Michigan Department of Environmental Quality
Water Division
January 2003

Total Maximum Daily Load for *Escherichia coli* for Lime Creek (Prattville Drain and Lime Lake) Hillsdale 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 Lime Creek, including Prattville Drain and Lime Lake, in the Bean Creek Watershed, located in Hillsdale County, Michigan.

PROBLEM STATEMENT

Prattville Drain and Lime Lake were first placed on the Section 303(d) list in 1998. This TMDL listing addressed approximately one-half mile of stream in the vicinity of Wright Township. The TMDL reach is on the Section 303(d) list as:

PRATTVILLE DRAIN & LIME LAKE WBID#: **060102B**
County: Hillsdale HUC: 4100006 Size: 0.5 M
Location: Wright Township
Problem: **Untreated sewage discharge, pathogens (Rule 100).**
TMDL YEAR(s): 2003 RF3RchID: 4100006 236

Prattville Drain and Lime Lake (Figure 1) were placed on the Section 303(d) list (Creal and Wuycheck, 2002) due to impairment of recreational uses as indicated by the presence of elevated levels of *E. coli*. Records dating back to 1969 document the discharge of raw sewage to Lime Lake from the unincorporated village of Prattville via an open drainage ditch (Cooley, 1969). Subsequent sampling in 1992 again documented raw or partially untreated sewage in Prattville Drain (Wiseley, 1992). These conditions agree with recent monitoring data (Table 1) collected by the Michigan Department of Environmental Quality (MDEQ). The 2002 monitoring season documented exceedances of the WQS for *E. coli* at all stream stations sampled during the total body contact recreational season (Table 1 and Figure 2). Thirty-day geometric mean *E. coli* concentrations in Prattville Drain at Young Drive, one of the two inlets to Lime Lake, ranged from 243 *E. coli* per 100 milliliters (ml) in August 2002, to 9,849 *E. coli* per 100 ml in July 2002. This particular station exhibited 30-day geometric mean concentrations above 1,000 *E. coli* per 100 ml for seven consecutive weeks. Daily geometric means at this station were greater than 100,000 *E. coli* per 100 ml on two sampling events in July 2002(Table 1).

Lime Creek was also sampled as part of this TMDL monitoring both upstream and downstream of Lime Lake. In general, *E. coli* concentrations were lower downstream of Lime Lake. Thirty-day geometric mean concentrations ranged from 107 *E. coli* per 100 ml in June 2002 at

Prattville Road (Lime Lake outlet), to 4,837 *E. coli* per 100 ml in July 2002 at Lime Lake Road (Lime Lake inlet). Lime Creek at Lime Lake Road exhibited the second highest 30-day geometric mean *E. coli* concentrations sampled relative to Prattville Drain. In addition, both Lime Creek stations upstream of Lime Lake exhibited 30-day geometric mean concentrations above 1,000 *E. coli* per 100 ml for at least six consecutive weeks. Daily geometric means at various stations in Lime Creek were greater than 10,000 *E. coli* per 100 ml on six occasions in July 2002.

Sampling in Lime Lake documented only one exceedance of the total body contact standard in May 2002 at all four locations sampled (Table 1 and Figure 3). With the exception of this single exceedance, Lime Lake met total body contact recreational standards for the remainder of the sampling season. This indicates that conditions in Lime Lake are typically acceptable, even though the two small streams flowing into Lime Lake are not meeting WQS for *E. coli*.

The official Section 303(d) listing for Prattville Drain and Lime Lake was 0.5 mile in Wright Township. Based on a review of the listing and the 2002 monitoring data, the listed TMDL reach would more appropriately be described as Lime Creek upstream four miles from US-127 to Coman Road, including Lime Lake and Prattville Drain. Lime Creek has fairly small flows in this area (Table 2).

NUMERIC TARGET

The impaired designated use 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.

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, the 2002 monitoring data indicated exceedances of WQS. Stations with the highest concentrations are located upstream of Lime Lake, particularly the two lake inlets.

SOURCE ASSESSMENT

For this TMDL, a significant amount of the pathogen load likely enters Lime Creek by both wet and dry weather sources, such as agricultural run-off and illicit connections. To illustrate this, daily geometric mean *E. coli* concentrations were plotted in relation to precipitation that had occurred in the 24 hours prior to sampling (Figure 4). *E. coli* levels were elevated during both wet and dry weather conditions. Based on this, it is evident that there is both continuous (dry weather) and wet weather sources of *E. coli* to Lime Creek.

Potential pathogen sources for this waterbody have historically been noted from illicit discharges in the area of Prattville. Since 1969, monitoring has documented an ongoing problem regarding the discharge of raw or partially treated sewage to Lime Lake via Prattville Drain. Due to lack of funding, the problem has yet to be resolved. This situation continues to cause problems as indicated by data collected by the MDEQ. Monitoring in 2002 showed the greatest exceedances measured in Prattville Drain - daily geometric means were greater than 100,000 *E. coli* per 100 ml on two different occasions. *E. coli* counts of this magnitude are often indicative of the presence of human sewage (Pitt, 1998).

Besides human sources, other potential sources of *E. coli* are likely agricultural given the land use in the watershed. The state of Michigan issued a general National Pollutant Discharge Elimination System (NPDES) permit for Concentrated Animal Feeding Operations (CAFOs) on December 13, 2002. Farms meeting the definition of a CAFO must submit an application to be covered by this permit, which requires discharges to surface waters to meet WQS. In addition, the permittees must prepare a Comprehensive Nutrient Management Plan (CNMP). CNMPs identify actions that will be implemented to meet clearly defined nutrient management goals and ensure pollution prevention at CAFOs. Permit issuance for CAFOs will be addressed by priority and/or in accordance with the waterhshed schedule. There is one animal farm within the TMDL reach that is large enough to be classified as a CAFO, the Vreba-Hoff Dairy II, located northeast of sampling point LL-2A in Wright Township.

In addition, a majority of farmland in the watershed has been heavily tiled for maximum drainage, making it possible for *E. coli* to discharge to nearby waterbodies via either overland runoff or through field tiles. Animal wastes are generally sprayed or injected on the land throughout the watershed making field run-off a potential contributor of *E. coli* to Lime Creek. Despite the relatively small amount of rain (less than 0.5 inches) on July 9, 2002, one of the two highest sampling events for *E. coli* coincided with that date. One possible explanation to the extremely high concentrations is that this event was the first precipitation in the area in four weeks. These findings agree with data collected by local groups collecting independent *E. coli* data in the watershed (Kauffman, 2002).

In an additional effort to identify possible sources of *E. coli* to the TMDL watershed, the MDEQ collected two samples for Deoxyribonucleic acid (DNA) ribotyping analysis on September 17, 2002. This is the latest available technology that extracts DNA from *E. coli* isolates. After a complex process, the DNA are compared to a library of known source isolates. The results of the ribotyping analysis indicate that Lime Creek at Lime Lake Road (Lime Lake inlet), the station with the second highest overall *E. coli* concentrations, contain *E. coli* of both human and nonhuman origin (Table 3). The ribotyping results in Lime Creek at US-127 (station LL-9) indicate that at low *E. coli* levels, all sources were of nonhuman origin. In general, it appears that the lower the *E. coli* concentrations are, the less likely the sources are of human origin. Conversely, the higher *E. coli* concentrations are associated with sources of human origin.

LINKAGE ANALYSIS

The link between the *E. coli* concentrations in Lime 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 river and any needed load reductions. For this TMDL, a significant amount of the pathogen load likely enters Lime Creek by both wet and dry weather sources, such as agricultural run-off and illicit connections.

The guiding water quality management principle used to develop the TMDL was that compliance with the numeric pathogen target in Lime Creek and Prattville Drain depends on the

control of *E. coli* from illicit connections and agriculture influences. If the *E. coli* inputs can be controlled, then total body contact recreation in Lime Creek and Prattville Drain 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, *E. coli* sources to Lime Creek and Prattville Drain 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 is equal to the target concentration of 130 *E. coli* per 100 ml in all portions of the TMDL reach for each month of the recreational season (May through October).

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 waterbody. 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

At this time, there are no known permitted point source discharges to Lime Creek and Prattville Drain; therefore, the WLA is equal to zero. However, the state of Michigan has issued a general CAFO permit on December 13, 2002. A farm operation in the watershed meeting the definition of a CAFO is likely to be covered by this permit. If this occurs, then the WLA would be 130 *E. coli* per 100 ml.

LAs

Because this TMDL is concentration-based, the LA is equal to 130 *E. coli* per 100 ml. The determination of individual LAs will be based on the assumption of equal bacteria loads per unit area for all lands in 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 local unit of government in the watershed. This TMDL reach is located entirely in Wright Township.

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 thorough 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 2002, pathogens were monitored weekly at nine stations from May through August 2002. Of the stations sampled, four were on Lime Creek, four were on Lime Lake, and one was on Prattville Drain. Future monitoring will take place after the area of Prattville has been sewered and as part of the five-year basin monitoring. When 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.

In addition, a two-year Clean Michigan Initiative grant was awarded to Community Action (Project Number 480642-01) for the Lime Creek Watershed Water Quality Monitoring Project. The objective of the project is to monitor several waterbodies in Hillsdale and Lenawee Counties. There is also an on-going monitoring project by the Environmentally Concerned Citizens of South Central Michigan (ECCSCM). This group independently monitors waterbodies for *E. coli* and dissolved oxygen. The additional data collected by Community Action and ECCSCM provide a valuable screening tool for the area water quality.

REASONABLE ASSURANCE ACTIVITIES

Illicit discharges and agricultural runoff appear to be the main sources of *E. coli* to Prattville Drain and Lime Creek. The area of Prattville is scheduled to be sewered with construction proposed to begin in the summer of 2003.

The state of Michigan has issued a general NPDES permit for CAFOs. As stated previously, farms meeting the definition of a CAFO will be covered by this permit, which requires discharges to surface waters to meet WQS. In addition, the permittee must prepare a CNMP, which will identify actions designed to meet clearly defined nutrient management goals and ensure pollution prevention at CAFOs. Permit issuance for CAFOs will be addressed by priority and/or

in accordance with the waterhshed schedule. Both the CAFO permit and the CNMP program will reduce the effect of agricultural run-off, including *E. coli*, on surface waterbodies in the TMDL reach. Currently, the MDEQ is working with the one known animal feeding operation in the TMDL watershed to develop a CNMP.

Prepared by: Christine Alexander, Aquatic Biologist
Surface Water Quality Assessment Section
Water Division
Michigan Department of Environmental Quality
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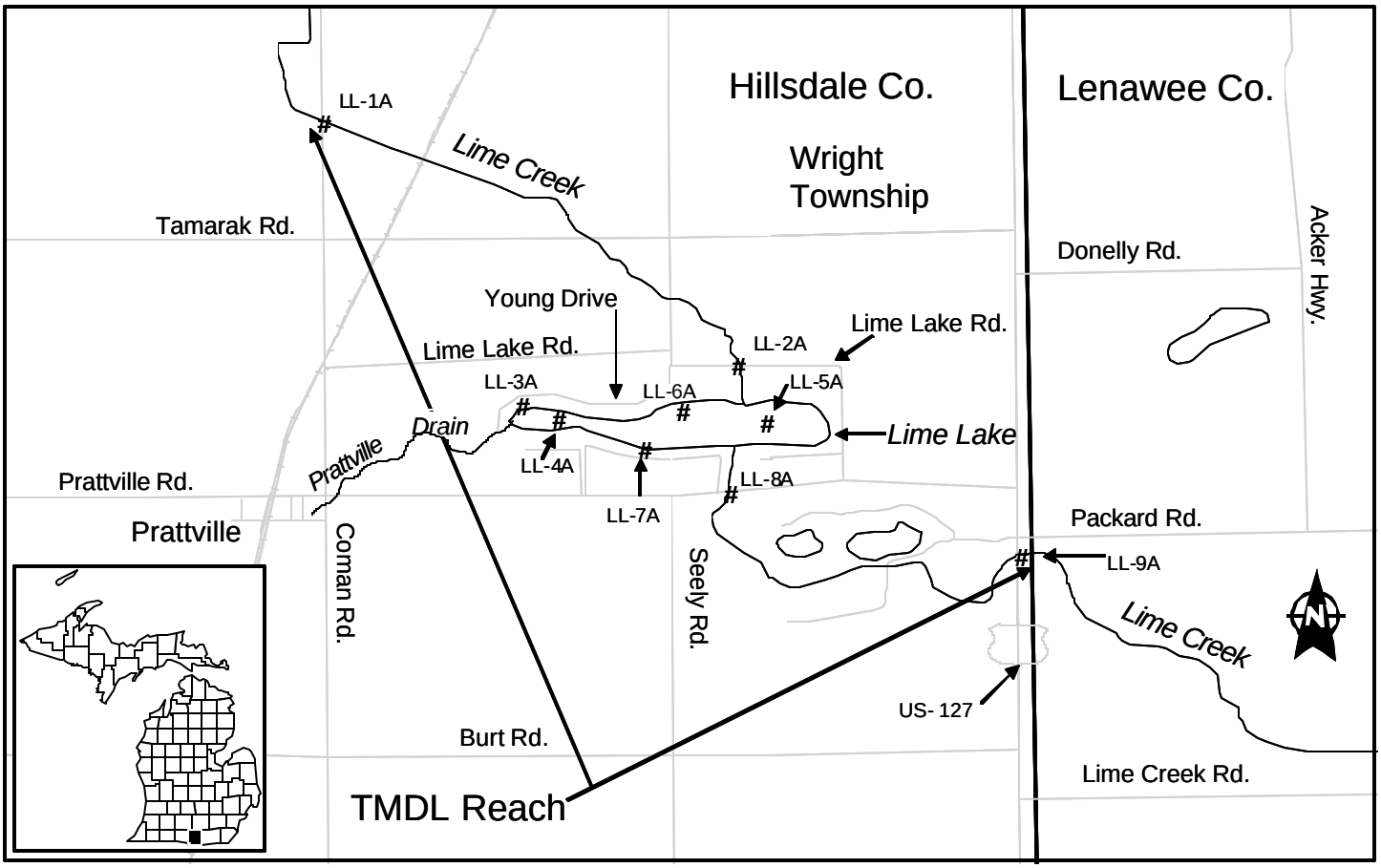


Figure 1. Prattville Drain and Lime Lake *E. coli* sampling locations, Wright Township, Michigan, 2002.

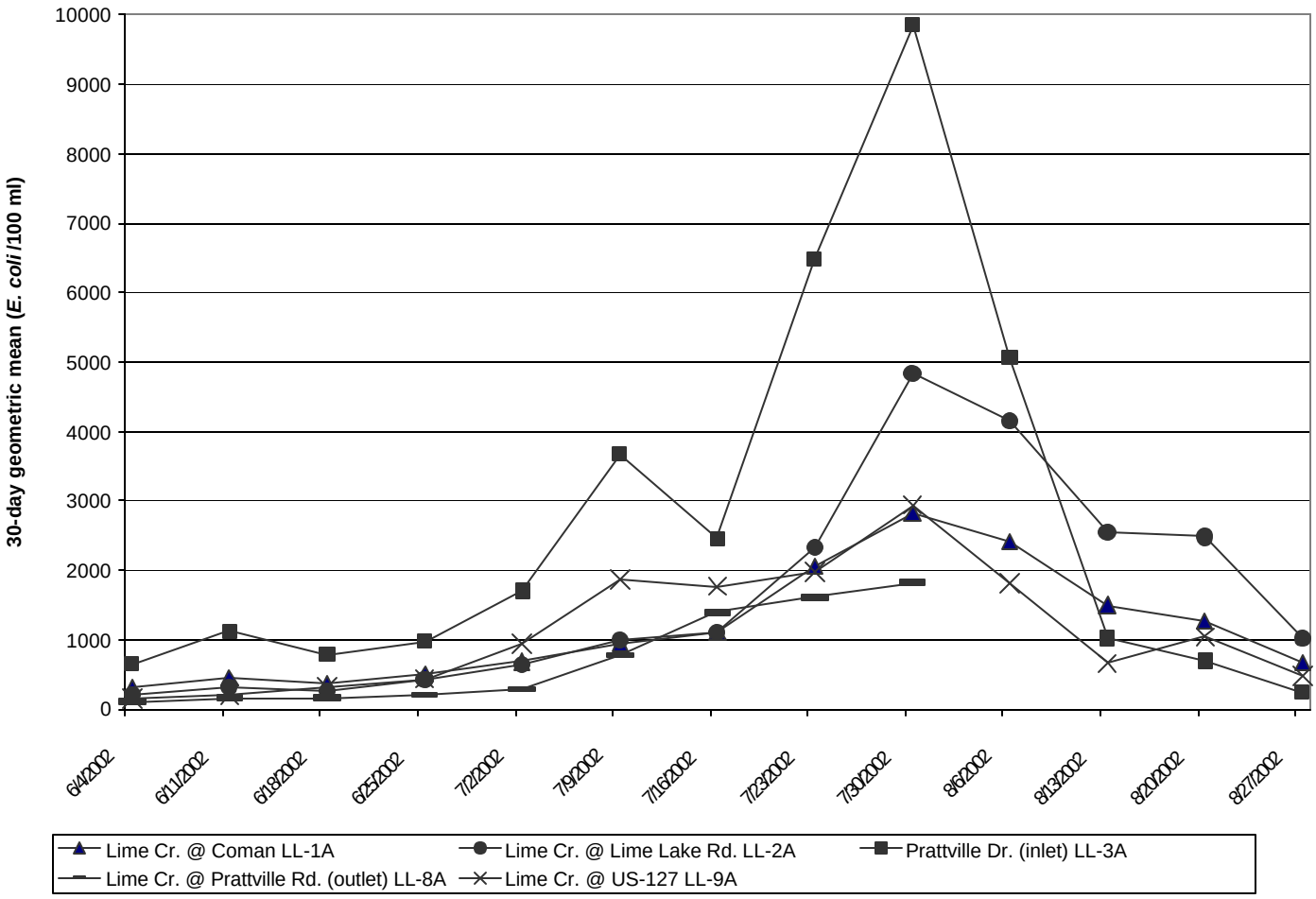


Figure 2. Thirty-day Geometric mean for *E. coli* in Lime Creek and Prattville Drain in 2002.

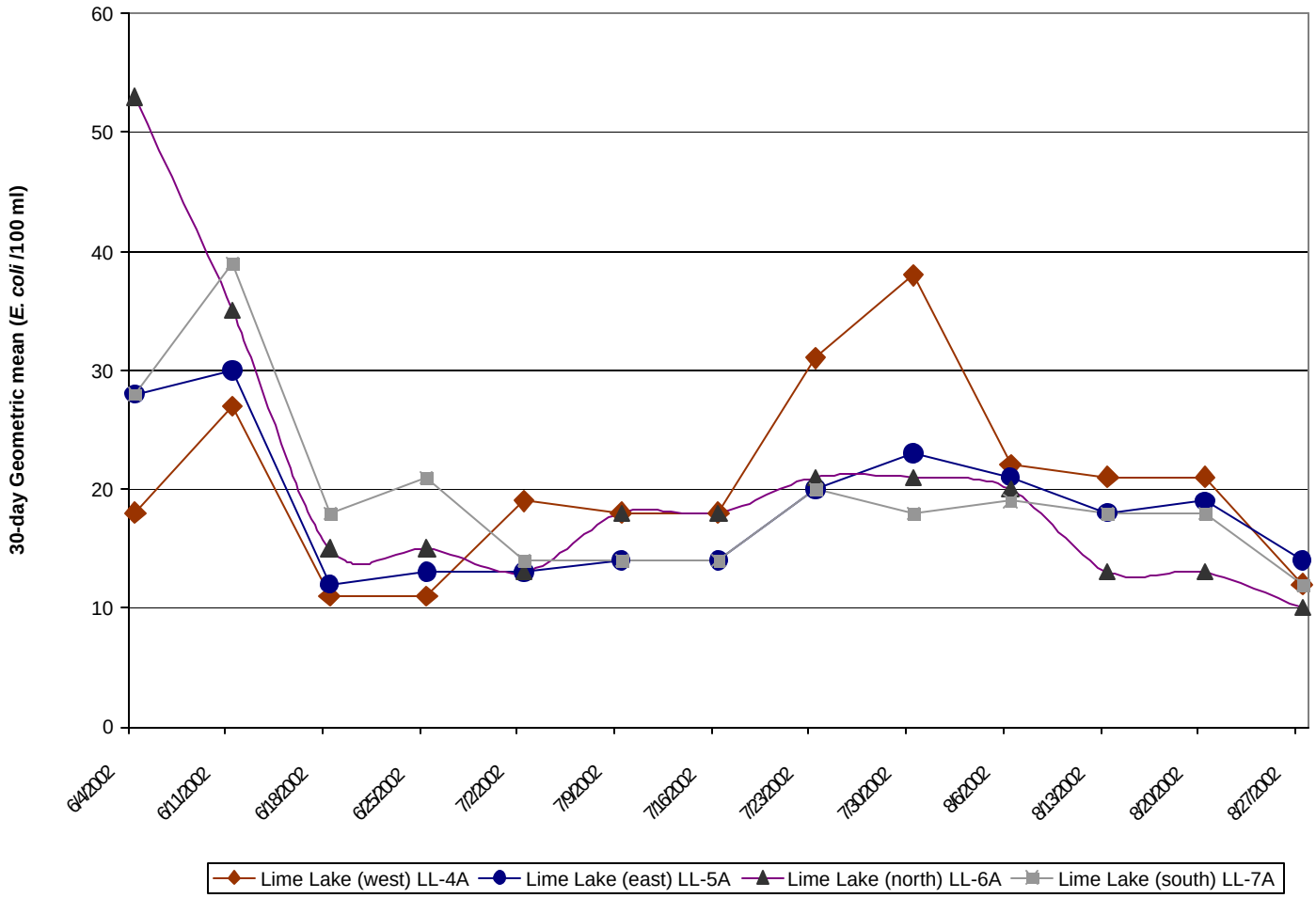
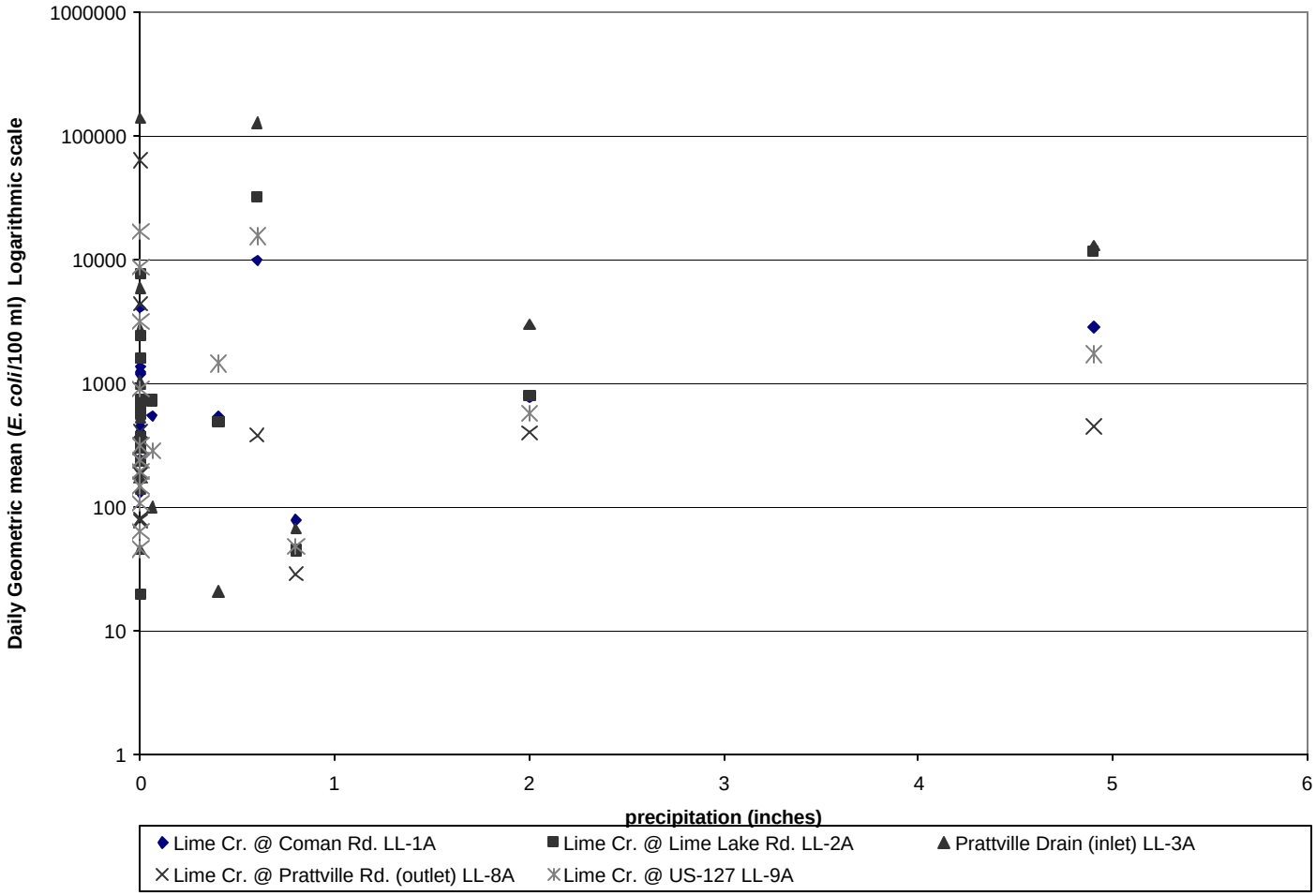


Figure 3. Thirty-day Geometric mean for *E. coli* in Lime Lake, Hillsdale County, Michigan, 2002.



*precipitation data based on a 24-hour rain event from gages located in Adrian, Michigan.

Figure 4. Daily geometric mean *E. coli* concentration vs precipitation.

Table 1. MDEQ 2002 *E. coli* monitoring data for Lime Creek (including Prattville Drain and Lime Lake)(*E. coli*/100 ml). Shaded areas indicate exceedances of the Water Quality Standard.

	Lime Creek @ Coman Rd. LL-1A			Lime Creek @ Lime Lake Rd. (inlet) LL-2A			Prattville Dr. @ Young Drive (inlet) LL-3A			
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**	**Weather data**
5/7/2002	79	79	----	52	45	----	61	67	----	foggy, 65°
	99			43			68			
	63			41			73			
5/14/2002	1200	1361	----	2100	2483	----	5400	6023	----	sunny, 65°
	1500			2700			7100			
	1400			2700			5700			
5/21/2002	60	133	----	10	20	----	100	536	----	sunny, 45°
	30			40			1100			
	1300			20			1400			
5/28/2002	200	246	----	190	235	----	740	171	----	partly cloudy, 65°
	310			110			670			
	240			620			10			
6/4/2002	860	776	307	900	810	212	3200	3047	646	overcast, 55°
	680			730			3400			
	800			810			2600			
6/11/2002	570	587	458	370	346	318	860	1043	1118	sunny, 75°
	600			340			1100			
	590			330			1200			
6/18/2002	440	456	368	910	752	251	490	1008	782	clear, 75°
	450			820			1900			
	480			570			1100			
6/25/2002	400	600	498	400	304	432	1300	1608	974	hazy, 85°
	900			350			2000			
	600			200			1600			

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

	Lime Creek @ Coman Rd. LL-1A			Lime Creek @ Lime Lake Rd. (inlet) LL-2A			Prattville Dr. @ Young Drive (inlet) LL-3A			
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**	**Weather data**
7/2/2002	1100	1195	683	1500	1594	634	4100	2787	1704	clear, 85°
	1600			2700			1600			
	970			1000			3300			
7/9/2002	6400	4104	953	8600	7744	995	150000	141780	3673	rain, 75°
	2000			7500			100000			
	5400			7200			190000			
7/16/2002	1000	1256	1110	570	569	1099	160	139	2455	clear, 80°
	1800			620			130			
	1100			520			130			
7/23/2002	7000	10027	2060	29000	32374	2332	140000	129743	6487	partly
	12000			26000			120000			cloudy, 75°
	12000			45000			130000			
7/30/2002	3000	2865	2816	12000	11657	4837	12000	12974	9849	clear, 85°
	2800			12000			14000			
	2800			11000			13000			
8/6/2002	550	548	2409	690	736	4144	70	100	5063	clear, 65°
	600			760			110			
	500			760			130			
8/13/2002	320	381	1497	660	676	2545	50	46	1017	partly
	410			640			40			sunny, 75°
	420			730			50			
8/20/2002	580	542	1266	500	499	2479	10	21	695	clear, 70°
	550			620			30			
	500			400			30			
8/27/2002	1100	404	666	440	367	1012	570	670	243	clear, 70°
	1200			350			440			
	50			320			1200			

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

	Lime Lake (west end) LL-4A			Lime Lake (east end) LL-5A			Lime Lake (north shore) LL-6A			
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**	**Weather data**
5/7/2002	2	1	----	7	8	----	72	77	----	foggy, 65°
	1			10			71			
	1			7			89			
5/14/2002	590	667	----	870	738	----	630	765	----	sunny, 65°
	800			680			710			
	630			680			1000			
5/21/2002	10	10	----	10	10	----	20	13	----	sunny, 45°
	10			10			10			
	10			10			10			
5/28/2002	10	10	----	140	24	----	10	29	----	partly
	10			10			10			cloudy, 65°
	10			10			240			
6/4/2002	10	20	18	20	13	28	40	20	53	overcast, 55°
	10			10			10			
	80			10			20			
6/11/2002	10	10	27	10	10	30	10	10	35	sunny, 75°
	10			10			10			
	10			10			10			
6/18/2002	10	10	11	10	10	12	10	10	15	clear, 75°
	10			10			10			
	10			10			10			
6/25/2002	10	10	11	10	13	13	10	13	15	hazy, 85°
	10			20			20			
	10			10			10			

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

	Lime Lake (west end) LL-4A			Lime Lake (east end) LL-5A			Lime Lake (north shore) LL-6A			
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**	**Weather data**
7/2/2002	200	136	19	40	23	13	10	14	13	clear, 85°
	50			30			10			
	250			10			30			
7/9/2002	10	14	18	10	20	14	10	93	18	rain, 75°
	10			40			10			
	30			20			8000			
7/16/2002	10	10	18	10	10	14	10	10	18	clear, 80°
	10			10			10			
	10			10			10			
7/23/2002	4600	140	31	40	50	20	50	27	21	partly cloudy, 75°
	30			40			40			
	20			80			10			
7/30/2002	100	27	38	20	29	23	10	13	21	clear, 85°
	20			30			20			
	10			40			10			
8/6/2002	10	10	22	10	13	21	10	10	20	clear, 65°
	10			10			10			
	10			20			10			
8/13/2002	10	10	21	10	10	18	10	10	13	partly sunny, 75°
	10			10			10			
	10			10			10			
8/20/2002	10	10	21	10	13	19	10	10	13	clear, 70°
	10			10			10			
	10			20			10			
8/27/2002	10	10	12	10	13	14	10	10	10	clear, 70°
	10			10			10			
	10			20			10			

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

	Lime Lake (south shore) LL-7A			Lime Creek @ Prattville Rd. (outlet) LL-8A			Lime Creek @ US-127 LL-9A			
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	Weather data
5/7/2002	2	2	----	26	29	----	46	48	----	foggy, 65°
	3			29			50			
	1			34			48			
5/14/2002	660	638	----	930	190	----	910	910	----	sunny, 65°
	690			10			900			
	570			740			920			
5/21/2002	10	10	----	130	78	----	50	46	----	sunny, 45°
	10			120			40			
	10			30			50			
5/28/2002	160	138	----	130	80	----	30	64	----	partly cloudy, 65°
	150			80			30			
	110			50			290			
6/4/2002	10	10	28	450	402	107	550	580	150	overcast, 55°
	10			400			740			
	10			360			480			
6/11/2002	10	10	39	220	239	163	200	195	198	sunny, 75°
	10			230			230			
	10			270			160			
6/18/2002	10	13	18	160	182	161	9400	8786	312	clear, 75°
	10			180			8800			
	20			210			8200			
6/25/2002	40	23	21	230	243	203	390	241	433	hazy, 85°
	10			240			90			
	30			260			400			

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

	Lime Lake (south shore) LL-7A			Lime Creek @ Prattville Rd. (outlet) LL-8A			Lime Creek @ US-127 LL-9A			
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**	**Weather data**
7/2/2002	10	16	14	400	410	281	2400	3198	948	clear, 85°
	10			420			4700			
	40			410			2900			
7/9/2002	10	13	14	73000	64337	775	16000	16943	1861	rain, 75°
	20			64000			16000			
	10			57000			19000			
7/16/2002	10	10	14	4100	4426	1389	180	150	1767	clear, 80°
	10			4700			170			
	10			4500			110			
7/23/2002	30	62	20	390	383	1612	14000	15616	1982	partly cloudy, 75°
	130			390			16000			
	60			370			17000			
7/30/2002	10	16	18	540	451	1824	1700	1733	2940	clear, 85°
	20			500			1700			
	20			340			1800			
8/6/2002	10	18	19	*	----	----	330	285	1813	clear, 65°
	30			*			260			
	20			*			270			
8/13/2002	10	10	18	*	----	----	100	107	658	partly sunny, 75°
	10			*			110			
	10			*			110			
8/20/2002	10	10	18	*	----	----	1200	1461	1037	clear, 70°
	10			*			1300			
	10			*			2000			
8/27/2002	10	10	12	*	----	----	360	313	475	clear, 70°
	10			*			370			
	10			*			230			

* data not collected due to dry conditions.

Table 2. Lime Creek average flows (cfs) at US-127, Hillsdale County, Michigan.

May	June	July	August	September	October
4.1	1.9	1.1	0.7	0.6	0.6

Table 3. Discriminant Analysis of Ribotype Profiles of *E. coli* isolates from water samples received on September 18, 2002.

Sample number Fecal coliform mpn/100 ml[2]	*E. coli* isolate number	Probability value per source[*1]	
		non-human	human
LL-2A mpn = 1,100	1 2 3 4 5	0.00 0.00 1.00 1.00 0.00	1.00 1.00 0.00 0.00 1.00
LL-9A mpn = 240	1 2 3 4 5	1.00 1.00 1.00 1.00 1.00	0.00 0.00 0.00 0.00 0.00

[*]100 times the probability value equals % probability of true sources

[1]Ribotyping analysis was performed by the method of Salina et al. 1998. Briefly, chromosomal DNA was extracted from *E. coli* isolates and digested with *Hind/III*. Fragments were separated by agarose electrophoresis. The DNA was then transferred and fixed to a Zeta-probe membrane. A cDNA probe complimentary to the *E. coli* 16S and 23S rDNA was labeled with digoxigenin-dUTP and was used to probe the membranes. The resulting genetic fingerprint was translated to a binary code based on the presence and absence of predetermined bands. The resulting binary code was then analyzed by discriminate analysis using SAS (registered) software against a vast library of known source isolates.

[2]Standard methods for the Examination of Water and Wastewater method 9223 (APAHA. 1998).