Michigan Department of Environmental Quality
Water Bureau
August 2007

Total Maximum Daily Load for Phosphorus for Pine Creek Gratiot 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 total phosphorus loads that will enable WQS to be attained in Pine Creek, a tributary of the Maple River, located in Gratiot County, Michigan.

PROBLEM STATEMENT

The TMDL reach for Pine Creek appears on the 2006 Section 303(d) list as:

PINE CREEK WBID#: 082821L
County: Gratiot County Size: 9 M
Location: SW of Ithaca. Grant Road us/ to 0.8 miles u/s of St. Charles Road
NHD Reach Code: 04050005000219
Problem Summary: Nuisance plant growths, Phosphorus
TMDL YEAR(s): 2007

Pine Creek was placed on the Section 303(d) list due to documented nuisance plant conditions (Edly and Wuycheck, 2006). Monitoring data collected by the Michigan Department of Environmental Quality (MDEQ) in 1997 and 2002 documented nuisance plant growth and bacterial slimes. The presence of nuisance plant conditions indicates that the other indigenous aquatic life and wildlife designated use is not supported.

NUMERIC TARGET

The WQS that applies to total phosphorus is found in Rule 60 (R 323.1060) 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, and is defined as follows:

R 323.1060 Plant Nutrients
(1) Consistent with Great Lakes protection, phosphorus which is or may readily become available as a plant nutrient shall be controlled from point source discharges to achieve 1 milligram per liter of total phosphorus as a maximum monthly average effluent concentration unless other limits, either higher or lower, are deemed necessary and appropriate by the department.

(2) In addition to the protection provided under subrule (1) of this rule, nutrients shall be limited to the extent necessary to prevent stimulation of growths of aquatic rooted, attached, suspended, and floating plants, fungi or bacteria which are or may become injurious to the designated uses of the surface waters of the state.

The goal of 0.08 milligrams per liter (mg/l) of total phosphorus is recommended for Pine Creek. This average in-stream concentration was chosen as a target based upon phosphorus concentrations in other streams in the Maple River watershed for which nuisance aquatic plant growths have not been observed. The MDEQ data show that many tributaries to the Maple River have total phosphorus concentrations between 0.03 and 0.08 mg/l. Data from a study done on Spaulding Drain, a tributary to the Maple River, show that total phosphorus ranged from 0.015 to 0.079 mg/l during summer monthly sampling in 2002 and 2003 (Roush, 2003), and was determined to be meeting WQS. Like Pine Creek, Spaulding Drain is a maintained drain without much relief and is surrounded by intensive agricultural land uses. Therefore, a target concentration of 0.08 mg/l is a realistic goal for Pine Creek, and will be used to develop the Pine Creek total phosphorus TMDL.

DATA DISCUSSION

Pine Creek was sampled for total phosphorus at four stations in September 2006 (Table 1 and Figure 1). The average total phosphorus concentration was 0.22 mg/l. The MDEQ staff also visited Pine Creek in 1997 and 2002 (Table 1). In 1997, the stream was noticeably impaired, with excessive rooted aquatic plant growth (Hanshue, 2002), and the total phosphorus concentration during this survey was 0.2 mg/l. In 2002, it was noted that the removal of streamside cover and nutrient enrichment had resulted in excessive rooted aquatic plant growth and floating algae (Rockafellow, 2003). Water chemistry data from 2002, were collected upstream and downstream of discharging tile drain where total phosphorus concentrations at both locations exceeded 0.2 mg/l.

SOURCE ASSESSMENT

Pine Creek primarily drains agricultural land and is located entirely in the Southern Michigan Northern Indiana Till Plain ecoregion (Omernik and Gallant, 1988). The drainage has little topographic relief and has been extensively channelized and tiled. Pine Creek is similar to most of the streams in southern Gratiot County, in that its entire length is actively maintained as an agricultural drain. Almost all of the riparian vegetation has been removed in the TMDL reach, manure is spread on fields throughout the watershed, and cattle access to the stream has been noted on multiple occasions. All of these changes to the watershed increase the phosphorus load to the Pine Creek TMDL reach and the potential for nutrient expression. Another potential, but undocumented, source of total phosphorus to Pine Creek is illicit discharges from residential units, which are reportedly common throughout Gratiot County. The local health department has been notified that illicit discharges may be present in the area.

Table 1. Water chemistry data from Pine Creek.

	Pine Creek at Johnson Road	Pine Creek at Fillmore Rd. u/s tile drain	Pine Creek at Fillmore Rd. d/s tile drain	Pine Creek at Alger Road	Pine Creek at Johnson Road	Pine Creek u/s confl. with North Shade Drain	Pine Creek at Grant Road
Date	6/19/1997	8/1/2002	8/1/2002	9/5/2006	9/5/2006	9/5/2006	9/5/2006
Total Phosphorus (mg/l)	0.2	0.22	0.36	0.21	0.194	0.27	0.197
Ortho-phosphate (mg/l)	0.159	0.14 DL	0.17 DL	0.131	0.098	0.143	0.139
pH	--	--	--	7.58	7.7	8.52	7.71
Conductivity (umho/cm)	--	--	--	888	811	778	763
Total Kjeldahl Nitrogen (mg/l)	1.46	2.8	2.9	1.13	2.1	1.18	0.89
Nitrate + Nitrite (mg/l)	1.53	5.2	8.8	0.2	1.44	1.94	1.16
Ammonia (mg/l)	0.4	0.8 DL	1.2	0.23	0.87	0.063	0.122
Nitrite (mg/l)	0.155	0.27	0.26	0.019	0.135	0.127	0.061
Solids – Suspended (mg/l)	--	45	410	13	6	27	7

All phosphorus loadings to Pine Creek are from land-based sources. Loadings from these sources were determined based on land uses in the drainage basin (Table 2). Land use proportions were derived using the Long-Term Hydrologic Impact Assessment (L-THIA) Web-based application created and maintained by Purdue University and the USEPA (Purdue University and USEPA, 2004; Choi et al., 2005). This geographic information system-based software uses the event mean concentration and curve number procedures to calculate daily pollutant loads based on site-specific land use, soil type, and meteorological data. The default site-specific data include 30 meter resolution land use data from National Land Cover Database and average annual precipitation data. The L-THIA application is supported by staff of the USEPA, Region 5.

Table 2. Calculated land use/cover in the Pine Creek watershed.

Land Use/Cover	Area (acres)	Percent
Water	671	2
Urban/Residential	64	< 1
Urban/Commercial	5	< 1
Agricultural	26594	78
Grass/Pasture	3483	10
Forest	3161	9
Total	33978	100

There are three National Pollutant Discharge Elimination System (NPDES) permits within the Pine Creek watershed (Table 3). There are two general permits for concentrated animal feeding operations (CAFOs) and one stormwater general permit.

Table 3. Permitted Discharges in the Pine Creek watershed.

Facility	Permit Number	Acres	Latitude	Longitude
MIS410000 Stormwater Permit	Storm Water from Industrial Activities			
Sparks Pickle Co-Ithaca	MIS410369	5	43.2775	-84.675833
MIG010000 General Permit	New Large Concentrated Animal Feeding Operations			
Nathan Duflo Farm-CAFO	MIG010006	570	43.21448	-84.8001
MIG440000 General Permit	Concentrated Animal Feeding Operations			
Vanderploeg Holsteins-CAFO	MIG440002	1032	43.27542	-84.63829

The daily load of total phosphorus to Pine Creek was estimated to be 40.7 pounds per day using basic input options in the L-THIA model. These include watershed specific land use and soil type proportions, default curve numbers, and average precipitation rates. This load

represents the pollutant load from all sources to the TMDL reach, including both land use (Table 2) and NPDES permits (Table 3).

LINKAGE ANALYSIS

The observed total phosphorus standard nonattainment in Pine Creek can be attributed to a number of factors. The growth of aquatic plants and algae in a stream is controlled, in part, by nutrients and light availability. Pine Creek is not shaded by riparian vegetation, which allows plant growth within the stream to increase as total phosphorus concentrations increase.

Phosphorus can exist in dissolved forms and particulate forms sorbed to solids. When dissolved, some of the phosphorus is available for use by aquatic plants and increased growth in rooted plants and floating algae can result. Phosphorus in the particulate form can be released as dissolved phosphorus under certain conditions, contributing to increased plant growth. Solids that run off of the land into Pine Creek, or that are discharged directly to the stream, are a significant load of particulate phosphorus in agricultural watersheds.

LOADING CAPACITY (LC) DEVELOPMENT

The LC represents the maximum daily loading that can be assimilated by the water body while still achieving WQS. However, because Pine Creek is a flowing water body, the total phosphorus concentration, versus the load, is expected to be the predominant influence on nuisance aquatic plant growth and will be the goal for this TMDL. We have established the total phosphorus numeric target for Pine Creek at 0.08 mg/l. The current average concentration of total phosphorus in Pine Creek is 0.22 mg/l. The numeric target of 0.08 mg/l represents a 64 percent reduction from the current concentration. To reach the target, we propose to reduce the load of total phosphorus by 64 percent, from 40.7 pounds per day to 14.7 pounds per day (Table 4).

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:

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

<u>WLAs</u>

There are three NPDES permitted point source discharges within the listed reach of Pine Creek; two general permits, Nathan Duflo Farm-CAFO (MIG010006) and Vanderploeg Holsteins-CAFO (MIG440002), and a stormwater general permit for Sparks Pickle Co-Ithaca (MIS410369). The wasteload for these permits was calculated based on the land under jurisdiction of each of these NPDES permits.

The five acres delineated in L-THIA as urban-commercial, were assumed to be the area of land associated with the Sparks Pickle Co-Ithaca stormwater permit. To determine the area of land

Table 4. Summary of the total phosphorus LC development for Pine Creek, Gratiot County, Michigan.

Source Category	Acres	Estimate Current TP (pounds/day)	TMDL TP Target Load TP (pounds/day)
WLA Components:			
Sparks Pickle Co-Ithaca	5	0.008	0.003
Nathan Duflo Farm - CAFO	570	0.870	0.278
Vanderploeg Holsteins - CAFO	1032	1.576	0.504
CAFO Subtotal:	1602	2.44	0.782
WLA Total:	1607	2.45	0.785
LA Components:			
Water	671	0	0
Urban/Residential	64	0.054	0.017
Agricultural	24992	38.2	12.2
Grass/Pasture	3483	0.014	0.014
Forest	3161	0.007	0.007
LA Subtotal:	32371	38.28	12.2
Totals:	33978	40.7	13
MOS			1.7
Daily TMDL Load Target			14.7

associated with the CAFO general permits, the area of the fields with a potential to receive CAFO manure applications was totaled. To determine the target phosphorus load, each estimated current phosphorus load was reduced by 68 percent, an additional 4 percent reduction over the targeted load to address the MOS. The calculated existing and target loads from these sources are 2.45 pounds per day and 0.785 pounds per day, respectively (Table 4).

LAs

The nonpoint source and natural background levels of phosphorus are combined to produce the LA. The primary sources of total phosphorus in the Pine Creek watershed are runoff from various land uses, including agricultural land, and potentially illicit discharges from septic systems. The current estimated loading of phosphorus is 38.28 pounds per day. The total LA is 12.2 pounds per day, which equates to a 68 percent reduction of total phosphorus (Table 4).

MOS

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 WLA or LA through conservative assumptions) or explicit (i.e., expressed in the TMDL as a portion of the loadings). This TMDL uses an explicit MOS.

The total phosphorus goal for Pine Creek is 0.08 mg/l, which is a 64 percent reduction in phosphorus concentration from current conditions. The WLA and LA were calculated to achieve a phosphorus goal of 0.07 mg/L, a 68 percent reduction in the phosphorus load, and the difference assigned to the MOS. This results in a MOS of 1.7 pounds per day of phosphorus.

Although a TMDL must specify load reductions, the primary goal of this TMDL is to achieve the concentration target. A concentration target is more relevant than a load-based target for Pine Creek, and many headwater stream systems, because storm event-related sediment loadings, with the associated phosphorus, tend to pass quickly through to slower flow areas downstream. This rapid movement of loadings is further enhanced in an agriculture watershed, such as the Pine Creek watershed which has been altered to rapidly move rainwater and the associated sediment load downstream. Because the concentration goal of 0.08 mg/L is expected to attain WQS, the sediment loading target is secondary, and the MOS of 1.7 pounds per day phosphorus is considered appropriate.

SEASONALITY AND CRITICAL CONDITIONS

The period of time when it is most critical to meet the 0.08 mg/l phosphorus goal in Pine Creek is the summer. Between June and September, environmental conditions, such as higher temperatures and lower flows, are most likely to result in nuisance plant growth if nutrient concentrations exceed the goal. In the non-summer months, cooler water temperature, higher flows, and reduced light intensity greatly limit the growth of aquatic plants to the point where nuisance conditions will not occur even if nutrient concentrations are elevated. Therefore, if the 0.08 mg/l goal is met during the summer period, WQS are expected to be attained the remainder of the year.

MONITORING

Future monitoring will be conducted to assess whether activities implemented under the TMDL result in water quality improvements. This monitoring will be conducted as resources allow. Typically, the MDEQ monitors watersheds in accordance with the five-year NPDES permit

review process. Total phosphorus standard attainment will result in the water bodies being removed from the Section 303(d) list, while continued nonattainment will result in further evaluation under the TMDL process. Pine Creek is scheduled for monitoring in 2007 and 2012.

REASONABLE ASSURANCE ACTIVITIES

The Friends of the Maple River is a community group working on the Maple River watershed, which includes Pine Creek. The mission of the Friends of the Maple River is to "preserve, improve, and educate the public regarding the wise use of the Maple River and its watershed." The Friends of the Maple River plan to develop a watershed management plan and have applied for state grants to work on the plan. The group will be helpful in finding locations in the Pine Creek watershed to implement Best Management Practices and communicating with landowners to increase the level of implementation.

Pine Creek is also scheduled for monitoring by the MDEQ, Water Bureau, during the summer of 2007. This monitoring will include both an investigation on the locations of cattle access sites and aquatic macroinvertebrate monitoring. Limiting cattle access sites and reducing any illicit discharges will also reduce the load of phosphorus to Pine Creek.

Prepared by: Sarah Holden, Aquatic Biologist
Surface Water Assessment Section
Water Bureau
Michigan Department of Environmental Quality
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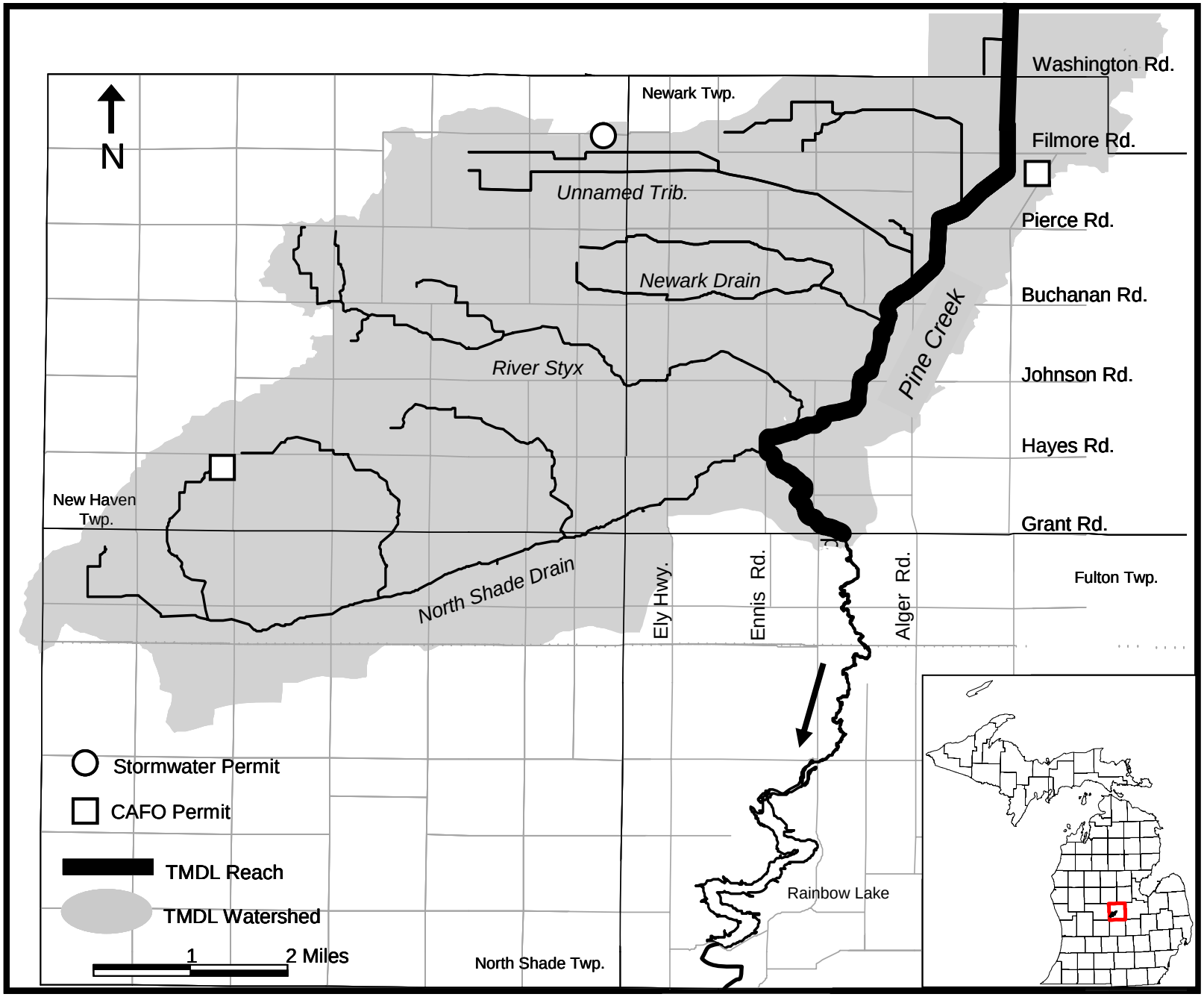

Figure 1. Pine Creek total phosphorus TMDL area, Gratiot County, MI.