



Daily geometric means for samples collected at Allen Road (upstream of the TMDL reach) indicate WQS were being met. Additional data collected downstream of the TMDL reach at Sutton Road indicated slight exceedances of the thirty-day geometric mean in July 2001, but did not exceed the daily WQS in either year.

## NUMERIC TARGET

The impaired designated use for the River Raisin at this location 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, the 2001 and 2002 monitoring data indicated exceedances of WQS in the TMDL reach with the highest concentrations in the vicinity of the city of Clinton.

## SOURCE ASSESSMENT

The River Raisin reach addressed in this TMDL is located entirely in Clinton Township in Lenawee County (Figure 1). There are two permitted point source discharges in the listed reach of the River Raisin, the Clinton Wastewater Treatment Plant (WWTP) (MI0021661) and the Tecumseh WWTP (MI0020583). Municipalities include the village of Clinton, the city of Tecumseh, and Clinton Township.

Primary pathogen sources for this waterbody are typical of urban, and suburban land uses including storm water runoff. Secondary sources include agricultural inputs based on land use in the watershed. Monitoring data for 2001 indicate the highest exceedances appear to originate in the vicinity of Clinton and continue downstream to Staib Road (Table 1). Sampling within the impoundment (RR-6A) and directly below it (RR-6B) in the vicinity of Tecumseh, indicated the WQS were consistently met. Sampling at the downstream location of M-50, where the River Raisin has moderately high flows (Table 3), indicated random exceedances, likely from the city of Tecumseh. Further downstream at Russell Road showed only slight exceedances of the thirty-day geometric mean in 2001. Sampling below the TMDL reach at Sutton Road indicated slight exceedances of the thirty-day WQS.

As stated above, there are two permitted point source discharges to the River Raisin in the TMDL reach, the Clinton WWTP and the Tecumseh WWTP. The village of Clinton has a continuous discharge of 0.45 million gallons per day (MGD) and has a limit of 200 fecal coliform per 100 ml as a monthly average. The city of Tecumseh has a continuous discharge of 1.61 MGD and also has a limit of 200 fecal coliform per 100 ml as a monthly average. Both WWTPs 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 are 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 sources 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. Actual Discharge Monitoring Report data submitted by the village of Clinton and the city of Tecumseh indicate fecal coliform levels are below their permitted levels.

## **LINKAGE ANALYSIS**

The link between the *E. coli* concentration in the River Raisin 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, the primary loading of pathogens likely enters the River Raisin by both wet and dry weather conditions and storm water related nonpoint sources.

Based on the available sampling data, multiple locations on the River Raisin were not meeting WQS. The guiding water quality management principle used to develop the TMDL was that compliance with the numeric pathogen target in the River Raisin depends on the continued control of point source *E. coli*, the control of *E. coli* in storm water, and agricultural inputs. If the *E. coli* inputs can be controlled, then total body contact recreation in the River Raisin 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 the River Raisin 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 for the River Raisin at Russell Road 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 waterbody. Conceptually, this definition is denoted by the equation:

$$\text{TMDL} = \sum \text{WLAs} + \sum \text{LAs} + \text{MOS}$$

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

There are two permitted point source discharges of treated human sewage to the listed reach of the River Raisin, the village of Clinton (MI0021661) and the city of Tecumseh (MI0020583). As previously stated, when the WWTPs are meeting their permit 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.

### 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. As stated in the Source Assessment section, the primary sources of *E. coli* appears to be in the vicinity of the village of Clinton and the city of Tecumseh. Therefore, the relative responsibility for achieving the necessary reductions of bacteria will be focused on these two areas. The listed reach of the River Raisin is entirely in Clinton 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 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 ten stations from May through July (Figure 1). Two locations, Allen Road (RR-1A) and Tecumseh/Evans Highway (RR-6A, the impoundment) were terminated during the 2001 sampling season. Alternate locations, Tecumseh/Evans Highway (RR-6B, downstream from the impoundment) and Sutton Road (RR-1B), were added to replace them. In 2002, pathogens were monitored at eight stations from May through June.

Future monitoring is anticipated to occur after completion of activities to reduce pathogen inputs occur in the village of Clinton and the city of Tecumseh. 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.

## **REASONABLE ASSURANCE ACTIVITIES**

Under the NPDES permit program, the Clinton WWTP and the Tecumseh WWTP are responsible for meeting their effluent limits for fecal coliform. Compliance is determined based on review of Discharge Monitoring Report data by the MDEQ. As previously stated, the WWTPs are presently disinfecting their effluent and meeting their limits for fecal coliform.

If found to be applicable, municipalities mentioned above may be to the Phase II storm water permits. These permits will require activities that reduce *E. coli* inputs through the public education, storm water management plan, and illicit connection identification and elimination requirements.

In addition, the River Raisin Watershed is one of three watersheds in Michigan taking part in the Conservation Reserve Enhancement Program (CREP). The CREP is an extension of the Conservation Reserve Program (CRP), which offers farmers annual rental payments for taking agricultural lands out of production. The CREP extends the scope of the CRP program and allows the enrollment of land associated with specific conservation practices that improve water quality and wildlife habitat. Beneficial activities associated with this program include the installation of filter strips, riparian buffer strips, controlled livestock access, and wetland restoration. Once installed, these practices will aid in the reduction of *E. coli* by limiting cattle access to streams and by filtering over land runoff to the stream. Currently, there are approximately 389 contracts in the watershed that will last between 10 to 15 years.

There have also been several demonstration projects under Section 319 for the River Raisin in the past and one project currently open. The River Raisin Initiative, project #1999-0074, seeks to establish the necessary foundations to restore the River Raisin by initiating basin-wide

programs for long-term protection. Tasks of the grant include fostering community action in the watershed, the development of an information and education campaign, development of an Adopt-A-Stream program, and the implementation of Best Management Practices. Beneficial activities from Best Management Practices will likely be the reduced delivery of sediment to the River Raisin. Other practices, such as controlled livestock access and planting riparian vegetation, may also result in a reduction of *E. coli* inputs from nonpoint sources in the watershed.

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## REFERENCES

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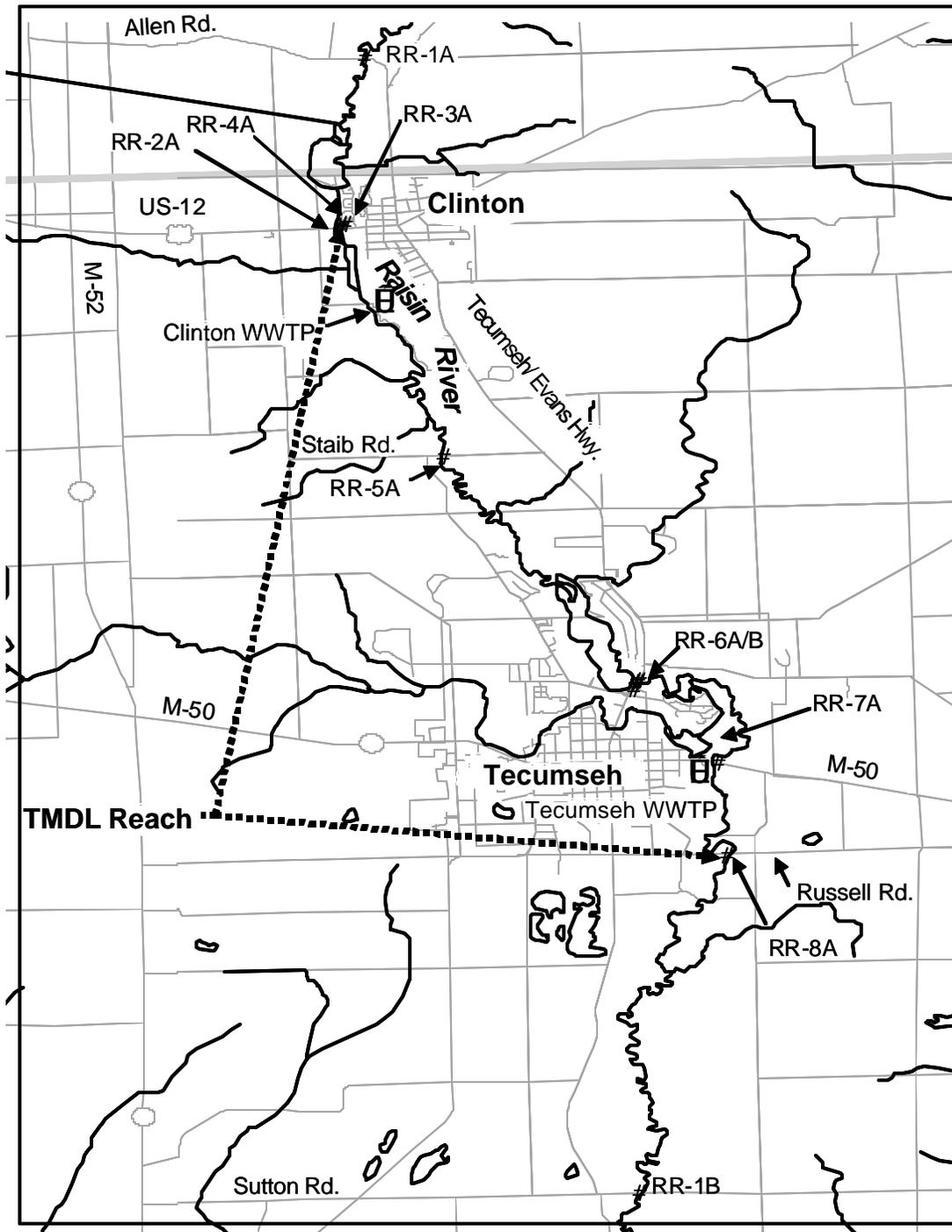


Figure 1. The River Raisin *E. coli* sampling locations, Clinton Township, Michigan, 2001-2002.

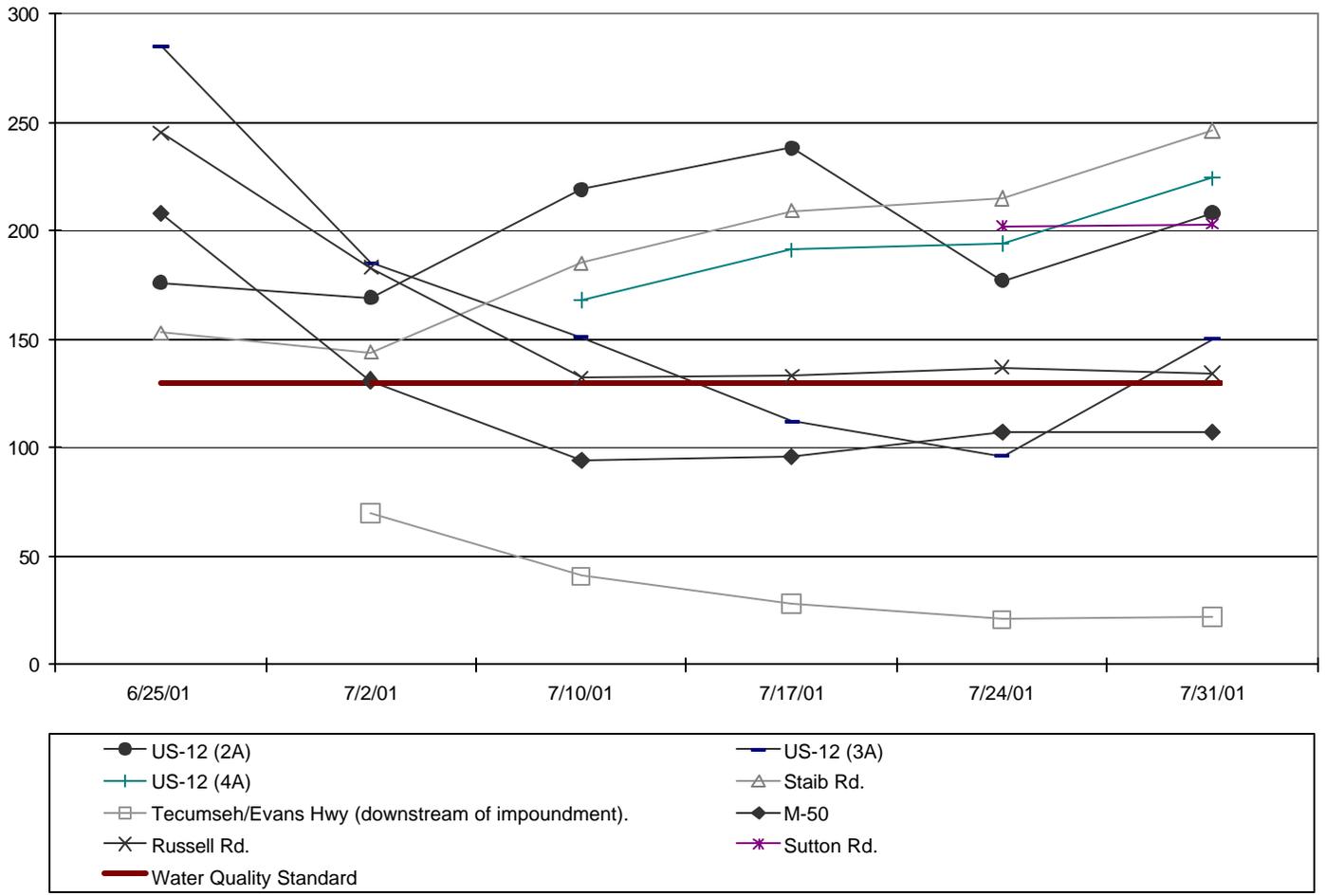


Figure 2. Thirty-day Geometric mean for *E. coli* in the River Raisin for 2001 for all stations excluding Allen Road and the impoundment at Tecumseh/Evans Highway (RR-6A).

Table 1. MDEQ 2001 *E. coli* monitoring data for the River Raisin (*E. coli*/100 ml). Shaded areas indicate exceedances of the Water Quality Standard.

DATE	Allen Rd. RR-1A			E US-12 RR-2A			E US-12 (by Waterwheel Estates) RR-3A			Weather data
	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	
5/23/2001	80	77	---	190	151	---	830	840	---	partly cloudy, mild
	70			120			820			
	80			150			870			
6/4/2001	80	94	---	140	140	---	360	256	---	overcast, cool
	130			180			310			
	80			110			150			
6/11/2001	70	88	---	70	70	---	400	316	---	sunny, warm
	110			100			110			
	90			50			720			
6/18/2001	230	203	---	17,000	749	---	60	467	---	overcast, light drizzle
	280			190			2,700			
	130			130			630			
6/25/2001	*	---	---	120	153	176	140	59	285	sunny, warm
				200			30			
				150			50			
7/2/2001	*	---	---	160	121	169	110	96	185	sunny, cool
				110			100			
				100			80			
7/10/2001	*	---	---	530	517	219	90	93	151	sunny, humid
				500			80			
				520			110			
7/17/2001	*	---	---	100	106	238	60	71	112	cloudy humid
				170			100			
				70			60			
7/24/2001	*	---	---	170	171	177	210	213	96	mostly sunny hot & humid
				210			230			
				140			200			

\* indicates a sample was not taken at this station.

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

DATE	Allen Rd. RR-1A			E. US-12 RR-2A			E. US-12 (by Waterwheel Estates) RR-3A			Weather data
	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	
7/31/2001	*	---	---	320 360 360	346	208	520 590 610	572	150	warm, humid
5/15/2002	*	---	---	60 100 100	84	---	60 180 120	109	---	sunny, 55° F
5/22/2002	*	---	---	400 20 40	68	---	60 60 80	66	---	sunny, 60°F
5/29/2002	*	---	---	80 120 140	110	---	80 100 160	109	---	overcast, 65°F
6/5/2002	*	---	---	20 20 340	51	---	200 1,200 3,000	896	---	rain, 70°F
6/12/2002	*	---	---	80 60 20	46	68	80 240 240	166	163	overcast, 70° F

\* indicates a sample was not taken at this station.

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

DATE	E. US-12 (pipe discharge) RR-4A			Staib Rd. RR-5A			Tecumseh/Evans Hwy (impoundment) RR-6A			Tecumseh/Evans Hwy (d/s impoundment) RR-6B			Weather data
	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	
5/23/2001	*	---	---	160 220 150	174	---	70 80 30	55	---	*	---	---	partly cloudy, mild
6/4/2001	*	---	---	100 90 220	126	---	*	---	---	250 250 270	256	---	overcast, cool
6/11/2001	90 80 90	87	---	110 100 130	113	---	*	---	---	120 30 90	69	---	sunny, warm
6/18/2001	140 120 130	130	---	200 190 220	203	---	*	---	---	20 50 50	37	---	overcast, light drizzle
6/25/2001	200 110 200	164	---	220 200 110	169	153	*	---	---	90 70 70	76	---	sunny, warm
7/2/2001	180 130 190	164	---	120 110 150	126	144	*	---	---	20 30 60	33	70	sunny, cool
7/10/2001	400 500 420	438	168	380 410 560	444	185	*	---	---	20 10 30	18	41	sunny, humid
7/17/2001	160 180 160	166	191	250 130 280	209	209	*	---	---	10 10 10	10	28	cloudy humid
7/24/2001	130 120 170	138	194	210 230 260	232	215	*	---	---	10 10 10	10	21	mostly sunny hot & humid

\* indicates a sample was not taken at this station.

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

DATE	E. US-12 (pipe discharge) RR-4A			Staib Rd. RR-5A			Evans Highway (impoundment) RR-6A			Evans Highway (d/s impoundment) RR-6B			Weather data
	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	
7/31/2001	370	339	224	410	331	246	*	---	---	110	87	22	warm, humid
	340			260						120			
	310			340						50			
5/15/2002	180	182	---	140	80	---	*	---	---	20	38	---	sunny, 55° F
	140			180						140			
	240			20						20			
5/22/2002	40	40	---	20	25	---	*	---	---	80	32	---	sunny, 60°F
	80			20						20			
	20			40						20			
5/29/2002	60	46	---	40	50	---	*	---	---	40	43	---	overcast, 65°F
	80			80						20			
	20			40						100			
6/5/2002	140	233	---	660	773	---	*	---	---	160	73	---	rain, 70°F
	300			1,400						120			
	300			500						20			
6/12/2002	160	68	88	20	36	78	*	---	---	40	25	39	overcast, 70° F
	20			20						20			
	100			120						20			

\* indicates a sample was not taken at this station.

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

DATE	M-50 RR-7A			Russell Rd. RR-8A			Sutton Rd. RR-1B			Weather data
	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	
5/23/2001	530	582	---	680	556	---	*		---	partly cloudy, mild
	580			460						
	640			550						
6/4/2001	560	642	---	530	638	---	*		---	overcast, cool
	740			680						
	640			720						
6/11/2001	50	68	---	110	89	---	*		---	sunny, warm
	70			80						
	90			80						
6/18/2001	90	77	---	340	118	---	*		---	overcast, light drizzle
	50			60						
	100			80						
6/25/2001	190	199	208	230	236	245	240	250	---	sunny, w arm
	180			250			240			
	230			230			270			
7/2/2001	50	58	131	160	128	183	100	103	---	sunny, cool
	50			110			110			
	80			120			100			
7/10/2001	100	118	94	140	126	132	260	299	---	sunny, humid
	110			160			250			
	150			90			410			
7/17/2001	70	79	96	50	92	133	200	200	---	cloudy humid
	100			110			200			
	70			140			200			
7/24/2001	110	131	107	140	136	137	180	217	202	sunny hot & humid
	120			150			210			
	170			120			270			

\* indicates a sample was not taken at this station.

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

DATE	M-50 RR-7A			Russell Rd. RR-8A			Sutton Rd. RR-1B			Weather data
	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	
7/31/2001	210	199	107	210	216	134	260	257	203	warm, humid
	250			200			250			
	150			240			260			
5/15/2002	260	328	---	20	106	---	380	132	---	sunny, 55° F
	340			200			300			
	400			300			20			
5/22/2002	20	29	---	40	36	---	20	42	---	sunny, 60°F
	20			60			60			
	60			20			60			
5/29/2002	40	25	---	20	20	---	20	52	---	overcast, 65°F
	20			20			60			
	20			20			120			
6/5/2002	40	75	---	20	80	---	20	32	---	rain, 70°F
	40			420			80			
	260			60			20			
6/12/2002	20	20	51	20	40	48	60	36	51	overcast, 70° F
	20			40			20			
	20			80			40			

\* indicates a sample was not taken at this station.

Table 3. River Raisin average flows (cfs) at M-50, vicinity of Tecumseh, Michigan.

<b>May</b>	<b>June</b>	<b>July</b>	<b>August</b>	<b>September</b>	<b>October</b>
180	92	55	47	58	74