Appendix

D

LOADING ANALYSIS INFORMATION
GRAND RIVER (UPPER) WATERSHED

Table of Contents

D1 Background

From data collected in 2007 and 2008 the upper Grand River was found to have warm water habitat (WWH) and recreation use impairments. Table D-1 below lists the impaired locations with associated causes and the actions taken to address impairments.

Table D-1. Summary of impairments in the Grand River (upper) watershed and methods used to address impairments.

Assessment Unit (04110004)	Narrative Description	Causes of Impairment[1]	Action Taken
Headwaters Grand River (04110004 01)			
01 01 *Priority points: 6*	Dead Branch	Insufficient data to assess (ALU)	No action necessary
		Bacteria (RU)	Bacteria TMDL
01 02 *Priority points:11*	Headwaters Grand River	Direct habitat alterations (ALU)	Habitat TMDL
		Bacteria (RU)	Bacteria TMDL
		No impairment (PDWSU)	No action necessary
01 03 *Priority points:6*	Baughman Creek[2]	Natural conditions (flow or habitat) (ALU)	No action necessary
		Bacteria (RU)	Bacteria TMDL
01 04 *Priority points:6*	Center Creek-Grand River	Ammonia (total) (ALU)	TKN[3] TMDL as surrogate
		Total Kjeldahl nitrogen (ALU)	TKN TMDL
		Total dissolved solids (ALU)	TKN TMDL as surrogate
		Organic enrichment (sewage) biological indicators) (ALU)	TKN TMDL as surrogate
		Natural (flow or habitat) (ALU)	No action necessary
		Bacteria (RU)	Bacteria TMDL
01 05 *Priority points:8*	Coffee Creek-Grand River	No impairment (ALU)	No action necessary
		Bacteria (RU)	Bacteria TMDL
01 06 *Priority points:5*	Swine Creek	No impairment (ALU)	No action necessary
		Bacteria (RU)	Bacteria TMDL
Rock Creek (04110004 02)			
02 01 *Priority points:5*	Upper Rock Creek	Insufficient data to assess (ALU)	No action necessary
		Bacteria (RU)	Bacteria TMDL
02 02 *Priority points:7*	Middle Rock Creek	Total dissolved solids (ALU)	TDS TMDL
		Nutrient/eutrophication biological indicators (ALU)	TP[4] TMDL
		Bacteria (RU)	Bacteria TMDL

Assessment Unit (04110004)	Narrative Description	Causes of Impairment[1]	Action Taken
02 03 *Priority points:5*	Lower Rock Creek	Low flow alterations (ALU)	Not addressed
		Nutrient/eutrophication biological indicators (ALU)	TP TMDL
		Total dissolved solids (ALU)	Ammonia TMDL as surrogate
		Ammonia (total) (ALU)	Ammonia TMDL
		Bacteria (RU)	Bacteria TMDL
Phelps Creek-Grand River (04110004 03)			
03 01 *Priority points:5*	Phelps Creek[2]	Natural conditions (flow or habitat)	No action necessary
		Bacteria (RU)	Bacteria TMDL
03 02 *Priority points:9*	Hoskins Creek	Direct habitat alterations (ALU)	Habitat TMDL
		Natural conditions (flow or habitat) (ALU)	No action necessary
		Bacteria (RU)	Bacteria TMDL
03 03 *Priority points:10*	Mill Creek-Grand River	Low flow alterations (ALU)	Not addressed
		Natural conditions (flow or habitat) (ALU)	No action necessary
		Bacteria (RU)	Bacteria TMDL
03 04 *Priority points:10*	Mud Creek	Direct habitat alterations (ALU)	Habitat TMDL
		Bacteria (RU)	Bacteria TMDL
03 05 *Priority points:7*	Plum Creek-Grand River	No impairment (ALU)	No action necessary
		Bacteria (RU)	Bacteria TMDL
Three Brothers Creek-Grand River (04110004 05)			
05 01 *Priority points:8*	Three Brothers Creek-Grand River[2]	Natural conditions (flow or habitat) (ALU)	No action necessary
		Bacteria (RU)	Bacteria TMDL
05 02 *Priority points:6*	Bronson Creek-Grand River[2]	Natural conditions (flow or habitat) (ALU)	No action necessary
		Bacteria (RU)	Bacteria TMDL

[1] ALU = aquatic life use
RU = recreation use
[2] The category for aquatic life use is 4n (natural causes and sources only).
[3] TKN stands for total Kjeldahl nitrogen.
[4] TP stands for total phosphorus.

D2 Methods

D2.1 Recreation Use: Load Duration Curves

Recreation use was not supported in multiple assessment units in which at least one site's geometric mean did not attain the water quality standards criteria. A study was carried out to develop an *E. coli* total maximum daily load (TMDL) as required by Section 303(d) of the Clean Water Act and the United States Environmental Protection Agency's Water Quality Planning and Management Regulations (Title 40 of the Code of Federal Regulations, Part 130). This TMDL report defines in-stream bacterial conditions, potential sources, bacteria targets and needed reductions and recommends implementation strategies.

D2.1.1 Justification of Method

Load duration curves can assist in distinguishing between point and nonpoint sources that contribute to *E. coli* loading by highlighting the flow conditions under which impairment occurs. At lower stream flow levels, little to no in-stream dilution of *E. coli* is occurring due to dry conditions lacking runoff. Because of this, any point source *E. coli* contributions to the stream will result in higher concentrations of *E. coli*. If there are a high number of samples under dry weather or low flow conditions that fall above the target curve, there is a likelihood of nearby point sources of *E. coli.* Examples of bacteria point sources include combined sewer overflows (CSOs), municipal separate storm sewer systems (MS4s) or wastewater treatment plants. High bacteria levels under low flow conditions may also indicate concentrated cattle grazing in the stream channel, leaking sewer lines, or failing home sewage treatment systems (HSTS).

D2.1.2 Description of Method

In order to determine the magnitude of bacteria impairment and differentiate between types of bacteria sources contributing to impairment, load duration curves (LDCs) were calculated for analyzed sites following the methods described in U.S. EPA's *An Approach for Using Load Duration Curves in the Development of TMDLs* (U.S. EPA 2007b). See Figure D-1 and Table D-2 for examples.

Under elevated flow conditions, point sources are assumed to be masked by in-stream dilution, therefore high *E. coli* loading is caused by precipitation washoff or erosion of contaminated land surfaces. Among many possibilities, some typical nonpoint sources of *E. coli* include manure spreading and washoff from livestock feeding operations. Scenarios where high *E. coli* loads exist under mid-range flow conditions, or high loads occur under all conditions, can be attributed to a mixture of point and nonpoint sources. Site investigation using digital mapping, aerial photography or an on-the-ground visit can help further develop priorities for implementation based on the LDC evidence for either point or nonpoint sources of *E. coli*.

It is important to note that the load duration curve method does not enable one to attribute impairment to any particular source; instead it is a tool used to determine the flow conditions under which impairment occurs and the probable types of sources contributing to that impairment.

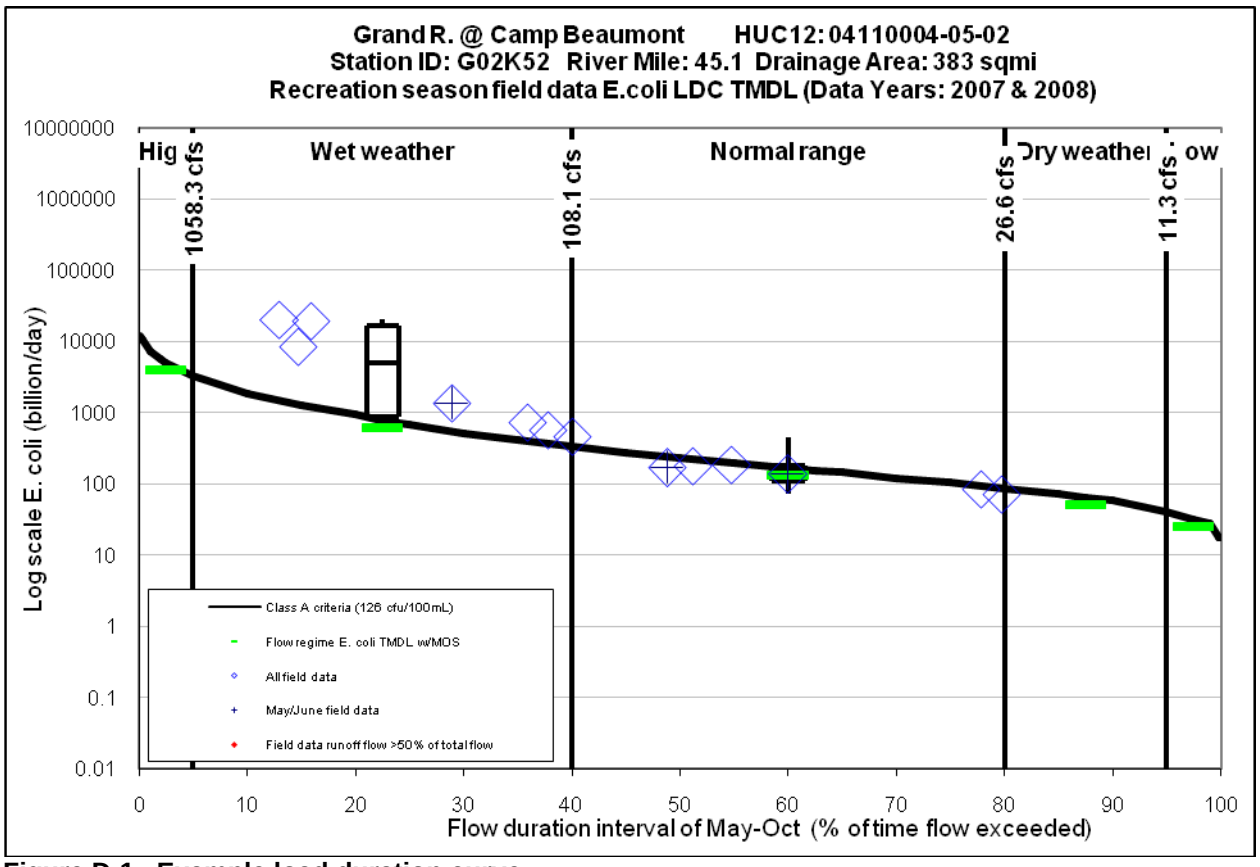

Figure D-1. Example load duration curve.

Table D-2. Example TMDL table calculations (from above load duration curve).

Flow regime TMDL analysis *E. coli* **(billion bacteria/day)**	**High**	**Wet weather**	**Normal range**	**Dry weather**	**Low**
Duration interval	0-5%	5-40%	40-80%	80-95%	95-100%
Samples per regime	0	6	7	0	0
Median sample load	N/A	4903	166.35	N/A	N/A
TMDL	**5,047.59**	**785.693**	**167.384**	**64.127**	**31.455**
WLA: total	**5.679**	**5.679**	**5.679**	**5.679**	**5.679**
Bloomfield High School	0.043	0.043	0.043	0.043	0.043
Bridge Lake Farm WWTP	0.016	0.016	0.016	0.016	0.016
Bristol Local School	0.107	0.107	0.107	0.107	0.107
Camp Whitewood	0.038	0.038	0.038	0.038	0.038
Cardinal Local School District	0.029	0.029	0.029	0.029	0.029
End of Commons General Store	0.014	0.014	0.014	0.014	0.014
Geauga Co. Parkman WWTP	0.711	0.711	0.711	0.711	0.711
Glenbeigh Hospital	0.095	0.095	0.095	0.095	0.095
Grand Valley Conservation Center	0.095	0.095	0.095	0.095	0.095
Halfway Restaurant	0.001	0.001	0.001	0.001	0.001
Hartsgrove BP	0.002	0.002	0.002	0.002	0.002
Hartsgrove General Store	0.005	0.005	0.005	0.005	0.005
Kool Lakes Family Campground	0.143	0.143	0.143	0.143	0.143
Middlefield MHP	0.095	0.095	0.095	0.095	0.095
Middlefield Orig. Cheese Coop.	0.049	0.049	0.049	0.049	0.049
Nelson Ledges Estate MHP	0.143	0.143	0.143	0.143	0.143
ODOT Rome Maint. Outpost	0.007	0.007	0.007	0.007	0.007
Orwell WWTP	2.48	2.48	2.48	2.48	2.48
Rigsby Ranch FKA River Pines	0.119	0.119	0.119	0.119	0.119
Roaming Shores WWTP	0.763	0.763	0.763	0.763	0.763
Rock Ck. STP	0.033	0.033	0.033	0.033	0.033
Shively Land Co. LLC	0.017	0.017	0.017	0.017	0.017
Southington Estates LLC	0.143	0.143	0.143	0.143	0.143
Southington Local Schools	0.095	0.095	0.095	0.095	0.095
Windsor Community Center	0.011	0.011	0.011	0.011	0.011
Grand Valley Nature Conservancy	0.095	0.095	0.095	0.095	0.095
Kampf Apartments	0.052	0.052	0.052	0.052	0.052
Trumbull County Commissioners & Others MS4	0.278	0.278	0.278	0.278	0.278
LA	3,961.723	611.874	125.883	44.723	19.043
MOS: 20%	**1,009.518**	**157.139**	**33.477**	**12.826**	**6.291**
AFG: 1.4%	**70.666**	**11**	**2.343**	**0.898**	**0.44**
Nonpoint (LA) % load reduction required	No Data	**84%**	**None**	No Data	No Data

Values were adjusted for rounding.

Five sampling locations were established within the watershed, and these sites were used for further study of the sources of recreation use non-attainment in impaired nested subwatersheds. These five sites included two sites on the main stem of the Grand River and three tributary sites on Trumbull, Phelps and Swine Creeks. These five sites included all impaired areas in the watershed (see Table D-3).

Table D-3. Locations of *E. coli* LDCs and nested subwatersheds included in each curve.

Load Duration Curve Site	Nested Subwatershed Location	Nested Subwatersheds Included
Phelps Creek @ Windsor Rd. extension	04110004 03 01	03 01 (Phelps Creek portion)
Swine Creek @ Curtis Middlefield Rd	04110004 01 06	01 06 (Swine Creek portion)
Grand R. @ US-6	04110004 03 05	01 01 01 02 01 03 01 04 01 05 01 06 03 01 03 02 03 03 03 05 (above river mile 55.62)
Grand River @ Camp Beaumont	04110004 05 01	02 01 02 02 02 03 03 04 03 05 (below river mile 55.62) 05 01 05 02
Trumbull Creek @ Riverdale Rd.	04110004 05 02	05 02 (Trumbull Creek portion)

An outline of LDC development specific to the upper Grand River watershed is as follows:

1. An historical daily flow record was obtained for the USGS Gage 04212100 on the Grand River near Painesville, OH. A long-term water level recorder was installed on the Grand River at Camp Beaumont (G02K52) throughout the 2008 recreation season in order to determine hourly flow rates. A relationship between the flow record at Camp Beaumont for the 2008 recreation season and the USGS gage was used to extrapolate a long term flow record for Camp Beaumont for the period of record including the recreation seasons of 1998 through 2008. Dates outside of the recreation season (May 1 through October 31) were excluded from the record. This flow record was then ordered and ranked to determine, for each daily flow, the percentage of the period of record when that flow was equaled or exceeded. This flow exceedance range constitutes the basis for the x-axis in each LDC graph.
2. In-stream bacteria loads were determined for each sampling event using stream sample bacteria concentration in conjunction with flow data for each sampling location. At the appropriate flow exceedance, the corresponding *E. coli* concentration for a stream sample was plotted as a point on the y-axis of the LDC. In order to determine the sample sites' flow, sampling locations were assigned scaled flows based on the ratio of each sampling location's drainage area compared to that of the Camp Beaumont site.
3. Target *E. coli* loads were calculated by applying the applicable *E. coli* WQS concentration value at each flow exceedance value for the entire flow duration interval.

4. A margin of safety was added to account for any lack of knowledge concerning the relationship between load and wasteload allocations and water quality.
5. An allowance for future growth, based upon census population growth projections, was factored into any needed load reductions. There were no point source expansions planned.
6. The LDCs were divided into five hydrologic regimes and within each regime the total required nonpoint load reduction percentage is calculated by incorporating the margin of safety and allowance for future growth into the target load and determining the difference between this target and the existing load in each flow regime.

A "TMDL table" is associated with each LDC, detailing the information that is graphically presented in the LDC figure. Each table contains the following information for each hydrologic regime:

- number of samples
- median sample *E. coli* load
- total maximum daily load (TMDL)
- wasteload allocation (WLA) for each point source
- nonpoint load allocation (LA)
- margin of safety (MOS) load
- allowance for future growth (AFG) load
- nonpoint (LA) % load reduction required

Target and Existing Deviation

For a given impaired site, each hydrologic condition (high flows, moist conditions, mid-range conditions, dry conditions or low flows) was assigned a target bacteria loading rate (cfu/day) by multiplying the class A *E. coli* water quality standard, 126 cfu/100 ml, by the median flow of each hydrologic class at that site and a constant, used to convert cubic feet per second to milliliters per day: $T = Q_m * S * C$; where T = target bacteria load, Q_m = median flow for a specific hydrologic class, S = water quality standard (126 cfu/100 ml) and C = a unit conversion constant (cubic feet per second to milliliters per day). Median observed bacteria loads in each hydrologic condition were compared to the median target value in that condition, after incorporating a margin of safety and allowance for future growth, in order to quantify needed reductions.

Wasteload Allocation

Each discharger in the upper Grand River watershed is assigned a wasteload allocation (WLA) based upon the design flow of the treatment facility and the Class A water quality standard. These WLAs are listed in the TMDL table that corresponds with each sampling site. Because a given facility operates at most times at some fraction of its design flow, the WLA for each facility includes an amount of reserve capacity up to the design flow of the facility.

The wasteload allocation for each facility is included for all nested, downstream LDCs within the watershed. For example, the Cardinal Local School District WLA is included in the LDC for the most immediate downstream sampling location, *Phelps Creek @ Windsor Rd. Extension*, as well as the two other downstream sampling locations, *Grand River @ US-6 (RM 55.62)* and *Grand River @ Camp Beaumont (RM 45.1)*.

Load Allocation

The load duration curve method was selected to assign in-stream bacteria loads at a given site to one or several potential bacteria sources (see U.S. EPA 2007b). In a load duration curve, patterns of bacteria impairment can be examined and addressed relative to the flow conditions under which they occur which allows a set of potential bacteria sources specific to a given site to be highlighted. Under the highest flow conditions, point sources are likely to be masked by in-stream dilution; therefore high bacteria measurements in these conditions are associated with precipitation washoff or erosion of contaminated land surfaces. Impairments under mid-range flows can be caused by a mixture of point and nonpoint sources. Under the lowest flow conditions, recreation use impairments are generally attributable to sources not associated with runoff events, such as a failing HSTS or in-stream livestock.

Sampling locations were visited under a range of different flow conditions during the recreation season. Daily loading of bacteria was calculated for each site utilizing *E. coli* stream sample data. Existing in-stream loads, target loads and load duration curves were calculated from the collected data. Using these data and notes about land use, recommendations regarding sources and potential implementation were developed.

Margin of Safety

The Clean Water Act requires that a TMDL include a margin of safety (MOS) to account for any lack of knowledge concerning the relationship between load and wasteload allocations and water quality. U.S. EPA guidance explains that the MOS may be implicit (i.e., incorporated into the TMDL through conservative assumptions in the analysis) or explicit (i.e., expressed in the TMDL as loadings set aside for the MOS).

An implicit MOS is incorporated in various ways, including in the derivation of the *E. coli* water quality criterion and in not considering the die-off of pathogens as part of the TMDL calculations. The implicit MOS is also enhanced by the use of the geometric mean target (which is a seasonal target) to calculate daily loads. In addition, an explicit MOS has been applied as part of all of the bacteria TMDLs by reserving 20% of the allowable load because of the broad fluctuation of *E. coli* concentrations that occurs in nature and the relatively low numbers of data points available for this analysis. The explicit MOS in each allocation is shown in the TMDL allocation tables throughout Section D3.

Seasonality and Critical Conditions

Stream recreation occurs in a variety of forms, from wading to fishing to canoeing, and in a wide range of stream flow conditions. In order to ensure that recreation use is protected whenever recreation might occur, *E. coli* TMDLs are established for all flow conditions during the recreation season (May 1 through October 31), when people are most likely to fish, wade, swim and boat in streams.

In-stream bacteria loads vary by source and can occur across the hydrograph, from washoff of land-deposited bacteria under moist conditions to in-stream livestock and failing HSTS in low flow conditions. Nonpoint sources to which bacteria loads are allocated in the upper Grand River basin include livestock, both manure washoff and in-stream animals, and failing HSTS.

Allowance for Future Growth

The upper Grand River watershed lies within Ashtabula, Geauga, Trumbull and Portage counties. The average population change projection from 2010 to 2020 of the four counties is an increase of 1.4%. In order to ensure recreation use attainment in the future, an allowance for future growth (AFG) factor of 1.4% was applied to each TMDL (ODD 2003).

D2.2 Aquatic Life Use: Nutrients and Total Dissolved Solids

D2.2.1 Linkage and Justification of Methods

How the identified stressors lead to impaired uses
In freshwater systems, phosphorus is typically the nutrient that is in short supply relative to biological needs, which means that the productivity of aquatic plants and algae can be controlled by limiting the amount of phosphorus entering the water. Large diurnal swings in pH and dissolved oxygen may occur as excessive amounts of nutrients are metabolized by aquatic plants and algae. The range of these swings often exceeds the state water quality criteria established to protect fish and other aquatic organisms in their various life stages. Therefore, the amount of phosphorus currently entering these waters exceeds the seasonal loading capacity and must be reduced if these water quality problems are to be resolved. The sources of phosphorus loading vary depending on the human activities and conditions in a specific watershed (U.S. EPA 2007a).

Though phosphorus can be the limiting factor in the growth of algae, nitrogen is also a critical component, therefore nitrogen is also addressed in this report. Both nitrogen and phosphorus can enter waterways through soil erosion attached to soil particles, dissolved in crop field water via field tiles, failing home sewage treatment systems, and other routes.

Direct linkage
While the Ohio EPA does not currently have statewide numeric criteria for nutrients, potential targets have been identified in a technical report titled *Association Between Nutrients, Habitat, and the Aquatic Biota in Ohio Rivers and Streams* (Ohio EPA 1999). This document, herein referred to as the *Associations* document, provides the results of a study analyzing the effects of nutrients on the aquatic biological communities of Ohio streams and rivers. The study reaches a number of conclusions and stresses the importance of habitat and other factors, in addition to in-stream nutrient concentrations, as having an impact on the health of biological communities. The study also includes proposed total phosphorus target concentrations based on observed concentrations associated with acceptable ranges of expected biological communities. The total P and nitrogen targets used in this report are shown in Table D-4. It is important to note that these nutrient targets are not codified in Ohio's water quality standards; therefore, there is a certain degree of flexibility as to how they can be used in TMDL development.

Ohio's standards also include narrative criteria that limit the quantity of nutrients that may enter state waters. Specifically, OAC Rule 3745-1-04 (E) states that all waters of the state, "…shall be free from nutrients entering the waters as a result of human activity in concentrations that create nuisance growths of aquatic weeds and algae." In addition, OAC Rule 3745-1-04(D) states that all waters of the state, "…shall be free from substances entering the waters as a result of human activity in concentrations that are toxic or harmful to human, animal or aquatic life and/or are rapidly lethal in the mixing zone." Excess concentrations of nutrients that contribute to non-attainment of biological criteria may fall under either OAC Rule 3745-1-04 (D) or (E) prohibitions.

Justification of Methods

The mass balance method was used for Lebanon Creek, Center Creek and Rock Creek for nutrient (total Kjeldahl nitrogen and total phosphorus) TMDLs because the method compares observed data with in-stream targets. Because the basins studied are small and have a short time of travel, a more complex loading analysis method was not necessary. This simple mass balance method accounts for point sources and nonpoint sources of nutrients.

LDCs were used for Whetstone Creek and Lebanon Creek for ammonia and TDS, respectively. This method also directly compares actual data to targets, so it is reflective of existing conditions and problems. As stated in Section D2.1.1, LDCs also indicate in what flows target exceedances occur, which can then indicate sources of pollutants.

Flow alteration impairments are dealt with by calculating area water yield from precipitation and applying that to the impaired site to determine what the target flow should be. The existing unnaturally low flow is then subtracted from it, leaving the needed increase in flow to meet the target. One potential weakness of this method is that there is no way to know what the existing impoundment-influenced 7Q10 is for this site, so zero flow over the impoundment during critical flow periods is assumed. The assumption makes sense because of its small drainage area of 3.04 mi^2.

Center Creek (04110004 01 04)

Upstream from Center Creek is Champion Heights, a densely populated, unsewered suburb of the City of Warren. There are approximately 322 unsewered houses, as counted from aerial photography, in the northernmost portion of Champion Heights in an area 0.528 square miles that lies in the Center Creek basin. The impact from these homes is impairing Center Creek at RM 6.25 and RM 3.03. Biology indicated home sewage as a probable source (Ohio EPA 2009):

> "The riffle habitat was devoid of sensitive EPT and had an unusually high abundance of flatworms (facultative taxa often associated with enrichment effects). Unusually high siltation and algal growths were observed at this station."

The causes listed in Table D-1 for impairments at both sites on Center Creek include ammonia (total), total Kjeldahl nitrogen, total dissolved solids (TDS), organic enrichment (sewage) biological indicators, and natural (flow or habitat – wetlands at RM 3.03). The source of these causes, with the exception of natural causes, is the unsewered housing mentioned above. When HSTS fail, human waste builds in the system and eventually exits to the nearest waterway. Raw or poorly treated waste is high in phosphorus, ammonia (which breaks down into various forms of nitrogen) and TDS.

Total Kjeldahl nitrogen (TKN) is an analytical name for total of ammonia + organic nitrogen (N), so pollution from failing HSTS would generate both ammonia and organic N; using TKN would directly represent this relationship. Nitrogen (as ammonia and/or TKN), solids (as total suspended or total dissolved) and biological oxygen demand are all well documented constituents of home sewage (U.S. EPA 2002). TKN is used as a surrogate for ammonia, TDS and organic enrichment since all parameters have the same source. The impact from the wetlands is not quantified in this report.

Whetstone Creek (04110004 02 03)

Whetstone Creek, a Rock Creek tributary, is impaired due to elevated total dissolved solids, ammonia, and nutrients. The source of ammonia and TDS is not readily evident. However, although they are different parameters, their concentrations increased and decreased in parallel when measured at different times, suggesting a response to a single or related source.

Possibilities of sources include failing HSTSs, illegal dumping of brine water or some other type of waste water, high TDS in ground water coming through HSTSs, leaching from an old "toxic dump," or some other unknown source. Ohio EPA did extensive research to determine the source of TDS and ammonia in Whetstone Creek but could not conclusively identify a source. Since additional sampling in 2008 identified significant decreases in TDS and TKN (ammonia was not sampled but is a component of TKN), it seems likely that a one-time spill of some kind or intermittent dumping is the source of both parameters, as indicated by the following text (Ohio EPA 2009):

> "…the elevated fecal counts in Whetstone Creek and Lebanon Creek were associated with high TDS and nitrates, as well as ammonia and Kjeldahl nitrogen, suggesting a slug of untreated nitrogenous wastes, possibly from a spill or illegal dumping."

While Ohio EPA cannot conclusively identify a source for ammonia and TDS, it seems probable that the source is the same and that addressing the ammonia in Whetstone Creek (if a source can be identified) will also address the TDS. Therefore, ammonia is used as a surrogate for TDS.

D2.2.2 Target Development and Deviation

Existing loads for various parameters related to the cause of impairment for each site were compared to target loads that were derived using either a WQS if available, i.e., ammonia and TDS, a value from the *Associations* document (Ohio EPA 1999), or a value based on median statewide data from similar facilities with monitoring; see Table D-4.

Table D-4. Target values used for TMDL calculations.

Parameter	Stream	Value (mg/l)	Basis
Ammonia	*Whetstone Creek*		
	In-stream	2.2	WQS based on pH = 7.70, and temp. = 19.67
	discharger	3	Based on median statewide facility data
Total Kjeldahl Nitrogen	*Center Creek*		
	In-stream	0.4	*Associations* document (Ohio EPA 1999)
	Discharger	1.56	Based on median statewide facility data
Total Phosphorus	*Lebanon Creek*		
	In-stream	0.1	*Associations* document (Ohio EPA 1999)
	Discharger	3	Based on median statewide facility data
Total Dissolved Solids	*Lebanon Creek*		
	in-stream and discharger	1500 (800)	Existing (and potential future) WQS

The field flow measurements-based regression formula used for the LDCs for Rock Creek were also used to calculate the 7Q10 for the purposes of these TMDLs. The Grand River at Painesville USGS gage (04212100) 7Q10 was entered into the Rock Creek regression formula to determine the Rock Creek 7Q10. That value was then divided by the Rock Creek at Dodgeville Rd. site drainage area to determine a 7Q10 yield, which was then multiplied by the drainage areas of the sites with impairments to calculate the 7Q10s for those sites (see Table D-5). These streams are contained within the Rock Creek basin.

Table D-5. Flow calculations for the Center, Whetstone and Lebanon Creek sites.

USGS gage 04209500 Grand R. near Bristol, 1941 - 1947		**Center Cr. RM 6.25**	**Center Cr. RM 3.03**	**Whetstone RM 2.0**	**Lebanon Cr. RM 1.93**
DA (mi^2)	89.7		Drainage area (mi2)		
7Q10, summer (cfs)	0.5	**6.4**	**11.6**	**5.9**	**4**
USGS gage 04212100, Painesville		**Calculated 7Q10 (cfs) w/ DA & regression methods**			
DA (mi^2)	685	**DA method using gage 04209500**			
7Q10, summer (cfs)	9	0.036	0.065	0.033	0.022
		site DA/Grand R @ Bristol DA*Grand R @ Bristol 7Q10			
Rock Cr. @ Dodgeville					
DA (mi^2)	42.5	**Regression method using gage 04212100 for Rock Cr 7Q10, then using the DA calc method**			
regression formula		0.044	0.080	0.040	0.027
		site DA/Rock Cr DA*Rock Cr summ 7Q10			
regression formula based on Rock Cr at Dodgeville Rd. and Grand R at Painesville Qs					
Rock Cr Q = 0.0498 * USGS Q ^ 0.8043					
7Q10, summer (cfs)	0.292				
Gray highlighting indicates value used in a formula.					
Light blue highlighting indicates formula result.					

Tables D-13 and D-14 in Section D3 show the existing average loads, TMDL target loads, and percent load reduction.

Critical Conditions

The *Biological and Water Quality Study for the Upper Grand River* (Ohio EPA 2009) discusses that the pollutant sources are likely from a mobile home park and unsewered homes. These are sources that tend to have their greatest negative effect during periods of low flow.

As a result, the critical condition for nutrients and total dissolved solids is the summer dry period when environmental stress upon aquatic organisms is greatest. It is during this period that water is lowest and these parameters are most concentrated. Samples were taken during this period and are therefore reflective of the critical condition.

Figure D-2 shows the Grand River flow conditions from the Camp Beaumont long term level recorder site. The four chemical samples used in the TMDLS in Tables D-13 and D-14 were collected under these flow conditions. These four sample values used to derive the existing conditions were taken during the 54th, 70th, 77th and 89th percentile flow exceedance conditions. The sample values were averaged in order to calculate the loads, so the average condition can be considered summer dry period conditions.

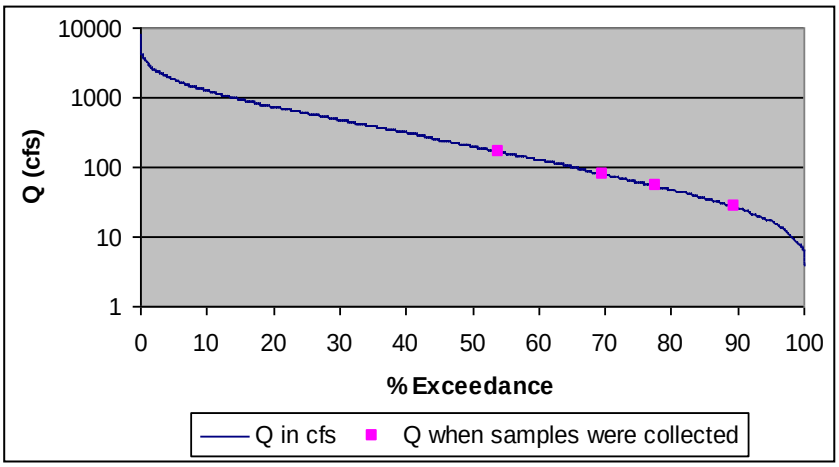

Figure D-2. Flow conditions under which samples were collected.

D2.2.3 Lower Rock Creek at SR 45

Both flow starvation and elevated nutrients are causes of impairment in Rock Creek at SR 45, the elevated nutrients exacerbating the impairment from flow starvation. To correct for this, seasonal TMDLs were calculated for total phosphorus (see Table D-20).

WLA and LA Methodology

Seasonal TMDLs, WLAs and LAs, were calculated for Rock Creek at SR 45 for total phosphorus (tot P). The WLA is calculated for Roaming Shores WWTP, which discharges to Rock Creek 1.48 miles upstream of the SR 45 sentinel site. From 14 samples in 2006 (1) and 2007 (13), nutrient and flow data were separated into seasons; winter, spring, summer and fall. Seasonal averages were calculated for existing conditions and target conditions. Target loads are based on nutrient targets from the *Associations* document (Ohio EPA 1999) and average flows for each season. No total phosphorus samples were collected in the fall so values from summer were used. Average seasonal flows were calculated by developing a regression between the measured flows at Rock Creek at SR 45 and the long-term flow developed at the Grand River Camp Beaumont site, the details of which are discussed below.

Long-term Flow Development for Rock Creek and Other Sentinel Sites
Six sentinel sites were created in the upper Grand River Basin in order to determine major influences on the overall Grand River basin. Rock Creek at Dodgeville Rd. is one of these sentinel sites. Flow data from the Grand River at Camp Beaumont site was used to calculate long-term flows for the six sentinel sites because the use of a long-term level recorder there increased the accuracy of the calculated long-term flow.

The method used to derive the long-term dataset for flow at the Grand River Beaumont Camp site is based on long-term level recorder data (feet [ft]), which started 1/24/07 and ended 10/27/08, a total of 21 months. The level data (ft) were then correlated to 8 measured flows at the site using the USGS tapedown regression method (Hirsch and Gilroy 1982). From this regression formula a flow was calculated for each point in time (4 times/hour) the level recorder collected level data. These flows were consolidated into daily flows using a pivot table. Then the daily flows from the level recorder site were related to the daily flows on the same dates from both the Grand River and Chagrin River USGS gages to see which matched best. The Grand River gage had an $R^2 = 0.83$ and the Chagrin gage had an $R^2 = 0.66$, so the Grand River gage (04212100) was selected for use in calculating the long-term 10 year flow data set for the level recorder site. Because the level recorder transducer would become submerged at extremely high flows all flow values which exceeded 4000 cfs at the Grand River gage site (around 1300 cfs at the level recorder site) were eliminated to avoiding skewing calculated flows (see Figure D-3). Then the calculated level recorder daily flows from 1/24/07 through 10/27/08 were related to the Grand River USGS gage flow data for the same dates and using the regression formula a daily flow for 10+ years was developed for the level recorder site. Once the final long term (1/1/1997 - 12/8/2008) dataset for the Camp Beaumont level recorder site was created it was checked against the 8 flows measured at the site; the ensuing relationship has an $R^2 = 0.97$ (see Figure D-4) showing the calculated long-term flows accuracy.

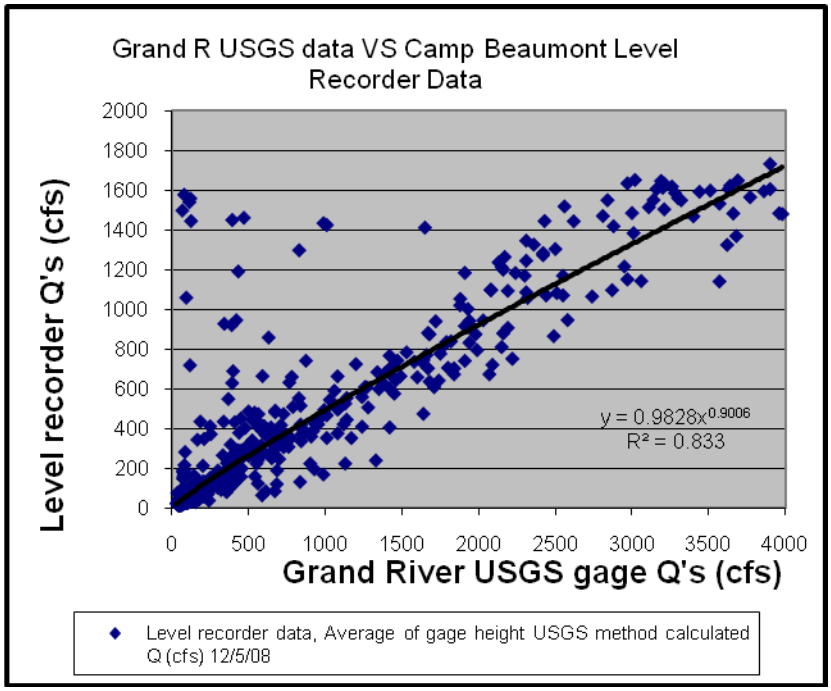

Figure D-3. Grand River USGS data plotted against Camp Beaumont level recorder data.

The TMDL results tables are broken down into three sections: allowable loads, existing loads and needed reduction. The allowable loads section is broken down into total allocation with MOS and AFG, WLA and LA. The total allocation is the product of the average seasonal flow, the target concentration, and a conversion factor to convert mg/l and cfs to kg/d. That product is multiplied by the sum of the margin of safety and allowance for future growth, each of which is discussed below. The WLA is calculated using a mass balance equation for Roaming Shores WWTP, the single permitted discharger upstream of the SR 45 site, and uses annual average values from discharge monitoring reports for flow, a target of 0.10 mg/l for total phosphorus, and upstream seasonal field values for flow and concentration from the Rock Creek site at Dodgeville Road. The LA is calculated as the difference between the total allocation with MOS and AFG, and the WLA. The same method was used to obtain Tables D-13 and D-14.

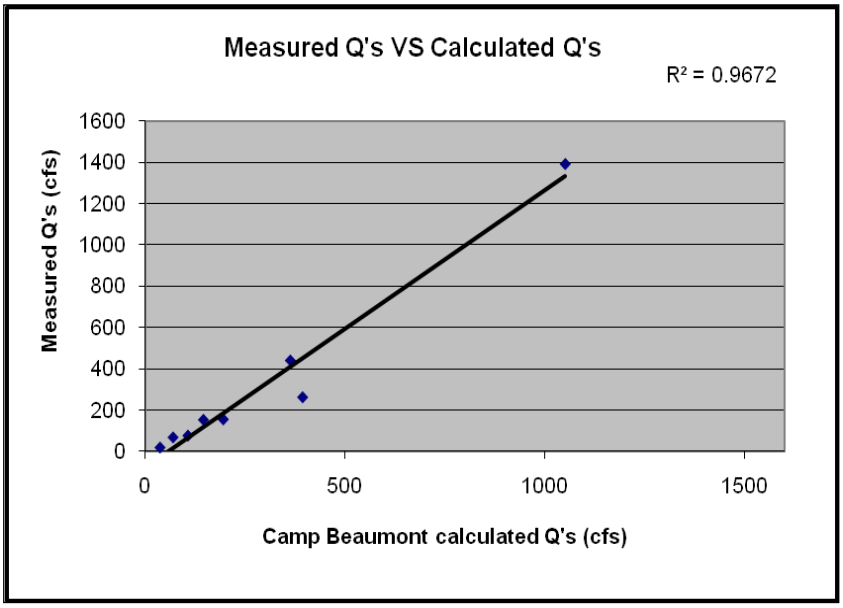

Figure D-4. Measured flows vs. calculated flows.

The existing loads for Roaming Shores WWTP are the product of the average annual flow and total phosphorus concentration from discharge monitoring report data and the conversion factor (2.446723). Roaming Shores WWTP does not monitor for total phosphorus so average annual data were used from the next closest WWTP which does, Orwell. Orwell is a small town approximately 10 miles from Roaming Shores in the Rock Creek headwaters. The needed reduction for the WLA and LA is the difference between the existing load and the allowable load. In some instances the existing loads are already less than the allowable, therefore no reduction is necessary. The needed reduction is given as a load and a percentage.

Critical Conditions

One major issue with elevated in-stream total phosphorus is the increase in algal mass and resulting large dissolved oxygen swings. The critical conditions for algae production occur during summer and early fall when temperatures are hot and flows are low. The loads expressed in Table D-20 use seasonal average flows in the calculations including summer and fall conditions which, therefore, take into consideration critical conditions.

Margin of Safety and Allowance for Future Growth

An explicit margin of safety of 5% is given to the allocation. Because the input values are based on measured values there is a higher level of confidence in them than commonly used assumed or text book values, therefore 5% is an adequate MOS.

The Ashtabula county population is projected to increase by 1.4 percent from 2010 to 2030 according to county census data, therefore the allowable future growth is set at 1.4%.

D2.3 Aquatic Life Use: Habitat Alteration (QHEI Analysis)

The Grand River headwaters (RM 94.3), Hoskins Creek (RM 4.88) and Crooked Creek (RM 3.8) were found to be impaired due to direct habitat alterations; therefore, a habitat TMDL was calculated for each.

D2.3.1 Habitat TMDL Targets and the Qualitative Habitat Evaluation Index

Poor habitat quality is an environmental condition, rather than a pollutant load, so development of a load-based TMDL for habitat is not possible. Nonetheless, habitat is an integral part of

stream ecosystems and has a significant impact on aquatic community assemblage and consequently on the potential for a stream to meet the biocriteria within Ohio's water quality standards (see below). In addition, U.S. EPA acknowledges that pollutants, conditions or other environmental stressors can be subject to the development of a TMDL to abate those stressors in order to meet water quality standards (U.S. EPA 1991). Thus, sufficient justification for developing habitat TMDLs is established.

The Qualitative Habitat Evaluation Index (QHEI) was developed by the Ohio EPA (Ohio EPA 1989) with one of the objectives being to create a means for distinguishing impacts to the aquatic community from pollutant loading versus poor stream habitat. The design of the QHEI in conjunction with its statistically strong correlation to the biocriteria makes it an appropriate tool for developing habitat TMDLs.

The QHEI assigns a numeric value (out of a possible 100) to an individual stream segment (typically 150-200 m in length) based on the quality of its habitat. The actual number values of the QHEI scores do not represent the quantity of any physical properties of the system but provide a means for comparing the relative quality of stream habitat. However, even though the numeric value is derived qualitatively, subjectivity is minimized because scores are based on the presence and absence and relative abundance of unambiguous habitat features. Reduced subjectivity was an important consideration in developing the QHEI and has since been evidenced through minimal variation between scores from various trained investigators at a given site as well as consistency with repeated evaluations (Ohio EPA 1989).

The QHEI evaluates six general aspects of physical habitat that include channel substrate, in-stream cover, riparian characteristics, channel condition, pool/riffle quality, and gradient. Within each of these categories or sub-metrics, points are assigned based on the ecological utility of specific stream features as well as their relative abundance in the system. Demerits (i.e., negative points) are also assigned if certain features or conditions are present which reduce the overall utility of the habitat (e.g., heavy siltation and embedded substrate). These points are summed within each of the six sub-metrics to give a score for that particular aspect of stream habitat. The overall QHEI score is the sum of all of the sub-metric scores.

Since its development the QHEI has been used to evaluate habitat at most biological sampling sites and currently there is an extensive database that includes QHEI scores and other water quality variables. Strong correlations exist between QHEI scores and some its component submetrics and the biological indices used in Ohio's water quality standards such as the Index of Biotic Integrity (IBI). Through statistical analyses of data for the QHEI and the biological indices, target values have been established for QHEI scores with respect to the various aquatic life use designations (Ohio EPA 1999). For aquatic life use designations of warm water habitat (WWH) and exceptional warm water habitat (EWH) overall QHEI scores of 60 and 75, respectively, are targeted to provide reasonable certainty that habitat is not deficient to the point of precluding attainment of the biocriteria.

One of the strongest correlations found through these statistical analyses described above is the negative relationship between the number of "modified attributes" and the IBI scores. Modified attributes are features or conditions that have low value in terms of habitat quality and therefore are assigned relatively fewer points or negative points in the QHEI scoring. A subgroup of the modified attributes shows a stronger impact on biological performance; these are termed high influence modified attributes.

In addition to the overall QHEI scores, targets for the maximum number of modified and high influence modified attributes have been developed. For streams designated as WWH, there should no more than four modified attributes of which no more than one should be a high influence modified attribute. For EWH streams there should be no more than two modified attributes and zero high influence attributes. Of the three sites impaired for habitat, two are EWH streams and one is designated as WWH. Table D-6 lists modified and high influence modified attributes and provides the QHEI targets used for this habitat TMDL.

Table D-6. QHEI targets for the habitat TMDL.

	Overall QHEI Score		All Modified Attributes	
			High Influence Modified Attributes	All Other Modified Attributes
Range of Possibilities	12 to 100 points		- Channelized or no recovery - Silt/muck substrate - Low sinuosity - Sparse/no cover - Max pool depth < 40 cm (wadeable streams only)	- Recovering channel - Sand substrate (boat sites) - Hardpan substrate origin - Fair/poor development - Only 1-2 cover types - No fast current - High/moderate embeddedness - Ext/mod riffle embeddedness - No riffle
Targets	**WWH**	Overall score ≥ 60	Total number < 2	Total number < 5[1]
	EWH	Overall score ≥ 75	Total number < 0	Total number < 3[1]
TMDL Points if Target Satisfied	+1		+1	+1

[1] Total num. of modified attributes includes those counted towards the high influence modified attributes.

For simplicity, a pass/fail distinction is made telling whether each of the three targets are being met. Targets are set for: 1) the total QHEI score, 2) maximum number of all modified attributes, and 3) maximum number of high influence modified attributes only. If the minimum target is satisfied, then that category is assigned a “1”, if not, it is assigned a “0”. To satisfy the habitat TMDL, the stream segment in question should achieve a score of three.

D2.3.2 Margin of Safety

There is an implicit margin of safety applied to the habitat and sediment TMDLs based on conservative target values used. The targets from the *Association Between Nutrients, Habitat, and the Aquatic Biota in Ohio Rivers and Streams* (Ohio EPA 1999) are conservative because attainment of aquatic life uses has been demonstrated even when the targets are not met.

D2.4 Aquatic Life Use: Dam Removal Analysis

Flow starvation caused by impoundments is a cause of impairment at Mill Creek and Rock Creek. Because the cause of impairment is not a pollutant, a TMDL cannot be developed.

However, the following analysis determines existing flow at the sites below the dam and potential flow without the dams in order to determine the impact dam removal would have on the flows in the stream. The difference is the needed increase in flow in order to meet the flow requirements of the two sites.

D2.4.1 Mill Creek

The existing flow for Mill Creek is determined using a drainage area yield from calculated flows at the Rock Creek at Dodgeville road sentinel site. Mill Creek and Rock Creek lie on opposite sides of the Grand River from each other. The calculated Dodgeville flows are based on measured flows. Phelps Creek is an adjacent basin and has data from a USGS gage (04210000), which was retired in 1959. Data from this gage were not used in favor of the more recently measured data but did help to validate the calculated flows. For instance, at the Mill Creek impaired site, RM 4.94, the 7Q10 calculated flow using the Rock Creek flow data is 0.02 cfs, using the drainage area yield against the retired USGS gage on Phelps Creek it is also 0.02 cfs.

Table D-7 compares the site's low flow with and without the impoundment. The drainage area of the site is 3.04 mi^2 but the impoundment lies upstream of it and in effect removes 2.82 mi^2 of drainage from the site, which based on the calculations in Table D-21 is 93% of the drainage area (and therefore flow). Even at its full drainage area, it is likely the flow will stop during the critical period in August and September, though water would possibly remain in pools. With 93% less water because of the impoundment, the stream's flow will cease sooner in the season, occur for a longer period of time, and pools are far likelier to dry up. With no water in the stream, fish and macroinvertebrate populations die off. Therefore, if the impoundment were removed, the restricted 93% of drainage area and flow would reach the site and would greatly increase the chances of obtaining its use designation.

Table D-7. Dam removal flow changes for Mill Creek.

Source	Drainage Area (mi^2) [1]	7Q10 (cfs)	7Q10 (cf/day)
Mill Creek RM 5.7 (at impoundment)	2.82	0.0193	1,671
Mill Creek RM 4.94 (impaired site) effective DA	0.22	0.0015	130
Mill Creek RM 4.94 (w/o impoundment)	3.04	0.0208	1,802
% of Q that is restricted		93	93
Needed flow increase			1,671

Note: Because the drainage area is small the calculations assume zero flow through the dam at 7Q10.

[1] USGS 2006.

[2] DA flow yield derived from USGS, Low Flow Characteristics of Ohio, 1997 (USGS 2001).

D2.4.2 Lower Rock Creek

Flow starvation was determined to be a cause of impairment at the Rock Creek at SR 45 site, with the upstream impoundment at Lake Roaming Rock as the cause. To demonstrate this, long-term flows were calculated for the impaired SR 45 Rock Creek site and the upstream Rock Creek site at Dodgeville Road. The long-term flows were used to create flow duration curves, where each average daily flow is ranked by percent exceedance. Then the lowest flows for each site were graphed for comparison (Figure D-5). The figure shows that the Rock Creek at SR 45 site does have lower flows during the critical flow period (< 25^{th} percentile flows), than the

Dodgeville Rd. site even though the drainage area is 40% greater (Figure D-5). This demonstrates that even though the SR 45 site has a greater drainage area it has unusually low flows during critical low flows.

To determine the targeted flows at critical flows, the flow yield was calculated using the Dodgeville Road site data and applied to the SR 45 site. The result is calculated target flows that would exist without an impoundment (see Figure D-6). The difference between this flow and the existing flow becomes the amount needed to help eliminate low flow alteration as a cause of impairment.

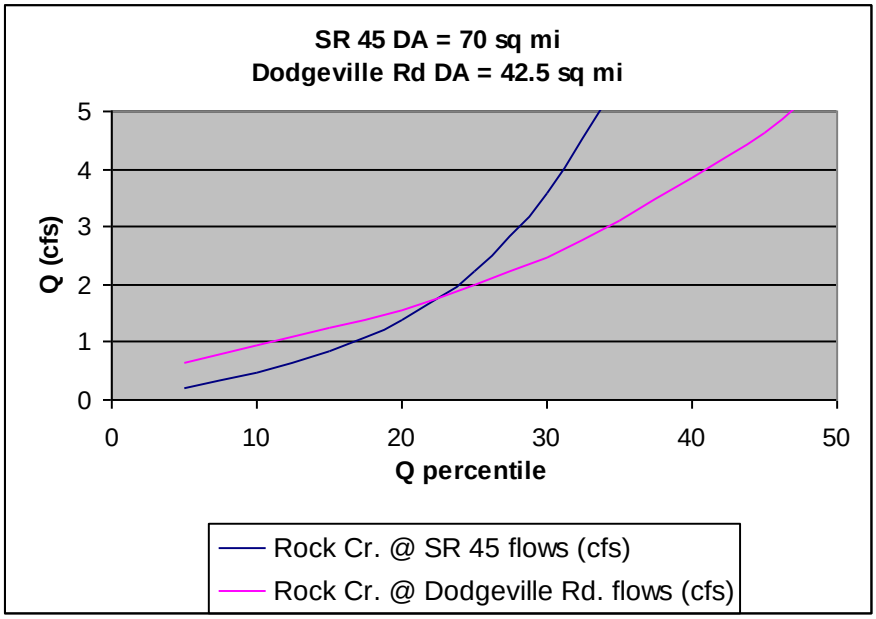

Figure D-5. Critical flows for two Rock Creek sites demonstrate the effect of the impoundment.

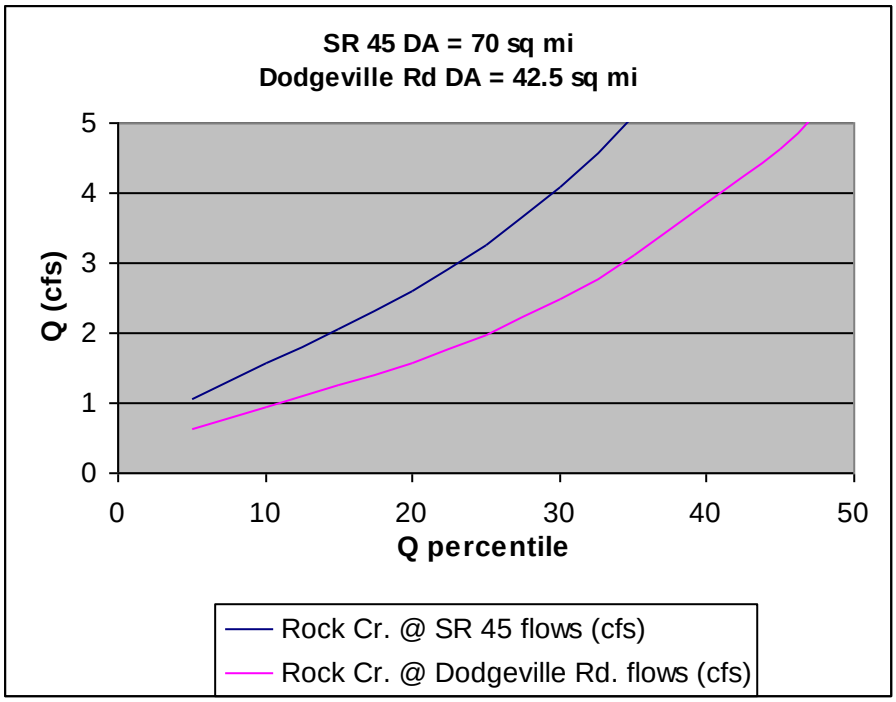

Figure D-6. Rock Creek flow assuming no impoundment.

Table D-8 shows the needed low flow volumes at various percentile intervals (5th, 10th, 15th, and 20th), along with the existing volumes and needed increased volumes in order to meet the use designation attainment. These percentile flows represent the lowest flows; for instance, the 5th percentile is a flow that is exceeded 95 percent of the time. Here too, the most likely way of increasing flow in Rock Creek at SR 45 is to remove the impoundment.

Table D-8. Dam removal flow changes for Rock Creek at State Route 45.

Percentiles	Existing Rock Creek @ SR 45 flows (cfs) with impoundment	Flows (cfs) assuming no impoundment, with a 3% error set-aside	Needed increase in flow[1] (cfs)	Needed increase in flow (cf/day)
5	0.21	1.09	0.88	76,032
10	0.48	1.61	1.13	97,632
15	0.85	2.12	1.27	109,728
20	1.37	2.67	1.30	112,320

[1] Calculated by subtracting the existing critical flows from the critical flows with no impoundment and a 3% error set-aside.

Since Lake Roaming Rock is large enough, developed and has interested parties, it is assumed that controlling the amount of flow through or over the dam will be considered as an option. The flow modeling is more exact in this instance because it uses USGS gage-based drainage area yields to calculate potential stream flow at the modeled site locations (downstream from the Lake Roaming Rock dam and Mill Creek). The calculated yields on Rock Creek are calibrated with measured flows on the creek. Though there is high confidence in the results, 3% of the total flows were “set aside” to account for any error.

D3 Results

D3.1 Recreation Use Results

In the sequence of figures and tables below, the load duration curve for each site (Figures D-7 through D-11) is shown followed by the TMDL table for that site.

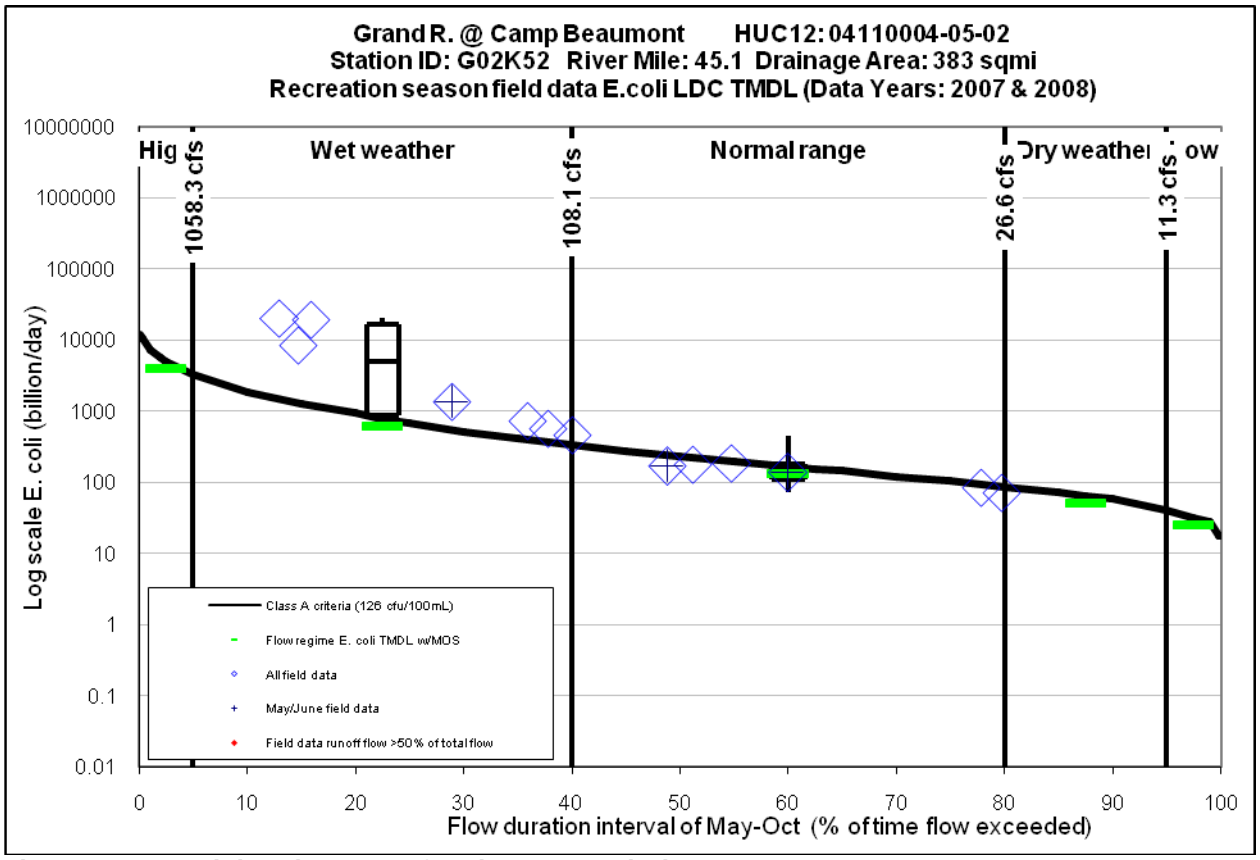

Figure D-7. Load duration curve for site on Grand River @ Camp Beaumont.

Table D-9. TMDL table for site on Grand River @ Camp Beaumont.

Flow regime TMDL analysis *E. coli* **(billion bacteria/day)**	**High**	**Wet weather**	**Normal range**	**Dry weather**	**Low**
Duration interval	0-5%	5-40%	40-80%	80-95%	95-100%
Samples per regime	0	6	7	0	0
Median sample load	N/A	4903	166.35	N/A	N/A
TMDL	**5,047.59**	**785.693**	**167.384**	**64.127**	**31.455**
WLA: total	**5.679**	**5.679**	**5.679**	**5.679**	**5.679**
Bloomfield High School	0.043	0.043	0.043	0.043	0.043
Bridge Lake Farm WWTP	0.016	0.016	0.016	0.016	0.016
Bristol Local School	0.107	0.107	0.107	0.107	0.107
Camp Whitewood	0.038	0.038	0.038	0.038	0.038
Cardinal Local School District	0.029	0.029	0.029	0.029	0.029
End of Commons General Store	0.014	0.014	0.014	0.014	0.014
Geauga Co. Parkman WWTP	0.711	0.711	0.711	0.711	0.711
Glenbeigh Hospital	0.095	0.095	0.095	0.095	0.095
Grand Valley Conservation Center	0.095	0.095	0.095	0.095	0.095
Halfway Restaurant	0.001	0.001	0.001	0.001	0.001
Hartsgrove BP	0.002	0.002	0.002	0.002	0.002
Hartsgrove General Store	0.005	0.005	0.005	0.005	0.005
Kool Lakes Family Campground	0.143	0.143	0.143	0.143	0.143
Middlefield MHP	0.095	0.095	0.095	0.095	0.095
Middlefield Orig. Cheese Coop.	0.049	0.049	0.049	0.049	0.049
Nelson Ledges Estate MHP	0.143	0.143	0.143	0.143	0.143
ODOT Rome Maint. Outpost	0.007	0.007	0.007	0.007	0.007
Orwell WWTP	2.48	2.48	2.48	2.48	2.48
Rigsby Ranch FKA River Pines	0.119	0.119	0.119	0.119	0.119
Roaming Shores WWTP	0.763	0.763	0.763	0.763	0.763
Rock Ck. STP	0.033	0.033	0.033	0.033	0.033
Shively Land Co. LLC	0.017	0.017	0.017	0.017	0.017
Southington Estates LLC	0.143	0.143	0.143	0.143	0.143
Southington Local Schools	0.095	0.095	0.095	0.095	0.095
Windsor Community Center	0.011	0.011	0.011	0.011	0.011
Grand Valley Nature Conservancy	0.095	0.095	0.095	0.095	0.095
Kampf Apartments	0.052	0.052	0.052	0.052	0.052
Trumbull County Commissioners & Others MS4	0.278	0.278	0.278	0.278	0.278
LA	3,961.723	611.874	125.883	44.723	19.043
MOS: 20%	**1,009.518**	**157.139**	**33.477**	**12.826**	**6.291**
AFG: 1.4%	**70.666**	**11**	**2.343**	**0.898**	**0.44**
Nonpoint (LA) % load reduction required	No Data	**84%**	**None**	No Data	No Data

Values were adjusted for rounding.

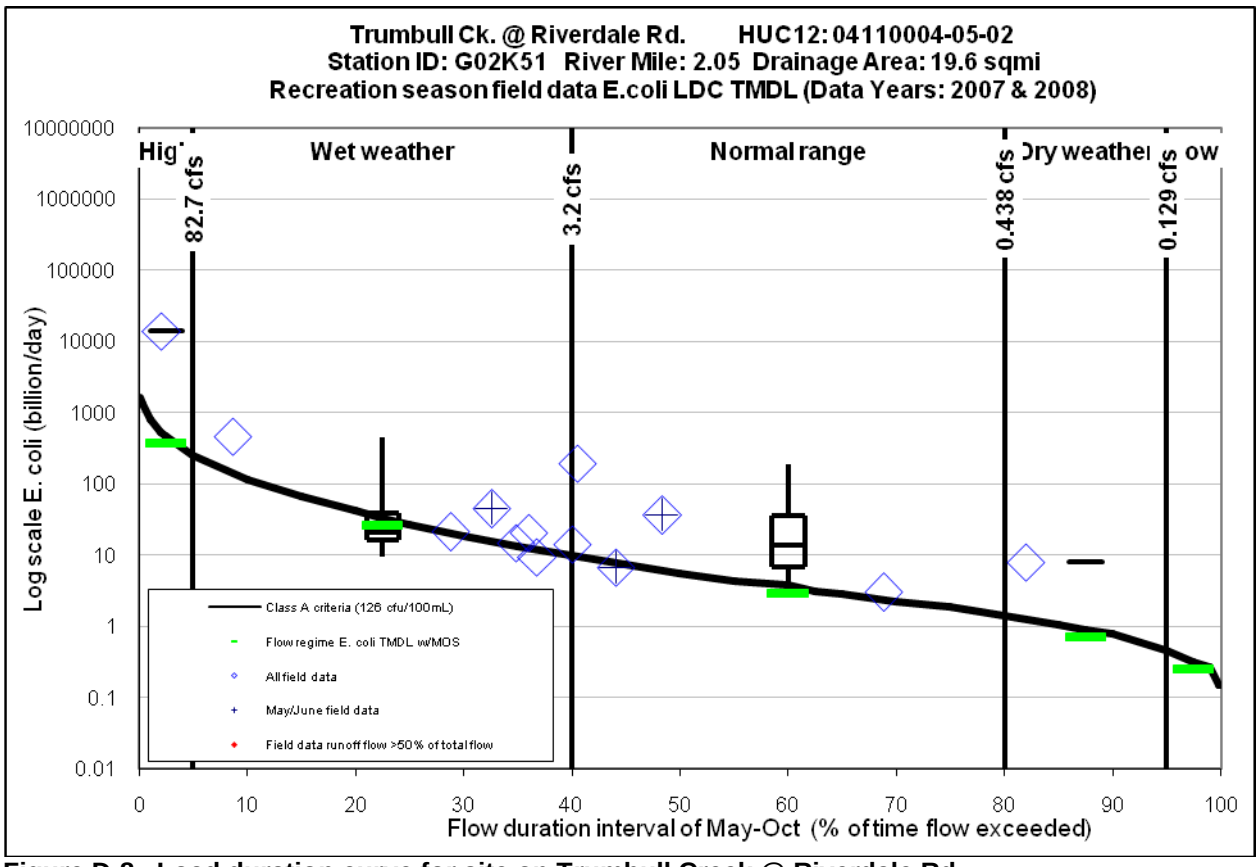

Figure D-8. Load duration curve for site on Trumbull Creek @ Riverdale Rd.

Table D-10. TMDL table for site on Trumbull Creek @ Riverdale Rd.

Flow regime TMDL analysis *E. coli* **(billion bacteria/day)**	**High**	**Wet weather**	**Normal range**	**Dry weather**	**Low**
Duration interval	0-5%	5-40%	40-80%	80-95%	95-100%
Samples per regime	1	6	5	1	0
Median sample load	13,937	20.8	14.08	8.020	N/A
TMDL	**473.499**	**33.039**	**3.757**	**0.900**	**0.323**
WLA: total	**0.058**	**0.058**	**0.058**	**0.058**	**0.058**
Great Lakes Medieval Faire	0.053	0.053	0.053	0.053	0.053
Plank Road Tavern	0.006	0.006	0.006	0.006	0.006
LA	**372.112**	**25.910**	**2.895**	**0.649**	**0.196**
MOS: 20%	**94.700**	**6.608**	**0.751**	**0.180**	**0.065**
AFG: 1.4%	**6.629**	**0.463**	**0.053**	**0.013**	**0.005**
Nonpoint (LA) % load reduction required	**97%**	**None**	**73%**	**89%**	No Data

Values were adjusted for rounding.

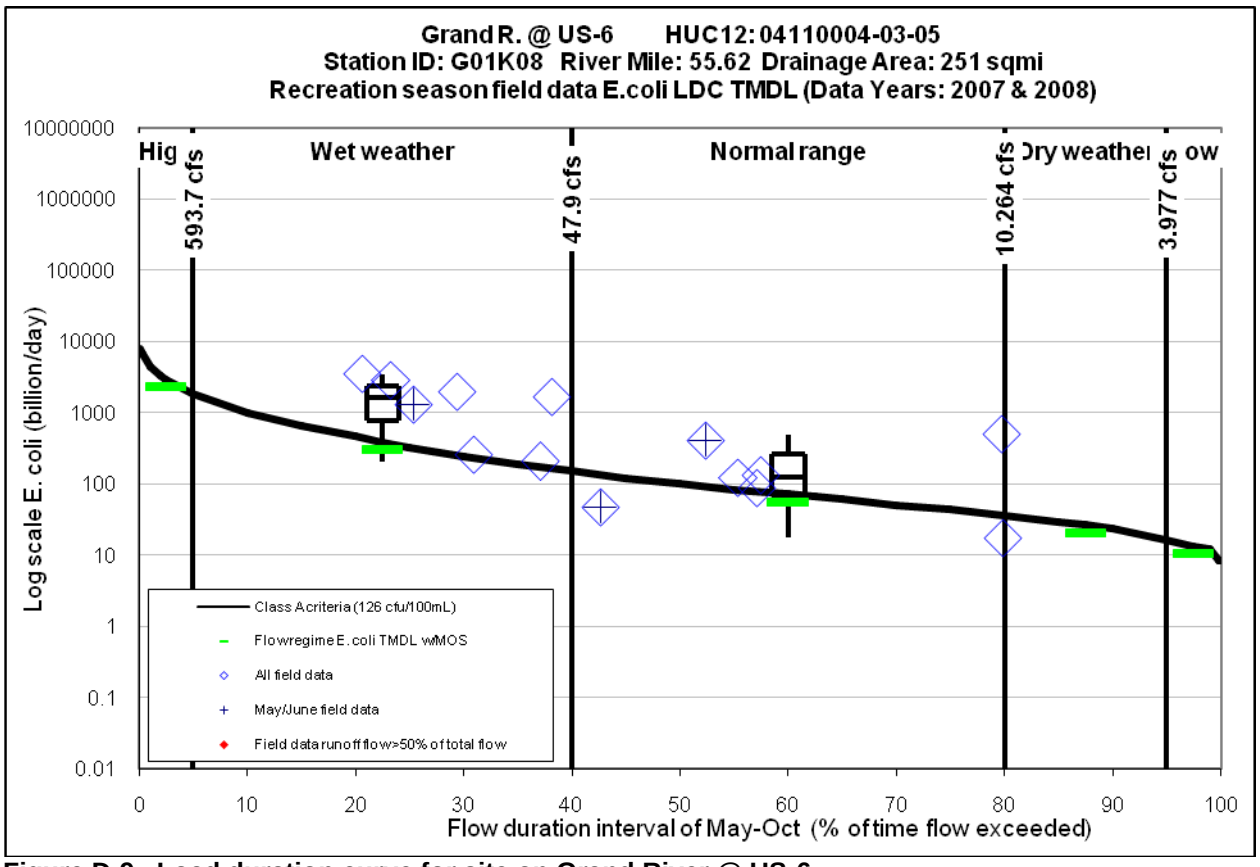

Figure D-9. Load duration curve for site on Grand River @ US-6.

Table D-11. TMDL table for site on Grand River @ US-6.

Flow regime TMDL analysis					
***E. coli* (billion bacteria/day)**	**High**	**Wet weather**	**Normal range**	**Dry weather**	**Low**
Duration interval	0-5%	5-40%	40-80%	80-95%	95-100%
Samples per regime	0	7	7	0	0
Median sample load	N/A	1,650	123	N/A	N/A
TMDL	**2,960.383**	**380.808**	**71.345**	**26.423**	**13.468**
WLA: total	**4.736**	**4.736**	**4.736**	**4.736**	**4.736**
Bloomfield High School	0.043	0.043	0.043	0.043	0.043
Bridge Lake Farm WWTP	0.016	0.016	0.016	0.016	0.016
Bristol Local School	0.107	0.107	0.107	0.107	0.107
Camp Whitewood	0.038	0.038	0.038	0.038	0.038
Cardinal Local School District	0.029	0.029	0.029	0.029	0.029
End of Commons General Store	0.014	0.014	0.014	0.014	0.014
Geauga Co. Parkman WWTP	0.711	0.711	0.711	0.711	0.711
Glenbeigh Hospital	0.095	0.095	0.095	0.095	0.095
Grand Valley Country Manor	0.095	0.095	0.095	0.095	0.095
Halfway Restaurant	0.001	0.001	0.001	0.001	0.001
Hartsgrove BP	0.002	0.002	0.002	0.002	0.002
Hartsgrove General Store	0.005	0.005	0.005	0.005	0.005
Kool Lakes Family Campground	0.143	0.143	0.143	0.143	0.143
Middlefield MHP	0.095	0.095	0.095	0.095	0.095
Middlefield Orig. Cheese Coop.	0.049	0.049	0.049	0.049	0.049
Nelson Ledges Estate MHP	0.143	0.143	0.143	0.143	0.143
ODOT Rome Maint. Outpost	0.007	0.007	0.007	0.007	0.007
Orwell WWTP	2.48	2.48	2.48	2.48	2.48
Rigsby Ranch FKA River Pines	0.119	0.119	0.119	0.119	0.119
Shively Land Co. LLC	0.017	0.017	0.017	0.017	0.017
Southington Estates LLC	0.143	0.143	0.143	0.143	0.143
Southington Local Schools	0.095	0.095	0.095	0.095	0.095
Windsor Community Center	0.011	0.011	0.011	0.011	0.011
Trumbull County Commissioners & Others MS4	0.278	0.278	0.278	0.278	0.278
LA	**2,322.146**	**294.599**	**51.362**	**16.053**	**5.871**
MOS: 20%	**592.057**	**76.141**	**14.249**	**5.265**	**2.674**
AFG: 1.4%	**41.444**	**5.33**	**0.997**	**0.369**	**0.187**
Nonpoint (LA) % load reduction required	No Data	**82%**	**58%**	No Data	No Data

Values were adjusted for rounding.

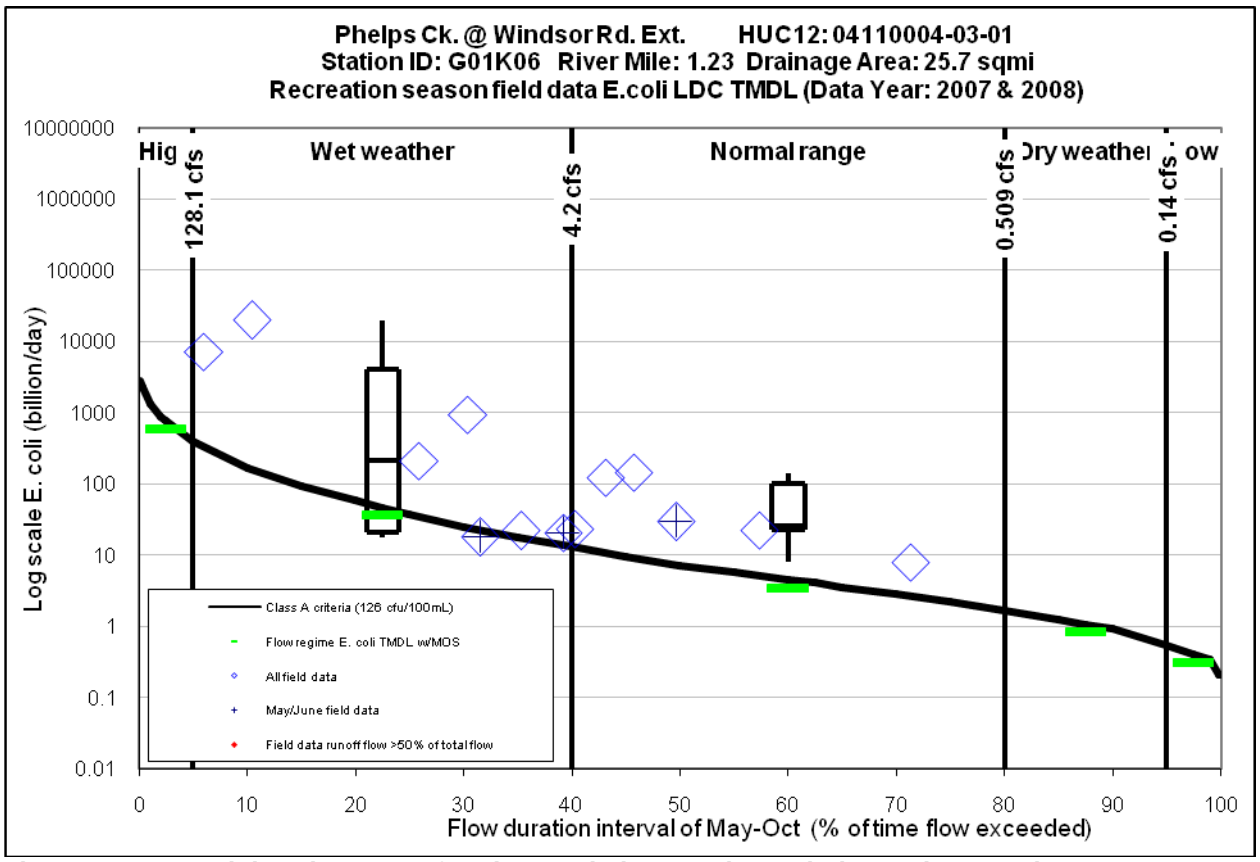

Figure D-10. Load duration curve for site on Phelps Creek @ Windsor Rd. Extension.

Table D-12. TMDL table for site on Phelps Creek @ Windsor Rd. Extension.

Flow regime TMDL analysis					
***E. coli* (billion bacteria/day)**	**High**	**Wet weather**	**Normal range**	**Dry weather**	**Low**
Duration interval	0-5%	5-40%	40-80%	80-95%	95-100%
Samples per regime	0	7	6	0	0
Median sample load	N/A	211	26	N/A	N/A
TMDL	**758.670**	**46.042**	**4.431**	**1.072**	**0.400**
WLA: total	**0.116**	**0.116**	**0.116**	**0.116**	**0.116**
Camp Whitewood	0.038	0.038	0.038	0.038	0.038
Cardinal Local School District	0.029	0.029	0.029	0.029	0.029
Middlefield Orig. Cheese Coop.	0.049	0.049	0.049	0.049	0.049
LA	**596.198**	**36.073**	**3.367**	**0.726**	**0.198**
MOS: 20%	**151.734**	**9.208**	**0.886**	**0.214**	**0.080**
AFG: 1.4%	**10.621**	**0.645**	**0.062**	**0.015**	**0.006**
Nonpoint (LA) % load reduction required	No Data	**78%**	**83%**	No Data	No Data

Values were adjusted for rounding.

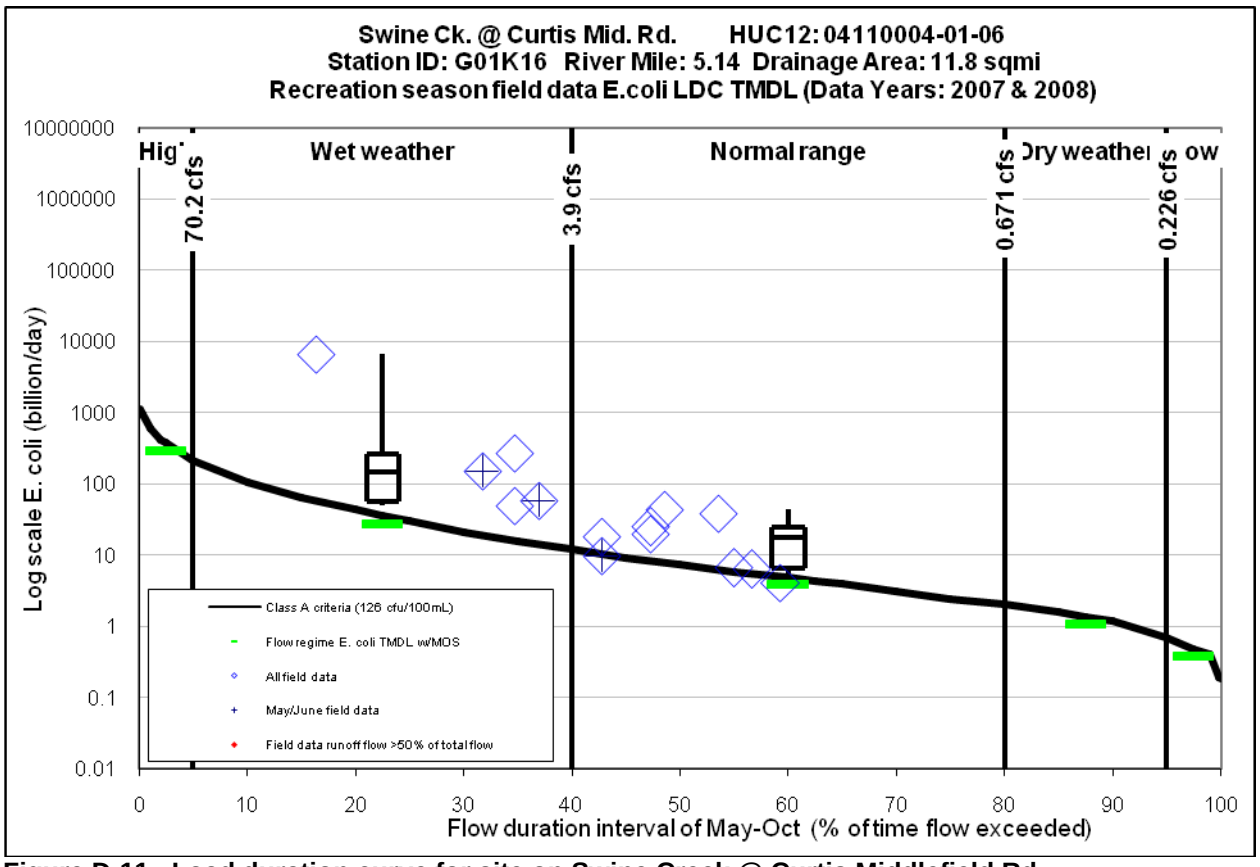

Figure D-11. Load duration curve for site on Swine Creek @ Curtis Middlefield Rd.

Table D-13. TMDL table for site on Swine Creek @ Curtis Middlefield Rd.

Flow regime TMDL analysis *E. coli* **(billion bacteria/day)**	**High**	**Wet weather**	**Normal range**	**Dry weather**	**Low**
Duration interval	0-5%	5-40%	40-80%	80-95%	95-100%
Samples per regime	0	5	9	0	0
Median sample load	N/A	150	18	N/A	N/A
TMDL	**374.808**	**35.446**	**4.932**	**1.359**	**0.490**
WLA	None	None	None	None	None
LA	**294.599**	**27.861**	**3.876**	**1.068**	**0.385**
MOS: 20%	**74.962**	**7.089**	**0.986**	**0.272**	**0.098**
AFG: 1.4%	**5.247**	**0.496**	**0.069**	**0.019**	**0.007**
Nonpoint (LA) % load reduction required	No Data	**76%**	**73%**	No Data	No Data

Values were adjusted for rounding.

D3.2 Aquatic Life Use Results

D3.2.1 Nutrient and Total Dissolved Solids (TDS) TMDLs in Center, Whetstone and Lebanon Creeks

Tables D-15 and D-16 compare the existing and target loads and show the needed percent reduction and percent reduction with the margin of safety for two nutrient impaired streams in the upper Grand River basin. Parameters for which to calculate TMDLs were taken from the Ohio 2012 Integrated Report (Ohio EPA 2012).

Table D-14 shows the stream flows used to calculate the target concentrations shown in Tables D-15 and D-16.

Table D-14. Flows for concentration calculations.

Upper Grand River trib flows		Reference: Baughman Cr RM 3.30	Center Cr. RM 6.25	Center Cr. RM 3.03	Whetstone RM 2.0	Lebanon Cr. RM 1.93	conv.
	DA (sq mi)	*15.5*	*6.4*	*11.6*	*5.9*	*4*	mg/l * cf/s = kg/d
	calculated summer 7Q10 (cfs)	*4.427*	*0.044*	*0.080*	*0.040*	*0.027*	*2.4465758*
Permitted Q (cfs)	*Bristol Schools*	*0.007736*					
	Dean Haines Property	*0.002321*					

An implicit MOS exists since reductions reflect the critical condition (summer low flows). Targets are calculated for 7Q10 conditions. Loads that occur during flows greater than 7Q10, a much more common occurrence, will have much lower concentrations of these parameters because of dilution. To further be protective of the streams an explicit margin of safety of 5% was applied to the needed reduction percentage. Flow and concentration are used in the calculation of loads; these values can be a source of error. Since the flow calculations use values based on numerous measured flows from streams in the vicinity of the sites there is a high degree of confidence in the values used in the load calculations. Therefore, a MOS of 5% is a reasonable value to use.

Table D-15. Total Kjeldahl nitrogen TMDL results for Center Creek.

	River Mile 6.25 (kg/d)	River Mile 3.03 (kg/d)
Existing Average Load	0.1182	0.3183
TMDL	0.0526	0.2210
LA	0.0340	0.0649
WLA	0.0090	0.1419
Trumbull Co. MS4	0.0001	0.0001
Bristol School	N/A	0.1329
Dean Haines Property	0.0089	0.0089
MOS (5%)	0.0026	0.0111
AFG (1.4%)	0.0007	0.0031
Needed Overall Reduction (%)	**55%**	**31%**

Notes:
- Values have been adjusted for rounding.
- The basis for TKN is an analysis of the median value of all Ohio WWTPs and is appropriate for these smaller discharges if they are meeting their ammonia permit of 1.0 mg/l.
- There are no monitoring data for the facilities so the permit flow and concentrations values are used for both the existing and target values; therefore, the values are equal.
- The MS4 area is a very small fraction (0.21%) of the Center Cr. sub-basin; the allocation is taken from the LA.

The Ashtabula County population is projected to increase by 1.4 percent from 2010 to 2030 according to county census data, therefore the allowable future growth is set at 1.4%.

Wasteload Allocations (Center Creek)

There are two NPDES facilities in the basin: Bristol Schools, located above the Center Creek RM 3.03 site on an unnamed tributary, and the Dean Haines Property located in the headwaters above both sites. The basis for the TKN target is an analysis of the median value of all Ohio WWTPs and is appropriate for these smaller discharges if they are meeting their ammonia permit of 1.0 mg/l.

There are no monitoring data for the Dean Haines Property so the permit flow, which is very small at < 0.0015 MGD, and concentration values are used for both the existing and target values, therefore the values are equal and no reduction is needed. Since the load is permit-based the facility is not expected to reduce their load, no MOS or AFG is added.

Bristol Schools is located between RMs 6.25 and 3.03 therefore no calculation is needed for the RM 6.25 site.

The MS4 area is a very small fraction (0.21%) of the Center Cr. sub-basin; the wasteload allocation is taken from the LA.

Wasteload Allocations (Lebanon Creek)

The only discharger upstream from the Lebanon Creek sampling location is a small sanitary discharger named Kampf Apartments. Total phosphorus WLAs were calculated for the facility (Table D-16). The facility has no permit limits for total phosphorus. There are no discharge data, so 3.0 mg/l was assumed for a total phosphorus discharge concentration. Because the assumed discharge value is based on and therefore equal to the targets, there is no need for MOS or AFG, and the needed reduction is zero.

Table D-16. Total phosphorus TMDL for Lebanon Creek.

	Lebanon Creek (RM 1.93) (kg/d)
Existing Average Load	0.1418
TMDL	0.1343
LA	0.0008
WLA: Kampf Apartments	0.1249
MOS (5%)	0.0067
AFG (1.4%)	0.0019
Needed Overall Reduction (%)	**5.3%**

Load duration curves (LDCs) and loading tables were developed to address impairments from TDS for Lebanon Creek and TDS, ammonia, and total phosphorus for Whetstone Creek.

For Lebanon Creek, TDS LDCs are shown with the existing 1,500 mg/l WQS criterion (Figure D-12) and the possible future target of 800 mg/l (Figure D-13 and Table D-18) for comparison. Using the 1,500 mg/l criterion, a reduction of 28.0% is needed during low flow conditions (see Table D-17). Either there are no data or no reduction is needed in the other LDC flow condition categories.

Though biological indicators revealed nutrient related impairments on Whetstone Creek, the available water chemistry did not show elevated total phosphorus levels. This is because water chemistry data were not collected during a period of high in-stream nutrient concentrations, such as during a runoff event or before nutrients are utilized by macrophytes or algae. Because ammonia did have a WQS exceedance and because it often results from the same source (e.g., livestock runoff or poorly operating septic systems), it is used here as a surrogate for total phosphorus and TDS on Whetstone Creek. A 21.1% reduction is needed during the dry period (see Figure D-14 and Table D-19). Either there are no data or no reduction is needed in the other LDC flow condition categories.

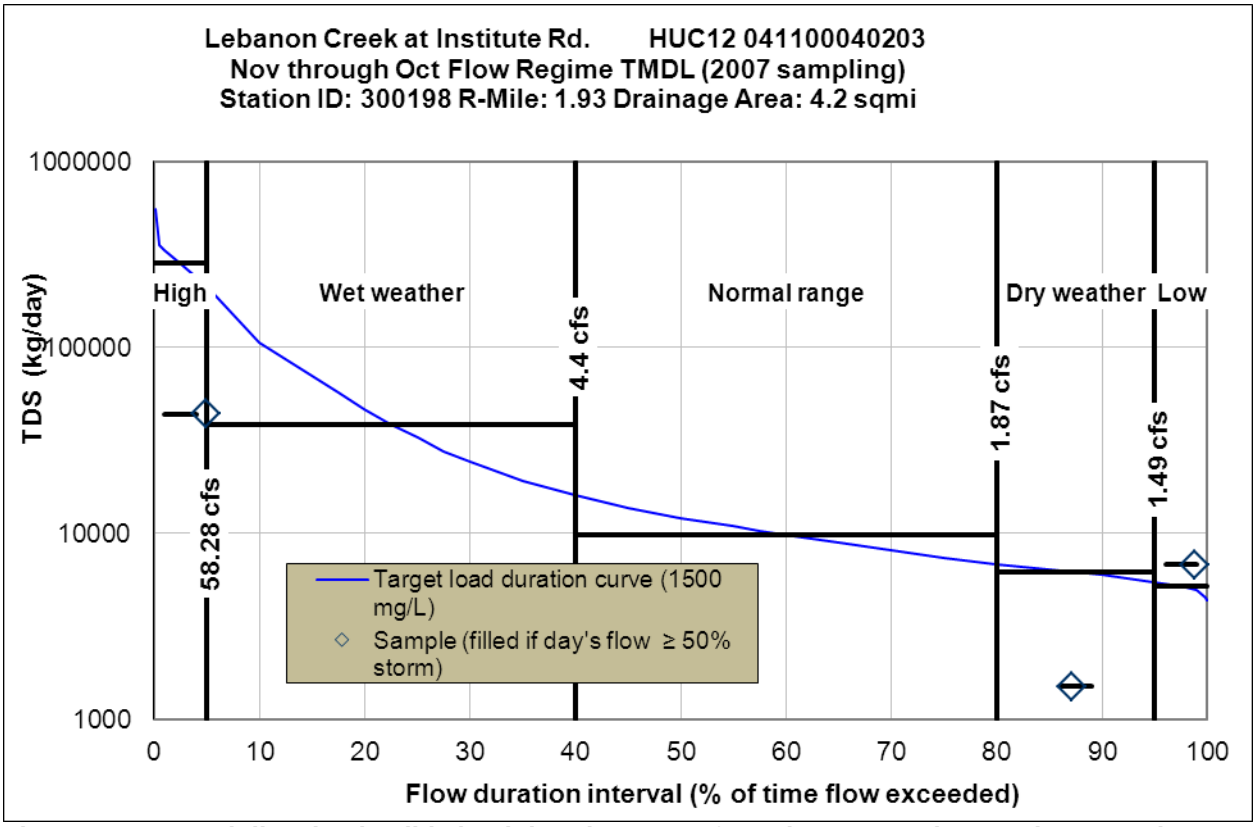

Figure D-12. Total dissolved solids load duration curve for Lebanon Creek at Institute Road (using 1,500 mg/l criterion).

Table D-17. Total dissolved solids TMDL for Lebanon Creek at Institute Road (using 1,500 mg/l criterion).

TMDL and duration intervals	High 0-5%	Wet weather 5-40%	Normal range 40-80%	Dry weather 80-95%	Low 95-100%
Total Maximum Daily Load	**284,194.25**	**38,790.46**	**9,945.33**	**6,238.77**	**5,284.60**
Wasteload Allocation	33.31	33.31	33.31	33.31	33.31
Load Allocation	266,029.34	36,282.32	9,277.51	5,807.42	4,914.13
Margin of Safety: 5%	14,209.71	1,939.52	497.27	311.94	264.23
Allowance for future growth: 1.4%	3,921.88	535.31	137.25	86.10	72.93
Total Load Reduction Required	**NA**	No Data	No Data	**NA**	**28.0%**

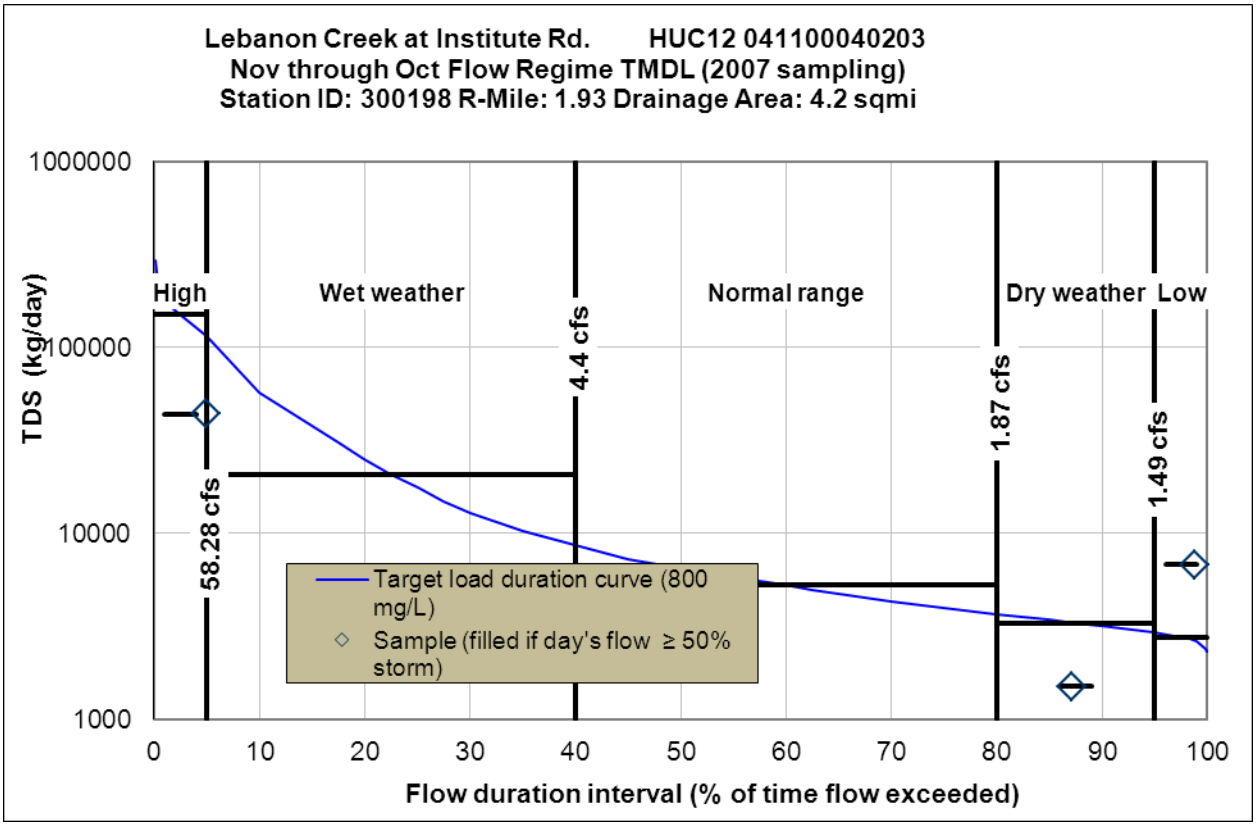

Figure D-13. Total dissolved solids load duration curve at 800 mg/l target for Lebanon Creek at Institute Road.

Table D-18. Total dissolved solids load information at 800 mg/l target for Lebanon Creek at Institute Road.

TMDL and duration intervals	High 0-5%	Wet weather 5-40%	Normal range 40-80%	Dry weather 80-95%	Low 95-100%
Total Maximum Daily Load	151,570.27	20,688.25	5,304.18	3,327.34	2,818.46
Wasteload Allocation	33.31	33.31	33.31	33.31	33.31
Load Allocation	141,866.77	19,335.02	4,932.46	3,081.75	2,605.33
Margin of Safety: 5%	7,578.51	1,034.41	265.21	166.37	140.92
Allowance for future growth: 1.4%	2,091.67	285.50	73.20	45.92	38.89
Total Load Reduction Required	NA	No Data	No Data	NA	61.6%

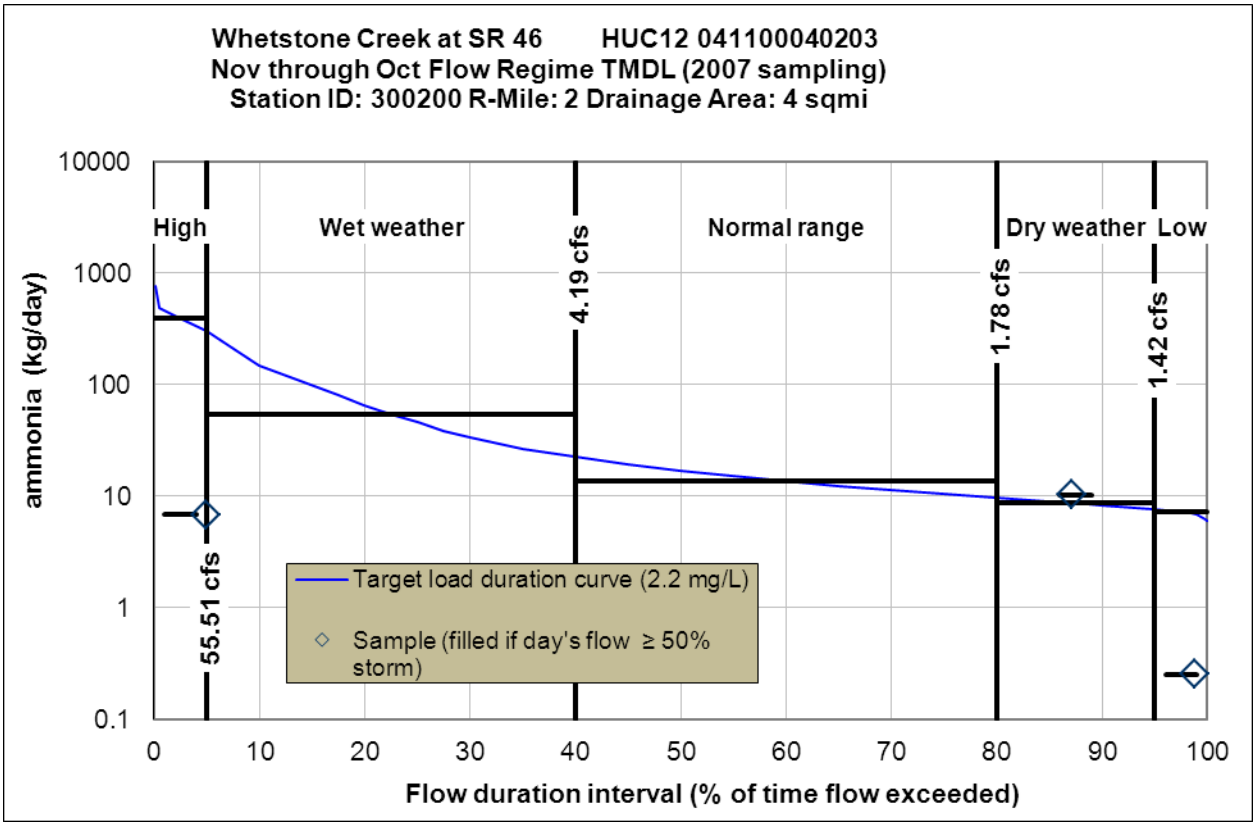

Figure D-14. Ammonia load duration curve for Whetstone Creek at S.R. 46.

Table D-19. Ammonia TMDL for Whetstone Creek at S.R. 46.

TMDL and duration intervals	High 0-5%	Wet weather 5-40%	Normal range 40-80%	Dry weather 80-95%	Low 95-100%
Total Maximum Daily Load	396.90	54.09	13.78	8.67	7.32
Wasteload Allocation	0.00	0.00	0.00	0.00	0.00
Load Allocation	371.58	50.64	12.90	8.11	6.85
Margin of Safety: 5%	19.85	2.70	0.69	0.43	0.37
Allowance for future growth: 1.4%	5.48	0.75	0.19	0.12	0.10
Total Load Reduction Required	**NA**	No Data	No Data	**21.1%**	**NA**

Conclusion

Based on observed data, reductions are needed in Center Creek for total Kjeldahl N. These reductions are needed at RM 6.25 and 3.03 and are 65% and 58%, respectively (Table D-15). Based on the *Biological and Water Quality Study of the Upper Grand River Basin* (Ohio EPA 2009), the sources from which the reductions should come may include Paradise Lake Mobile Home Park and unsewered homes along Housel Craft Road, Corey Hunt Road, and SR 45. Also, the feasibility of sanitary sewers for Bristol Township should be investigated. Addressing these sources will likely address issues with ammonia and TDS.

In Whetstone Creek, reductions are needed for ammonia (21.1% in dry weather). In Lebanon Creek, reductions are needed for total phosphorus (52.1%, see Table D-16) and TDS (28.0% at low flows). Despite follow-up monitoring in 2008, the sources were not identified. Long-term monitoring to observe various stream conditions across the stream hydrograph and through various seasons may be needed to pinpoint the source(s) of impairment.

D3.2.2 Nutrient TMDLs in Lower Rock Creek

TMDLs were calculated for Rock Creek at SR 45 because elevated nutrients are listed as a cause of impairment and likely worsen water quality in a stream already stressed by limited flow from the upstream impoundment (Lake Roaming Rock). The impoundment is 1.48 miles upstream of the site and the Roaming Shores WWTP discharges directly downstream of the impoundment in the spillway. WLAs were calculated for the WWTP, which does not have permit limits for total phosphorus. The in-stream target concentration of 0.10 mg/l total phosphorus is taken from the *Associations* document (Ohio EPA 1999).

Needed Reductions: Total Phosphorus

For total phosphorus seasonal WLAs, both the target and existing conditions assume the same concentration (3.2 mg/l) and the design plant flow (0.248 cfs) for flow volume. Therefore, the existing conditions equal the WLA and so no reduction is needed, with the exception of spring where a 0.20 kg/d reduction is required from the WWTP in order to meet in-stream total phosphorus targets. The spring WLA was lowered from 1.94 kg/d to 1.74 kg/d in order to give some minimal load (0.10 kg/d) to nonpoint sources. Other than the WLA reduction in spring, any needed reductions come from the LA. The LA reductions range from 0.45 kg/d in spring to 1.77 kg/d in winter (Table D-20).

Sources: Roaming Shores WWTP vs. Nonpoint Sources

Roaming Shores WWTP discharges total phosphorus at a concentration of 3.20 mg/l (average), but has a very small flow (avg. 0.248 cfs); see Table D-21. Comparatively, the upstream average input values are 0.08 mg/l for the total phosphorus concentration and 18.8 cfs for flow—lower concentrations but higher flows than the WWTP. At the impaired site, Rock Creek at SR 45, the flows are higher than the upstream site because of the addition of drainage area and the WWTP flow, thus the loads are higher. If the nonpoint source drainage between the upstream site and the downstream site contributed the same concentration as the upstream site, the WWTP would be the major contributor since the upstream site concentration, 0.08 mg/l, is less than the target of 0.1 mg/l. The fact that the WWTP flow is so low indicates that there is possibly another source.

Lake Roaming Rock is between the upstream site and the impaired site and may contribute phosphorus from the sediment. Table D-20 shows the needed reductions of total phosphorus for both the WWTP and nonpoint sources. The wastewater treatment plant needs to reduce its load by 0.20 kg/d (10.3%) in the summer. The nonpoint source needed load reductions range from 0.45 kg/d in the spring up to a 1.77 kg/d in the winter.

Conclusion

The nonpoint source runoff above Lake Roaming Rock contributes a total phosphorus load less than the load allocation, so reductions are not needed. The reductions based on the mass balance calculations for Roaming Shores WWTP alone would not be adequate to meet targets,

so reductions are needed from the load allocation contribution between the upstream site and the Rock Creek at SR 45 site, which is mostly Lake Roaming Rock.

In conclusion, reductions are needed for total phosphorus nonpoint sources (LA) downstream of the Rock Creek at Dodgeville Road site and a minimal amount during the spring from the WWTP (WLA).

Table D-20. Total phosphorus TMDL for Rock Creek.

	TMDL (kg/d)				TMDL (mg/l)	Existing Loads (kg/d)		Needed Reduction (kg/d)		Needed Reduction (%)	
	total allocation	total allocation w/ MOS and AFG	Roaming Shores WWTP (WLA)	Rock Creek at SR 45 (LA)	Roaming Shores WWTP (WLA)	Roaming Shores WWTP	Rock Creek at SR 45	Roaming Shores WWTP	Rock Creek at SR 45	Roaming Shores WWTP	Rock Creek at SR 45
win	6.92	6.48	1.94	4.54	3.2	1.94	6.31	NA**	1.77	NA	28.1
spr	6.70	6.27	1.94	4.33	3.2	1.94	4.78	NA**	0.45	NA	9.41
sum	1.97	1.84	1.74	0.10*	2.87	1.94	1.49	0.20	1.39	10.3	93.3
fal	2.81	2.63	1.94	0.69	3.2	1.94	2.14	NA**	1.45	NA	67.8

Notes:

* The total allocation is less than the WLA assuming the WWTP receives its existing average tot P as its discharge limit and assuming there must be some minimal amount for the LA. The WLA was reduced from 1.94 kg/d to 1.74 kg/d in order to give some minimal assimilative capacity (0.10 kg/d) to the LA.

** For total phosphorus both the WLA target and existing conditions assume the same concentration (3.2 mg/l) and the design plant flow for flow, therefore the existing conditions equal the WLA and so no reduction is needed. Any needed reduction is to come from the LA in order to prevent undue burden on the WWTP.

NA indicates that there is a negative needed reduction because existing loads are less than the allocated loads, so no reduction is necessary.

Table D-21. Rock Creek nutrient (TP) TMDL input values.

	Q_d (mg/l)	Q_p (mg/l)	C_p (mg/l)	Q_u (cfs)	C_u (mg/l)	Target Concentration (mg/l)
win	28.3			28.0	0.092	
spr	27.4			27.1	0.072	
summ	8.04			7.79	0.078	
fall	11.5			11.2	0.078	
assumed		0.248	3.200			0.100

Notes:
Impaired site = Rock Cr. @ SR 45
Q_d flow at Rock Cr @ SR 45
Q_p design flow at Roaming Shores WWTP
C_p concentration @ Roaming Shores WWTP based on its annual tot P average concentration
Q_u flow at Rock Cr. upst WWTP @ Dodgeville Rd, calculated as the downstream site at SR 45 flow minus the Roaming Shores WWTP flow (Qd – Qp).
C_u concentration Rock Cr. upst WWTP @ Dodgeville Rd
2.4467 is the conversion factor used to convert (cfs * mg/l) to kg/d

D3.2.3 Habitat Alteration TMDL

The results of the habitat assessment for the sites impaired due to habitat alteration in the Grand River, Crooked Creek and Hoskins Creek are shown below in Table D-22.

Table D-22. Habitat TMDLs.

		Habitat TMDL						
TMDL Targets	**Use**	**Allocations**			**Subscore**			**TMDL**
	WWH	> 60 = 1 pt	TMDL	< 5 = 1 pt				3 pts
	EWH	> 75 = 1 pt	32	< 3 =1 pt				3 pts
Existing Scores Stream/River (Use) *(Nested Subwatershed)*	River Mile	QHEI Score	# of High Influence Attributes	Total # of Modified Attributes	QHEI	High Influence	# Modified Attributes	Total Habitat Score
Headwaters Grand River (04110004 01)								
Grand River (EWH) *(04110004 01 02)*	94.3	58	1	2	0	0	0	0
Phelps Creek-Grand River (04110004 03)								
Crooked Creek (WWH) *(04110004 03 04)*	3.8	55	6	6*	0	0	0	0
Hoskins Creek (EWH) *(04110004 03 02)*	4.88	63.5	2	0*	0	0	1	1

* *The Modified Attributes include the High Influence Attributes, so the total Modified Attributes score is equal to the Modified Attributes score plus the High Influence Attributes score.*

To satisfy the habitat TMDL, the stream should achieve a target score of three. The scores above show that the Grand River (RM 94.3), Crooked Creek (RM 3.8) and Hoskins Creek (RM 4.88) do not meet minimum habitat target of 3, and missed the target by 3 points for the Grand River and Crooked Creek and 2 points for Hoskins Creek.

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