5.0 Watershed analysis, loading capacity, and allocations

5.1 Nutrient/Dissolved oxygen TMDL

As explained in Chapter 4, the QUAL2K model examines several parameters including dissolved oxygen and total phosphorus. Summer low flow conditions were simulated to examine these parameters. The reach modeled starts in the downstream section of East Branch Nimishillen Creek and continues downstream to just upstream of the mouth of Nimishillen Creek (river mile 0.62). East Branch is joined by Middle Branch Nimishillen Creek to form the mainstem Nimishillen Creek at the mainstem's river mile (RM) 14.72. This model is built to consider the East Branch and mainstem as one stream with the Middle Branch as a tributary (as seen in Figure 4.2 in Chapter 4). The RMs shown on the figures in this section consider the RMs for East Branch as a continuation of the mainstem's RM (i.e., add 14.72 to the East Branch's RM to determine the model RM).

Two municipal wastewater treatment plants and one industrial discharger are included in this modeling reach's critical low flow simulations. The Nimishillen QUAL2K model begins just upstream of the Louisville WWTP (3PD00033) discharge at East Branch RM 4.46 (Nimishillen QUAL2K RM of 19.18). Louisville WWTP has a 3.09 cubic feet per second (cfs) design flow. The industrial facility Republic Technologies International (RTI, 3ID00000) has several discharges to East Branch Nimishillen Creek between East Branch RM 1.09 and 0.45 (or model RMs of 15.81 and 15.17). Only ~~3~~ three of RTI's outfalls are considered to be discharging during low flow conditions: 003, 011 and 010. Outfall 010 has the highest design flow of 4.24 cfs while the other two combined are considered to be 0.47 cfs. Republic Storage Systems (3ID00007) is not considered for the low flow runs of the Nimishillen QUAL2K model because its outfalls are intermittent. The Canton Water Pollution Control Facility (3PE00000), discharging on the mainstem Nimishillen Creek's RM 10.0, has the highest design flow considered in the model at 60.34 cfs.

No other permitted dischargers on the Nimishillen QUAL2K modeled stream section are considered to be flowing in a low flow critical condition. No storm water is considered to occur during this low flow period. Because of this, no MS4 (permitted municipal storm water) is included in this critical condition or in the D.O. and T.P. pollutant allocations. Dischargers on tributaries that are considered to be flowing on any given day, such as the outfall 015 of the Timken Company on Hurford Run, with a design flow of 5.42 cfs, are included in the low flow model simulations. Complete records of the low flow considerations and calculations and water quality inputs can be reviewed upon request.

Dissolved oxygen

Figure 5-1 shows the dissolved oxygen (D.O.) in the Nimishillen QUAL2K model by river mile for the first model run. This shows the model predictions of D.O. under low flow conditions when the both Louisville WWTP and Canton WPCF are discharging at their design flow effluent with a quality of 5.0 mg/l D.O. This is the minimum limit currently in place for both of these facilities. The model predicted diel average, maximum and

minimum D.O. are shown on this figure. Also included are lines showing the average and minimum D.O. water quality standards for the warm water habitat aquatic life use, 5.0 and 4.0 mg/l respectively. Seen on this figure, the model predicts both an average and minimum D.O. water quality standard violation downstream of the Louisville WWTP and an average violation downstream of the Canton WPCF. Both of these areas of low D.O. occur downstream the WWTPs, showing the typical D.O. sag expected below enriched WWTP effluent (Chapra, 1997). There is also a shaded area that includes a minimum D.O. that is very low. This is an area of uncertainty and the low D.O. has been determined not to be due to Louisville WWTP's effluent. This low D.O. exists in the model due to increased amount of sediment oxygen demand (SOD) that was added to this reach during model calibration. This specific stream reach has been unassessed by Ohio EPA and therefore it's predicted D.O. violation is not considered further.

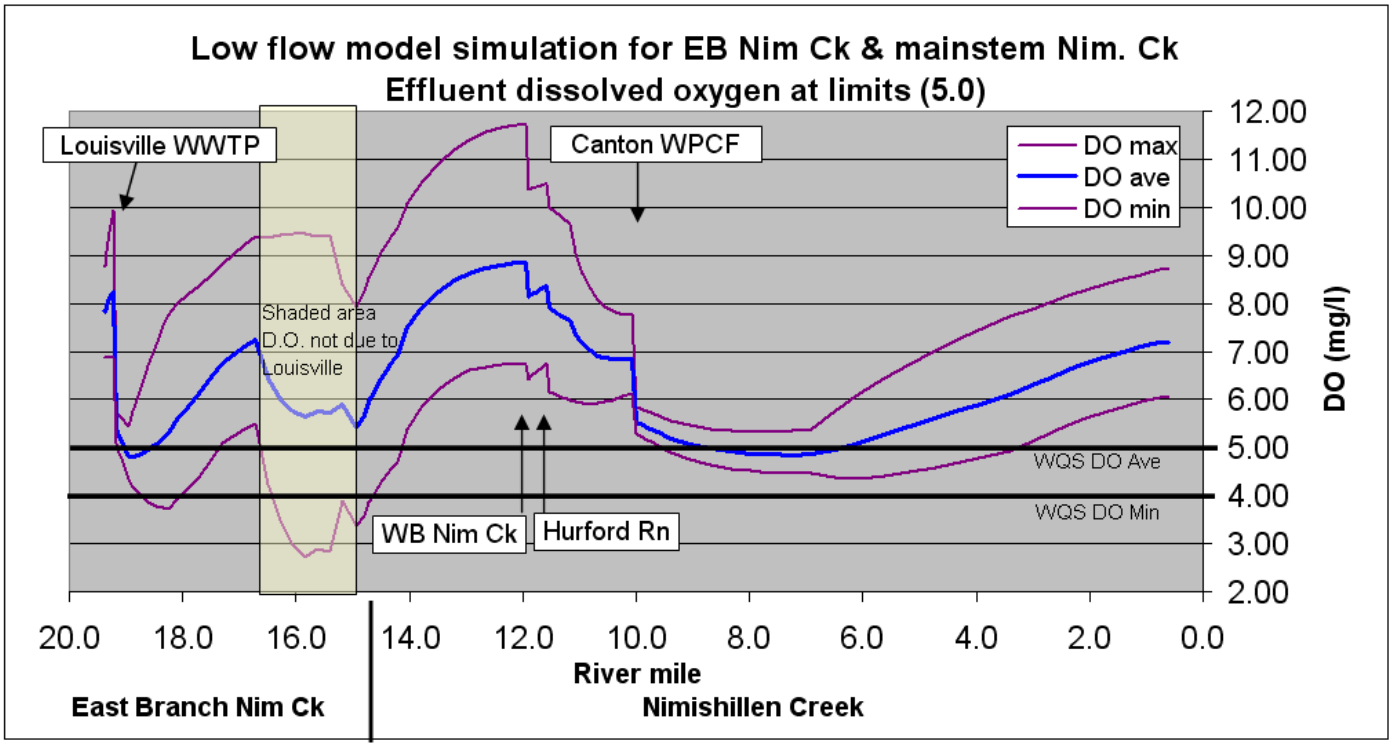


Figure 5-1. DO model results at 5 mg/l effluent D.O.

Figure 5-2 shows a model simulation of the Nimishillen QUAL2K that considers both Louisville WWTP and Canton WPCF effluent to be discharging at a constant D.O. level of 6.0 mg/l. As can be seen in this figure, no instream D.O. violations would occur in the stream were these limits put into place. Based on a review of both plant's self monitoring monthly operating records it appears both plants are in general already discharging effluent at or higher than 6.0 mg/l. Since this limit adequately addresses any instream D.O., there are no further recommendations based on the D.O. targets.

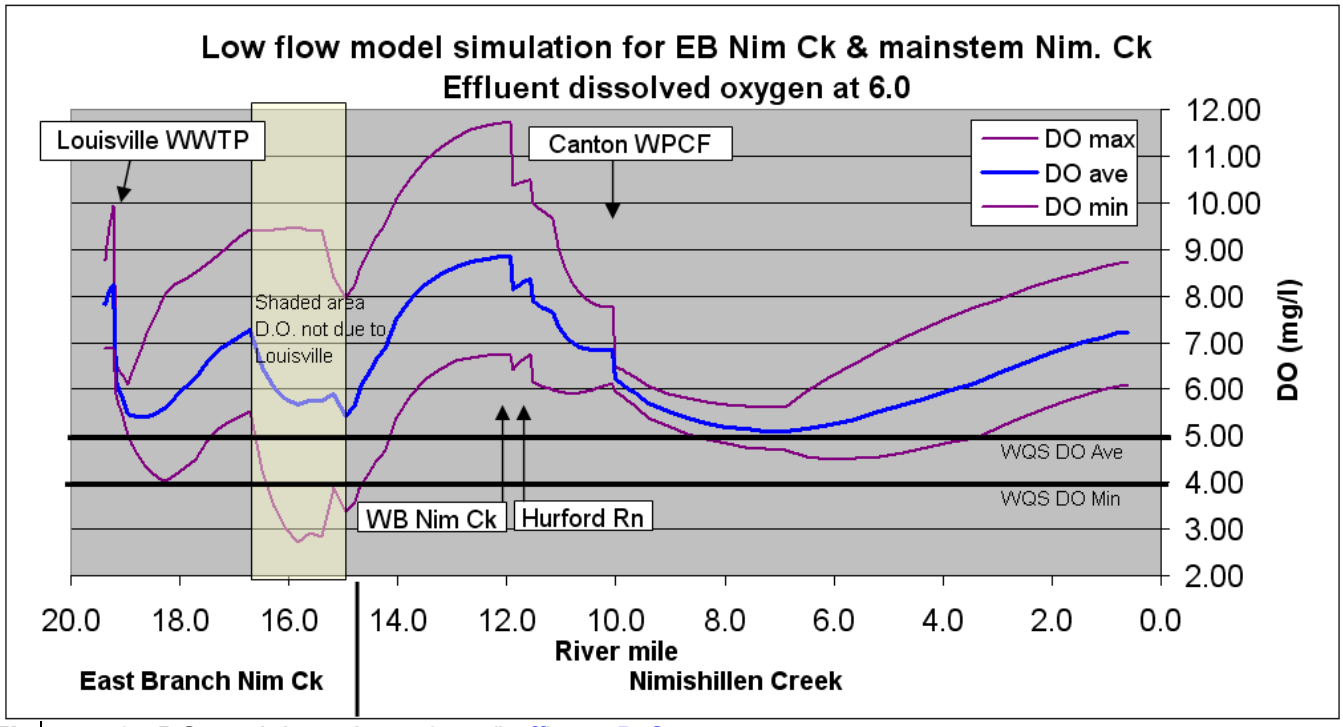


Figure 5-2. DO model results at 6 mg/l effluent D.O.

Total phosphorus

Total phosphorus (T.P.) was examined ~~throughout~~ using the Nimishillen QUAL2K model at the same low flow critical condition as was D.O. Because of the complexity of the interaction of total phosphorus in the model among various inputs and assimilation and decay over time and distance, it is helpful to establish a "point of compliance" as a means to determine whether the target is being met. Such a compliance point also may have utility as a monitoring location if water quality trading is pursued as an implementation option. Ohio EPA is identifying a compliance point for each of the streams being modeled:

- East Branch Nimishillen Creek at RM 0.05 (pedestrian bridge in Cook Park)
- Nimishillen Creek at RM 0.62 (SR 183).

Figure 5-3 shows the T.P. throughout the model reach when simulated at critical condition with the WWTPs discharging at their design flows. Neither WWTP currently has a T.P. limit however both monitor effluent T.P. Using that self monitoring data the average projected effluent quality (PEQ) was calculated for the last 5 years of data. The Louisville WWTP's average PEQ for T.P. is 1.06 mg/l with 242 observations and the Canton WPCF's average PEQ for T.P. is 2.52 mg/l with 521 observations. Figure 5-3 shows the T.P. warm water target, 0.1 mg/l. It can be seen on this figure that the target T.P. concentration is not met on the East Branch Nimishillen Creek downstream of Louisville WWTP. The main stem Nimishillen Creek only meets the target upstream of the Canton WPCF between its formation (at the confluence of East Branch and Middle Branch Nimishillen creeks) and Hurford Run.

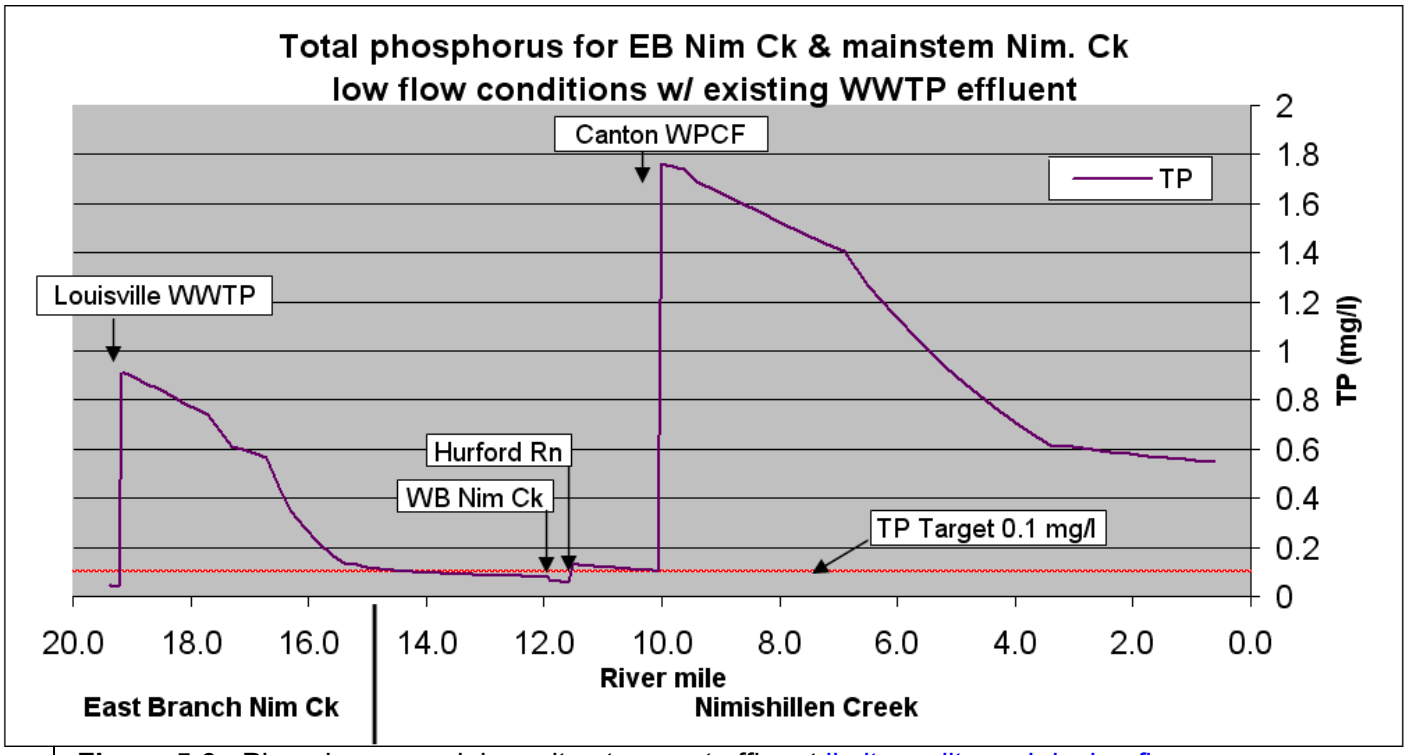


Figure 5-3. Phosphorus model results at current effluent ~~limits~~quality and design flows

Model simulations examining alternative effluent levels were carried out for Louisville WWTP and Canton WPCF. Figure 5-4 shows the portion of the Nimishillen QUAL2K model of the East Branch Nimishillen Creek and upper section of the main stem Nimishillen Creek. This figure shows the T.P. at the existing WWTP effluent (as in Figure 5-3) in addition to the T.P. if the WWTP discharges at a T.P. concentration of 1.0 mg/l. ~~It is noted on the figure~~Note that the T.P. target of 0.1 mg/l is met at the ~~mouth of the~~ East Branch Nimishillen Creek compliance point. A T.P. limit of 1.0 mg/l for Louisville WWTP is appropriate as a first step to reducing the stream's nutrient loads. With a T.P. limit of 1.0 mg/l future biological assessment of East Branch Nimishillen Creek could be carried out to examine if this reduction is adequate in restoring the stream's attainment status.

Figure 5-5 shows several modeling simulations of the Nimishillen QUAL2K model with Canton WPCF set at various T.P. effluent concentrations for the low flow critical condition. Each line represents the model's predicted instream T.P. concentration. The line showing the greatest concentration is the modeling run representing existing ~~conditions~~ concentration at design flows (the same data shown in Figure 5-3). Here it can be seen that were Canton WPCF limited to a T.P. effluent concentration of 1.0 mg/l, the T.P. target of 0.1 mg/l will not be met at the ~~mouth of the~~ Nimishillen Creek compliance point. A ~~The lowest~~ T.P. effluent concentration ~~simulation carried out, with the plant discharging at~~ of 0.4 mg/l~~, is included to show the T.P. effluent limit that~~ would ~~need to~~ be needed ~~in place were the Nimishillen~~ to meet the 0.1 mg/l target ~~near its mouth.~~ at the compliance point.

Tables 5-1 and 5-2 summarize the modeling ~~concentrations~~ simulations described in this section for Louisville WWTP and Canton WPCF. These tables also include the daily pollutant loads of the effluent sources and total stream pollutant load for this critical low flow condition.

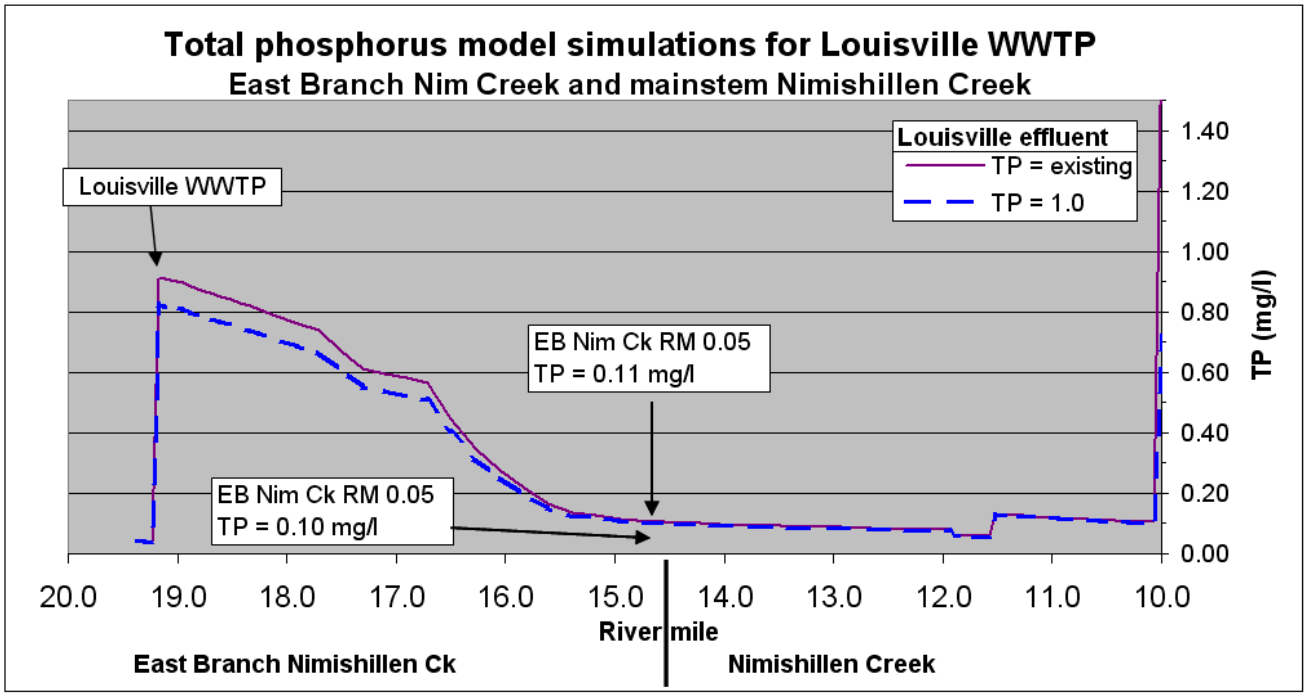


Figure 5-4. Phosphorus model results for Louisville WWTP

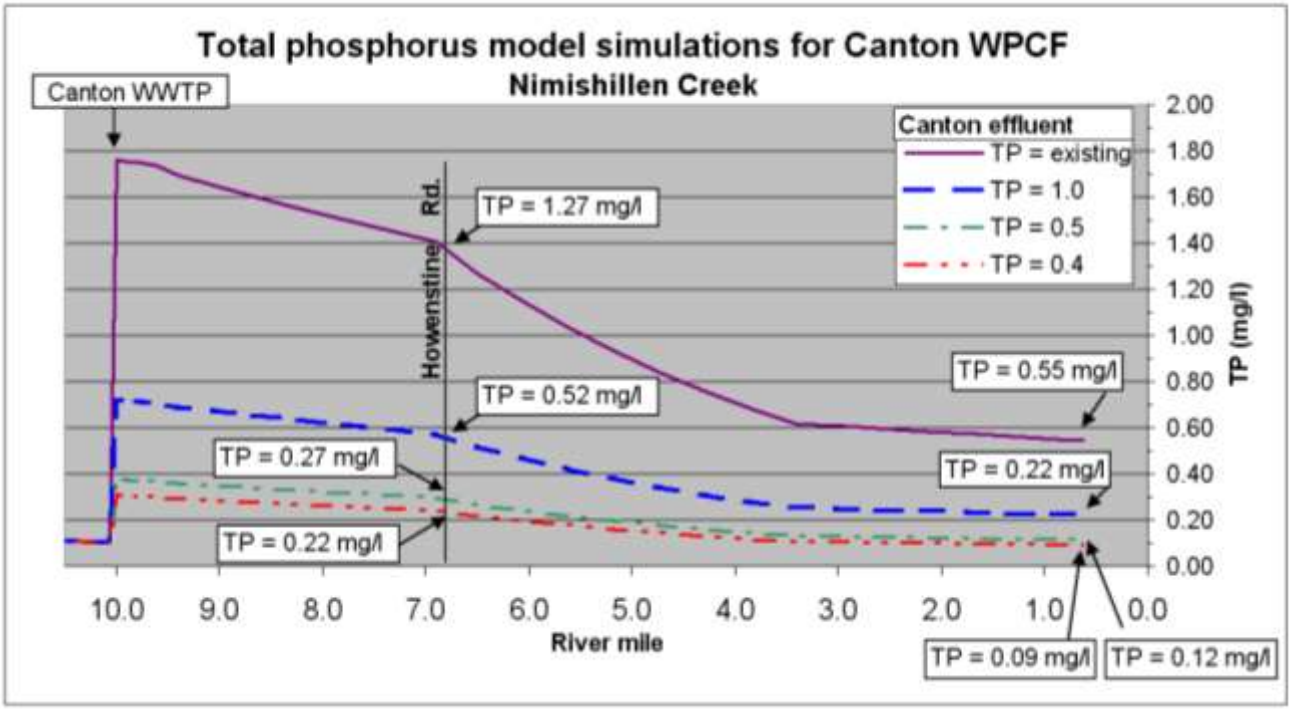


Figure 5-5. Phosphorus model results for Canton WWTP

Table 5-1. Louisville WWTP's model results for total phosphorus~~, projected limits~~ at ~~existing~~ 2.0 MGD ~~effluent~~ design flow

	~~Parameter~~	~~Effluent~~		~~EB Nim Ck at RM 0.05 - Critical condition flow of 9.5 cfs~~	
		~~Concentration[1]~~	~~Load[2]~~	~~Concentration[1]~~	~~Load[2]~~
~~Current limits~~	~~D.O.~~	~~5.0 minimum~~	~~-~~	~~5.66~~	
	~~T.P.~~	~~1.62~~	~~12.3~~	~~0.11~~	~~2.6~~
~~Proposed limits~~	~~D.O.~~	~~6.0 minimum~~	~~-~~	~~5.66~~	
	~~T.P.~~	~~1.0~~	~~7.57~~	~~0.10~~	~~2.3[‡]~~

~~[1] All concentrations are in mg/l [2] All loads are in kg/d [‡] Critical condition TMDL~~

Modeling Scenario	Effluent		East Branch Nimishillen Creek at Compliance Point (RM 0.05)	
	Concentration (mg/l)	Load (kg/d)	Concentration (mg/l)	Load (kg/d)
Current	1.62	12.3	0.11	2.6
Proposed	1.0	7.56	0.10	2.3

Table 5-2. Canton WPCF's model results ~~and projected limits at 3 levels of implementation~~ for total phosphorus at ~~existing~~ 39.0 MGD ~~effluent~~ design flow

~~Modeling Scenario~~	~~Parameter~~	~~Effluent~~		~~Nim.Ck at Howenstine Rd.~~	~~Nim. Ck at RM 0.62 - Critical condition flow of 89.0 cfs~~	
		~~Conc.[1]~~	~~Load[2]~~	~~Conc.[1]~~	~~Conc.[1]~~	~~Load[2]~~
~~Current (T.P. = existing)~~	~~D.O.~~	~~5.0 minimum~~	~~-~~	~~4.96 average~~	~~7.20 average~~	
	~~T.P.~~	~~2.52~~	~~372.0~~	~~1.27~~	~~0.55~~	~~119.8~~
~~Level 1 (T.P. = 1.0)~~	~~D.O.~~	~~6.0 minimum~~		~~5.14 average~~	~~7.21 average~~	
	~~T.P.~~	~~1.0~~	~~147.6~~	~~0.52~~	~~0.22~~	~~47.9 ‡~~
~~Level 2 (T.P. = 0.5)~~	~~D.O.~~	~~6.0 minimum~~	~~-~~	~~5.14 average~~	~~7.21 average~~	
	~~T.P.~~	~~0.5~~	~~73.8~~	~~0.27~~	~~0.12~~	~~26.1~~
~~Level 3 (T.P. = 0.4)~~	~~D.O.~~	~~6.0 minimum~~	~~-~~	~~5.14 average~~	~~7.21 average~~	
	~~T.P.~~	~~0.4~~	~~59.1~~	~~0.22~~	~~0.09~~	~~19.6~~

~~[1] All concentrations are in mg/l [2] All loads are in kg/d ‡ Critical condition TMDL~~

Modeling Scenario	Effluent		Nimishillen Creek at Howenstine Dr (RM 6.72)	Nimishillen Creek at Compliance Point (RM 0.62)	
	Concentration[1]	Load[2]	Concentration[1]	Concentration[1]	Load[2]
Current	2.52	372.0	1.27	0.55	119.8
Level 1	1.0	147.6	0.52	0.22	47.9
Level 2	0.5	73.8	0.27	0.12	26.1
Level 3	0.4	59.1	0.22	0.09	20.5

[1] All concentrations are in mg/l
[2] All loads are in kg/

While the recurrence of the critical condition stream flow is rare, T.P. is clearly above ~~its~~ the target in the Nimishillen Creek watershed throughout the stream's flow regime. Figures 5-6 and 5-7 ~~show~~ compare concentration duration curves with results from sampled T.P. data collected at Faircrest Road by Canton WPCF and at Howenstinee DriveRd. by Ohio EPA, respectively. In each of these figures the abscissa shows percentile of stream flow exceedance or the flow duration interval. The ordinate shows log T.P. concentration. Both of these plots indicate that T.P. is 1) consistently above the target concentration of 0.1 mg/l and 2) generally increasing with decreasing stream flows. With T.P. concentrations increasing at lower flows, it is clear that the dry-weather point sources' T.P.-rich effluent makes up an increased proportion of the stream flow.

~~Due to this, a practical T.P. limit of 1.0 mg/l is proposed for all WWTPs in the watershed with design flows at or greater than 100,000 gallons per day. The QUAL2K modeling results above show that this limit will not be protective of the T.P. target concentration downstream of Canton WPCF during critical low flow events. However, applied annually, this limit should provide ample instream nutrient reduction in order to make~~

some improvements to aquatic life throughout the watershed while creating reasonable additional NPDES limits. Based on the results of the next periodic biological assessment these limits should be reexamined as should the stream's T.P. concentration.

Additionally regarding in Figures 5-6 and 5-7, the Faircrest Road data (Figure 5-6) shows a general, slightly higher concentration of T.P. at various flow regimes when compared to Howenstinee Road Drive (Figure 5-7). Since Howenstinee Rd. Drive is

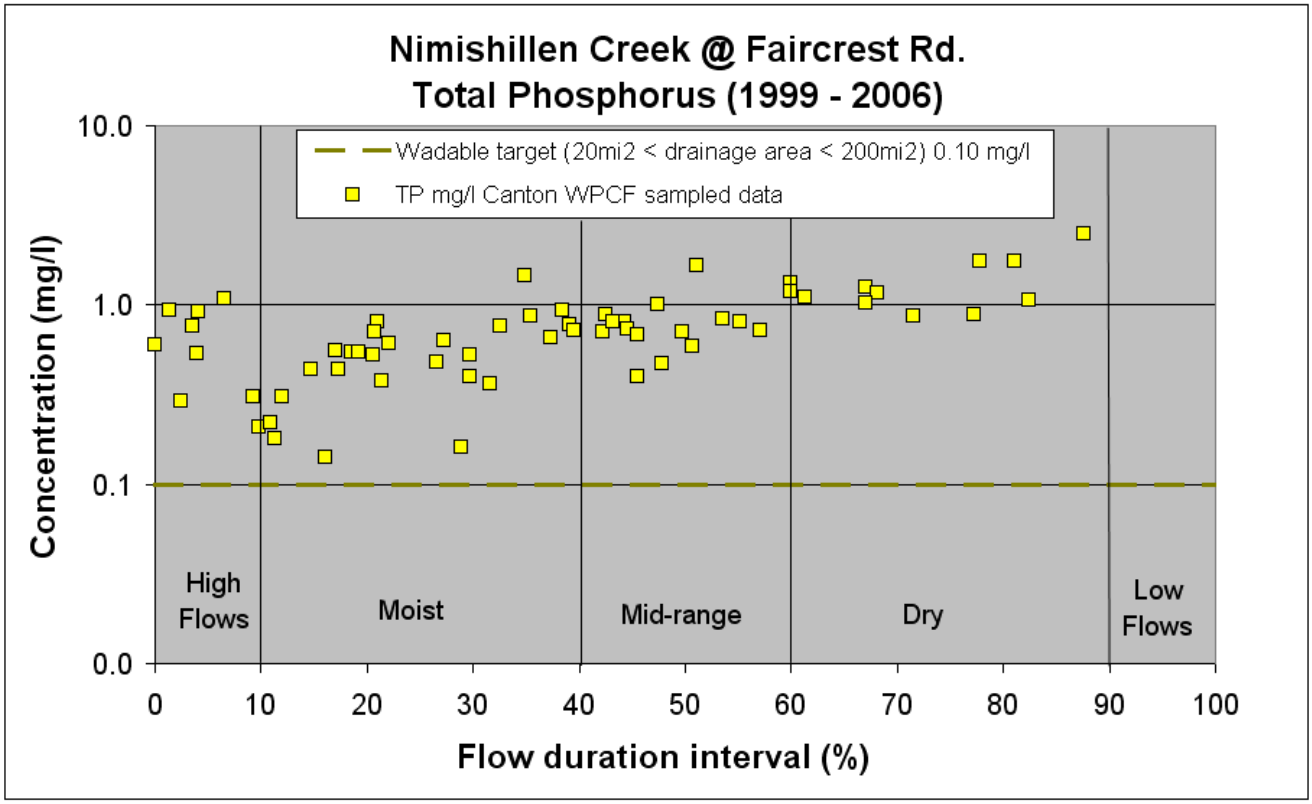
Table 5-3. TMDL and allocations for TP

Stream	**TMDL* (kg/d)**	**WLA (kg/d)**	**LA (kg/d)**
East Branch Nimishillen Creek	2.3	9.31	0.11
Nimishillen Creek‡	47.9	162.82	1.45

* This is the loading capacity at the mouth of the stream (after instream decay)
‡These allocations included all loads that enter the Nimishillen Creek; including East Branch Nimishillen Creek

2.95 river miles downstream of Faircrest Road this confirms the longitudinal T.P. decay predicted by the QUAL2K modeling.

TMDL allocations for phosphorus are summarized in Table 5-3.



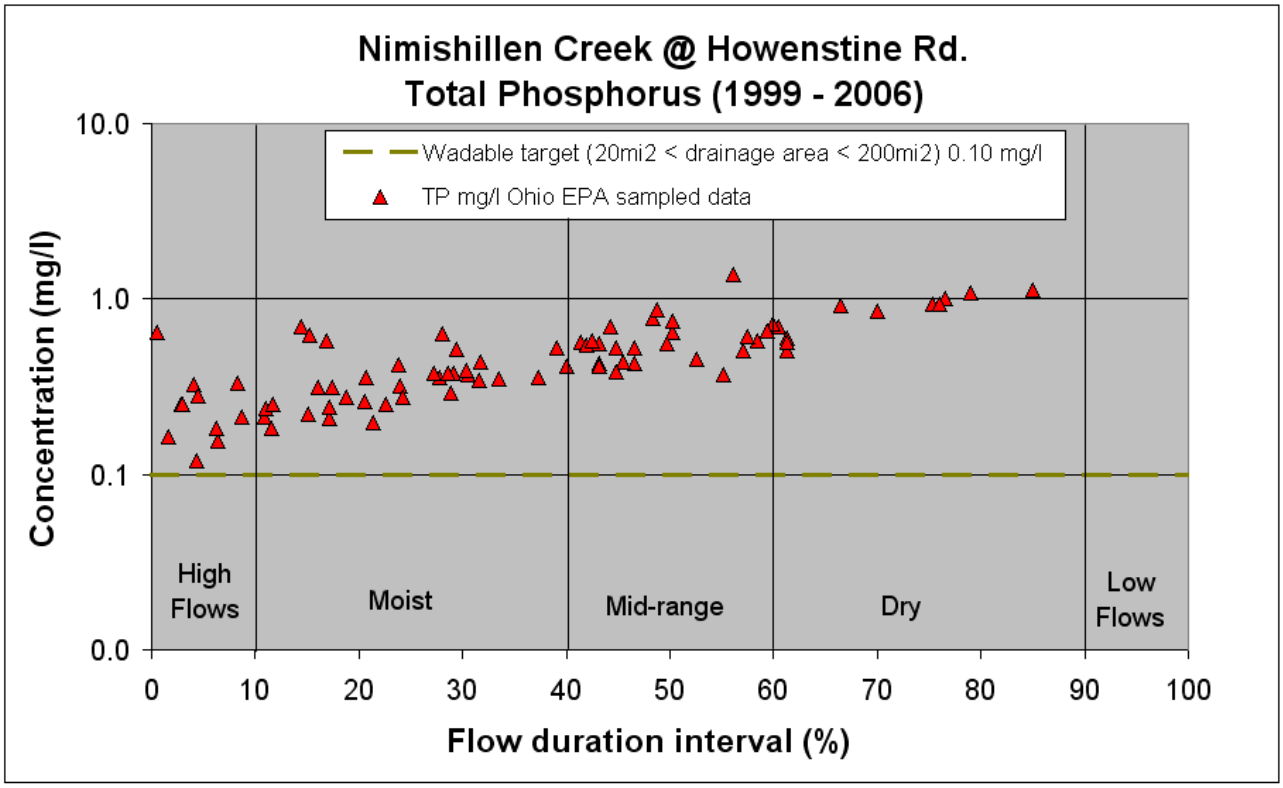


Figure 5-6. Nimishillen Creek phosphorus @ Faircrest Road
Figure 5-7. Nimishillen Creek phosphorus @ Howenstein~~e~~ Drive~~Road~~

TMDL allocations for phosphorus are summarized in Table 5-3. As discussed earlier, Ohio EPA established compliance points on each of the streams being modeled. Since the model simulates instream T.P. decay in a manner similar to natural conditions, the distance from a point source to a compliance point must be taken into consideration. The greater the distance from point sources to the compliance points the more assimilation of that source's T.P. is expected. The TMDL for each compliance point is the total critical condition flow at that point times the instream target concentration (0.1 mg/l T.P.). As shown in Figures 5-4 and 5-5, the allocated loads outlined in Table 5-3 decay to the target concentration of 0.10 mg/l at the compliance point in East Branch Nimishillen Creek and on the mainstem Nimishillen Creek. Thus, the T.P. loads allocated to the sources (the load and wasteload allocations) do not explicitly add up to the TMDL.

Effluent concentrations outlined in Table 5-3 for Louisville WWTP and Canton WWTP are determined via modeling described above. The T.P. concentration for the other facilities represents their current observed or assumed values. Since all of these are well below 1.0 mg/l already, these allocations represent no expected reductions.

Table 5-3. TMDL and allocations for total phosphorus

	Design Flow (MGD)	Phosphorus ~~Quality~~ WLA/LA at Source[2]		Phosphorus Loads at Compliance Points[1] (kg/d)		
		Conc (mg/l)	Load (kg/d)	TMDL[2]	WLA[2]	LA[2]
East Branch Nimishillen				2.34	~~9.31~~ 2.315	~~0.11~~ 0.026
Louisville WWTP	2.00	1.00	7.56			
Republic Steel Corp. 010 outfall	2.74	0.16	1.66			
Republic Steel Corp. other outfalls	0.30	0.08	0.09			
Nonpoint sources	-	-	0.11			
Nimishillen Creek				21.78	~~66.27~~ 21.368	~~1.34~~ 0.416
Canton WPCF	39.00	0.40	59.05			
Canton Water Dept. NE Plant	0.16	1.00	0.60			
Marathon Ashland Petroleum	1.67	0.27	1.70			
Timken Company	3.50	0.27	3.58			
Nonpoint sources	-	-	1.34			

1 Compliance point is at RM 0.05 on East Branch Nimishillen Creek and at RM 0.62 on Nimishillen Creek. The allocations for the Nimishillen Creek compliance point reflect the sum of the loads contributed in Nimishillen Creek. The allocations for the East Branch compliance point reflect the

sum of the loads contributed in East Branch. The loads contributed upstream of the East Branch compliance point are included in the model and are reflected in the Nimishillen compliance point.

2 The loads contributed to the streams (LAs and the individual WLAs) decay to achieve the allocations at both compliance points.

As shown in Figures 5-6 and 5-7 the effluents from the point sources are rich in total phosphorus during the critical low flow period. Therefore, a T.P. limit of 1.0 mg/l is recommended for all WWTPs in the watershed with design flows at or greater than 100,000 gallons per day. While the QUAL2K modeling results indicate that this limit will not meet the T.P. target concentration at the compliance point during critical low flow events, it does represent a significant (approximately 60%) reduction in T.P. load from the Canton WPCF. Applied on an annual basis, this limit should provide enough instream nutrient reduction to improve aquatic life throughout the watershed while imposing achievable NPDES limits. Any further reduction in effluent limits should be evaluated after these limits are being attained and an evaluation of the biological condition of the streams has been completed.

Indirectly addressed nutrient impairment, non-point sources reduction

Impairment is caused by nutrients and/or organic enrichment in several stream reaches that are not assessed by the QUAL2K modeling in the Nimishillen Creek watershed. These are outlined in Table 4-1 of Chapter 4.

Nutrient and organic enrichment causes of impairment are addressed indirectly in this TMDL for watersheds of Swartz Ditch, the upper East Branch Nimishillen Creek including its unnamed tributary at RM 4.67 and the West Branch Nimishillen Creek. The bacteria TMDLs calculated for these watersheds addresses the primary sources of nutrient and organic enrichment. This is because the recommended pollutant allocations for these watersheds to meet their determined bacteria TMDL calls for reductions of fecal coliform sourced from 1) cows grazing in the streams, 2) runoff from managed lands and 3) failing home sewage treatment systems. Limiting livestock and human waste from being directly discharged to streams will reduce all nutrients associated with that waste. Implementation efforts that reduce the amount of fecal coliform bacteria that runs off the land, such as filter strips in grazing lands and better pet waste removal practices in urban lands, will also directly reduce the amount of nutrients that are washed off into the streams.

The lower 14-digit HUC of Middle Nimishillen Creek (020) has 2 assessment sites that are also impaired by nutrients. These are sites on the Middle Nimishillen Creek itself, and not the mainstem Nimishillen Creek. No bacteria TMDL was necessary for this 14-digit HUC because these sites meet the primary recreational use standards (this is a more highly urbanized subwatershed). This 14-digit HUC is downstream of the 14-digit HUC 010 (upper Middle Nimishillen Creek). That entire 14-digit HUC (which includes Swartz Ditch) receives a bacteria TMDL in this report. For the same argument as explained in the previous paragraph, this bacteria TMDL should be adequate to reduce nutrients in the 14-digit HUC 020.

While the indirect manner of addressing nutrient and organic enrichment impairment for the stream reaches explained in this subsection does not fulfill expectations of a full TMDL, the bacteria TMDLs and their recommended allocations should act as a surrogate for adequately addressing these causes of impairment.

5.2 Bacteria (Pathogen) TMDL