Michigan Department of Environmental Quality
Water Bureau
July 2006

Total Maximum Daily Load for *E. coli* for Lincoln Lake Kent County

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 water bodies that are not meeting water quality standards (WQS). The TMDL process establishes the allowable loadings of pollutants for a water body 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 *E. coli* that will result in the attainment of the applicable WQS in Lincoln Lake, located in Kent County, Michigan (Figure 1). Lincoln Lake flows to the Flat River via the Clear Creek.

PROBLEM STATEMENT

The TMDL reach for Lincoln Lake appears on the Section 303(d) list as:

LINCOLN LAKE PINE RESORT BEACH WBID#: 082807Al
County: Kent Size: .1 M
Location: NW of Greenville
NHD Reach Code: 04050006001995
Problem Summary: Pathogens (Rule 100).
TMDL YEAR(s): 2006

Lincoln Lake was placed on the Section 303(d) list due to impairment of recreational uses as indicated by the presence of elevated levels of *E. coli* (Wolf and Wuycheck, 2004). Data submitted by the Kent County Health Department indicated exceedances of the WQS at the Lincoln Lake Pine Resort Beach in 2001 and 2002 (MDEQ, 2002). Monitoring data collected in 2005 by the Michigan Department of Environmental Quality (MDEQ) for Lincoln Lake, two inlets, and one outlet documented exceedances of the WQS for *E. coli* at several sampling locations during the total body contact recreational season of May 1 through October 31 (Figures 2-5, Tables 1 and 2).

The 2005 data collected for the original listing, Lincoln Lake Pine Resort Beach, indicate two exceedances of the daily geometric mean WQS out of 21 samples collected. This frequency of exceedances is considered to meet WQS (Edly and Wuycheck, 2006). However, the data also indicate other reaches do not meet WQS and the listing should be modified to include these reaches. The 2008 Integrated Report will reflect the following modified listing: 0.1 miles of Lincoln Lake, at the Lincoln Lake Department of Natural Resources Boat Launch; Clear Creek inlet, from Meddler Avenue downstream approximately 0.15 miles to the confluence with Lincoln Lake; Clear Creek outlet, from Lincoln Lake downstream approximately 0.4 miles to Lincoln Lake Avenue and the northern inlet to Lincoln Lake.

NUMERIC TARGET

The impaired designated use addressed by this TMDL is total body contact recreation. The designated use rule (R 323.1100 of the Part 4 rules, WQS, promulgated under Part 31, Water Resources Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended) states that this water body 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 *E. coli* per 100 milliliters (ml), as a 30-day geometric mean. Compliance shall be based on the geometric mean of all individual samples taken during five or more sampling events representatively spread over a 30-day period. Each sampling event shall consist of three 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 ml. Compliance shall be based on the geometric mean of three or more samples taken during the same sampling event at representative locations within a defined sampling area.

For this TMDL, the WQS of 130 *E. coli* per 100 ml as a 30-day geometric mean and 300 *E. coli* per 100 ml as a daily geometric mean are the target levels for the TMDL reach from May 1 to October 31. As previously stated, the 2005 monitoring data indicated exceedances of WQS at several stations sampled.

DATA DISCUSSION

Lincoln Lake, two inlets, and one outlet were sampled at 11 locations to address this TMDL listing (Figure 1). With respect to Lincoln Lake proper, exceedances of the 30-day geometric mean WQS were only observed at the boat launch station (LIN-07). Thirty-day geometric mean *E. coli* concentrations in Lincoln Lake ranged from 20 *E. coli* per 100 ml in June southwest of the boat launch (LIN-08) to 236 *E. coli* per 100 ml in June at the boat launch (LIN-07) (Figure 2, Table 1). The daily geometric mean was exceeded at more than half of the locations on Lincoln Lake. Daily geometric mean concentrations ranged from 20 *E. coli* per 100 ml at multiple locations to 1,218 *E. coli* per 100 ml in June at the boat launch (LIN-07) (Figure 3, Table 1).

Two inlets to Lincoln Lake and one outlet were also sampled. Clear Creek, the inlet on the west side of Lincoln Lake, had the highest *E. coli* concentrations of those observed during this sampling. This station exceeded the 30-day geometric mean WQS the entire sampling season. Thirty-day geometric mean *E. coli* concentrations ranged from 22 *E. coli* per 100 ml in June at the outlet (LIN-02) to 2,141 *E. coli* per 100 ml in July in the Clear Creek inlet (LIN-01) (Figure 4, Table 2). Daily geometric means ranged from 20 *E. coli* per 100 ml at multiple inlet and outlet stations to 5,310 *E. coli* per 100 ml in June in the Clear Creek inlet (LIN-01) (Figure 5, Table 2).

SOURCE ASSESSMENT

The official listed reach for Lincoln Lake is the Lincoln Lake Pine Resort Beach. The Lincoln Lake TMDL watershed is located primarily in Spencer (Kent County) and Maple Valley Townships (Montcalm County). The primary pathogen sources for this water body are likely failing or improperly functioning septic systems, wildlife contributions, agricultural inputs, and contributions from Clear Creek, an inlet to Lincoln Lake.

Lincoln Lake has experienced problems related to exceedances of bacterial WQS similar to other lakes where residences are located on small lots without adequate space to install properly functioning septic systems. The Kent County Health Department reports routine requests for assistance from residents in the Silver Beach Association (located on Lincoln Lake) for septic system repairs or replacement (Overmyer, 2006). The Kent County Health Department estimates failing septic systems discharge approximately one million gallons per day of domestic sewage to ground water or local waterways (Hegarty, 2002).

Lincoln Lake Pine Resort Beach, the beach on the northeast end of Lincoln Lake (LIN-11) with reported beach closures in the past, had two exceedances of the daily geometric mean in June 2005 (Table 1). Field observations at this sampling location indicate a large population of waterfowl frequent the area and utilize the beach and may be a localized source of *E. coli*. Research indicates that avian species (ducks, geese, crows, sea gulls, pigeons, and starlings) were a major source (50 percent) of *E. coli* contamination at a beach in southeastern Michigan (Samadpour, 2001). Human inputs are not suspected from the Lincoln Pines Resort, a manufactured housing and recreational vehicle community. This community utilizes a lagoon system for sewage waste treatment.

Agriculture, including grass and pasture land, accounts for approximately 70 percent of the land use in the TMDL watershed and can be a source of bacterial contamination in surface waters (Purdue University and USEPA, 2004). *E. coli* have been shown to enter water bodies from pastureland runoff and land applications of manure via field drainage systems, such as tiles. Field tiles provide for significant transport of enteric bacteria through tile drainage systems under all manure application protocols and environmental conditions (Jamieson et al., 2002). Overland runoff from land application of manure is another possible source of *E. coli* (Oliver et al., 2005).

Data collected from the Clear Creek inlet sampled on the west side of Lincoln Lake (LIN-01) indicate exceedances of the 30-day geometric mean for the entire sampling season (Table 2). This station had five events with *E. coli* concentrations greater than 1,000 *E. coli* per 100 ml. Four of those events were associated with precipitation events and concentrations were greater than 3,000 *E. coli* per 100 ml. A sample at this location was collected to determine if the fecal *Bacteroidetes* human gene biomarker was present. This technique is designed around the principle that fecal *Bacteroidetes* are found in large quantities of feces of warm-blooded animals. Certain categories of *Bacteroidetes* have been shown to be predominately found in humans and can be used as indicators of human fecal contamination (Source Molecular, 2006). It is one of many approaches that can be used to aid in source identification. The inlet sample was collected on August 5, 2005, and the fecal *Bacteroidetes* human gene biomarker was not detected in the sample. It should be noted that one sample does not imply that human sources of *E. coli* are not present at this location. The results indicate that on the day the sample was collected, the human gene biomarker was not detected. Agricultural runoff from upstream may be a potential source of the *E. coli* levels found at this location.

There are three permits within the Lincoln Lake TMDL watershed. One permit-by-rule for the Kent County Road Commission (MIR106514), one Municipal Separate Storm Sewer Permit for the Michigan Department of Transportation (MDOT) (MI0057364) and one ground water discharge permit issued to Lincoln Pines, Inc (GW 185900403). The permit-by-rule involves earthwork in the TMDL watershed and is not considered a significant source of *E. coli*. The MDOT statewide storm water permit is prohibited from discharges that may cause or contribute to a violation of WQS. The Lincoln Pines Resort (known as Lincoln Pines, Inc.) operates under a state-issued groundwater permit. The lagoon system is designed to discharge to an irrigation bed for infiltration to ground water. The irrigation bed vents to Lincoln Lake; however, the bed is located a significant distance from Lincoln Lake and is not suspected to be a source of *E. coli*

due to biological treatment of the water as it filters through the soil. There are no concentrated animal feeding operations in the Lincoln Lake TMDL watershed.

LINKAGE ANALYSIS

Determining the link between the *E. coli* concentrations in Lincoln Lake and the potential sources is necessary to develop the TMDL. This link provides the basis for estimating the total assimilative capacity of the water body and any needed load reductions. For this TMDL, the loading of pathogens appears to enter Lincoln Lake during all weather conditions (i.e., wet and dry weather events). Potential sources of *E. coli* to Lincoln Lake and Clear Creek include failing or improperly functioning septic systems, wildlife, and agriculture.

The guiding water quality management principle used to develop the TMDL was that compliance with the numeric pathogen target in Lincoln Lake depends on the control of *E. coli* from wet and dry weather sources. If the *E. coli* inputs can be controlled to meet the numeric standards, then total body contact recreation in Lincoln Lake will be restored and protected.

TMDL DEVELOPMENT

The TMDL represents the maximum loading that can be assimilated by the water body while still achieving WQS. As indicated in the Numeric Target section, the targets for this pathogen TMDL are the 30-day geometric mean WQS of 130 *E. coli* per 100 ml and daily geometric mean of 300 *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 WQS Rules R 323.1082 (Mixing Zones) and R 323.1090 (Applicability of WQS). In general, the lowest monthly 95 percent 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 fecal coliform per 100 ml regardless of stream flow. Therefore, the design stream flow is not a critical condition for determining the allowable loading of pathogen for wastewater treatment plants. In addition, sources of pathogens to Lincoln Lake arise from a mixture of wet and dry weather-driven nonpoint sources. 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 is equal to the target concentration of 130 *E. coli* per 100 ml as a 30-day geometric mean and daily geometric mean of 300 *E. coli* per 100 ml in all portions of the TMDL reach for each month of the recreational season (May through October). Expressing the TMDL as a concentration equal to the WQS ensures that the WQS will be met under all flow and loading conditions; therefore, a critical condition is not applicable for this TMDL.

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 within the WLA or LA, 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. This pathogen TMDL will not be expressed on a mass loading basis and is concentration based, consistent with the USEPA regulations in 40 CFR, Section 130.2(i).

WLAs

There are two National Pollutant Discharge Elimination System permitted point source discharges within the listed reach of Lincoln Lake. The MDOT statewide permit (MI0057364) and the Kent County Road Commission (MIR 106514). The WLA for these permits is equal to 130 *E. coli* per 100 ml as a 30-day geometric mean and 300 *E. coli* per 100 ml as a daily geometric mean.

LAs

Because this TMDL is concentration based, the LA is equal to 130 *E. coli* per 100 ml as a 30-day geometric mean. This LA is based on the assumption that all land, regardless of use, will be required to meet the WQS. 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 local unit of government in the watershed. This TMDL reach is located in three municipalities (Table 3, Figure 6). Spencer Township (Kent County) makes up the largest portion of the watershed (47 percent).

There is one state-issued ground water permit within the Lincoln Lake TMDL reach for the Lincoln Pines Resort, Inc. (GW 185900403).

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, including the pollutant decay rate if applicable. The MOS can be either implicit (i.e., incorporated into the WLA or LA 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. Pathogen organisms ordinarily have a limited capability of surviving outside of their hosts and a rate of decay could be developed. However, applying a rate of decay could result in an allocation that would be greater than the WQS, thus no rate of decay is applied to provide for a greater protection of water quality. The MDEQ has determined that the use of the WQS of 130 *E. coli* per 100 ml for the WLA and LA is a more conservative approach than developing an explicit MOS and accounts for the uncertainty in the relationship between pollutant loading and water quality, based on available data and the assumption to not use a rate of decay. Applying the WQS to be met under all flow conditions also adds to the assurance that an explicit MOS is unnecessary.

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

Pathogens were monitored weekly at eight stations on Lincoln Lake, two inlets, and one outlet from May through September 2005. Future sampling by the MDEQ to evaluate WQS attainment will be conducted when control measures have taken place (i.e., best management practice installation or other corrective actions). Sampling will be performed in the appropriate frequency (as defined in the Numeric Target section) to determine if the 30-day geometric mean value of 130 *E. coli* per 100 ml and 300 *E. coli* per 100 ml as a daily maximum are being met.

REASONABLE ASSURANCE ACTIVITIES

Lincoln Pines, Inc. is responsible for complying with their state-issued groundwater permit. Compliance is based on field inspections and data review by the MDEQ.

The Kent County Health Department monitored *E. coli* at two locations on Lincoln Lake in 2001 and 2002. Funding for the monitoring program is no longer available but the county continues to provide cost share assistance to Lincoln Lake residents through other programs. The Kent Community Development Fund has helped residents upgrade/replace on-site septic systems and resolve issues with drinking water wells.

Lincoln Lake has two lake associations, the Property Owners Association of Lincoln Lake and the Silver Beach Property Owners Association. Residents work together to disseminate information about water quality in Lincoln Lake through public meetings and newsletter mailings.

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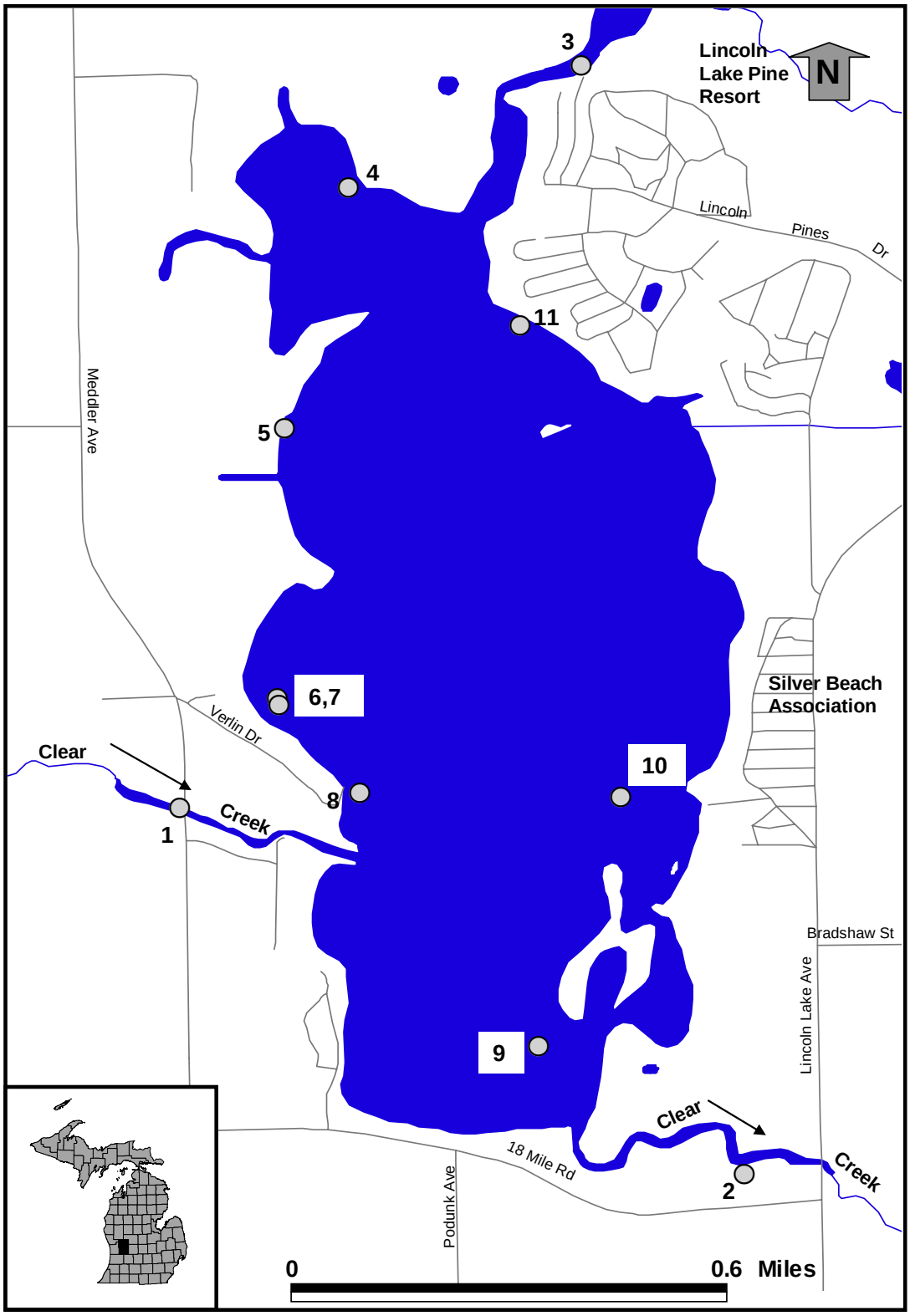

Figure 1. Lincoln Lake *E. coli* sampling locations, including two inlets and one outlet, northwest of Greenville , Kent County, Michigan, 2005.

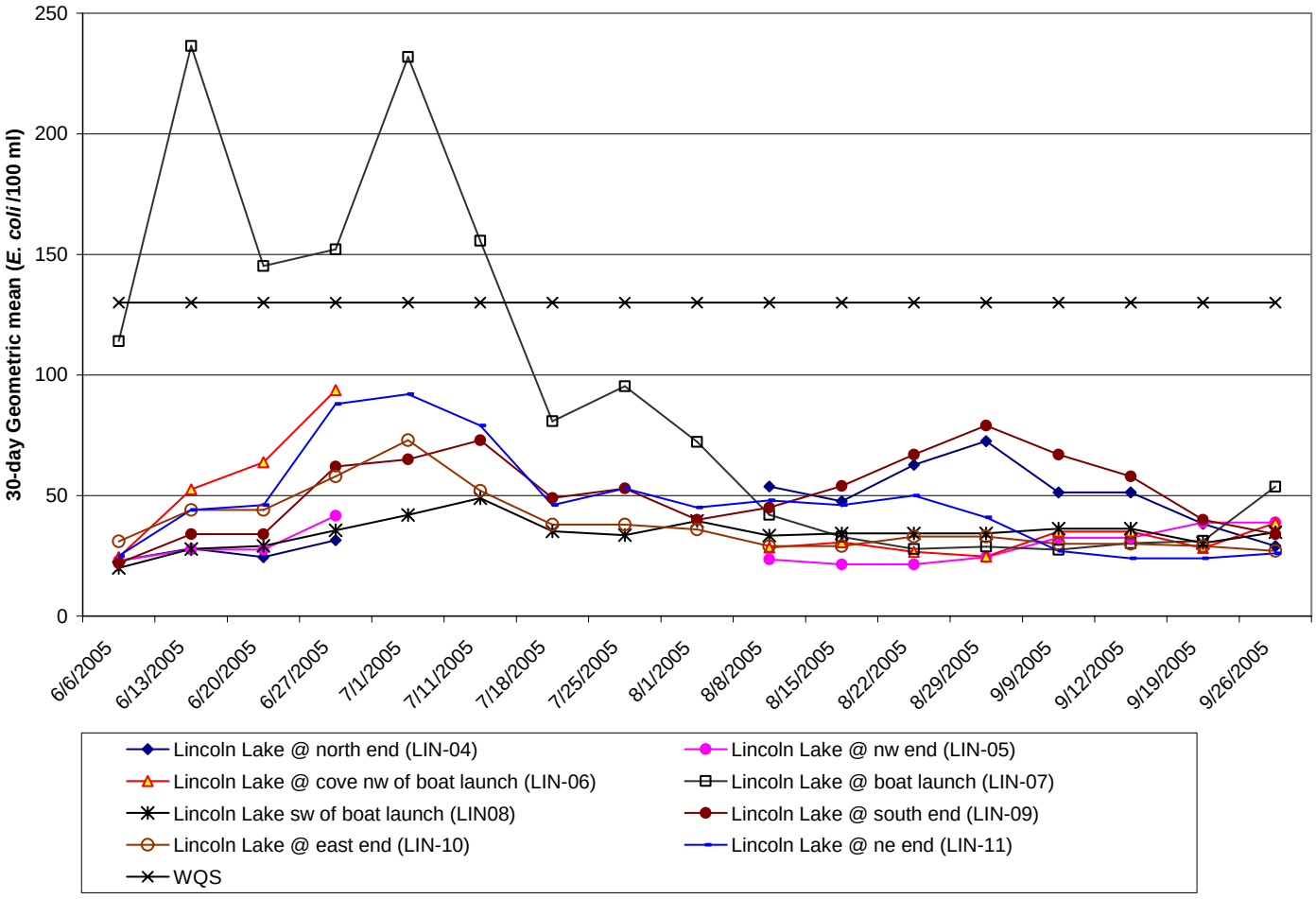

Figure 2. Thirty-day geometric mean for *E. coli* in Lincoln Lake, northwest of Greenville, Kent County, Michigan, 2005.

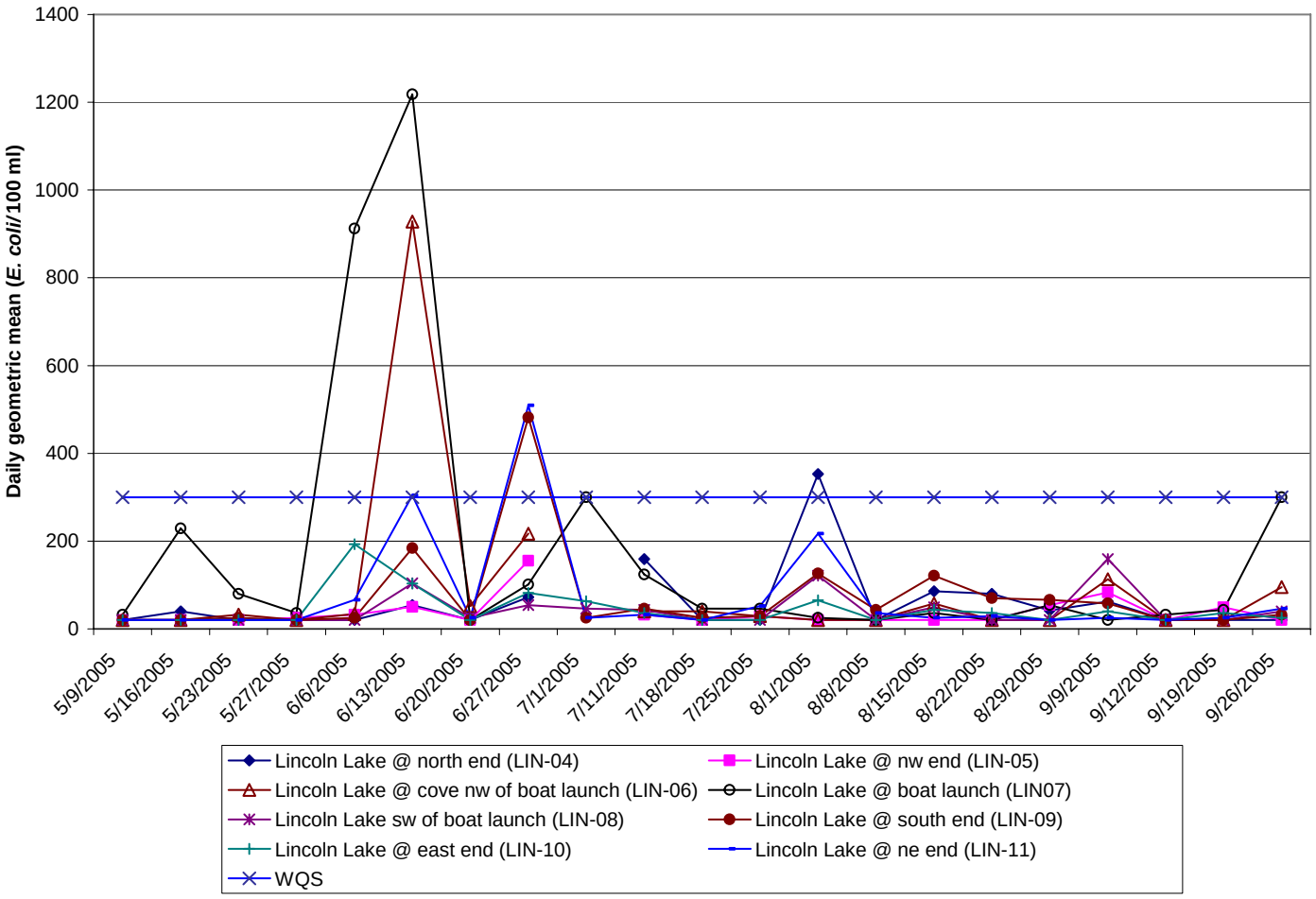

Figure 3. Daily geometric mean for *E. coli* in Lincoln Lake, northwest of Greenville, Kent County, Michigan, 2005.

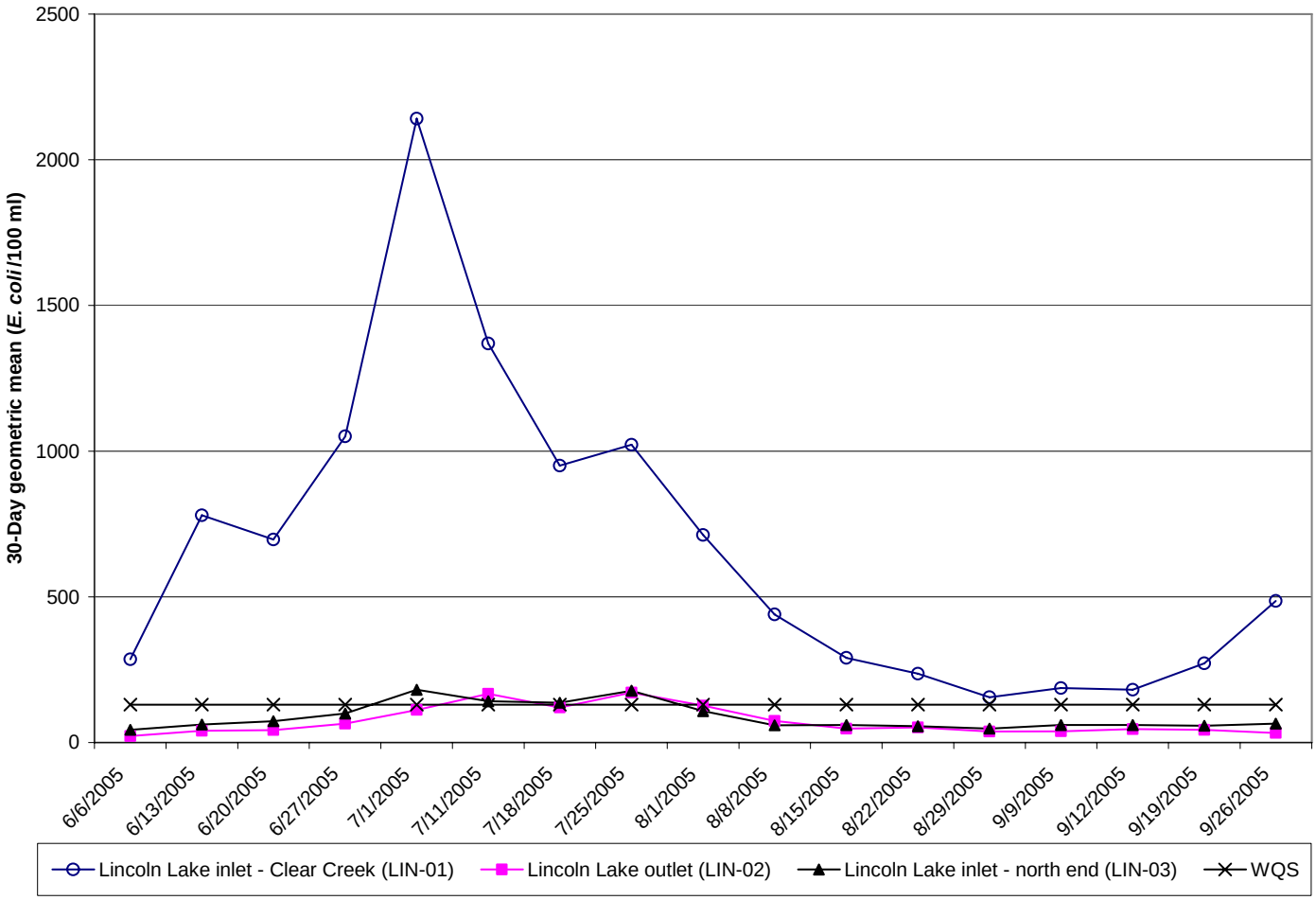

Figure 4. Thirty-day geometric mean for *E. coli* for two Lincoln Lake inlets and one outlet, northwest of Greenville, Kent County, Michigan, 2005.

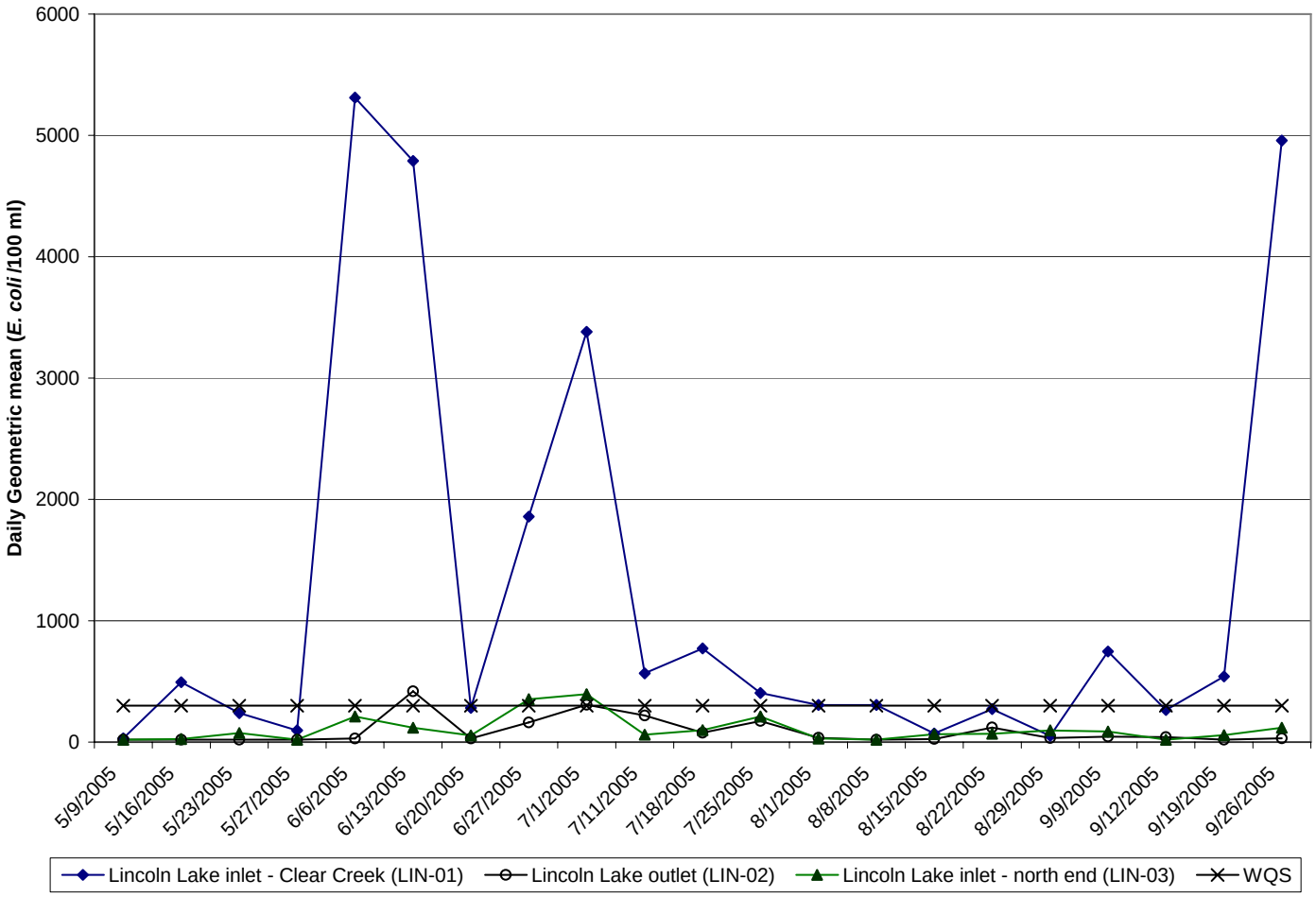

Figure 5. Daily geometric mean for *E. coli* for two Lincoln Lake inlets and one outlet, northwest of Greenville, Kent County, Michigan, 2005.

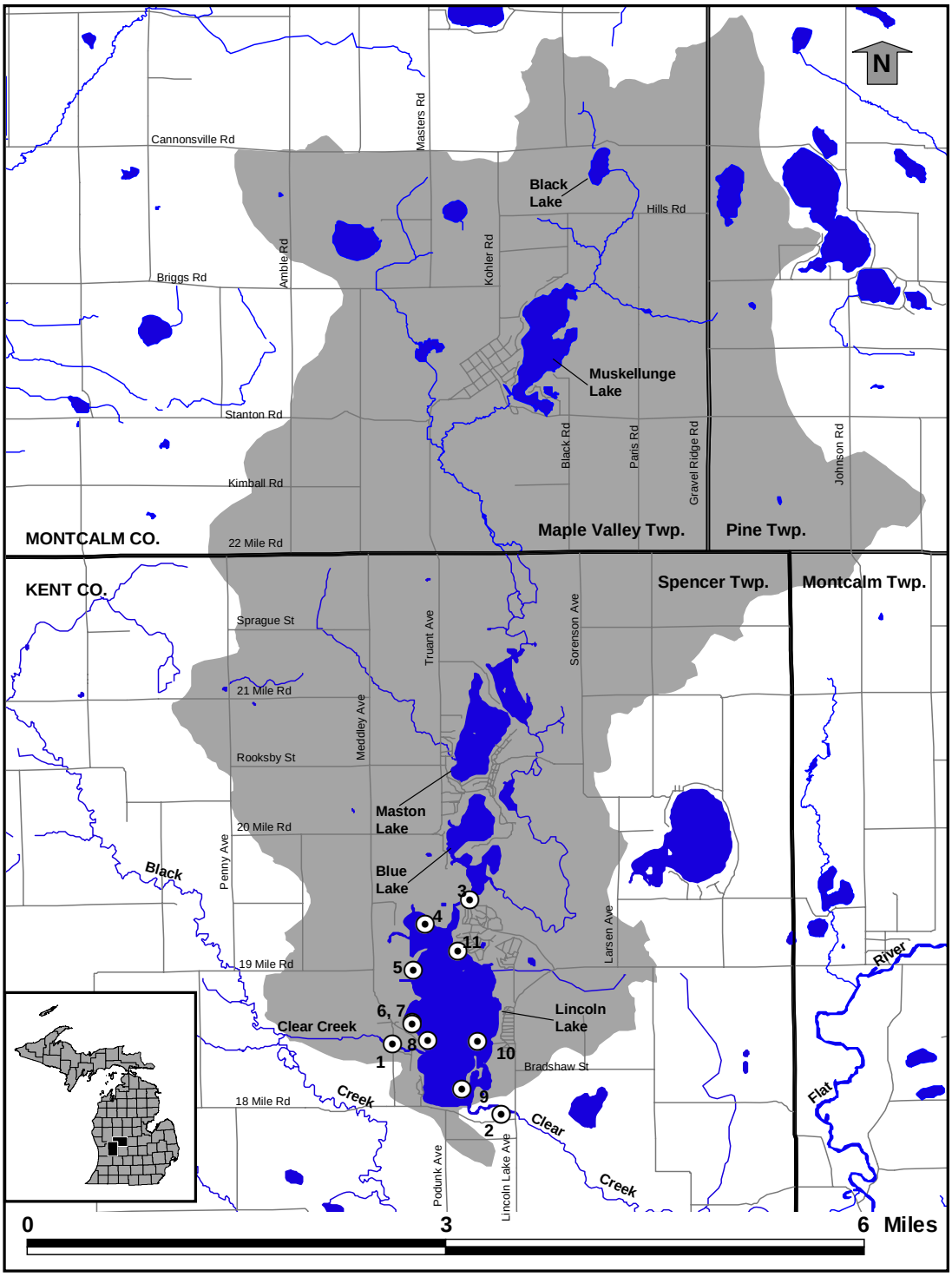

Figure 6. Stakeholders in the Lincoln Lake TMDL watershed, Kent and Montcalm Counties, Michigan, 2005.

Table 1. **MDEQ 2005 *E. coli* monitoring data (*E. coli*/100 ml) for Lincoln Lake northwest of Greenville. Shaded areas indicate exceedances of the WQS. Note: precipitation is noted for 24 hours preceding sampling. Gage located in Grand Rapids, Michigan.**

	Lincoln Lake at north end LIN-04			Lincoln Lake at northwest end LIN-05			Lincoln Lake at cove northwest of boat launch LIN-06			Lincoln Lake at boat launch LIN-07			Precipitation in inches
DATE	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	
5/9/2005	20	20	---	20	20	---	20	20	---	40	32	---	0.0"
	20			20			20			40			
	20			20			20			20			
5/16/2005	80	40	---	20	20	---	20	20	---	200	229	---	0.0"
	20			20			20			300			
	40			20			20			200			
5/23/2005	20	20	---	20	20	---	20	32	---	80	80	---	0.2"
	20			20			40			80			
	20			20			40			80			
5/27/2005	20	20	---	20	25	---	20	20	---	20	36	---	0.0"
	20			40			20			40			
	20			20			20			60			
6/6/2005	20	20	23	20	32	23	20	34	24	1800	912	114	0.9 "
	20			40			100			540			
	20			40			20			780			
6/13/2005	20	54	28	80	50	28	800	928	53	1320	1218	236	2.2"
	200			40			1000			1180			
	40			40			1000			1160			
6/20/2005	20	20	24	20	20	28	40	52	64	20	20	145	0.0"
	20			20			60			20			
	20			20			60			20			
6/27/2005	20	72	32	660	155	42	100	217	94	20	101	152	0.0"
	20			140			640			160			
	920			40			160			320			
7/1/2005	---	---	---	---	---	---	---	---	---	100	300	232	0.7"
	---			---			---			640			
	---			---			---			420			
7/11/2005	720	159	---	80	32	---	20	40	---	160	124	156	0.0"
	20			20			20			120			
	280			20			160			100			
7/18/2005	20	20	---	20	20	---	40	40	---	80	46	81	0.2"
	20			20			40			60			
	20			20			40			20			

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

DATE	Lincoln Lake at north end LIN-04			Lincoln Lake at northwest end LIN-05			Lincoln Lake at cove northwest of boat launch LIN-06			Lincoln Lake at boat launch LIN-07			Precipitation in inches
	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	

7/25/2005	20 20 20	20		20 20 60	29	---	60 20 20	29	---	80 60 20	46	95	0.9”
8/1/2005	540 120 680	353	---	20 20 20	20	---	20 20 20	20	---	20 20 40	25	72	0.0"
8/8/2005	20 20 20	20	54	20 20 20	20	24	20 20 20	20	28	20 20 20	20	42	0.0"
8/15/2005	100 80 80	86	48	20 20 20	20	22	20 100 100	58	31	120 20 20	36	33	0.0"
8/22/2005	140 60 60	80	63	20 20 20	20	22	20 20 20	20	27	20 20 20	20	28	0.0"
8/29/2005	20 60 60	42	73	100 80 20	54	24	20 20 20	20	25	40 40 100	54	29	0.0"
9/9/2005	40 60 100	62	51	120 80 60	83	32	120 600 20	113	35	20 20 20	20	28	0.0"
9/12/2005	20 20 20	20	51	20 20 20	20	32	20 20 20	20	35	40 40 20	32	30	0.0"
9/19/2005	20 20 20	20	38	100 20 60	49	39	20 20 20	20	28	100 40 20	43	31	0.0"
9/26/2005	20 20 20	20	29	20 20 20	20	39	60 120 120	95	39	440 220 280	300	54	0.4"

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

	Lincoln Lake southwest of boat launch LIN-08			Lincoln Lake at south end LIN-09			Lincoln Lake at east end LIN-10			Lincoln Lake at northeast end LIN-11			Precipitation in inches
DATE	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	
5/9/2005	20	20	---	20	20	---	20	20	---	20	20	---	0.0”
	20			20			20			20			
	20			20			20			20			
5/16/2005	20	20	---	20	20	---	20	20	---	20	20	---	0.0”
	20			20			20			20			
	20			20			20			20			
5/23/2005	20	20	---	40	25	---	20	20	---	20	20	---	0.2"
	20			20			20			20			
	20			20			20			20			
5/27/2005	20	20	---	20	20	---	20	20	---	20	20	---	0.0"
	20			20			20			20			
	20			20			20			20			
6/6/2005	20	20	20	20	25	22	320	193	31	20	66	25	0.9 "
	20			20			140			120			
	20			40			160			120			
6/13/2005	40	104	28	280	184	34	300	103	44	200	304	44	2.2"
	140			160			180			700			
	200			140			20			200			
6/20/2005	20	25	29	20	20	34	20	20	44	40	25	46	0.0"
	20			20			20			20			
	40			20			20			20			
6/27/2005	200	54	36	180	482	62	140	82	58	240	509	88	0.0"
	40			760			20			220			
	20			820			200			2500			
7/1/2005	40	46	42	20	25	65	160	63	73	20	25	92	0.7"
	60			40			80			20			
	40			20			20			40			
7/11/2005	20	43	49	40	46	73	20	36	52	80	32	79	0.0"
	20			120			20			20			
	200			20			120			20			
7/18/2005	20	20	35	20	25	49	20	20	38	20	20	46	0.2"
	20			20			20			20			
	20			40			20			20			

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

	Lincoln Lake southwest of boat launch LIN-08			Lincoln Lake at south end LIN-09			Lincoln Lake at east end LIN-10			Lincoln Lake at north east end LIN-11			Precipitation in inches
DATE	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	
7/25/2005	20 20 20	20	34	20 60 20	29	53	20 20 20	20	38	60 40 60	52	53	0.9”
8/1/2005	20 220 400	121	39	500 20 200	126	40	20 40 340	65	36	100 640 160	217	45	0.0"
8/8/2005	20 20 20	20	33	200 20 20	43	45	20 20 20	20	29	20 20 120	36	48	0.0"
8/15/2005	20 20 300	49	34	320 140 40	121	54	20 20 200	43	29	20 40 20	25	46	0.0"
8/22/2005	20 20 20	20	34	40 60 140	70	67	20 20 120	36	33	20 60 20	29	50	0.0"
8/29/2005	20 20 20	20	34	60 60 80	66	79	20 20 20	20	33	20 20 20	20	41	0.0"
9/9/2005	240 140 120	159	36	40 40 120	58	67	160 20 20	40	30	40 20 20	25	27	0.0"
9/12/2005	20 20 20	20	36	20 20 20	20	58	20 20 20	20	30	20 20 20	20	24	0.0"
9/19/2005	20 20 20	20	30	20 20 20	20	40	40 60 20	36	29	40 20 20	25	24	0.0"
9/26/2005	40 40 40	40	35	20 20 80	32	34	20 20 40	25	27	80 20 60	46	26	0.4"

Table 2. MDEQ 2005 *E. coli* monitoring data (*E. coli*/100 ml) for two Lincoln Lake inlets and one outlet, northwest of Greenville. Shaded areas indicate exceedances of the WQS. Note: precipitation is noted for 24 hours preceding sampling. Gage located in Grand Rapids, Michigan.

	Lincoln Lake inlet Clear Creek LIN-01			Lincoln Lake outlet LIN-02			Lincoln Lake inlet north end LIN-03			Precipitation in inches
DATE	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	
5/9/2005	40	32	---	20	20	---	20	20	---	0.0”
	40			20			20			
	20			20			20			
5/16/2005	660	494	---	20	20	---	20	25	---	0.0”
	240			20			20			
	760			20			40			
5/23/2005	200	239	---	20	20	---	520	75	---	0.2"
	680			20			20			
	100			20			40			
5/27/2005	80	96	---	20	20	---	20	20	---	0.0"
	140			20			20			
	80			20			20			
6/6/2005	7800	5310	286	20	29	22	140	211	44	0.9 "
	4000			60			420			
	4800			20			160			
6/13/2005	5200	4789	780	1000	418	40	100	119	62	2.2"
	4800			280			140			
	4400			260			120			
6/20/2005	200	282	697	20	29	43	20	56	73	0.0"
	800			60			220			
	140			20			40			
6/27/2005	2200	1858	1051	20	161	65	540	353	100	0.0"
	1800			300			340			
	1620			700			240			
7/1/2005	1400	3381	2141	2600	308	112	440	395	181	0.7"
	6000			280			540			
	4600			40			260			
7/11/2005	600	567	1369	200	219	167	20	61	142	0.0"
	800			220			20			
	380			240			580			
7/18/2005	1000	772	950	100	78	120	120	99	137	0.2"
	1000			60			100			
	460			80			80			

Table 2. continued (*E. coli*/100 ml).

DATE	Lincoln Lake inlet Clear Creek LIN-01			Lincoln Lake outlet LIN-02			Lincoln Lake inlet north end LIN-03			Precipitation in inches
	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	SAMPLE RESULTS	DAILY G. MEAN	30-day G. MEAN	
7/25/2005	320	405	1022	140	174	171	200	211	178	0.9”
	520			170			260			
	400			220			180			
8/1/2005	300	306	712	20	36	127	60	29	108	0.0"
	280			40			20			
	340			60			20			
8/8/2005	340	306	440	20	20	74	20	20	59	0.0"
	280			20			20			
	300			20			20			
8/15/2005	60	71	291	40	25	48	60	66	60	0.0"
	100			20			80			
	60			20			60			
8/22/2005	460	273	236	180	120	52	60	70	56	0.0"
	220			80			140			
	200			120			40			
8/29/2005	340	51	156	100	34	38	140	96	48	0.0"
	20			20			80			
	20			20			80			
9/9/2005	520	747	187	40	46	39	80	86	60	0.0"
	800			60			100			
	1000			40			80			
9/12/2005	460	264	181	60	42	46	20	20	60	0.0"
	400			60			20			
	100			20			20			
9/19/2005	380	541	272	20	20	44	80	58	58	0.0"
	520			20			60			
	800			20			40			
9/26/2005	3200	4958	486	80	32	33	60	119	65	0.4"
	6800			20			140			
	5600			20			200			

Table 3. Distribution of land for each municipality in the Lincoln Lake TMDL watershed.

Municipality	County	Square Miles	Percent
Spencer Township	Kent	11.1	47
Maple Valley Township	Montcalm	10.1	42
Pine Township	Montcalm	2.6	11
TOTAL		**23.8**	**100**