Michigan Department of Environmental Quality
Surface Water Quality Division
August 2002

Total Maximum Daily Load for *Escherichia coli* for Deer Creek, Berrien County, Michigan

INTRODUCTION

Section 303(d) of the federal Clean Water Act and the United States Environmental Protection Agency's (USEPA's) Water Quality Planning and Management Regulations (Title 40 of the Code of Federal Regulations (CFR), Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for waterbodies that are not meeting Water Quality Standards (WQS). The TMDL process establishes the allowable loadings of pollutants for a waterbody based on the relationship between pollution sources and in-stream water quality conditions. TMDLs provide states a basis for determining the pollutant reductions necessary from both point and nonpoint sources to restore and maintain the quality of their water resources. The purpose of this TMDL is to identify the allowable levels of *Escherichia coli* (*E. coli*) that will result in the attainment of the applicable WQS in Deer Creek, a small waterbody with relatively low flows (Table 1) in the Galien River Watershed, located in Berrien County.

PROBLEM STATEMENT

Deer Creek was first placed on the Section 303(d) list in 1998. This TMDL addresses approximately seven miles of stream. The TMDL reach is on the 2002 Section 303(d) list (Creal and Wuycheck, 2002) as:

Waterbody: **Deer Creek** WBID#: **083301D**
County: Berrien HUC: 4040001 Size: 7 M
Location: S. Br. Galien River confluence u/s to the headwaters in vicinity of Three Oaks
Problem: **Untreated sewage discharge, pathogens (Rule 100); Macroinvertebrate community rated poor; nuisance algae**
TMDL YEAR(s): 2002 2004 RF3RchID: 4040001 440 0.00

This TMDL addresses pathogens. Deer Creek is also on the Section 303 (d) list for poor macroinvertebrate communities and nuisance algae. These TMDLS are scheduled in 2004.

Deer Creek (Figure 1) was placed on the Section 303(d) list for *E. coli* due to impairment of recreational uses as indicated by the presence of elevated levels of *E. coli.* Recent monitoring data (Appendix 1) collected by the Michigan Department of Environmental Quality (MDEQ) in 2001 documents continued exceedances of the WQS for *E. coli* at all Deer Creek stations sampled (Table 2), with exception of the September sampling at Lakeside Road. Monthly geometric mean *E. coli* concentrations in Deer Creek for 2001 ranged from 74 *E. coli* per 100 milliliter (ml) in September at Lakeside Road to 1,273 *E. coli* per 100 ml in June at Basswood Rd. (Table 2).

Other waterbodies sampled for this TMDL include Chestnut Drain and the South Branch of the Galien River. Chestnut Drain, a small tributary to the headwaters of Deer Creek, originates in the village of Three Oaks and exhibited the highest *E. coli* concentrations observed in the 2001 sampling (Table 2 and Figure 2). Concentrations ranged from 1,266 *E. coli* per 100 ml in June to 5,794 *E. coli* per 100 ml in May and the drain and appears to be a substantial dry weather source of *E. coli* to Deer Creek. The South Branch of the Galien River was sampled upstream (Forest Lawn Road) and downstream (Lakeside Road) of the confluence with Deer Creek.

Slightly elevated levels of *E. coli* were found at both stations. Monthly geometric means at Forest Lawn Road (upstream) ranged from 334 *E. coli* per 100 ml in September to 698 *E. coli* per 100 ml in July. Monthly geometric means for *E. coli* at Lakeside Road (downstream) ranged from 266 *E. coli* per 100 ml in June to 730 *E. coli* per 100 ml in July.

NUMERIC TARGET

The impaired designated use for Deer Creek addressed by this TMDL is total body contact recreation. Rule 100 of the Michigan WQS requires that this waterbody be protected for total body contact recreation from May 1 to October 31. The target levels for this designated use are the ambient *E. coli* standards established in Rule 62 of the WQS as follows:

> R 323.1062 Microorganisms.
> Rule 62. (1) All waters of the state protected for total body contact recreation shall not contain more than 130 *Escherichia coli (E. coli)* per 100 milliliters, as a 30-day geometric mean. Compliance shall be based on the geometric mean of all individual samples taken during 5 or more sampling events representatively spread over a 30-day period. Each sampling event shall consist of 3 or more samples taken at representative locations within a defined sampling area. At no time shall the waters of the state protected for total body contact recreation contain more than a maximum of 300 *E. coli* per 100 milliliters. Compliance shall be based on the geometric mean of 3 or more samples taken during the same sampling event at representative locations within a defined sampling area.

In addition, permitted sanitary wastewater discharges have an additional target:

> Rule 62. (3) Discharges containing treated or untreated human sewage shall not contain more than 200 fecal coliform bacteria per 100 milliliters, based on the geometric mean of all of 5 or more samples taken over a 30-day period, nor more than 400 fecal coliform bacteria per 100 milliliters, based on the on the geometric mean of all of 3 or more samples taken during any period of discharge not to exceed 7 days. Other indicators of adequate disinfection may be utilized where approved by the department.

Sanitary wastewater discharges are considered in compliance with the WQS of 130 *E. coli* per 100 ml if their National Pollutant Discharge Elimination System (NPDES) permit limit of 200 fecal coliforms per 100 ml as a monthly average is met. This is assumed because *E. coli* are a subset of fecal coliform (American Public Health Association, 1995). When the wastewater of concern is sewage, fecal coliform is substantially higher than *E. coli* (Whitman, 2001). When the point source dischargers are meeting their limit of 200 fecal coliform per 100 ml, it can reasonably be assumed that there are less than 130 *E. coli* per 100 ml in the effluent.

For this TMDL, the WQS of 130 per 100 ml as a 30-day geometric mean is the target level for the TMDL reach from May 1 to October 31. As previously stated, 2001 monitoring data indicated consistent exceedances of WQS in the TMDL reach with particularly high levels of *E. coli* in Chestnut Drain in the village of Three Oaks.

SOURCE ASSESSMENT

Deer Creek is located entirely in Three Oaks Township in Berrien County. The TMDL reach is from the confluence of Deer Creek with the South Branch of the Galien River upstream to the headwaters in the vicinity of the village of Three Oaks (Figure 1). There are two permitted point

source discharges to Deer Creek, the Three Oaks Waste Water Sewage Lagoon (WWSL) (MIG580294) and Vickers Engineering (MIS410232). Municipalities include Three Oaks Township and the village of Three Oaks (Figure 3).

Potential pathogen sources for this waterbody appear to be due in part to storm water from the village of Three Oaks, illicit connections, sewage overflows, and agricultural inputs. The 2001 monitoring data was collected during typical stream flow conditions and indicates both continuous and storm water-related inputs.

As stated above, there are two permitted point source discharges to Deer Creek, Vickers Engineering and the Three Oaks WWSL. Vickers Engineering has a permitted storm water discharge to Deer Creek. In addition to storm water, this facility has a septic tank drain field used for treatment of their sanitary and industry discharge. By the aid of an economic development grant, the facility's sanitary and industrial waste will be discharged to the village of Three Oaks sanitary sewer system (MDEQ district correspondence, 2002), eliminating any potential inputs to Deer Creek from their septic tank.

The Three Oaks WWSL is permitted to discharge during the months of March through May and October through December. The discharge period overlaps the recreational season in May and October only. The facility has a fecal coliform limit of 200 per 100 ml as a monthly average and will be considered in compliance with the WQS of 130 *E. coli* per 100 ml if their NPDES permit limit of 200 fecal coliform per 100 ml as a monthly average is met. As previously discussed, this is assumed because *E. coli* are a subset of fecal coliform (American Public Health Association, 1995). When the wastewater of concern is sewage, fecal coliform is substantially higher than *E. coli* (Whitman, 2001). When the point source is meeting their limit of 200 fecal coliform of 100 ml, it can reasonably be assumed that there are less than 130 *E. coli* per 100 ml in the effluent. However, records maintained by the MDEQ document an overflow from the Three Oaks WWSL and an out of season discharge in 1997 and 2000, resulting in bacterial slime growth in Deer Creek. The village of Three Oaks is currently under an Administrative Consent Order (ACO) (SW99-007) to separate their sanitary sewer lines from their storm sewers. The project is expected to be completed by March 1, 2003. In addition, monitoring data collected in 2001 indicate Chestnut Drain, originating in Three Oaks, is a substantial source of *E. coli* even in dry weather (Appendix 1).

LINKAGE ANALYSIS

The link between the *E. coli* concentration in Deer Creek and the potential sources is the basis for the development of the TMDL. The linkage is defined as the cause and effect relationship between the selected indicators and the sources. This provides the basis for estimating the total assimilative capacity of the creek and any needed load reductions. For this TMDL, the primary loading of pathogens likely enters Deer Creek by both continuous and, to some degree, storm water related nonpoint sources.

The guiding water quality management principle used to develop the TMDL was that compliance with the numeric pathogen target in Deer Creek depends on the control of point source *E. coli,* the control of *E. coli* in illicit connections, and storm water. If the *E. coli* inputs can be controlled, then total body contact recreation in Deer Creek will be protected.

TMDL DEVELOPMENT

The TMDL represents the maximum loading that can be assimilated by the waterbody while still achieving WQS. As indicated in the Numeric Target section, the target for this pathogen TMDL is the WQS of 130 *E. coli* per 100 ml. Concurrent with the selection of a numeric concentration endpoint, TMDL development also defines the environmental conditions that will be used when defining allowable levels. Many TMDLs are designed around the concept of a "critical

condition." The "critical condition" is defined as the set of environmental conditions that, if controls are designed to protect, will ensure attainment of objectives for all other conditions. For example, the critical conditions for the control of point sources in Michigan are given in R 323.1082 and R 323.1090. In general, the lowest monthly 95% exceedance flow for streams is used as a design condition for point source discharges. However, for pathogens in point source discharges of treated or untreated human sewage, levels are restricted to a monthly average limit of 200 per 100 ml for fecal coliform regardless of stream flow. Therefore, the design stream flow is not a critical condition for determining the allowable loading of pathogens for wastewater treatment plants. In addition, other *E. coli* sources to Deer Creek arise from a mixture of wet and dry weather-driven nonpoint sources, and there is no single critical condition that is protective for all other conditions. For these sources, there are a number of different allowable loads that will ensure compliance, as long as they are distributed properly throughout the watershed.

For most pollutants, TMDLs are expressed on a mass loading basis (e.g., pounds per day). For *E. coli*, however, mass is not an appropriate measure, and the USEPA allows pathogen TMDLs to be expressed in terms of organism counts (or resulting concentration) (USEPA, 2001). Therefore, this pathogen TMDL is concentration-based consistent with R 323.1062, and the TMDL at the confluence with the South Branch of the Galien River is equal to the target concentration of 130 *E. coli* per 100 ml for each month of the recreational season (May through October).

For this TMDL, an allocation strategy for nonpoint sources has been selected that assumes equal bacteria loads per unit area for all lands within the watershed. The point sources are handled consistent with Rule 62(3).

ALLOCATIONS

TMDLs are comprised of the sum of individual waste load allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources and natural background levels. In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly, that accounts for uncertainty in the relation between pollutant loads and the quality of the receiving water body. Conceptually, this definition is denoted by the equation:

$$TMDL = \sum WLAs + \sum LAs + MOS$$

The term TMDL represents the maximum loading that can be assimilated by the receiving water while still achieving WQS. The overall loading capacity is subsequently allocated into the TMDL components of WLAs for point sources, LAs for nonpoint sources, and the MOS. As previously indicated, this pathogen TMDL will not be expressed on a mass loading basis and is concentration-based consistent with USEPA regulations in 40 CFR, Section 130.2(i).

WLAs

The village of Three Oaks WWSL (MIG580294) is the only permitted point source discharge that contains treated or untreated human sewage to the listed reach of Deer Creek. This facility has a seasonal discharge during the months of March through May and October through December and has a limit of 200 fecal coliform per 100 ml as a monthly average. As previously stated, when the WWSL is meeting their fecal coliform limit, it is assumed the WQS will be met in the discharge. Therefore, the WLA will be equal to 130 *E. coli* per 100 ml for the months of May and October.

LAs

Because this TMDL is concentration-based, the LA is equal to 130 *E. coli* per 100 ml. The assumption used in the allocation strategy is that there are equal bacteria loads per unit area for all lands within the watershed. Therefore, the relative responsibility for achieving the necessary reductions of bacteria and maintaining acceptable conditions will be determined by the amount of land under the jurisdiction of the various units of local government within the watershed. Table 3 gives the relative land in the watershed for each of the local units of governments. This gives a clear indication of the relative amount of effort that will be required by each entity to restore and maintain the total body contact designated uses to Deer Creek. However, as noted previously, Chestnut Drain located in the village of Three Oaks appears to be a significant source of *E. coli* to Deer Creek. It is anticipated that this problem will be addressed under the current Administrative Consent Order (ACO) and on-going construction of a new sanitary sewer system within the village limits of Three Oaks.

The government entities with land area in the Deer Creek Watershed are Three Oaks Township (87%), followed by the village of Three Oaks (13%) (Table 3).

MOS

This section addresses the incorporation of an MOS in the TMDL analysis. The MOS accounts for any uncertainty or lack of knowledge concerning the relationship between pollutant loading and water quality. The MOS can be either implicit (i.e., incorporated into the TMDL analysis through conservative assumptions) or explicit (i.e., expressed in the TMDL as a portion of the loadings). This TMDL uses an implicit MOS because no rate of decay was used.

SEASONALITY

Seasonality in the TMDL is addressed by expressing the TMDL in terms of a total body contact recreation season that is defined as May 1 through October 31 by R 323.1100 of the WQS. There is no total body contact during the remainder of the year primarily due to cold weather. In addition, because this is a concentration-based TMDL, WQS will be met regardless of flow conditions in the applicable season.

MONITORING

In 2001, pathogens were monitored at seven stations from May through September (Figure 1). Subsequent weekly sampling began at all stations on May 15, 2002 and will continue through September, 2002. If sampling in early in 2002 continues to show that WQS are exceeded, sampling will be oriented towards source identification. If these results indicate that the waterbody may be meeting WQS, sampling will be conducted at the appropriate frequency to determine if the 30-day geometric mean value of 130 *E. coli* per 100 ml is being met.

Future monitoring will be conducted at appropriate stations after March 1, 2003. All hook-ups to the sanitary sewer are required by the ACO to be completed by this date. When results indicate that the waterbody may be meeting WQS, sampling will be conducted at the appropriate frequency to determine if the 30-day geometric mean value of 130 *E. coli* per 100 ml is being met.

REASONABLE ASSURANCE ACTIVITIES

Due to numerous past unauthorized lagoon discharges, sewer extensions, and lift station failures, the village of Three Oaks is under an ACO (SW99-007) to update their sanitary sewer system. The upgraded system will eliminate excessive infiltration and inflow, which will alleviate overflows from the lagoons. All construction and residential hook-ups are required by the ACO by March 1, 2003, although the project is anticipated to be completed before that date.

The Berrien County Drain Commission has been awarded a Section 319 Watershed Management Grant. The grant includes the development of a comprehensive watershed management plan and implementing an Information and Education strategy that identifies target audiences and delivers messages based on the sources and causes of nonpoint solution. The group began meeting in 2001 to conduct activities aimed at restoring the Galien River Watershed.

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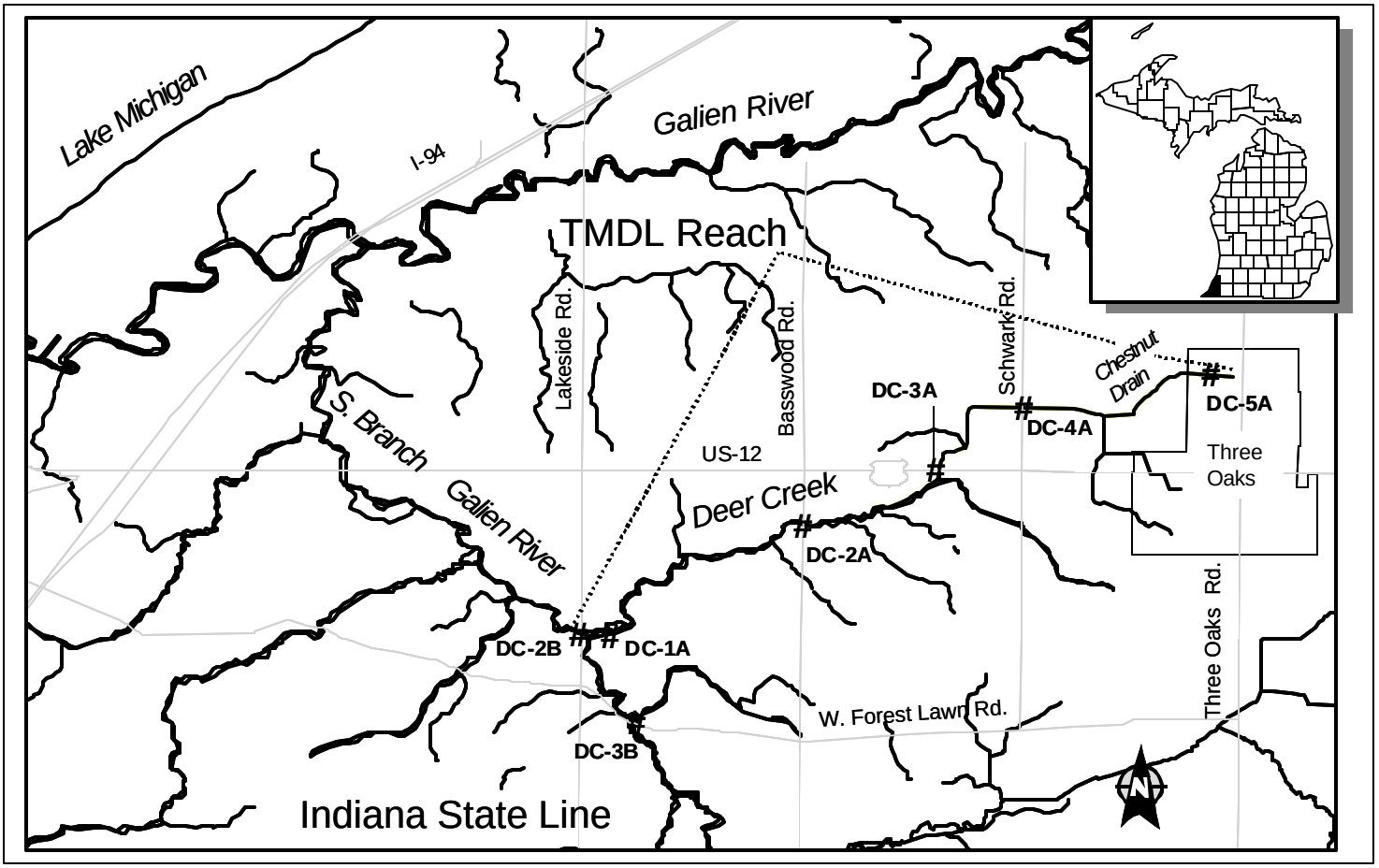

Figure 1. Deer Creek *E. coli* sampling locations, vicinity of Three Oaks, Michigan, 2001.

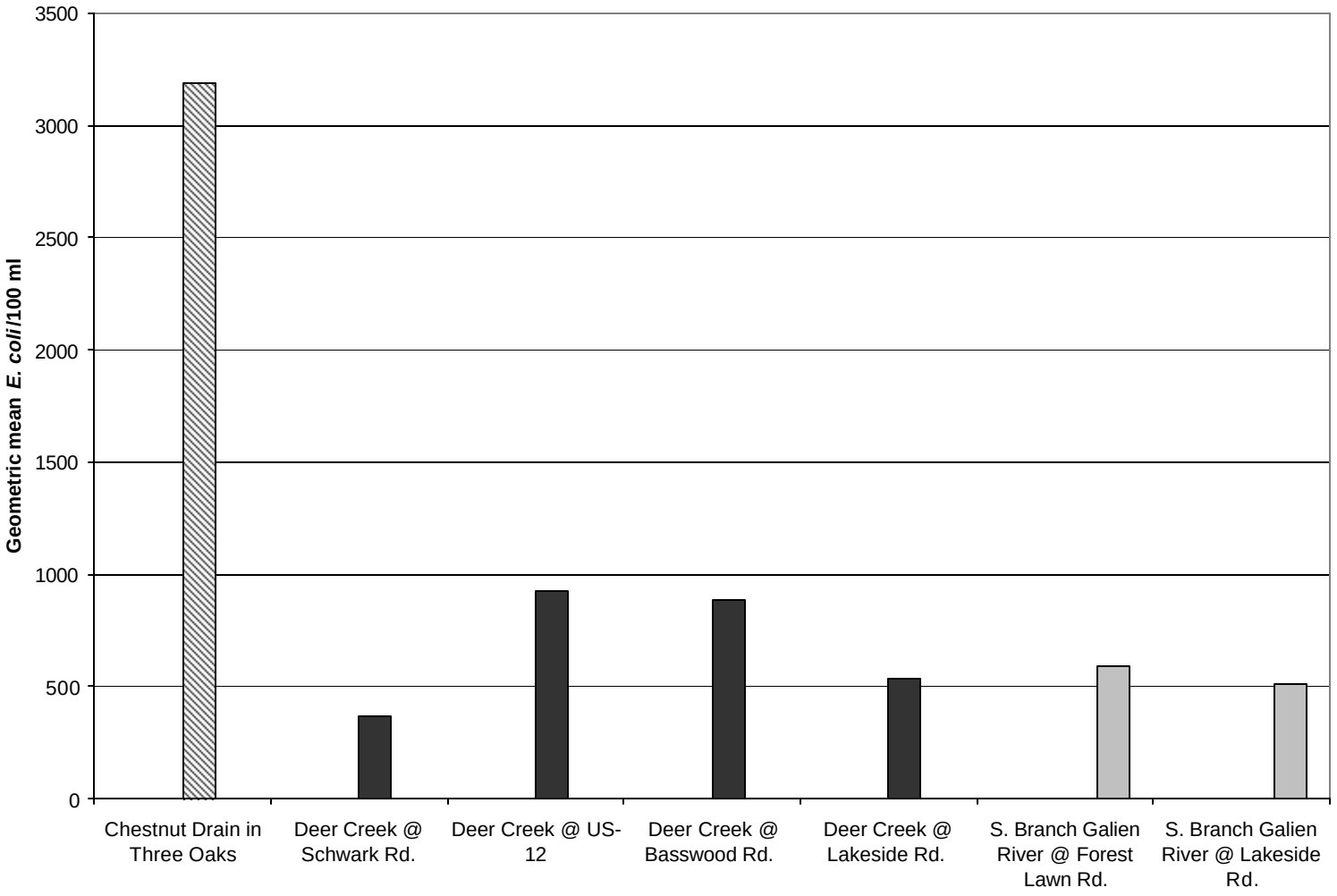

Figure 2. Geometric mean *E. coli* results from Deer Creek and related waterbodies, vicinity of Three Oaks, Three Oaks Township, Michigan, 2001.

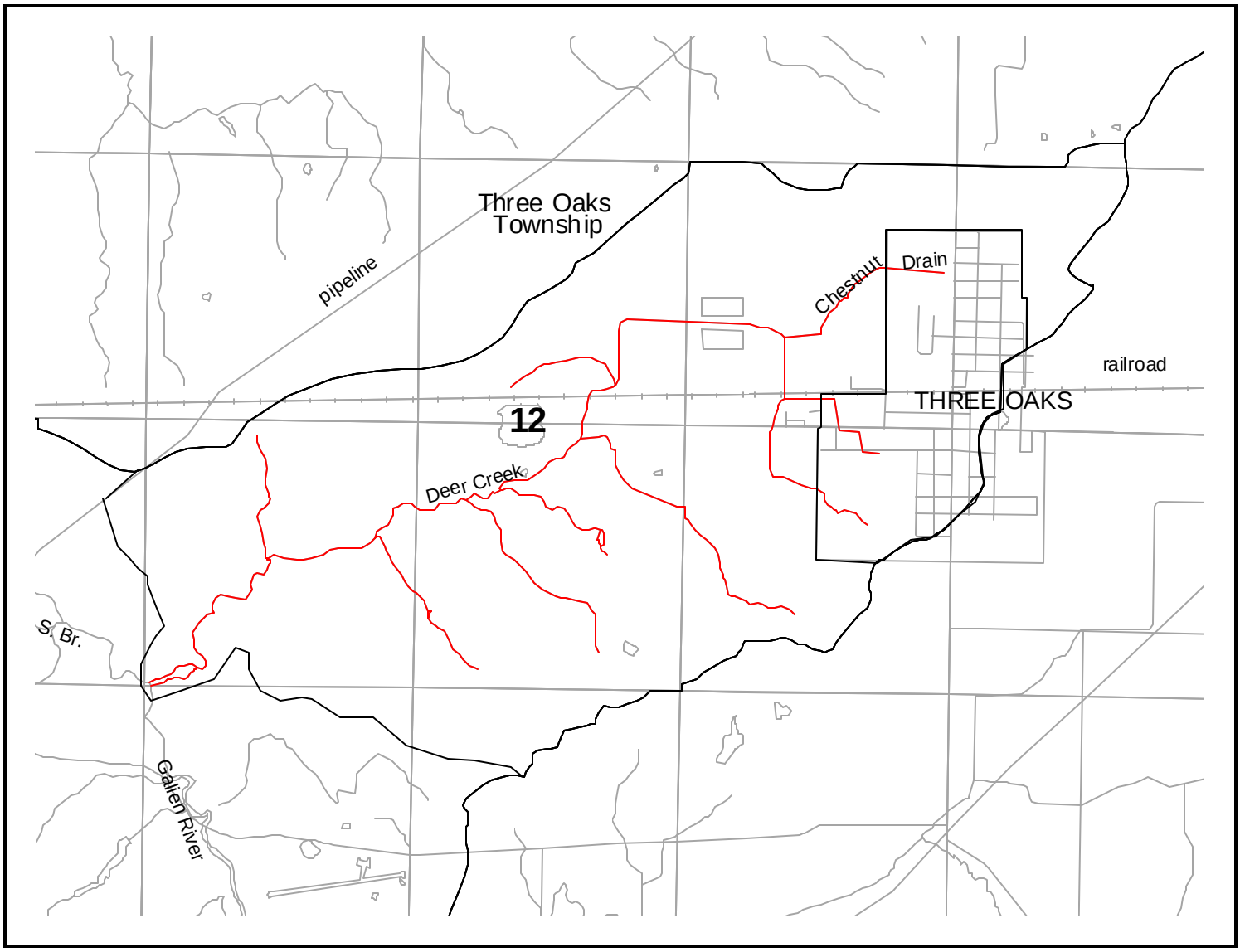

Figure 3. The Deer Creek Watershed, including the Village of Three Oaks and Three Oaks Township.

Table 1. Deer Creek average flows (cfs) at the confluence of the South Branch Galien River.

May	June	July	August	September	October
5.3	3.8	2.6	2.3	2.2	2.5

Table 2. MDEQ *E. coli* data for Deer Creek and related waterbodies, vicinity of Three Oaks, Three Oaks Township, Michigan, 2001.

		***E. coli* concentration (#/100 ml)**			
Sample Location	**Month**	**minimum**	**geometric mean**	**maximum**	**# of results**
Chestnut Drain in Three Oaks	May	3,600	5,794	7,400	3
	June	380	1,266	9,100	9
	July	1,370	4,491	8,200	9
	August	1,700	4,419	14,500	12
	September	2,200	2,735	3,100	3
Deer Creek @ Schwark Rd.	May	730	816	980	3
	June	60	245	830	12
	July	70	204	800	12
	August	320	828	4,900	12
	September	290	394	480	3
Deer Creek @ US-12	May	500	564	620	3
	June	890	1,188	1,700	6
	July	*	*	*	*
	August	*	*	*	*
	September	*	*	*	*
Deer Creek @ Basswood Rd.	May	370	431	470	3
	June	850	1,273	1,900	6
	July	*	*	*	*
	August	*	*	*	*
		*	*	*	*
Deer Creek @ Lakeside Rd.	May	480	590	670	3
	June	400	743	1,900	12
	July	220	455	810	12
	August	120	679	4,500	15
	September	50	74	100	3
S. Branch Galien River @ Forest Lawn Rd.	May	*	*	*	*
	June	290	507	760	6
	July	360	698	1,030	12
	August	310	620	1,100	15
	September	240	334	410	3
S. Branch Galien River @ Lakeside Rd.	May	*	*	*	*
	June	200	266	340	6
	July	440	730	1,400	12
	August	70	499	1,070	15
	September	370	479	550	3

***** no data collected during this month at this location.

Table 3. Distribution of land for each municipality in the Deer Creek Watershed.

Municipality	Watershed Area (sq. mi.)	Percent Land Area in Watershed
Three Oaks Township	4.35	87
Village of Three Oaks	0.65	13
TOTAL	**5.0**	**100**

Appendix 1. MDEQ 2001 *E. coli* monitoring data for Deer Creek and related waterbodies (E. coli/100 ml). Data are presented upstream to downstream.

Chestnut Drain @ Three Oaks DC-5A	Deer Creek @ Schwark Rd. DC-4A	Deer Creek @ US-12 DC-3A	Deer Creek @ Basswood DC-2A	Weather data
5/29/2001	**5/29/2001**	**5/29/2001**	**5/29/2001**	Sunny, mild
3600	730	500	460	
7300	760	620	470	
7400	980	580	370	
6/6/2001	**6/6/2001**	**6/6/2001**	**6/6/2001**	Foggy, light drizzle
580	760	1100	1700	
900	830	1700	1700	
680	180	1000	1900	
6/13/2001	**6/13/2001**	**6/13/2001**	**6/13/2001**	Partly sunny, hot
9000	510	1240	940	
9100	380	890	850	
4200	520	1360	970	
6/20/2001	**6/20/2001**	**6/20/2001**	**6/20/2001**	Mostly cloudy, cool
380	90	not sampled	not sampled	
410	320	not sampled	not sampled	
440	330	not sampled	not sampled	
6/28/2001	**6/28/2001**	**6/28/2001**	**6/28/2001**	Sunny, hot and humid
SITE	100	not sampled	not sampled	
DRY	70	not sampled	not sampled	
	60	not sampled	not sampled	
7/5/2001	**7/5/2001**	**7/5/2001**	**7/5/2001**	Clear, sunny and mild
1370	800	not sampled	not sampled	
1820	660	not sampled	not sampled	
1820	700	not sampled	not sampled	
7/12/2001	**7/12/2001**	**7/12/2001**	**7/12/2001**	Mostly cloudy, mild
SITE	90	not sampled	not sampled	
DRY	90	not sampled	not sampled	
	70	not sampled	not sampled	
7/19/2001	**7/19/2001**	**7/19/2001**	**7/19/2001**	Hot and humid, light fog
8100	210	not sampled	not sampled	
8200	220	not sampled	not sampled	
8000	240	not sampled	not sampled	
7/26/2001	**7/26/2001**	**7/26/2001**	**7/26/2001**	Clear, sunny and mild
5800	130	not sampled	not sampled	
7700	110	not sampled	not sampled	
6900	160	not sampled	not sampled	
8/2/2001	**8/2/2001**	**8/2/2001**	**8/2/2001**	Overcast, hot and humid, light drizzle
9500	560	not sampled	not sampled	
9600	630	not sampled	not sampled	
14500	550	not sampled	not sampled	
8/9/2001	**8/9/2001**	**8/9/2001**	**8/9/2001**	Overcast, hot and humid
SITE	320	not sampled	not sampled	
DRY	330	not sampled	not sampled	
	350	not sampled	not sampled	
8/16/2001	**8/16/2001**	**8/16/2001**	**8/16/2001**	Heavy rain
8000	not sampled	not sampled	not sampled	
8000	not sampled	not sampled	not sampled	
8000	not sampled	not sampled	not sampled	
8/23/2001	**8/23/2001**	**8/23/2001**	**8/23/2001**	Overcast, mild, light fog
2700	4900	not sampled	not sampled	
2400	4900	not sampled	not sampled	
2400	3500	not sampled	not sampled	
8/29/2001	**8/29/2001**	**8/29/2001**	**8/29/2001**	Clear, sunny and cool
1720	610	not sampled	not sampled	
1700	550	not sampled	not sampled	
1800	510	not sampled	not sampled	
9/4/2001	**9/4/2001**	**9/4/2001**	**9/4/2001**	Mostly sunny, mild
3000	440	not sampled	not sampled	
3100	480	not sampled	not sampled	
2200	290	not sampled	not sampled	

Appendix 1 continued. (*E. coli*/100 ml)

Deer Creek @ Lakeside Rd. DC-1A	S. Branch of the Galien River @ Forest Lawn DC-3B	S. Branch of the Galien River @ Lakeside Rd. DC-2B	Weather data
5/29/2001	**5/29/2001**	**5/29/2001**	Sunny, mild
480	not sampled	not sampled	
670	not sampled	not sampled	
640	not sampled	not sampled	
6/6/2001	**6/6/2001**	**6/6/2001**	Foggy, light drizzle
1040	not sampled	not sampled	
1100	not sampled	not sampled	
1900	not sampled	not sampled	
6/13/2001	**6/13/2001**	**6/13/2001**	Partly sunny, hot
720	not sampled	not sampled	
530	not sampled	not sampled	
1060	not sampled	not sampled	
6/20/2001	**6/20/2001**	**6/20/2001**	Mostly cloudy, cool
770	450	270	
730	290	300	
680	330	280	
6/28/2001	**6/28/2001**	**6/28/2001**	Sunny, hot and humid
400	720	200	
420	760	340	
500	720	230	
7/5/2001	**7/5/2001**	**7/5/2001**	Clear, sunny and mild
560	530	760	
600	790	610	
450	780	580	
7/12/2001	**7/12/2001**	**7/12/2001**	Mostly cloudy, mild
220	360	470	
230	530	500	
250	530	440	
7/19/2001	**7/19/2001**	**7/19/2001**	Hot and humid, light fog
810	900	610	
710	700	520	
800	900	1400	
7/26/2001	**7/26/2001**	**7/26/2001**	Clear, sunny and mild
420	730	1220	
370	930	1220	
570	1030	1240	
8/2/2001	**8/2/2001**	**8/2/2001**	Overcast, hot and humid, light drizzle
330	670	500	
320	550	430	
350	690	550	
8/9/2001	**8/9/2001**	**8/9/2001**	Overcast, hot and humid
180	610	600	
160	600	620	
120	1100	520	
8/16/2001	**8/16/2001**	**8/16/2001**	Heavy rain
2800	1000	970	
4300	700	1070	
4500	700	1000	
8/23/2001	**8/23/2001**	**8/23/2001**	Overcast, mild, light fog
1000	780	530	
2000	740	70	
2200	660	630	
8/29/2001	**8/29/2001**	**8/29/2001**	Clear, sunny and cool
450	330	430	
500	390	310	
440	310	400	
9/4/2001	**9/4/2001**	**9/4/2001**	Mostly sunny, mild
50	240	370	
100	380	550	
80	410	540	