Assessment	NA
876700	Swan Creek	0	5	FAL	WWSF	Not Supporting	Default FAL	Impairment Unknown	Monitored	303d Listed
876700	Swan Creek	5	7	FAL	FAL	Not Assessed	LFF	NA	No Assessment	NA
877400	Sylvester Creek	0	8.54	FAL	FAL	Fully Supporting	Default FAL	NA	Monitored	NA
877400	Sylvester Creek	8.54	14.68	Class III Trout	FAL	Fully Supporting	Default FAL	NA	Monitored	NA
876300	Taylor Creek	0	6.06	FAL	WWSF	Not Supporting	Default FAL	Impairment Unknown	Monitored	303d Listed
876300	Taylor Creek	6.06	13	FAL	FAL	Fully Supporting	Default FAL	NA	Monitored	NA
876400	Willow Creek	0	3	FAL	WWSF	Fully Supporting	Default FAL	NA	Monitored	NA
876400	Willow Creek	3	10	FAL	FAL	Not Assessed	Default FAL	NA	No Assessment	NA

The watershed assessment table reflects the condition of waters in the study area watershed. This table data is stored in the Water Assessment Tracking and Electronic Reporting System (WATERS) and is updated on an ongoing basis via monitoring data and assessment calculations. The following definitions apply:

- Current Use – current condition of water based on monitoring data.
- Attainable Use – "ecological potential" of water based on water type, natural community, lack of human-induced disturbances.
- Supporting Attainable Use – decision on whether the water's current condition is supporting its designated use under "water quality standards".
- Designated Use – the water's classified use under NR102, Wisconsin Water Quality Standards, for Fish and Aquatic Life.
- Impairments – documented impacts on water condition due to pollution sources or changes in hydro-geomorphological changes.
- Assessment – field indicates what type of data or information supports the decisions in the table (current, attainable, and supporting attainable).
- Impaired Water Status – This column indicates the status of the impaired water for TMDL development.