

Michigan Department of Natural Resources and Environment
Water Resources Division
September 2010

Total Maximum Daily Load for *E. coli* for
Three Mile Creek and Holly Drain
Shiawassee 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, 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 Three Mile Creek, Holly Drain, and tributaries, located in Shiawassee County, Michigan (Figure 1).

PROBLEM STATEMENT

This TMDL addresses the listing that appears on the 2008 Section 303(d) list (LeSage and Smith, 2008) as:

THREE MILE CREEK

County: SHIAWASSEE

Location: Three Mile Creek

Use impairments: Total and partial body contact recreation.

Cause: *E. coli*

Source: Illicit connections to storm sewers.

TMDL Year(s): 2010

AUID: 040802030203-02

SIZE: 11.07 M

HOLLY DRAIN

County: SHIAWASSEE

Location: Burns and Vernon Drain, Holly Drain, Mikan Drain Unnamed Tributaries to Burns and Vernon Drain and Unnamed tributaries to Holly Drain

Use impairments: Total and partial body contact recreation.

Cause: *E. coli*

Source: Illicit connections to storm sewers.

TMDL Year(s): 2010

AUID: 040802030203-03

SIZE: 20.63 M

Three Mile Creek and Holly Drain are small tributaries in the Shiawassee River watershed, located in south central Michigan. Both water bodies were first placed on the Section 303(d) list in 2002 due to impairment of recreational uses by *E. coli* (Creal and Wuycheck, 1998). Illicit sewage discharges (i.e., untreated gray water and/or human sewage) have been documented in both Three Mile Creek and Holly Drain for many years (Paez and Gatzke, 2004). Sampling performed in 2000 by the Michigan Department of Natural Resources and Environment (DNRE) (formerly the Michigan Department of Environmental Quality) also documented elevated *E. coli* concentrations (Davidson, 2001). Monitoring data collected by the DNRE in 2007 documented multiple exceedances of the total body contact (TBC) and partial body contact (PBC) daily

maxima and TBC 30-day geometric mean WQS for *E. coli* during the TBC recreational season of May 1 through October 31 (Tables 1-3; Figures 2-9).

NUMERIC TARGET

The impaired designated uses addressed by this TMDL are TBC and PBC recreation. The designated use rule (Rule 100 [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 TBC recreation from May 1 through October 31 and PBC recreation year-round. The target levels for these designated uses 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.

Rule 62. (2) All surface waters of the state protected for partial body contact recreation shall not contain more than a maximum of 1,000 *E. coli* per 100 ml. 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.

The target for sanitary wastewater discharges is:

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 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.

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 maximum to protect the TBC use are the target levels for the TMDL reach from May 1 through October 31, and 1,000 *E. coli* per 100 ml as a daily maximum year-round to protect the PBC use.

DATA DISCUSSION

Stream Discharge Data

Stream discharge is used to assess potential sources of *E. coli* as described in the Source Assessment section. Stream discharge data for Three Mile Creek and Holly Drain were not available; therefore, stream flows were obtained from The United States Geological Survey (USGS) gauge located on Deer Creek near Dansville, Michigan (Gauge #4111500). Flows from this gauge were used to estimate flows in the TMDL watersheds and were chosen due to similar geology. The period of record for the gauge is 56 years.

Stream discharge for the TMDL watershed was developed using the drainage area ratio (DAR) method. DAR is a simple, widely used analytical approach to developing discharge for ungauged watersheds/sites using discharge data from gauged watersheds. This method assumes flow is proportional to drainage area and is defined in the following equation:

$$DAR = \frac{A_{\text{ungauged}}}{A_{\text{gauged}}}$$

Where:

A_{ungauged} = Area of ungauged watershed/site

A_{gauged} = Area of gauged watershed/site

Using the DAR method, discharge can be estimated for ungauged watersheds/sites using the following equation:

$$Q_{\text{ungauged}} = DAR \times Q_{\text{gauged}}$$

Where:

DAR = Drainage Area Ratio

Q_{gauged} = Discharge at gauged watershed/site

Q_{ungauged} = Discharge at ungauged watershed/site

The DAR method is most reliable when land use characteristics of the ungauged and gauged watersheds are similar.

Monitoring Data

Weekly *E. coli* data were collected by the DNRE from ten sites in Three Mile Creek, Holly Drain, and select tributaries from August 23 to October 24, 2007 (Figure 1). Precipitation data for the two days prior to each DNRE sampling event were obtained from a weather station located in Corunna, Michigan (National Oceanic and Atmospheric Administration, 2010). *E. coli* daily maximum and 30-day geometric mean data for 2007 are shown in Tables 1-3.

Three Mile Creek and Fullmer Drain

The highest daily maximum *E. coli* concentration observed in Three Mile Creek was 10,619 *E. coli* per 100 mL, recorded at Station TMC-4 (New Lothrop Road) on September 26, 2007, following a rainfall of 0.5 inches. The daily maximum TBC standard (300 *E. coli* per 100 mL) was exceeded at Station TMC-1 on 70 percent of sampling dates, at Station TMC-2 on 60 percent of sampling dates, at Station TMC-3 on 90 percent of sampling dates, and at Station TMC-4 on 90 percent of sampling dates. The 30-day geometric mean TBC standard (130 *E. coli* per 100 mL) was exceeded at all stations 100 percent of the time. The PBC recreation daily maximum standard (1,000 *E. coli* per 100 mL) was exceeded at Station TMC-1 on 40 percent of sampling dates, at Station TMC-2 on 20 percent of sampling dates, at Station TMC-3 on 60 percent of sampling dates, and at Station TMC-4 on 30 percent of sampling dates.

The highest daily maximum *E. coli* concentration observed in Fullmer Drain (Station TMC-5) was 7,286 *E. coli* per 100 mL on August 23, 2007, after 1.4 inches of rain. Fullmer Drain exceeded the daily maximum TBC standard on 80 percent of sampling dates while the 30-day

geometric mean TBC was exceeded 100 percent of the time. The PBC recreation maximum standard was exceeded on 40 percent of sampling dates.

Holly Drain and Mikan Drain

The highest daily maximum *E. coli* concentrations observed on Holly Drain was 25,814 *E. coli* per 100 mL and was recorded at Station TMC-9 (Bennington Road) on August 23, 2007, following a rainfall of 1.4 inches. The daily maximum TBC standard (300 *E. coli* per 100 mL) was exceeded at Station TMC-6 on 90 percent of sampling dates, at Station TMC-7 on 80 percent of sampling dates, at Station TMC-8 on 100 percent of sampling dates, and at Station TMC-9 on 80 percent of sampling dates. The 30-day geometric mean TBC standard (130 *E. coli* per 100 mL) was exceeded at all stations 100 percent of the time. The PBC recreation daily maximum standard (1,000 *E. coli* per 100 mL) was exceeded at Station TMC-6 on 20 percent of sampling dates, at Station TMC-7 on 20 percent of sampling dates, at Station TMC-8 on 50 percent of sampling dates, and at Station TMC-9 on 20 percent of sampling dates.

The highest daily maximum *E. coli* concentration observed in Mikan Drain (Station TMC-10) was 24,085 *E. coli* per 100 mL on August 23, 2007, after 1.4 inches of rain. Mikan Drain exceeded the daily maximum and 30-day TBC standards on 100 percent of sampling dates. The PBC recreation maximum standard was exceeded on 90 percent of sampling dates.

Bacterial Source Tracking

Two samples, one each from Stations TMC-3 (Three Mile Creek at Newburg Road) and TMC-10 (Mikan Drain at Newburg Road), were collected for bacterial source identification. The samples were collected on October 11, 2007, and were analyzed for fecal *Bacterioidetes* human gene biomarker by polymerase chain reaction. Station TMC-3 tested positive for the human gene biomarker while Station TMC-10 tested negative. The positive result at Station TMC-3 indicates that on October 11, 2007, the water sample collected was contaminated by human fecal material. Since *Bacterioidetes* are strict anaerobes and cannot survive extended periods of time outside the human host, the detection of this biomarker indicates recent, or nearby, fecal pollution. It is worth noting that there was no precipitation associated with the samples collected on October 11, 2007, indicating the human source of *E. coli* likely originates from a dry weather source (i.e., illicit connection, etc.). It should be noted that the negative result at Station TMC-10 does not necessarily mean that human contamination was not present; rather, it was not present in that particular sample.

SOURCE ASSESSMENT

Predominant land uses in the TMDL watershed are cultivated row crop (42.5 percent) followed by pasture/hay (25.9 percent) (USGS, 2000) (Table 4, Figure 10). There are seven municipalities in the watershed; Vernon Township makes up the largest percentage (65 percent) (Table 5). Potential sources of *E. coli* include failing on-site septic systems, illicit connections to community storm sewers and drains, pasture land runoff, manure spreading, and wildlife.

There are nine National Pollutant Discharge Elimination System (NPDES) permitted discharges to the TMDL reach, including two individual permits, five Certificates of Coverage (COC) under the General Industrial Storm Water permit, and two COCs under the General Wastewater Stabilization Lagoon permit (Table 6). There are no Concentrated Animal Feeding Operations in the watershed.

Three Mile Creek and Fullmer Drain

Many homes in the Three Mile Creek watershed are outside the city limits of Durand and a municipal sanitary sewer system is not currently available. Homeowners must rely on individual on-site septic systems for sanitary waste treatment. For a variety of reasons (e.g., age of the system, poor construction/maintenance, clay soils, etc.), many of these systems are failing and have been a significant source of *E. coli* to Three Mile Creek for many years. Recognizing that septic system failures in Vernon Township contribute to elevated *E. coli* concentrations in the city of Durand, numerous efforts have been taken by the city of Durand, Vernon Township, the Shiawassee County Health Department (SCHD), and the DNRE to address this issue. For instance, the SCHD conducted storm sewer outfall sampling in Vernon Township, near the southeast city limits of Durand, from 1999 to 2003. Data indicate concentrations of *E. coli* several orders of magnitude above the TBC recreation standard (Paez and Gatzke, 2004). The SCHD used Deoxyribonucleic acid analysis to determine whether the source of *E. coli* was of human or animal origin. Results indicate *E. coli* of human origin were found at two locations (Martin Drain and Genesee Drain) while *E. coli* of animal origin was found in Hampton Drain. Evidence of human sources of *E. coli* were found again in 2007 when sampling by the DNRE detected the presence of the fecal *Bacteroidetes* human gene biomarker at Station TMC-3, which is in close proximity to the Martin and Genesee Drains discussed above.

The persistent *E. coli* problems in Three Mile Creek prompted the SCHD to enact a special septic system ordinance in Sections 9, 10, 11, 14, 16, 21, and 22 of Vernon Township (Figure 1). Many septic systems located in these sections are known to be failing and, when replaced, must meet more stringent design requirements than systems allowed in neighboring sections. The SCHD also has enacted a point of sale ordinance in an effort to find and correct improperly operating or failing septic systems when homes change owners. Eight years of data collected by the SCHD indicate that approximately 25 percent of septic systems in Shiawassee County are in 'nonconformance' with the county ordinance (it should be noted that 'nonconformance' includes a broader category of septic system deficiencies that may not all directly contribute *E. coli* to Three Mile Creek [Johnson, 2010]). The chronic septic system failure situation also resulted in a Notice of Violation letter to Vernon Township in 2003 by the DNRE (Benton, 2003).

Agricultural land uses make up a majority of the watershed and, depending on land practices, are another source of *E. coli*. According to the 2007 Census of Agriculture, there are approximately 16,000 cattle, 2,200 hogs, 1,214 sheep, and 2,700 laying chickens living in Shiawassee County (United States Department of Agriculture, 2007). Land application of manure to tiled fields can be a significant source of *E. coli* via tile discharge, especially during precipitation events (Roger and Hanes, 2005; Monaghan and Smith, 2004). Likewise, overland runoff from manure application to fields adjacent to surface waters and animal access to surface waters is an additional source of *E. coli*. While conducting a watershed survey for the Mid-Shiawassee River Watershed Planning Project (2008), the Shiawassee County Conservation District noted horse access to Three Mile Creek near Station TMC-1.

Illegal dumping of trash containing pet wastes (such as cat litter or dog feces) and human waste (such as soiled diapers) can contribute to *E. coli* in surface water bodies. Foul smelling trash was noted at Station TMC-3 by the staff of the Shiawassee County Conservation District.

Holly Drain and Mikan Drain

The Holly Drain, and its tributary Mikan Drain, is impacted by failing on-site septic systems in rural areas similar to those described in the Three Mile Creek watershed above (Paez and Gatzke, 2004). Much of the Holly Drain watershed is included in the SCHD septic system ordinance that requires specific design requirements to protect public health and reduce *E. coli* impacts to nearby surface waters. Persistently high *E. coli* concentrations were observed in Mikan Drain at Station TMC-10 (Newburg Road). While *E. coli* at this station increases dramatically (e.g., greater than 24,000 *E. coli* per 100 mL) during precipitation events, consistent exceedances under low flow conditions suggest an illicit connection to the drain. DNRE source identification sampling on October 11, 2007, did not detect the fecal *Bacteroidetes* human gene biomarker; however, further sampling would be required to definitively say *E. coli* of human origin is not present at this location.

The city of Durand is in the process of addressing sanitary sewer overflows (SSOs) as a result of excess inflow and infiltration to their sanitary sewer system. An SSO is a release of raw or partially treated sewage from a sanitary sewer collection system that is designed to carry only sanitary waste. Overflows, or releases, occur when additional water (i.e., storm water or groundwater) enters the system and exceeds the capacity. According to DNRE records, there were no SSO events during the 2007 sampling period (DNRE, 2010); however, illicit sanitary connections from homes or businesses to the storm sewer system are a probable source of *E. coli* to Holly Drain. Manhole and storm drain sampling data collected by the SCHD from 1999 to 2003 indicate significant *E. coli* concentrations in the storm sewer system, which ultimately outlet to Holly Drain.

The village of Vernon is currently correcting problems with their wastewater stabilization lagoons (WWSLs) and excess infiltration to their storm sewer system. The excess flows in the sewer system have resulted in capacity problems in the village lagoons resulting in leakages and unauthorized discharges to Holly Drain. The WWSL problems have been a historic source of *E. coli* to Holly Drain.

Holly Drain is also heavily impacted by agricultural land uses. As described for Three Mile Creek above, certain agricultural practices can directly impact *E. coli* concentrations in surface waters. The highest daily geometric mean *E. coli* concentrations – from 16,000 to greater than 25,000 *E. coli* per 100 mL – were observed in Holly Drain in response to rain events. Particularly noteworthy are the WQS exceedances observed in Mikan Drain. DNRE field reviews in 2007 noted animal manure near Station TMC-10 (Newburg Road) and the Shiawassee County Conservation District field notes observed strong manure odors at this location during their 2009 field reconnaissance. In addition, the application of slaughterhouse waste (i.e., animal blood and wash down wastewater from animal processing) in the watershed is another potential source of *E. coli*.

DNRE staff observed trash in McLean Drain downstream of the city of Durand and upstream of Station TMC-8 (Vernon Road). Similarly, grass clippings laden with dog waste were also observed near this station by the Mid-Shiawassee River Watershed Planning Project (2008). Dumping trash containing fecal material in or near surface waters can substantially increase *E. coli* concentrations.

Load Duration Curve Analysis

To assist in determining potential sources of *E. coli* to the Three Mile Creek and Holly Drain TMDL watershed, a load duration curve analysis was developed for each sampling station as outlined by Cleland (2002). A load duration curve considers how flow conditions relate to a variety of pollutant sources (point and nonpoint sources). Data points above the curve on the

left side of the figures indicate exceedances of the daily target during higher flows (i.e., wet weather) while data points above the curve on the middle and right side of the figures indicate exceedances of the daily target under mid to low flow conditions (i.e., dry weather).

As discussed in the Data Discussion section, a ratio of the drainage area of the TMDL watersheds to the drainage area of the gauged watershed was calculated for each sample location. The load duration curves and associated drainage area ratios for each station sampled in the TMDL watersheds are included in Figures 11-20. The curves were generated by applying the drainage area ratios to gauged flows for the period of record (i.e., 56 years).

The load duration curves indicate that all sampling was conducted under mid range to dry flow conditions (shown by data points on the right side of Figures 11-20). Exceedances during drier flow conditions, as indicated by data points above the curve, generally indicate that sources of *E. coli* are not directly related to precipitation events (i.e., runoff). The most likely sources of *E. coli* during dry weather are constant sources, such as failing septic systems, animals with direct access to the water body, and illicit connections of sewage sources to surface water bodies throughout the watershed. It is important to note that while the load duration curves indicate overall dry weather sources, the highest *E. coli* concentrations observed at all stations occurred during mid range flows following a rain event of 1.4 inches on August 23, 2007.

LOADING CAPACITY (LC) DEVELOPMENT

The LC 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 TBC 30-day geometric mean WQS of 130 *E. coli* per 100 mL, daily maximum of 300 *E. coli* per 100 mL, and the PBC daily maximum WQS of 1000 *E. coli* per 100 mL. Concurrent with the selection of a numeric concentration endpoint, development of the LC requires identification of the critical condition. The “critical condition” is defined as the set of environmental conditions (e.g., flow) used in development of the TMDL that result in attaining WQS and have an acceptably low frequency of occurrence.

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). Therefore, this pathogen TMDL is concentration-based, consistent with R 323.1062, and the TMDL is equal to the TBC target concentrations of 130 *E. coli* per 100 mL as a 30-day geometric mean and daily maximum of 300 *E. coli* per 100 mL in all portions of the TMDL reach for each month of the recreational season (May through October). Year round protection is achieved with the partial body contact target concentration of 1000 *E. coli* per 100 mL as a daily maximum. 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.

LC

The LC is 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 LC 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:

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

The LC represents the maximum loading that can be assimilated by the receiving water while still achieving WQS. Because this TMDL is concentration-based, the total loading for this TMDL is equal to the TBC WQS of 130 *E. coli* per 100 mL as a 30-day geometric mean and 300 *E. coli* per 100 mL as a daily maximum during the recreation season, and PBC WQS of 1000 *E. coli* per 100 mL as a daily maximum for the remainder of the year.

WLAs

The WLAs for the facilities listed in Table 6 are equal to 130 *E. coli* per 100 mL as a 30-day geometric mean and 300 *E. coli* per 100 mL as a daily maximum during the recreational season between May 1 and October 31, and 1000 *E. coli* per 100 mL as a daily maximum year-round.

LAs

Because this TMDL is concentration-based, the LA is also equal to 130 *E. coli* per 100 mL as a 30-day geometric mean and 300 *E. coli* per 100 mL as a daily maximum during the recreational season and 1000 *E. coli* per 100 mL as a daily maximum year-round. 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 (Table 4). Seven municipalities have land area within the Three Mile Creek and Holly Drain TMDL watershed.

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 the load and WLAs and water quality in this TMDL. 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 proportion of the loadings). The application of the TBC WQS of 130 *E. coli* per 100 mL as a 30-day geometric mean and 300 *E. coli* per 100 mL as a daily maximum during the recreational season, and the PBC WQS of 1000 *E. coli* per 100 mL as a daily maximum year-round for the WLA and LA is a conservative approach because there is no uncertainty as to whether or not the WQS will be met at the source or within the receiving water. Therefore, this TMDL uses an implicit MOS.

SEASONALITY

The WQS for *E. coli* are expressed in terms of seasons, e.g., TBC from May 1 through October 31 and PBC year-round. Allocations and controls developed for the more protective TBC season are also expected to assure attainment of the daily maximum PBC WQS of 1000 *E. coli* per 100 mL, year-round. Because this is a concentration-based TMDL, WQS must be met regardless of flow conditions in the applicable season.

REASONABLE ASSURANCE ACTIVITIES

The Michigan Department of Transportation municipal separate storm sewer permit requires that, if a TMDL has been established by the DNRE, the permittee must develop, implement and enforce storm water controls designed to meet the permittee's responsibilities established in the TMDL.

The Durand Wastewater Treatment Plant (WWTP) and the three WWSLs identified in Table 6 are required to meet their NPDES permit limits. Michigan regulates discharges containing

treated or untreated human waste (i.e., sanitary wastewater) using fecal coliform as the indicator. Sanitary wastewater discharges are required to meet 200 fecal coliform per 100 mL as a monthly average and 400 fecal coliform per 100 mL as a maximum. Michigan's WQS for *E. coli* are based upon criteria in the USEPA's 1986 criteria document (USEPA, 1986). Specifically, the USEPA criterion of 126 *E. coli* per 100 mL is the basis for Michigan's TBC WQS of 130 *E. coli* per 100 mL. This criterion is intended to provide a level of protection of producing no more than 8 illnesses per 1,000 swimmers and approximates the degree of protection provided by the fecal coliform indicator of 200 fecal coliform per 100 mL bacteria standard recommended by the USEPA prior to the adoption of the 1986 criteria. The sanitary discharges are expected to be in compliance with the ambient PBC and TBC *E. coli* WQS if their NPDES permit limits for fecal coliform are met. All WWTPs provide year-round disinfection, providing another level of confidence that the WQS for *E. coli* will be met. According to DNRE discharge monitoring reports, the Durand WWTP and all three WWSLs are currently in compliance with the NPDES permit limits for fecal coliform.

The general industrial storm water permit (MIS210000) listed in Table 6 specifies that if a TMDL is established by the DNRE for a receiving water which restricts the discharge of any of the identified significant materials or constituents of those materials, then the Storm Water Pollution Prevention Plan shall identify the level of control for those materials necessary to comply with the TMDL and an estimate of the current annual load of those materials via storm water discharges to the receiving stream. In addition, storm water permit authorization requires facilities to obtain a certified operator who will have supervision and control over the control structures at the facility, eliminate any unauthorized non-storm water discharges, and develop and implement a storm water pollution prevention plan for the facility. The plan must include structural and nonstructural control measures.

The city of Durand is under an amended Administrative Consent Order with the DNRE to upgrade their sanitary sewer collection system (DNRE, 2009). Significant improvements are ongoing and include lining the existing sewer pipes and a home footing drain elimination plan, which will reduce excess infiltration to the sanitary sewer system (which leads to less frequent SSOs). Durand has inspected 80 percent of residences and businesses and found 350 illicit connections to the sanitary sewer system. To date, 90 percent of identified connections have been repaired. Durand has also inspected 100 percent of their 420 manholes to make necessary corrections to prevent excess water from entering the system. In addition to identifying illicit connections to the sanitary sewers, the city has identified several sanitary sewer connections to storm drains and failed septic systems (C2AE, 2010). Collectively, these upgrades will eliminate future raw sewage releases to Holly Drain by preventing storm water from entering the sanitary sewer system.

The village of Vernon is under an Administrative Consent Order with the DNRE to upgrade their WWSLs (DNRE, 2007). Upgrades include relining three existing lagoons to prevent future leakage and the construction of a fourth lagoon to address capacity problems. The additional lagoon is expected to be complete by September 2010, while efforts to reline the original three lagoons should be complete by September 2011. The efforts of the village are expected to prevent *E. coli* from their WWSLs from entering Holly Drain.

The SCHD has been very proactive in trying to address known septic system failures within the township. Past projects include an illicit connection detection and elimination project in Three Mile Creek and Holly Drain that help to identify problem areas in the municipalities and develop recommendations for future actions. They have also collected numerous years of *E. coli* data and partnered with local municipalities to eliminate sources of *E. coli*. As discussed in the Source Assessment section, the SCHD enacted a septic system ordinance in select sections of Vernon Township known to have septic system failures. When these systems are replaced, they must meet more stringent design requirements to eliminate sources of *E. coli* in the TMDL.

watershed. Finally, the SCHD (2009) is one of a select few county health departments in the state that has instituted a point of sale program. This program has resulted in approximately 2,400 point of sale home inspections with 7 percent of those requiring correction (Johnson, 2010).

Finally, the DNRE has invested a significant amount of time and resources over many years working with the local municipalities to correct ongoing water quality problems noted in the TMDL watershed. One of those efforts includes finding an economically feasible way to extend a municipal sewage system to areas with known *E. coli* problems.

A Section 319 watershed restoration project grant (#2009-0012) has been awarded to the Shiawassee County Conservation District for activities in the mid-Shiawassee River watershed, which includes Three Mile Creek and Holly Drain. Project objectives include the development of an updated watershed management plan, implementation of an information and education strategy, and the development of conservation plans for future implementation funding. Specific actions that will help reduce *E. coli* include the use of the Home*A*Syst and Farm*A*Syst Programs in the TMDL watershed. These programs are confidential self-assessments that homeowners can use to evaluate homes and property for pollution and health risks (Michigan State University Extension, 2010a; 2010b). The assessments will be used to educate residents in the TMDL watershed (and larger grant project area) on proper septic system care, illicit septic connections, and proper management of animal waste on farms. The Home*A*Syst packets will be distributed to residents who apply for septic system permits, when septic haulers pump individual septic tanks, and to plumbers and water softener companies. The grantees have also completed extensive reconnaissance of the watershed by walking each stream and tributary to identify problem areas and recommend follow-up action. The partners in this grant routinely refer water quality problems to the appropriate agency. For example, horse access to Three Mile Creek, near Station TMC-1, is being addressed by the grantee by working directly with the land owner(s) to provide an alternate source of drinking water for their horses. Finally, DNRE staff are collaborating with the grantee on approaches to address the various sources of nonpoint source pollution in the TMDL watershed. Discussion items include evaluating specific cropping practices in the TMDL watershed and the possibility of spring *E. coli* monitoring.

MONITORING

Future monitoring will take place as part of the five-year rotating basin monitoring, as resources allow, once actions have occurred to address sources of *E. coli*. When these results indicate that the water body 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 and daily maximum values of 300 *E. coli* per 100 ml and 1000 *E. coli* per 100 ml are being met.

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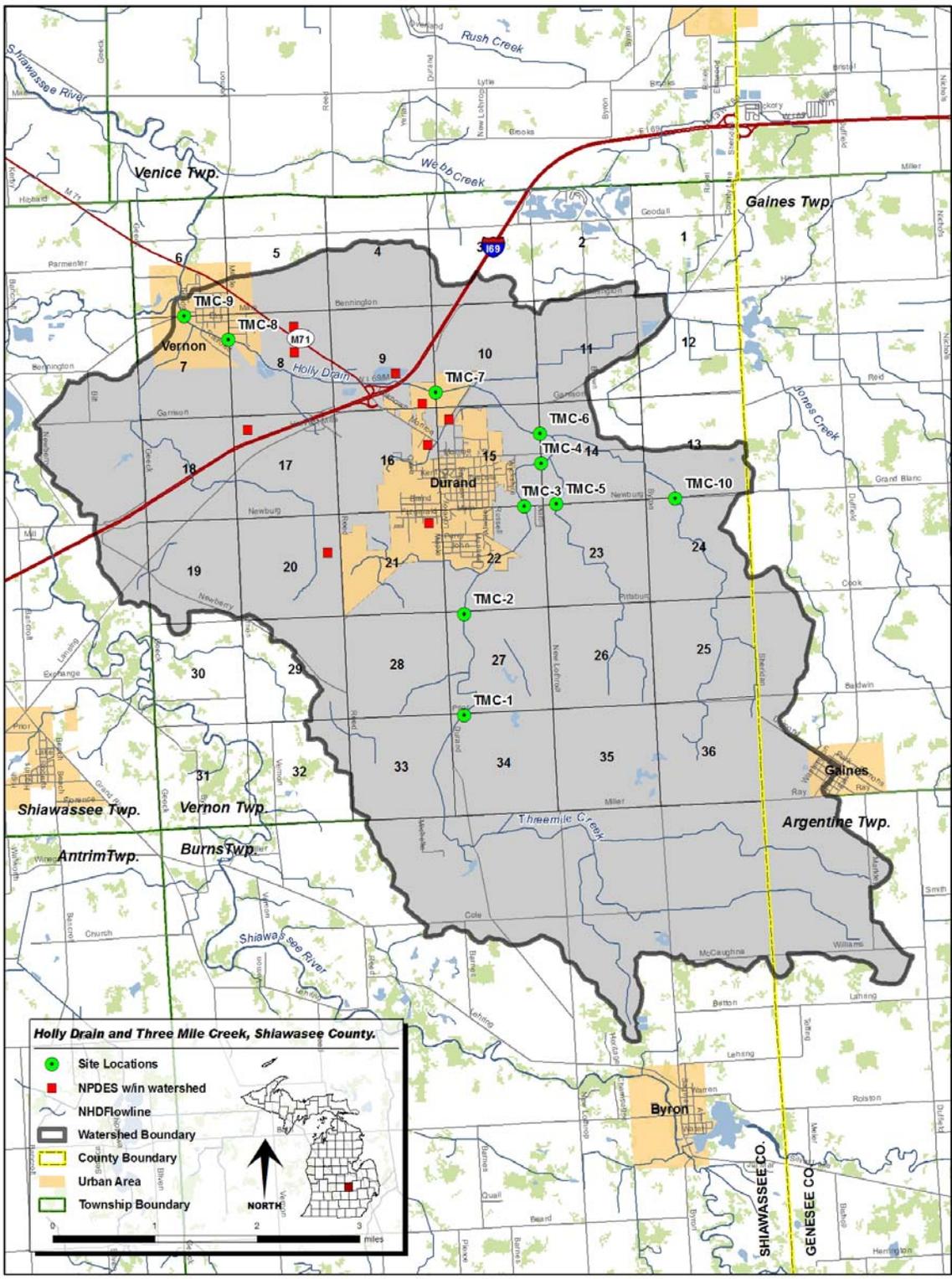


Figure 1. Three Mile Creek and Holly Drain TMDL monitoring sites and NPDES permitted facilities, Shiawassee County, Michigan.

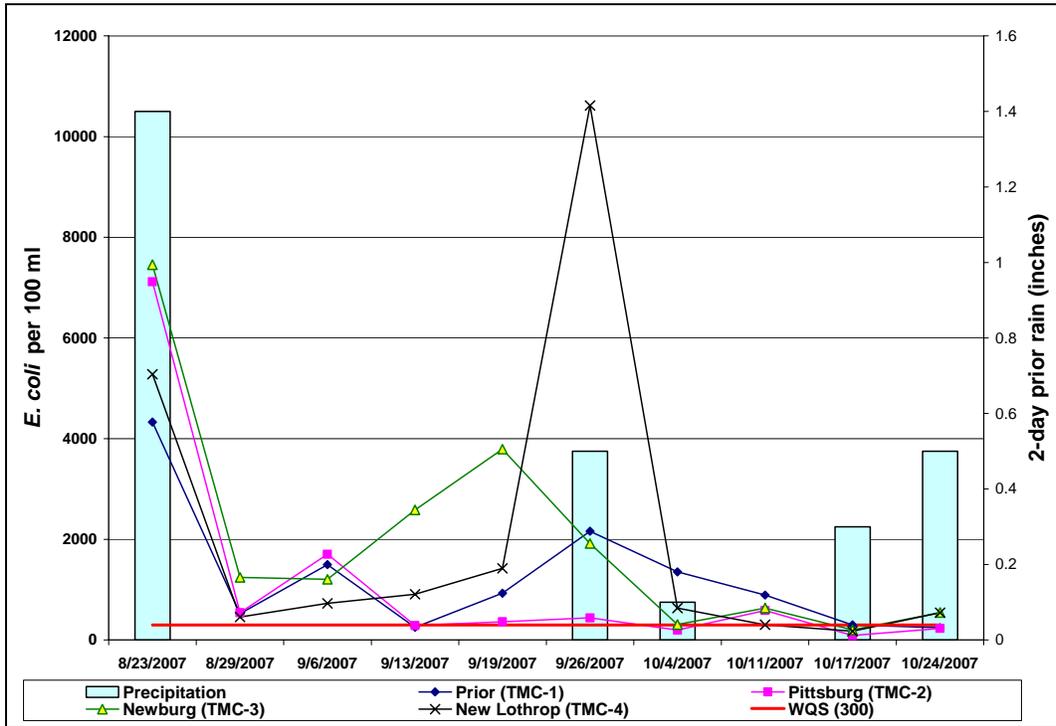


Figure 2. Daily maximum *E. coli* sampling results from Three Mile Creek (Stations TMC 1-4), Shiawassee County, Michigan.

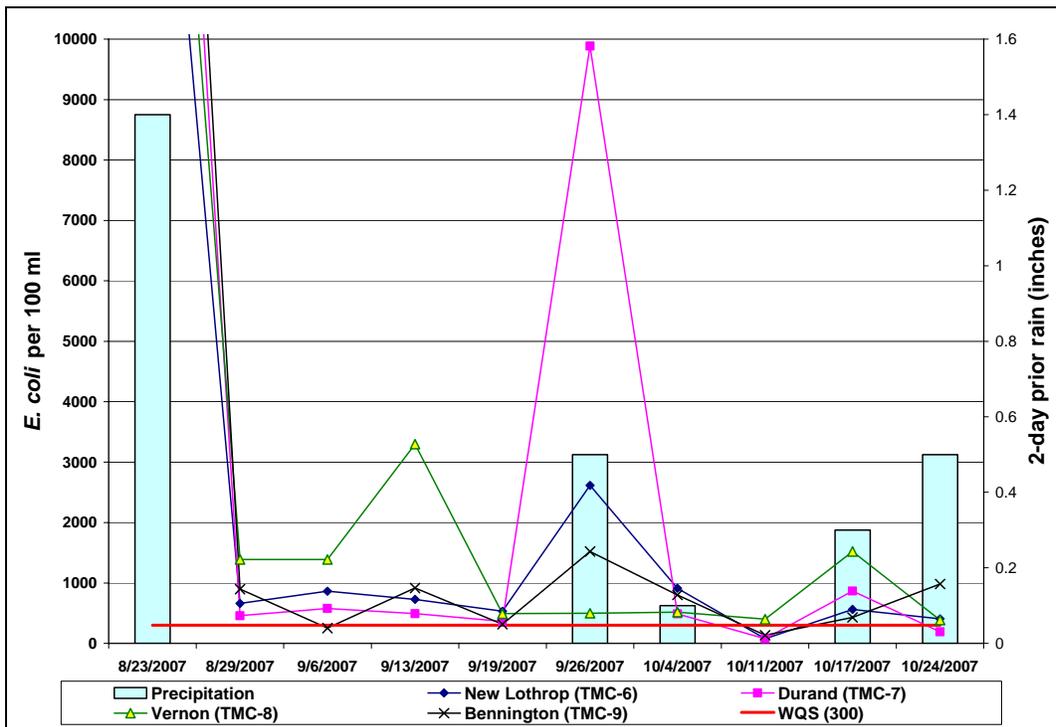


Figure 3. Daily maximum *E. coli* sampling results from Holly Drain (Stations TMC 6-9), Shiawassee County, Michigan.

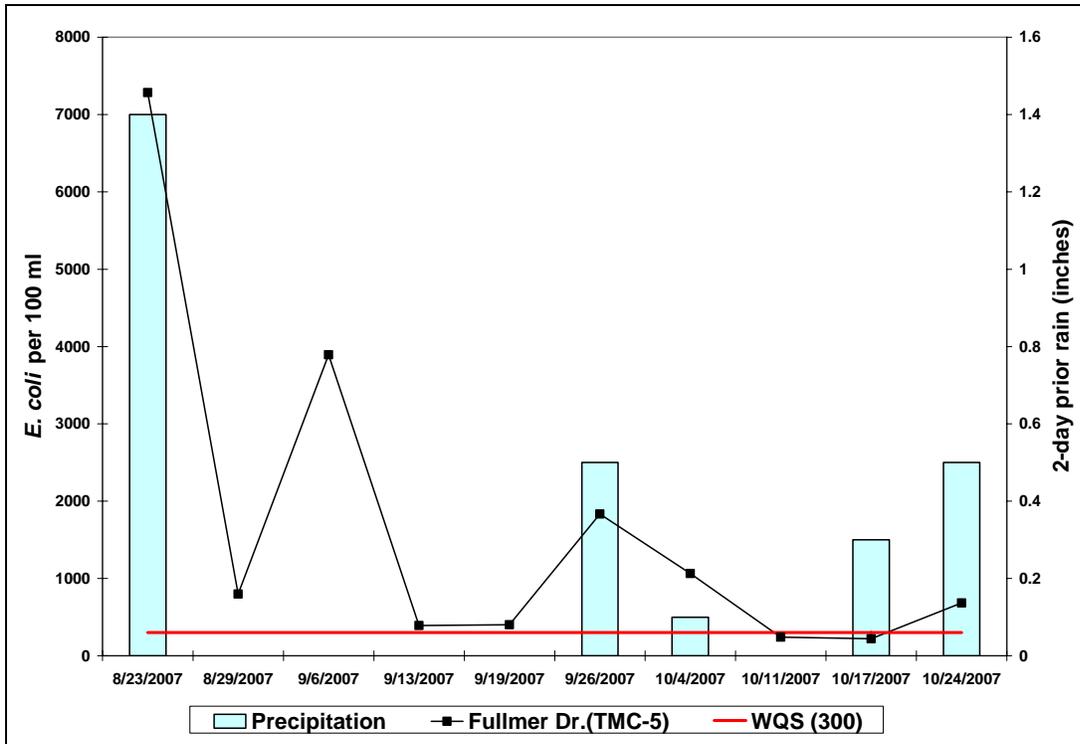


Figure 4. Daily maximum *E. coli* sampling results from Fullmer Drain (Station TMC-5), Shiawassee County, Michigan.

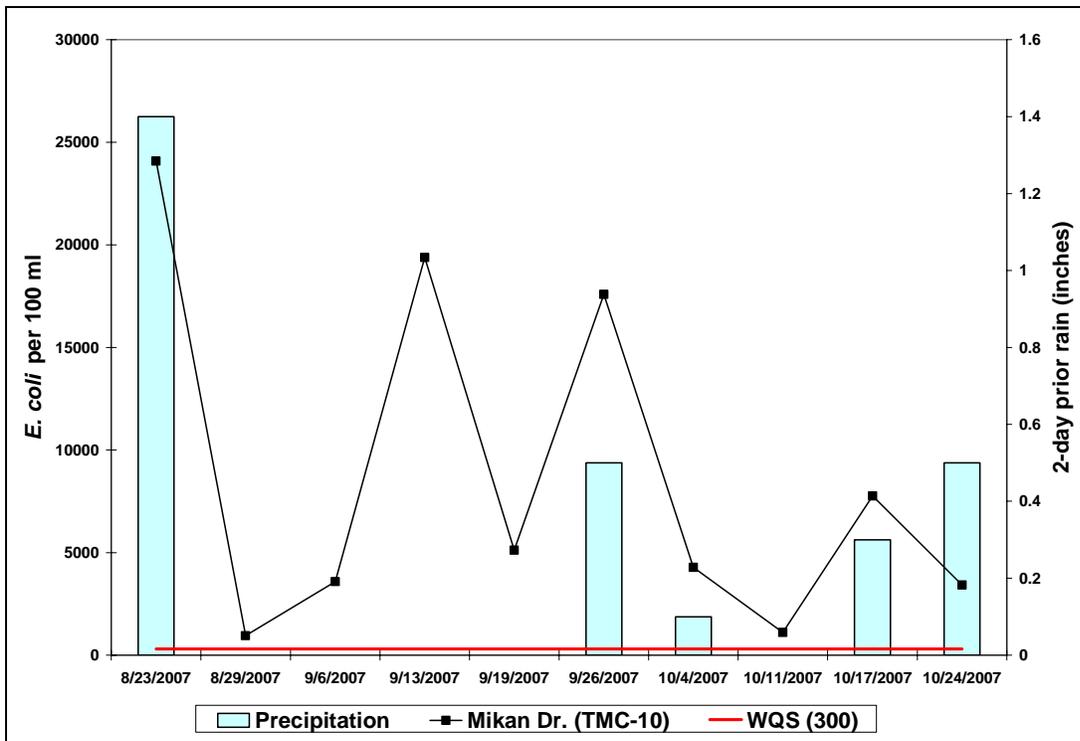


Figure 5. Daily maximum *E. coli* sampling results from Mikan Drain (Station TMC-10), Shiawassee County, Michigan.

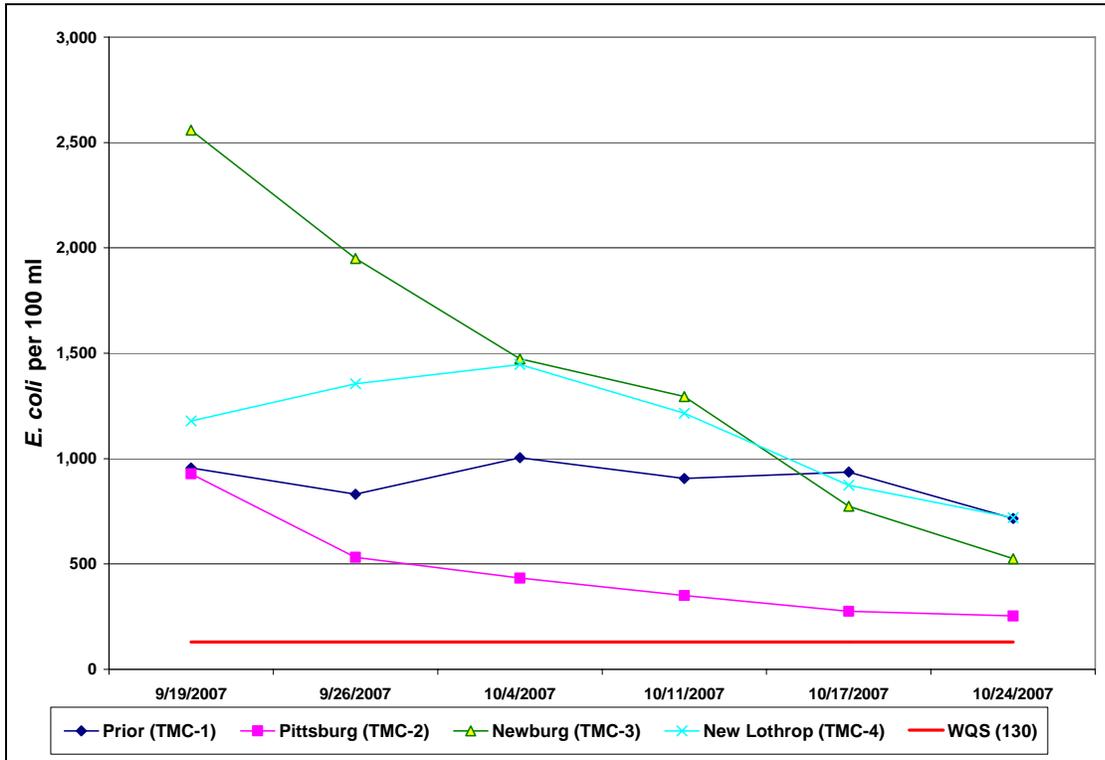


Figure 6. Thirty-day geometric mean *E. coli* sampling results from Three Mile Creek (Stations TMC 1-4), Shiawassee County, Michigan.

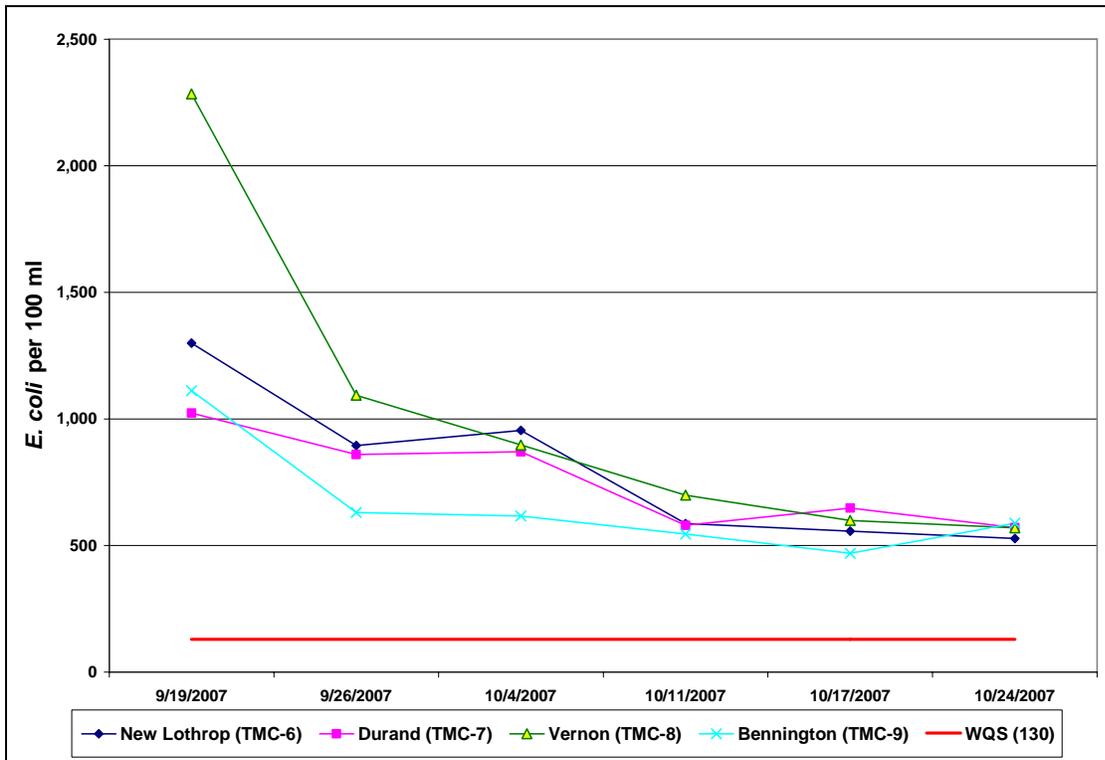


Figure 7. Thirty-day geometric mean *E. coli* sampling results from Holly Drain (Stations TMC 6-9), Shiawassee County, Michigan.

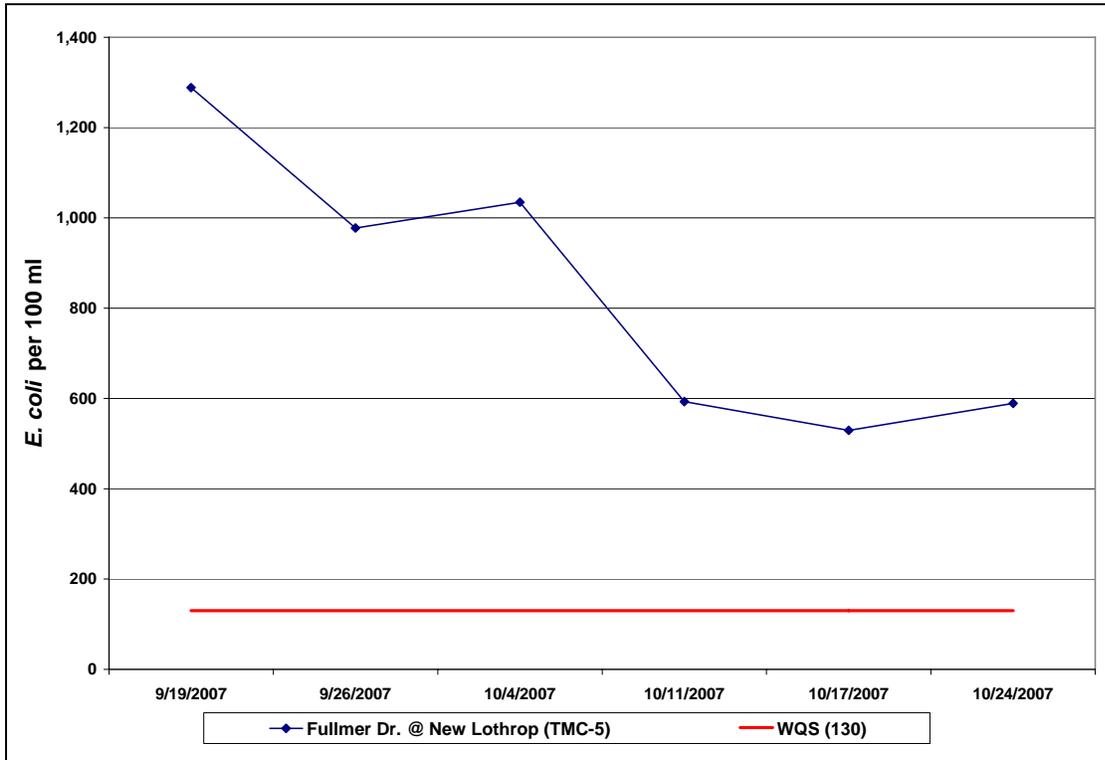


Figure 8. Thirty-day geometric mean *E. coli* sampling results from Fullmer Drain (Station TMC-5), Shiawassee County, Michigan.

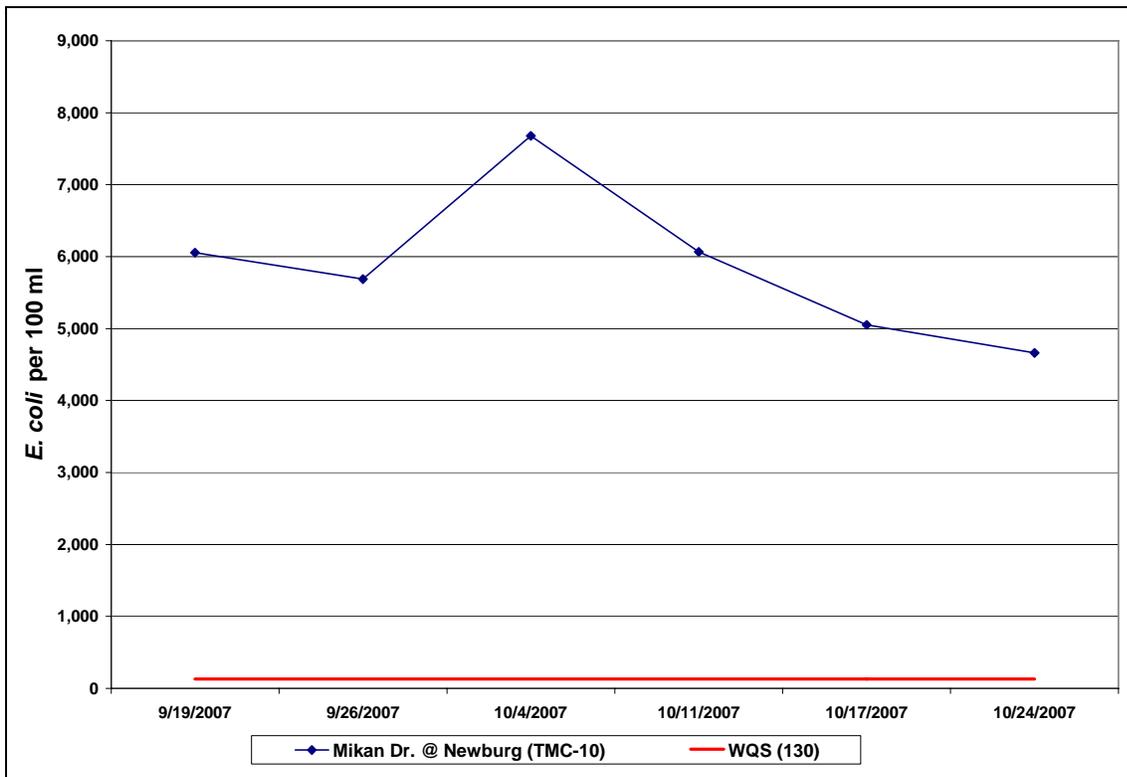


Figure 9. Thirty-day geometric mean *E. coli* sampling results from Mikan Drain (Station TMC-10), Shiawassee County, Michigan.

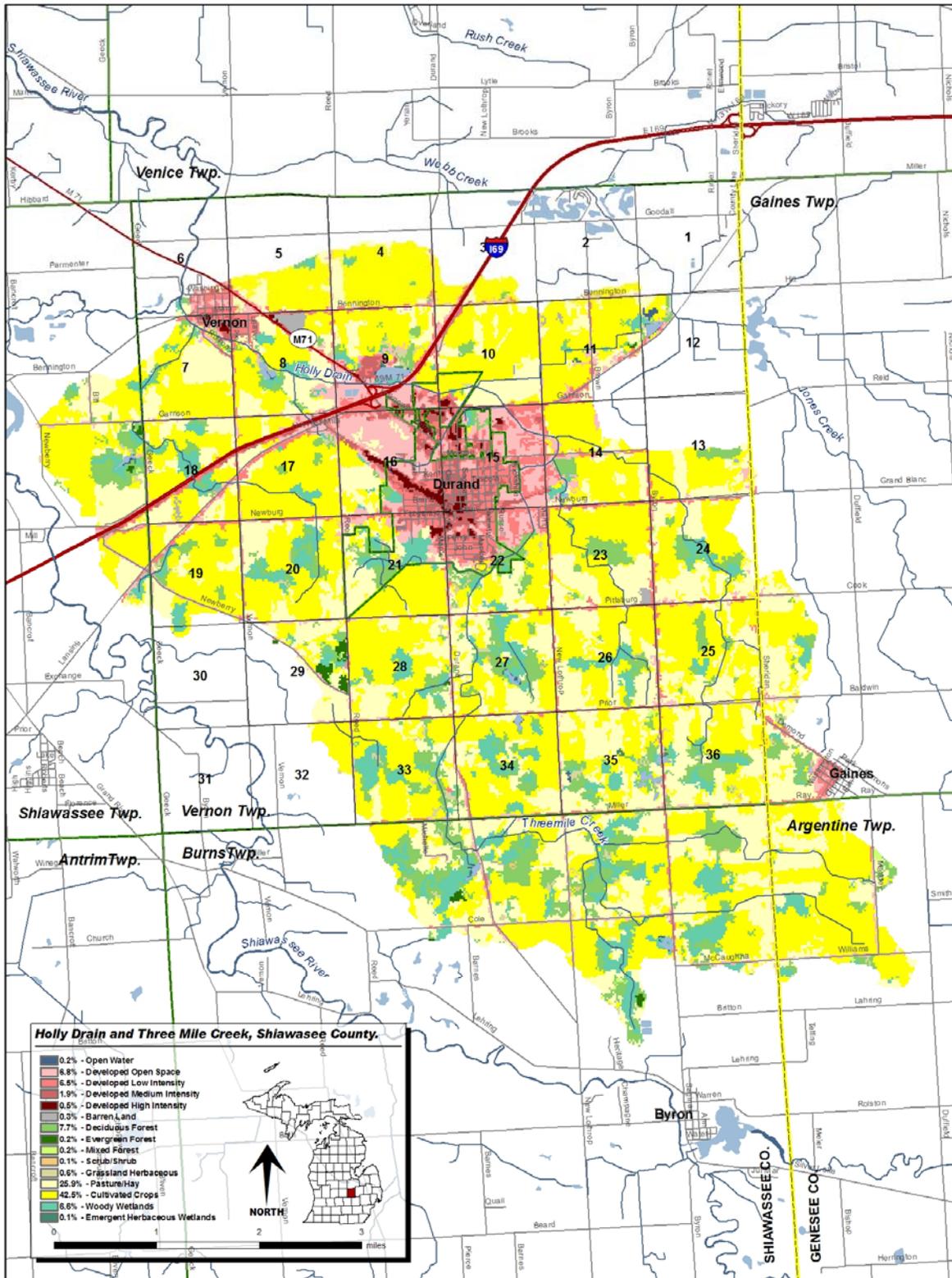


Figure 10. Land use in the Three Mile Creek and Holly Drain TMDL watershed, Shiawassee County, Michigan.

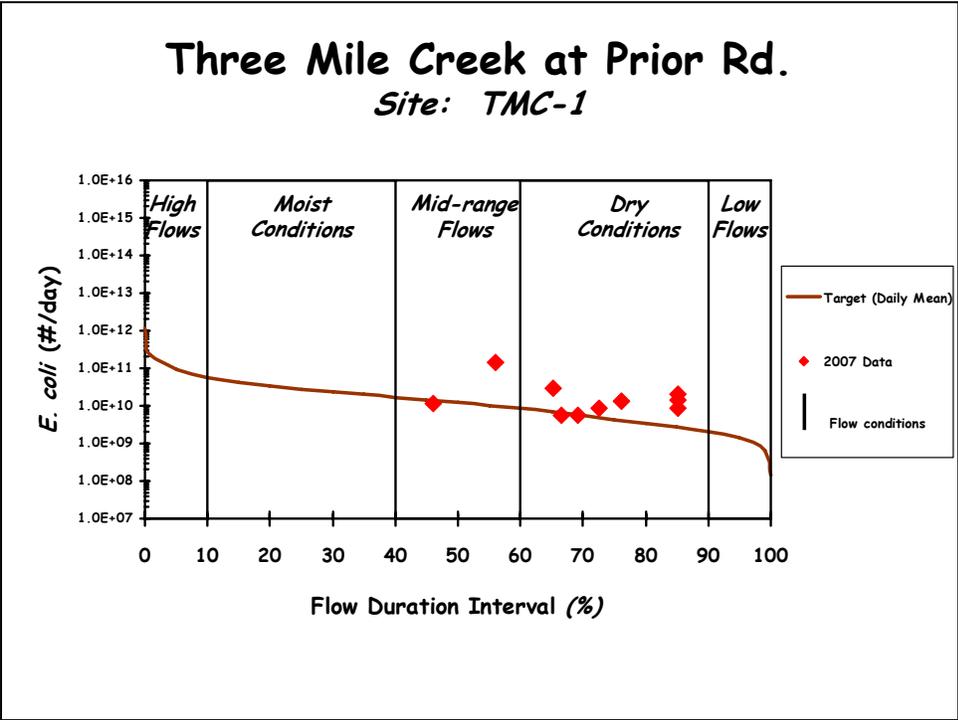


Figure 11. Load duration curve for Three Mile Creek at Prior Road. Curve is based on *E. coli* data and USGS Gauge 4111500 Duration Interval and a drainage area 8.70 square miles.

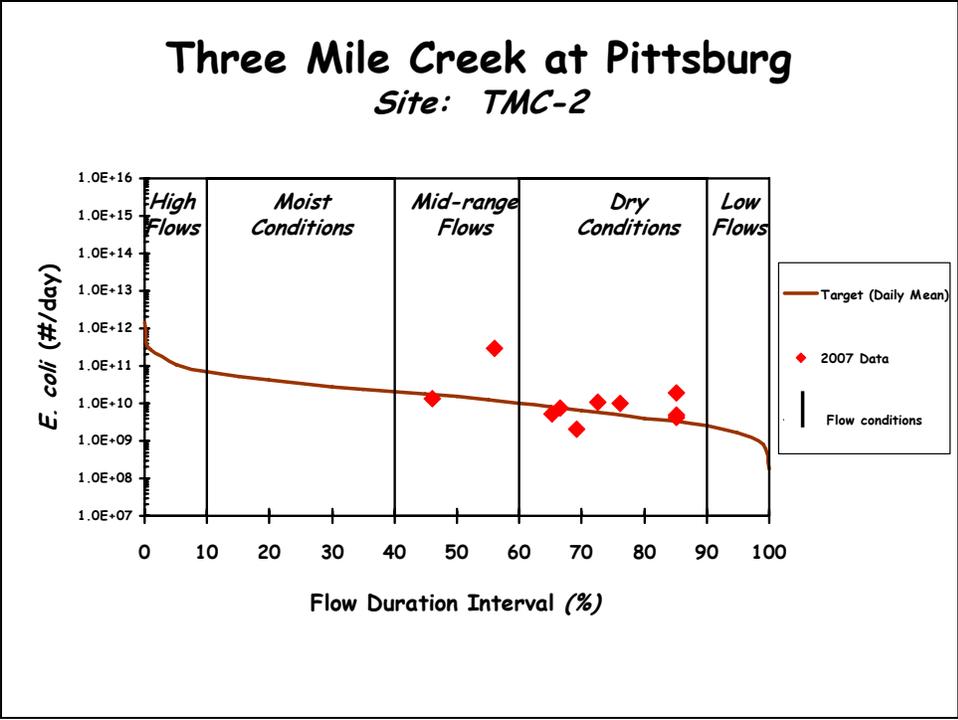


Figure 12. Load duration curve for Three Mile Creek at Pittsburg Road. Curve is based on *E. coli* data and USGS Gauge 4111500 Duration Interval and a drainage area 10.5 square miles.

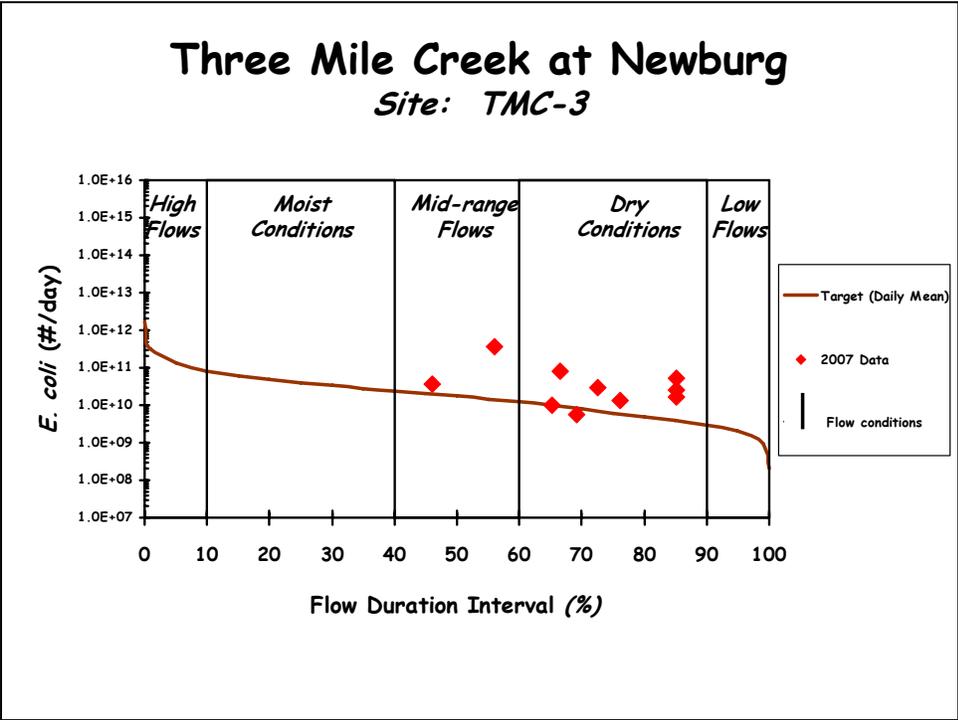


Figure 13. Load duration curve for Three Mile Creek at Newburg Road. Curve is based on *E. coli* data and USGS Gauge 4111500 Duration Interval and a drainage area 12.4 square miles.

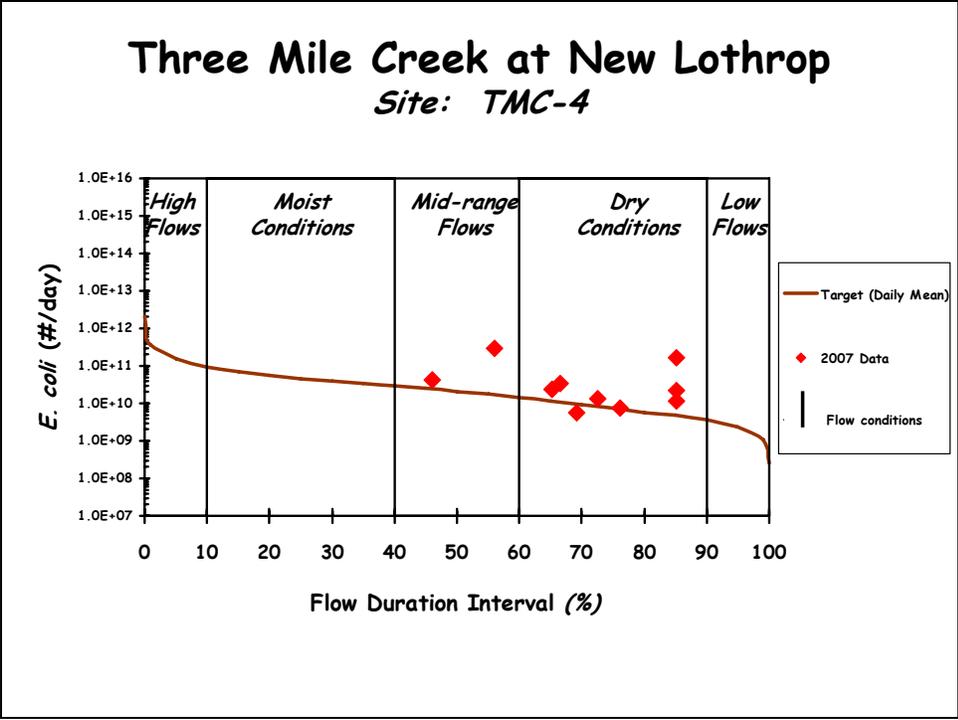


Figure 14. Load duration curve for Three Mile Creek at New Lothrop Road. Curve is based on *E. coli* data and USGS Gauge 4111500 Duration Interval and a drainage area 14.7 square miles.

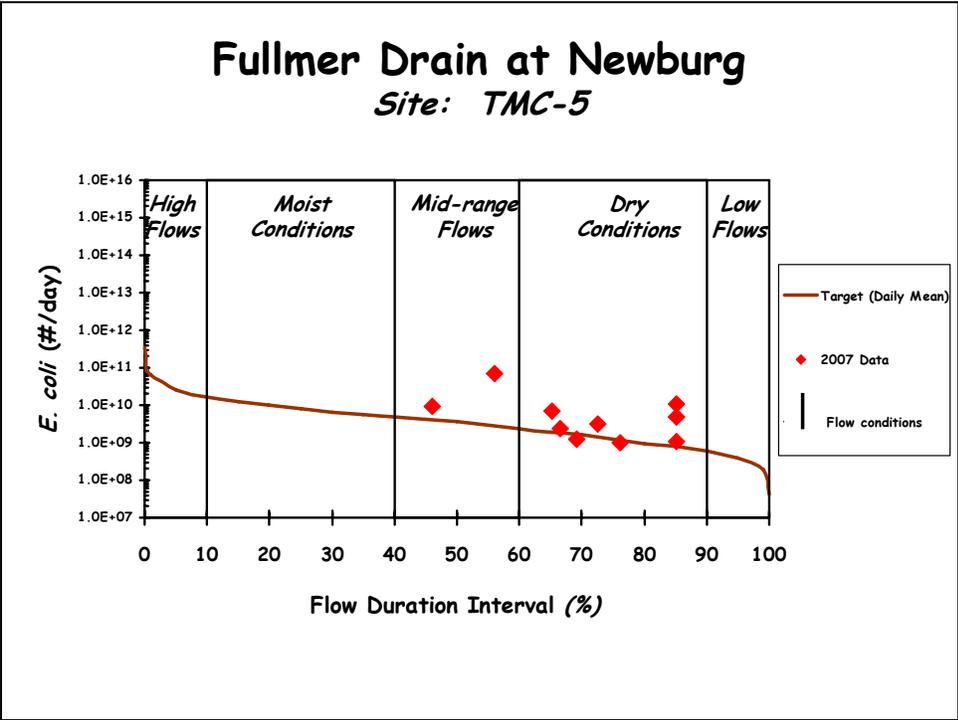


Figure 15. Load duration curve for Fullmer Drain at Newburg Road. Curve is based on *E. coli* data and USGS Gauge 4111500 Duration Interval and a drainage area 2.50 square miles.

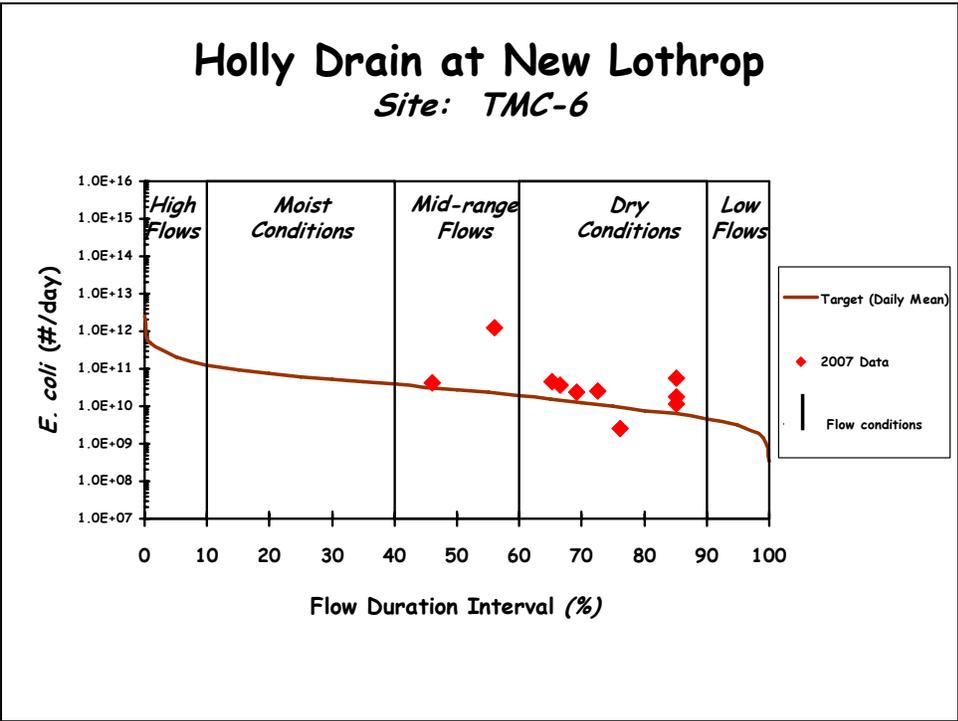


Figure 16. Load duration curve for Holly Drain at New Lothrop Road. Curve is based on *E. coli* data and USGS Gauge 4111500 Duration Interval and a drainage area 19.5 square miles.

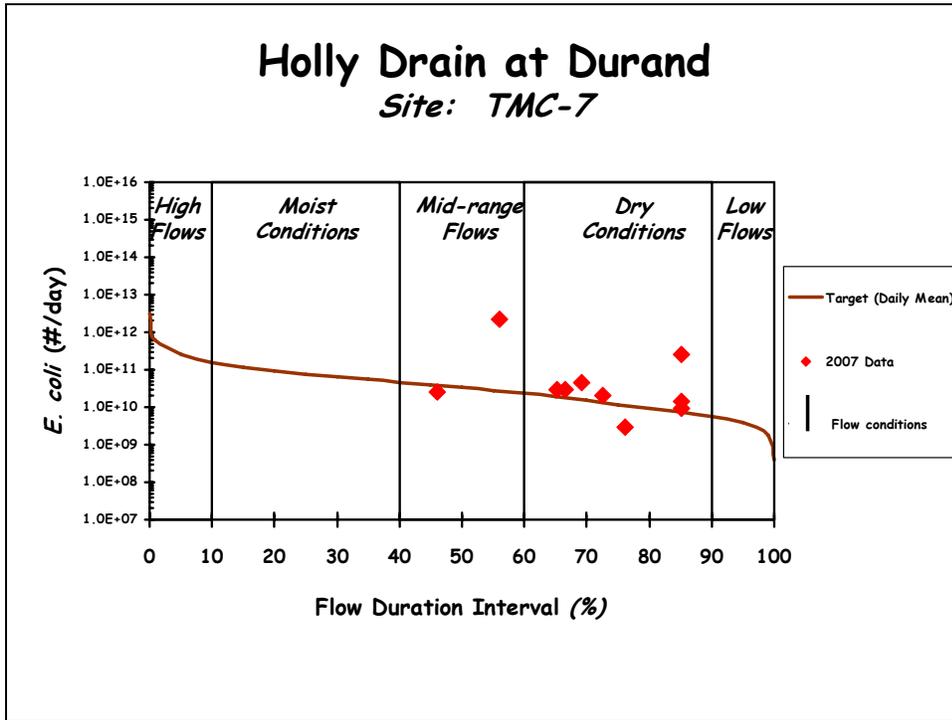


Figure 17. Load duration curve for Holly Drain at Durand Road. Curve is based on *E. coli* data and USGS Gauge 4111500 Duration Interval and a drainage area 23.8 square miles.

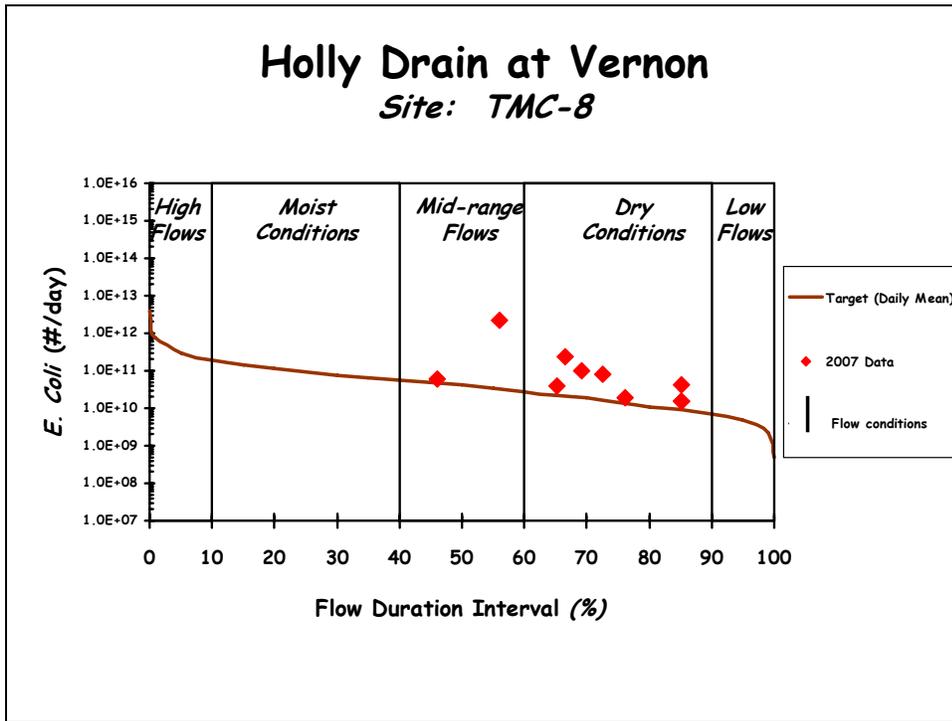


Figure 18. Load duration curve for Holly Drain at Vernon Road. Curve is based on *E. coli* data and USGS Gauge 4111500 Duration Interval and a drainage area 29.0 square miles.

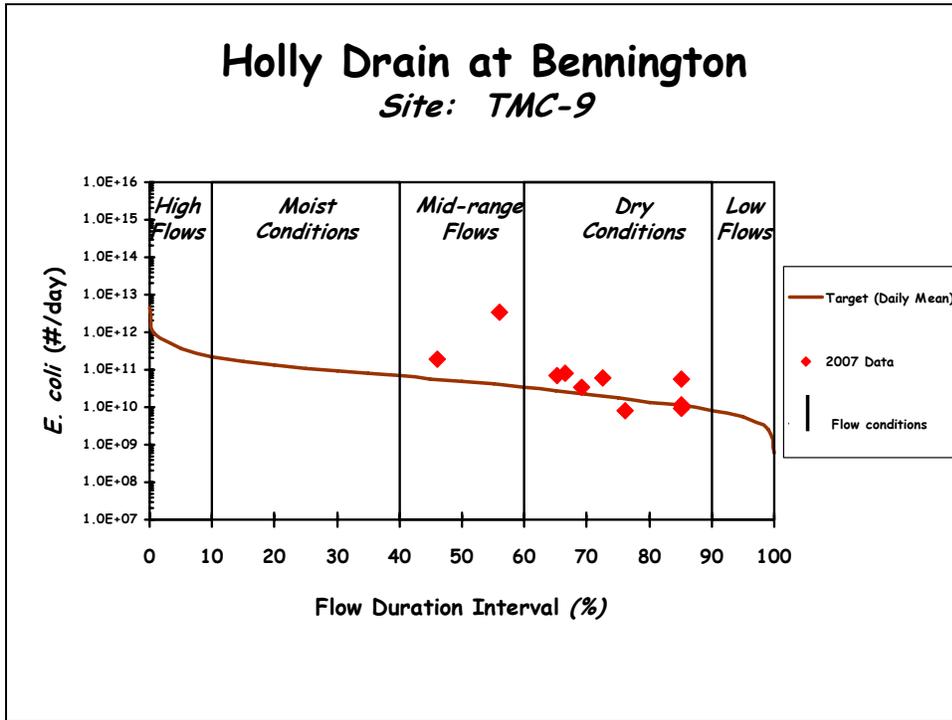


Figure 19. Load duration curve for Holly Drain at Bennington Road. Curve is based on *E. coli* data and USGS Gage 4111500 Duration Interval and a drainage area 34.7 square miles.

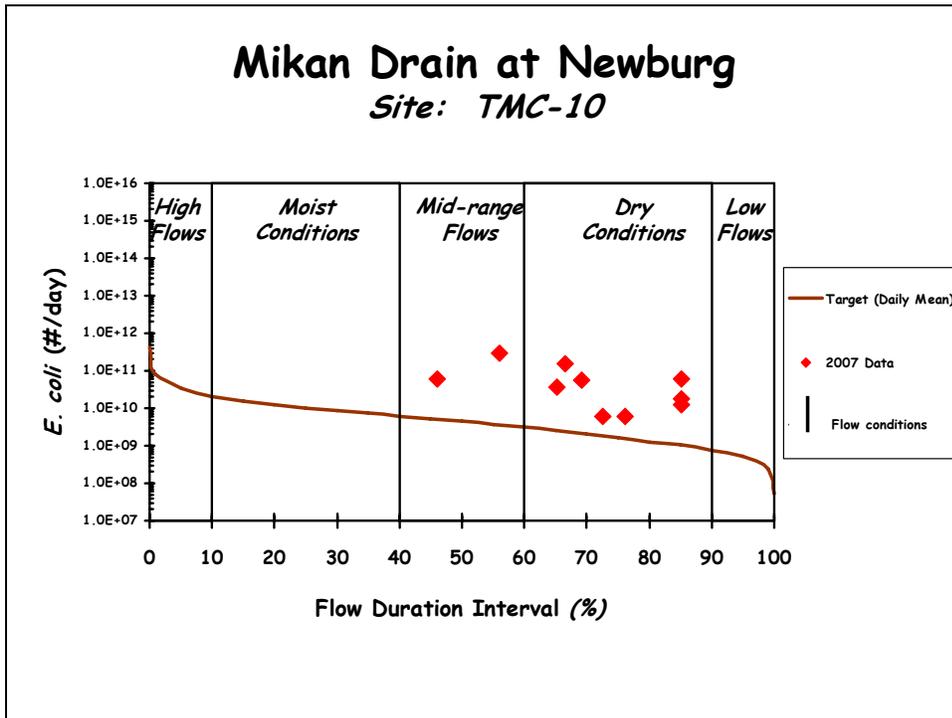


Figure 20. Load duration curve for Mikan Drain at Newburg Road. Curve is based on *E. coli* data and USGS Gage 4111500 Duration Interval and a drainage area 3.20 square miles.

Table 1. Weekly *E. coli* sampling results (counts per 100 mL) from Three Mile Creek. Exceedances of the daily geometric mean (300 *E. coli*/100 ml) and 30-day geometric mean (130 *E. coli*/100 ml) WQS are shaded. NOTE: The daily maximum is the geometric mean of the sample results. The 30-day geometric mean is a rolling geometric mean of the associated daily maximum and the four preceding daily maxima.

Date	Three Mile Creek @ Prior Rd.					Three Mile Creek @ Pittsburg Rd.					Three Mile Creek @ Newburg Rd.					Three Mile Creek @ New Lothrop Rd.					Notes
	TMC-1					TMC-2					TMC-3					TMC-4					
	Left	Center	Right	Daily Max	30-Day Geomean	Left	Center	Right	Daily Max	30-Day Geomean	Left	Center	Right	Daily Max	30-Day Geomean	Left	Center	Right	Daily Max	30-Day Geomean	
8/23/07	6,000	3,000	4,500	4,327	---	6,000	6,000	10,000	7,114	---	8,500	6,500	7,500	7,455	---	7,000	7,000	3,000	5,278	---	1.4" of rain
8/29/07	600	400	600	524	---	400	400	1,000	543	---	1,600	1,200	1,000	1,243	---	600	400	400	458	---	
9/6/07	1,200	2,000	1,400	1,498	---	1,400	1,600	2,200	1,702	---	1,000	2,200	800	1,207	---	600	800	800	727	---	
9/13/07	1,000	80	200	252	---	600	200	200	288	---	6,000	3,600	800	2,585	---	120	2,600	2,400	908	---	
9/19/07	1,000	800	1,000	928	955	600	400	200	363	928	10,800	1,800	2,800	3,790	2,558	800	1,000	3,600	1,423	1,178	
9/26/07	1,800	2,800	2,000	2,160	831	420	400	500	438	531	2,200	2,000	1,600	1,917	1,950	12,600	10,800	8,800	10,619	1,355	0.5" of rain
10/4/07	5,200	880	540	1,352	1,005	140	240	220	195	433	380	280	270	306	1,473	1,600	200	800	635	1,446	0.1" of rain
10/11/07	800	740	1,200	892	906	800	1,800	140	586	350	480	660	800	633	1,295	320	220	400	304	1,215	
10/17/07	420	120	520	297	936	120	40	140	88	276	460	60	280	198	774	60	220	400	174	873	0.3" of rain
10/24/07	340	100	420	243	716	260	200	260	238	253	420	120	3,200	544	525	240	660	1,000	541	720	0.5" of rain

Table 2. Weekly *E. coli* sampling results (counts per 100 mL) from Holly Drain. Exceedances of the daily geometric mean (300 *E. coli*/100 ml) and 30-day geometric mean (130 *E. coli*/100 ml) WQS are shaded. NOTE: The daily maximum is the geometric mean of the sample results. The 30-day geometric mean is a rolling geometric mean of the associated daily maximum and the four preceding daily maxima.

Date	Holly Drain @ New Lothrop Rd.					Holly Drain @ Durand Rd.					Holly Drain @ Vernon Rd.					Holly Drain @ Bennington Rd.					Notes
	TMC-6					TMC-7					TMC-8					TMC-9					
	Left	Center	Right	Daily Max	30-Day Geomean	Left	Center	Right	Daily Max	30-Day Geomean	Left	Center	Right	Daily Max	30-Day Geomean	Left	Center	Right	Daily Max	30-Day Geomean	
8/23/07	22,500	11,500	18,500	16,853	---	24,500	24,000	22,500	23,651	---	21,500	20,000	18,000	19,781	---	23,500	30,500	24,000	25,814	---	1.4" of rain
8/29/07	400	600	1,200	660	---	800	600	200	458	---	1,200	1,400	1,600	1,390	---	1,200	1,000	600	896	---	
9/6/07	800	1,000	800	862	---	1,200	200	800	577	---	1,600	1,400	1,200	1,390	---	400	200	200	252	---	
9/13/07	800	800	600	727	---	1,000	600	200	493	---	2,800	3,200	4,000	3,297	---	600	800	1,600	916	---	
9/19/07	600	500	500	531	1,299	200	600	400	363	1,023	200	600	1,000	493	2,284	400	200	400	317	1,111	
9/26/07	5,800	2,200	1,400	2,614	895	10,400	10,800	8,600	9,885	859	160	960	800	497	1,093	800	2,000	2,200	1,521	631	0.5" of rain
10/4/07	420	1,000	1,800	911	955	400	440	660	488	870	820	840	200	516	897	600	860	1,000	802	617	0.1" of rain
10/11/07	60	120	60	76	587	40	180	60	76	580	1,000	800	80	400	699	60	140	300	136	545	
10/17/07	420	680	620	562	557	880	800	920	865	648	1,400	1,400	1,800	1,522	599	200	1,000	400	431	469	0.3" of rain
10/24/07	380	380	460	405	528	420	60	280	192	571	520	420	260	384	570	520	3,800	480	983	588	0.5" of rain

Table 3. Weekly *E. coli* sampling results (counts per 100 mL) from Fullmer and Mikan Drains. Exceedances of the daily geometric mean (300 *E. coli*/100 ml) and 30-day geometric mean (130 *E. coli*/100 ml) WQS are shaded. NOTE: The daily maximum is the geometric mean of the sample results. The 30-day geometric mean is a rolling geometric mean of the associated daily maximum and the four preceding daily maxima.

Date	Fullmer Drain @ Newburg Rd.					Mikan Drain @ Newburg					Notes
	TMC-5					TMC-10					
	Left	Center	Right	Daily Max	30-Day Geomean	Left	Center	Right	Daily Max	30-Day Geomean	
8/23/07	6,500	8,500	7,000	7,286	--	14,500	23,500	41,000	24,085	--	1.4" of rain
8/29/07	800	800	800	800	--	1,200	1,200	600	952	--	
9/6/07	5,400	2,600	4,200	3,892	--	3,000	4,800	3,200	3,585	--	
9/13/07	500	200	600	391	--	10,500	23,500	29,500	19,380	--	
9/19/07	800	200	400	400	1,289	3,200	5,800	7,200	5,113	6,056	
9/26/07	2,800	1,000	2,200	1,833	978	21,800	19,800	12,600	17,586	5,687	0.5" of rain
10/4/07	1,200	1,000	1,000	1,063	1,035	7,400	6,600	1,600	4,275	7,679	0.1" of rain
10/11/07	580	600	40	241	593	600	1,400	1,600	1,104	6,067	
10/17/07	160	340	200	222	529	4,800	10,600	9,200	7,764	5,053	0.3" of rain
10/24/07	400	800	1,000	684	589	3,400	2,800	4,200	3,419	4,662	0.5" of rain

Table 4. Land use in the Three Mile Creek and Holly Drain TMDL watershed.

Landuse Type	sq mi	acres	Percentage
<i>Open Water</i>	0.09	54.6	0.2%
<i>Developed Open Space</i>	2.42	1550.3	6.8%
<i>Developed Low Intensity</i>	2.29	1462.5	6.5%
<i>Developed Medium Intensity</i>	0.68	436.6	1.9%
<i>Developed High Intensity</i>	0.17	106.4	0.5%
<i>Barren Land</i>	0.09	58.1	0.3%
<i>Deciduous Forest</i>	2.74	1750.8	7.7%
<i>Evergreen Forest</i>	0.08	52.7	0.2%
<i>Mixed Forest</i>	0.07	47.4	0.2%
<i>Scrub/Shrub</i>	0.02	13.6	0.1%
<i>Grassland Herbaceous</i>	0.20	130.5	0.6%
<i>Pasture/Hay</i>	9.16	5860.0	25.9%
<i>Cultivated Crops</i>	15.02	9614.6	42.5%
<i>Woody Wetlands</i>	2.33	1489.3	6.6%
<i>Emergent Herbaceous Wetlands</i>	0.03	16.0	0.1%
TOTAL	35.38	22643.6	100.0%

Table 5. Percent of land area in the Three Mile Creek and Holly Drain TMDL watershed located within each municipality.

Township	sq mi	acres	Total
<i>Argentine Twp.</i>	1.70	1088.0	4.8%
<i>Burns Twp.</i>	5.31	3398.4	15.0%
<i>Gaines Twp.</i>	1.05	672.0	3.0%
<i>Shiawassee Twp.</i>	1.55	992.0	4.4%
<i>Vernon Twp.</i>	23.09	14777.6	65.4%
<i>City of Durand</i>	1.94	1241.6	5.5%
<i>City of Vernon</i>	0.69	441.6	2.0%
TOTAL	35.33	22611.2	100.0%

Table 6. NPDES facilities discharging to the Three Mile Creek and Holly Drain TMDL watershed.

Designated Name	Permit Number	Township	Latitude	Longitude
Durand WWTP	MI0022063	Vernon	42.92583	-83.99083
MDOT State-wide MS4	MI0057364	Various	---	---
MIS210000: Storm Water from Industrial Activities in Cycle Year 2 Watersheds				
Beechcraft Products Inc	MIS210865	Vernon	42.92351	-83.98577
Durand Forms Inc-E Lansing Rd	MIS210625	Vernon	42.92000	-83.99000
Durand Forms Inc-Oak St	MIS210624	Vernon	42.92000	-83.99000
Premarc Corp-Marsh Products	MIS210215	Vernon	42.93722	-84.01528
Terex Simplicity-Durand	MIS210867	Vernon	42.90889	-83.99020
MIG580000: Wastewater Stabilization Lagoons				
Vernon WWSL	MIG580057	Vernon	42.93361	-84.01528
Country Manor MHP-Durand	MIG580074	Vernon	42.92278	-84.02472