MOON RUN WATERSHED TMDL
Allegheny County

For Acid Mine Drainage Affected Segments

Prepared by:

Pennsylvania Department of Environmental Protection

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Introduction

This report presents the Total Maximum Daily Loads (TMDLs) developed for segments in the Moon Run Watershed (Attachments A). These were done to address the impairments noted on the 1996 Pennsylvania Section 303(d) list of impaired waters, required under the Clean Water Act, and covers one segment on this list shown in Table 1. High levels of metals, and in some areas depressed pH, caused these impairments. All impairments resulted from acid drainage from abandoned coalmines. The TMDL addresses the three primary metals associated with acid mine drainage (iron, manganese, aluminum) and pH.

Table 1. 303(d) Sub-List
State Water Plan (SWP) Subbasin: 20-G Sewickley Creek

Year	Miles	Segment ID	DEP Stream Code	Stream Name	Designated Use	Data Source	Source	EPA 305(b) Cause Code
1996	2.5 3.6	4679	36730	Moon Run	WWF	305(b) Report	RE	Suspended Solids & Metals
1998	1.84	4679	36730	Moon Run	WWF	SWMP	AMD	Metals
2002	6.6	New survey; new id. 990102-1140-TVP	36730	Moon Run	WWF	SWMP	AMD	Metals & pH

Resource Extraction=RE
Warm Water Fishes = WWF
Surface Water Monitoring Program = SWMP
Abandoned Mine Drainage = AMD

See Attachment D, *Excerpts Justifying Changes Between the 1996, 1998, and 2002 Section 303(d) Lists.*

The use designations for the stream segments in this TMDL can be found in PA Title 25 Chapter 93.

[1] Pennsylvania's 1996, 1998, and 2002 Section 303(d) lists were approved by the Environmental Protection Agency (EPA). The 1996 Section 303(d) list provides the basis for measuring progress under the 1997 lawsuit settlement of *American Littoral Society and Public Interest Group of Pennsylvania v. EPA.*

Directions to the Moon Run Watershed

The Moon Run Watershed is located in Southwestern Pennsylvania, occupying the west central portion of Allegheny County. The watershed area is found on United States Geological Survey maps covering portions of the Ambridge, Emsworth, Pittsburgh West, and Oakdale 7.5-Minute Quadrangles. The area within the watershed consists of 5.5 square miles. A majority of the land within the Moon Run Watershed is developed with forestland scattered throughout. There is a small amount of agriculture in a portion of the watershed.

From Greensburg, Pa., take the PA turnpike west to exit 6, Monroeville/Pittsburgh, and follow Rt. 376 west to Rt. 279. Take Rt. 279 west until you reach Rt. 79, and follow Rt. 79 north until Moon Run is seen on the left hand side of Rt. 79, as the road is split between the north and south directions.

Segments addressed in this TMDL

There are no active mining operations in the watershed. All of the discharges in the watershed are from abandoned mines and will be treated as non-point sources. Each segment on the PA Section 303(d) list will be addressed as a separate TMDL. These TMDLs will be expressed as long-term, average loadings. Due to the nature and complexity of mining effects on the watershed, expressing the TMDL as a long-term average gives a better representation of the data used for the calculations. See Attachment C for TMDL calculations.

Clean Water Act Requirements

Section 303(d) of the 1972 Clean Water Act requires states, territories, and authorized tribes to establish water quality standards. The water quality standards identify the uses for each waterbody and the scientific criteria needed to support that use. Uses can include designations for drinking water supply, contact recreation (swimming), and aquatic life support. Minimum goals set by the Clean Water Act require that all waters be “fishable” and “swimmable.”

Additionally, the federal Clean Water Act and the Environmental Protection Agency’s (EPA) implementing regulations (40 CFR Part 130) require:

- States to develop lists of impaired waters for which current pollution controls are not stringent enough to meet water quality standards (the list is used to determine which streams need TMDLs);

- States to establish priority rankings for waters on the lists based on severity of pollution and the designated use of the waterbody; states must also identify those waters for which TMDLs will be developed and a schedule for development;

- States to submit the list of waters to EPA every two years (April 1 of the even numbered years);

- States to develop TMDLs, specifying a pollutant budget that meets state water quality standards and allocate pollutant loads among pollution sources in a watershed, e.g., point and nonpoint sources; and

- EPA to approve or disapprove state lists and TMDLs within 30 days of final submission.

Despite these requirements, states, territories, authorized tribes, and EPA had not developed many TMDLs. Beginning in 1986, organizations in many states filed lawsuits against the EPA for failing to meet the TMDL requirements contained in the federal Clean Water Act and its implementing regulations. While EPA has entered into consent agreements with the plaintiffs in several states, other lawsuits still are pending across the country.

In the cases that have been settled to date, the consent agreements require EPA to backstop TMDL development, track TMDL development, review state monitoring programs, and fund studies on issues of concern (e.g., AMD, implementation of nonpoint source Best Management Practices (BMPs), etc.).

These TMDLs were developed in partial fulfillment of the 1997 lawsuit settlement of *American Littoral Society and Public Interest Group of Pennsylvania v. EPA.*

Section 303(d) Listing Process

Prior to developing TMDLs for specific waterbodies, there must be sufficient data available to assess which streams are impaired and should be on the Section 303(d) list. With guidance from the EPA, the states have developed methods for assessing the waters within their respective jurisdictions.

The primary method adopted by the Pennsylvania Department of Environmental Protection (DEP) for evaluating waters changed between the publication of the 1996 and 1998 Section 303(d) lists. Prior to 1998, data used to list streams were in a variety of formats, collected under differing protocols. Information also was gathered through the Section 305(b)[2] reporting process. DEP is now using the Statewide Surface Waters Assessment Protocol (SSWAP), a modification of the EPA's 1989 Rapid Bioassessment Protocol II (RBP-II), as the primary mechanism to assess Pennsylvania's waters. The SSWAP provides a more consistent approach to assessing Pennsylvania's streams.

The assessment method requires selecting representative stream segments based on factors such as surrounding land uses, stream characteristics, surface geology, and point source discharge locations. The biologist selects as many sites as necessary to establish an accurate assessment for a stream segment; the length of the assessed stream segment can vary between sites. All the biological surveys included kick-screen sampling of benthic macroinvertebrates and habitat evaluations. Benthic macroinvertebrates are identified to the family level in the field.

[2] Section 305(b) of the Clean Water Act requires a biannual description of the water quality of the waters of the state.

After the survey is completed, the biologist determines the status of the stream segment. The decision is based on habitat scores and a series of narrative biological statements used to evaluate the benthic macroinvertebrate community. If the stream is determined to be impaired, the source and cause of the impairment is documented. An impaired stream must be listed on the state's Section 303(d) list with the source and cause. A TMDL must be developed for the stream segment and each pollutant. In order for the process to be more effective, adjoining stream segments with the same source and cause listing are addressed collectively, and on a watershed basis.

Basic Steps for Determining a TMDL

Although all watersheds must be handled on a case-by-case basis when developing TMDLs, there are basic processes or steps that apply to all cases. They include:

1. Collection and summarization of pre-existing data (watershed characterization, inventory contaminant sources, determination of pollutant loads, etc.);
2. Calculating TMDL for the waterbody using EPA approved methods and computer models;
3. Allocating pollutant loads to various sources;
4. Determining critical and seasonal conditions;
5. Public review and comment period on draft TMDL;
6. Submittal of final TMDL; and
7. EPA approval of the TMDL.

Watershed History

Moon Run is located in the Allegheny Plateau physiographic province. The Allegheny Plateau covers much of western Pennsylvania and the area consists primarily of extensively forested uplands and several major river valleys that dissect the highlands.

Structurally, Moon Run lies in between the southern end of the Brady's Bend syncline and the northern end of the "Nineveh" Anticline. The general strike in the area is about 45 degrees trending northwest and the dip of the area strata is around 2-3 degrees trending northeast.

The topography of the area consists of gently rolling hills on the order of 5 percent. The maximum elevation around the area is 1140 feet and the minimum elevation is about 700 feet where Moon Run enters the Ohio River.

Mining occurred in the Moon Run Watershed in the late 19th and early 20th centuries by the Moon Run and Pittsburgh Coal Companies. All mining was contained to the area above sampling point MOON03 (Attachment A). There is a deep mine in existence next to the stream, which is a major source of pollution to Moon Run. The locations of six abandoned discharges are known and can be found on the map in Attachment A. The area around Moon Run has also been heavily industrialized.

AMD Methodology

A two-step approach is used for the TMDL analysis of AMD impaired stream segments. The first step uses a statistical method for determining the allowable instream concentration at the point of interest necessary to meet water quality standards. This is done at each point of interest (sample point) in the watershed. The second step is a mass balance of the loads as they pass through the watershed. Loads at these points will be computed based on average annual flow.

The statistical analysis described below can be applied to situations where all of the pollutant loading is from non-point sources as well as those where there are both point and non-point sources. The following defines what are considered point sources and non-point sources for the purposes of our evaluation; point sources are defined as permitted discharges or a discharge that has a responsible party, non-point sources are then any pollution sources that are not point sources. For situations where all of the impact is due to non-point sources, the equations shown below are applied using data for a point in the stream. The load allocation made at that point will be for all of the watershed area that is above that point. For situations where there are point-source impacts alone, or in combination with non-point sources, the evaluation will use the point-source data and perform a mass balance with the receiving water to determine the impact of the point source.

Allowable loads are determined for each point of interest using Monte Carlo simulation. Monte Carlo simulation is an analytical method meant to imitate real-life systems, especially when other analyses are too mathematically complex or too difficult to reproduce. Monte Carlo simulation calculates multiple scenarios of a model by repeatedly sampling values from the probability distribution of the uncertain variables and using those values to populate a larger data set. Allocations were applied uniformly for the watershed area specified for each allocation point. For each source and pollutant, it was assumed that the observed data were log-normally distributed. Each pollutant source was evaluated separately using @Risk[3] by performing 5,000 iterations to determine the required percent reduction so that the water quality criteria, as defined in the *Pennsylvania Code. Title 25 Environmental Protection, Department of Environmental Protection, Chapter 93, Water Quality Standards,* will be met instream at least 99 percent of the time. For each iteration, the required percent reduction is:

PR = maximum {0, (1-Cc/Cd)} where (1)

PR = required percent reduction for the current iteration

Cc = criterion in mg/l

Cd = randomly generated pollutant source concentration in mg/l based on the observed data

Cd = RiskLognorm(Mean, Standard Deviation) where (1a)

Mean = average observed concentration

[3] @Risk – Risk Analysis and Simulation Add-in for Microsoft Excel, Palisade Corporation, Newfield, NY, 1990-1997.

Standard Deviation = standard deviation of observed data

The overall percent reduction required is the 99th percentile value of the probability distribution generated by the 5,000 iterations, so that the allowable long-term average (LTA) concentration is:

LTA = Mean * (1 – PR99) where (2)

LTA = allowable LTA source concentration in mg/l

Once the allowable concentration and load for each pollutant is determined, mass-balance accounting is performed starting at the top of the watershed and working down in sequence. This mass-balance or load tracking is explained below.

Load tracking through the watershed utilizes the change in measured loads from sample location to sample location, as well as the allowable load that was determined at each point using the @Risk program.

There are two basic rules that are applied in load tracking; rule one is that if the sum of the measured loads that directly affect the downstream sample point is less than the measured load at the downstream sample point it is indicative that there is an increase in load between the points being evaluated, and this amount (the difference between the sum of the upstream and downstream loads) shall be added to the allowable load(s) coming from the upstream points to give a total load that is coming into the downstream point from all sources. The second rule is that if the sum of the measured loads from the upstream points is greater than the measured load at the downstream point this is indicative that there is a loss of instream load between the evaluation points, and the ratio of the decrease shall be applied to the load that is being tracked (allowable load(s)) from the upstream point.

Tracking loads through the watershed gives the best picture of how the pollutants are affecting the watershed based on the information that is available. The analysis is done to insure that water quality standards will be met at all points in the stream. The TMDL must be designed to meet standards at all points in the stream, and in completing the analysis, reductions that must be made to upstream points are considered to be accomplished when evaluating points that are lower in the watershed. Another key point is that the loads are being computed based on average annual flow and should not be taken out of the context for which they are intended, which is to depict how the pollutants affect the watershed and where the sources and sinks are located spatially in the watershed.

For pH TMDLs, acidity is compared to alkalinity as described in Attachment B. Each sample point used in the analysis of pH by this method must have measurements for total alkalinity and total acidity. Net alkalinity is alkalinity minus acidity, both in units of milligrams per liter (mg/**l**) $CaCO_3$. Statistical procedures are applied, using the average value for total alkalinity at that point as the target to specify a reduction in the acid concentration. By maintaining a net alkaline stream, the pH value will be in the range between six and eight. This method negates the need to specifically compute the pH value, which for streams affected by low pH from AMD may not a true reflection of acidity. This method assures that Pennsylvania's standard for pH is met when the acid concentration reduction is met.

Information for the TMDL analysis performed using the methodology described above is contained in the "TMDLs by Segment" section of this report.

TMDL Endpoints

One of the major components of a TMDL is the establishment of an instream numeric endpoint, which is used to evaluate the attainment of applicable water quality. An instream numeric endpoint, therefore, represents the water quality goal that is to be achieved by implementing the load reductions specified in the TMDL. The endpoint allows for a comparison between observed instream conditions and conditions that are expected to restore designated uses. The endpoint is based on either the narrative or numeric criteria available in water quality standards.

Because most of the pollution sources in the watershed are nonpoint sources, the larges part of the TMDL is expressed as Load Allocations (LAs). All allocations will be specified as long-term average daily concentrations. These long-term average concentrations are expected to meet water-quality criteria 99% of the time as required in PA Title 25 Chapter 96.3(c). The following table shows the applicable water-quality criteria for the selected parameters.

Table 2. Applicable Water Quality Criteria

Parameter	***Criterion Value (mg/l)***	***Total Recoverable/Dissolved***
Aluminum (Al)	0.75	Total Recoverable
Iron (Fe)	1.50	30 day average; Total Recoverable
Manganese (Mn)	1.00	Total Recoverable
pH *	6.0-9.0	N/A

*The pH values shown will be used when applicable. In the case of freestone streams with little or no buffering capacity, the TMDL endpoint for pH will be the natural background water quality.

TMDL Elements (WLA, LA, MOS)

$$TMDL = WLA + LA + MOS$$

A TMDL equation consists of a wasteload allocation (WLA), load allocation (LA), and a margin of safety (MOS). The wasteload allocation is the portion of the load assigned to point sources. The load allocation is the portion of the load assigned to nonpoint sources. The margin of safety is applied to account for uncertainties in the computational process. The margin of safety may be expressed implicitly (documenting conservative processes in the computations) or explicitly (setting aside a portion of the allowable load). The TMDL allocations in this report are based on available data. Other allocation schemes could also meet the TMDL.

Allocation Summary

These TMDLs will focus remediation efforts on the identified numerical reduction targets for each watershed. The reduction schemes in Table 3 for each segment are based on the assumption that all upstream allocations are achieved and take into account all upstream reductions. Attachment C contains the TMDLs by segment analysis for each allocation point in a detailed discussion. As changes occur in the watershed, the TMDLs may be re-evaluated to reflect current conditions. An implicit MOS based on conservative assumptions in the analysis is included in the TMDL calculations.

The allowable LTA concentration in each segment is calculated using Monte Carlo Simulation as described previously. The allowable load is then determined by multiplying the allowable concentration by the flow and a conversion factor at each sample point. The allowable load is the TMDL.

Each permitted discharge in a segment is assigned a waste load allocation and the total waste load allocation (WLA) for each segment is included in this table. There are currently no permitted discharges in the watershed and therefore all WLAs are equal to zero. The difference between the TMDL and the WLA at each point is the load allocation (LA) at the point. The LA at each point includes all loads entering the segment, including those from upstream allocation points. The percent reduction is calculated to show the amount of load that needs to be reduced within a segment in order for water quality standards to be met at the point.

In some instances, instream processes, such as settling, are taking place within a stream segment. These processes are evidenced by a decrease in measured loading between consecutive sample points. It is appropriate to account for these losses when tracking upstream loading through a segment. The calculated upstream load lost within a segment is proportional to the difference in the measured loading between the sampling points.

Table 3. TMDL Component Summary for the Moon Run Watershed

Station	Parameter	Existing Load (lbs/day)	TMDL Allowable Load (lbs/day)	WLA (lbs/day)	LA (lbs/day)	Load Reduction (lbs/day)	Percent Reduction %
MOON05	*Moon Run upstream of Unnamed Tributary 36737*						
	Fe	8.9	3.2	0.0	3.2	5.7	64
	Mn	6.6	3.6	0.0	3.6	3.0	46
	Al	24.0	1.2	0.0	1.2	22.8	95
	Acidity	59.3	26.1	0.0	26.1	33.2	56
MOON04	*Mouth of Unnamed Tributary 36737*						
	Fe	0.9	0.7	0.0	0.7	0.2	22
	Mn	1.6	0.7	0.0	0.7	0.9	54
	Al	3.4	0.2	0.0	0.2	3.2	94
	Acidity	9.3	9.3	NA	NA	0.0	0

Station	Parameter	Existing Load (lbs/day)	TMDL Allowable Load (lbs/day)	WLA (lbs/day)	LA (lbs/day)	Load Reduction (lbs/day)	Percent Reduction %
MOON03	*Moon Run downstream of Unnamed Tributary 36732*						
	Fe	5.8	5.8	NA	NA	0.0	0
	Mn	6.0	5.1	0.0	5.1	0.0	0
	Al	19.2	2.1	0.0	2.1	0.0	0
	Acidity	0.0	0.0	NA	NA	0.0	0
MOON02	*Mouth of Unnamed Tributary 36731*						
	Fe	0.4	0.4	NA	NA	0.0	0
	Mn	0.1	0.1	NA	NA	0.0	0
	Al	ND	NA	NA	NA	0.0	0
	Acidity	0.0	0.0	NA	NA	0.0	0
MOON01	*Mouth of Moon Run*						
	Fe	ND	NA	NA	NA	0.0	0
	Mn	1.8	1.8	NA	NA	0.0	0
	Al	8.5	8.5	NA	NA	0.0	0
	Acidity	0.0	0.0	NA	NA	0.0	0

ND, values below the detection limit
NA meets WQS. No TMDL necessary.

In the instance that the allowable load is equal to the existing load (e.g. iron point MOON03, Table 3), the simulation determined that water quality standards are being met instream 99% of the time and no TMDL is necessary for the parameter at that point. Although no TMDL is necessary, the loading at the point is considered at the next downstream point. In addition, when all measured values are below the method detection limit, denoted by ND (e.g. aluminum point MOON02, Table 3), no TMDL is necessary. In this case the accounting for upstream loads is not carried through to the next downstream point. Rather, there is a disconnect noted and the allowable load is considered to start over because the water quality standard is satisfied.

Following is an example of how the allocations, presented in Table 3 are calculated. For this example, aluminum allocations for points MOON03, MOON04 and MOON05 are shown. As demonstrated in the example, all upstream contributing loads are accounted for at each point. Attachment C contains the TMDLs by segment analysis for each allocation point in a detailed discussion. These analyses follow the example. Attachment A contains a map of the sampling point locations for reference.

MOON05	Load (lbs/day)
Existing Load	24.0
Allowable Load	**1.2**
Load Reduction	22.8
% Reduction	95

1.2

MOON04	Load (lbs/day)
Existing Load	3.4
Allowable Load	**0.2**
Load Reduction	3.2
% Reduction	94

0.2

1.4 = **0.2** + **1.2**

1.0 = **1.4** * **0.70**

MOON03	Load (lbs/day)
Existing Load	19.2
Difference in Existing Load	-8.1
Load tracked from upstream	**1.4**
Percent loss due to instream process	30
Percent of loads tracked	**70**
Total Load tracked between points	**1.0**
Allowable Load	2.1
Load Reduction	0.0
% Reduction	0

Recommendations

To date no projects have been constructed in order to address the affects of abandoned mines and abandoned mine lands in the watershed. Passive treatment is a viable option for Moon Run.

Two primary programs provide maintenance and improvement of water quality in the watershed. DEP's efforts to reclaim abandoned mine lands, coupled with its duties and responsibilities for issuing NPDES permits, will be the focal points in water quality improvement.

Additional opportunities for water quality improvement are both ongoing and anticipated. Historically, a great deal of research into mine drainage has been conducted by DEP's Bureau of Abandoned Mine Reclamation, which administers and oversees the Abandoned Mine Reclamation Program in Pennsylvania; the United States Office of Surface Mining; the National Mine Land Reclamation Center; the National Environmental Training Laboratory; and many other agencies and individuals. Funding from EPA's CWA Section 319(a) Grant program and Pennsylvania's Growing Greener program has been used extensively to remedy mine drainage impacts. These many activities are expected to continue and result in water quality improvement.

The DEP Bureau of Mining and Reclamation administers an environmental regulatory program for all mining activities, mine subsidence regulation, mine subsidence insurance, and coal refuse disposal; conducts a program to ensure safe underground bituminous mining and protect certain structures form subsidence; administers a mining license and permit program; administers a regulatory program for the use, storage, and handling of explosives; provides for training, examination, and certification of applicants for blaster's licenses; administers a loan program for bonding anthracite underground mines and for mine subsidence; and administers the EPA Watershed Assessment Grant Program, the Small Operator's Assistance Program (SOAP), and the Remining Operators Assistance Program (ROAP).

Mine reclamation and well plugging refers to the process of cleaning up environmental pollutants and safety hazards associated with a site and returning the land to a productive condition, similar to DEP's Brownfields program. Since the 1960s, Pennsylvania has been a national leader in establishing laws and regulations to ensure reclamation and plugging occur after active operation is completed.

Pennsylvania is striving for complete reclamation of its abandoned mines and plugging of its orphaned wells. Realizing this task is no small order, DEP has developed concepts to make abandoned mine reclamation easier. These concepts, collectively called Reclaim PA, include legislative, policy land management initiatives designed to enhance mine operator, volunteer land DEP reclamation efforts. Reclaim PA has the following four objectives.

- To encourage private and public participation in abandoned mine reclamation efforts
- To improve reclamation efficiency through better communication between reclamation partners
- To increase reclamation by reducing remining risks

- To maximize reclamation funding by expanding existing sources and exploring new sources.

Reclaim PA is DEP's initiative designed to maximize reclamation of the state's quarter million acres of abandoned mineral extraction lands. Abandoned mineral extraction lands in Pennsylvania constituted a significant public liability – more than 250,000 acres of abandoned surface mines, 2,400 miles of streams polluted with mine drainage, over 7,000 orphaned and abandoned oil and gas wells, widespread subsidence problems, numerous hazardous mine openings, mine fires, abandoned structures and affected water supplies – representing as much as one third of the total problem nationally.

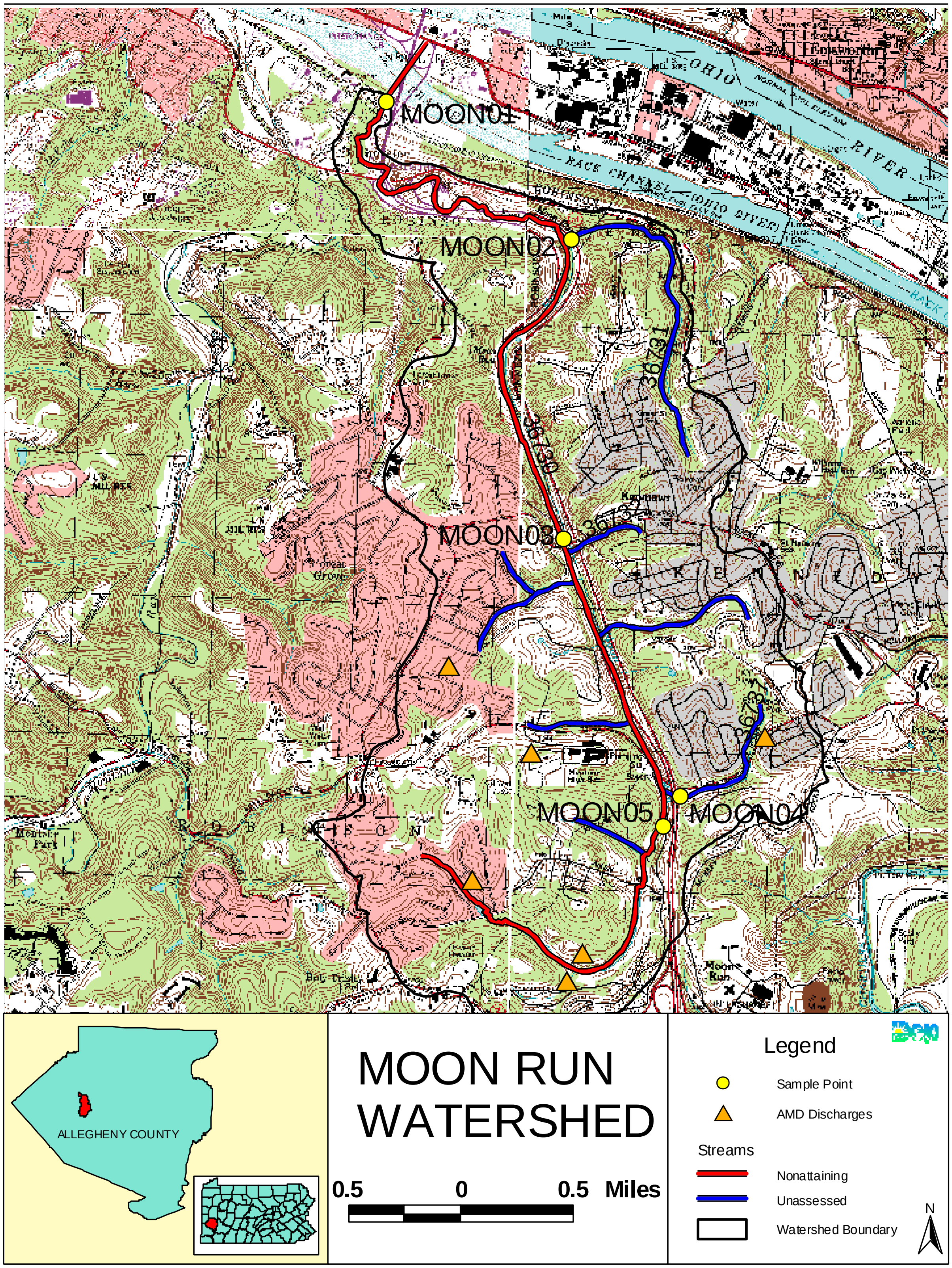
To date no projects have been constructed in order to address the affects of abandoned mines and abandoned mine lands in the watershed. Passive treatment is a viable option for Moon Run.

Public Participation

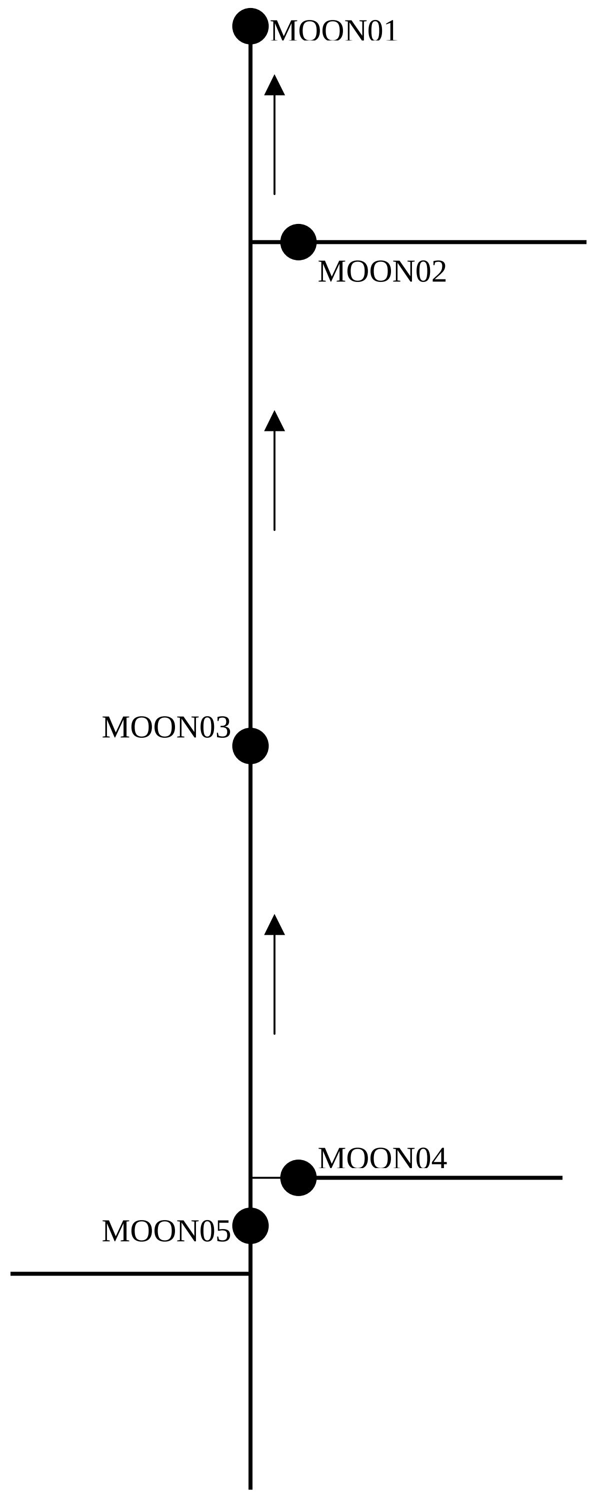
Public notice of the draft TMDL was published in the *Pennsylvania Bulletin* on July 17, 2004 and the *Suburban Gazette* on July 7, 2004 to foster public comment on the allowable loads calculated. The public comment period on this TMDL was open from July 17, 2004 to September 16, 2004. A public meeting was held on July 20, 2004 at the Robinson Township Municipal Building to discuss the proposed TMDL.

Attachment A

Moon Run Watershed Maps


MOON01
MOON02
MOON03
MOON04
MOON05
36730
36731
36732
36733
MOON RUN
WATERSHED
ALLEGHENY COUNTY
0.5 0 0.5 Miles
Legend
Sample Point
AMD Discharges
Streams
Nonattaining
Unassessed
Watershed Boundary
N

Moon Run Sampling Station Diagram
Arrows indicate direction of flow.
Diagram not to scale.



Attachment B

Method for Addressing Section 303(d) Listings for pH

Method for Addressing Section 303(d) Listings for pH

There has been a great deal of research conducted on the relationship between alkalinity, acidity, and pH. Research published by the Department of Environmental Protection demonstrates that by plotting net alkalinity (alkalinity-acidity) vs. pH for 794 mine sample points, the resulting pH value from a sample possessing a net alkalinity of zero is approximately equal to six (Figure 1). Where net alkalinity is positive (greater than or equal to zero), the pH range is most commonly six to eight, which is within the EPA's acceptable range of six to nine and meets Pennsylvania water quality criteria in Chapter 93.

The pH, a measurement of hydrogen ion acidity presented as a negative logarithm, is not conducive to standard statistics. Additionally, pH does not measure latent acidity. For this reason, and based on the above information, Pennsylvania is using the following approach to address the stream impairments noted on the Section 303(d) list due to pH. The concentration of acidity in a stream is at least partially chemically dependent upon metals. For this reason, it is extremely difficult to predict the exact pH values, which would result from treatment of abandoned mine drainage. Therefore, net alkalinity will be used to evaluate pH in these TMDL calculations. This methodology assures that the standard for pH will be met because net alkalinity is a measure of the reduction of acidity. When acidity in a stream is neutralized or is restored to natural levels, pH will be acceptable. Therefore, the measured instream alkalinity at the point of evaluation in the stream will serve as the goal for reducing total acidity at that point. The methodology that is applied for alkalinity (and therefore pH) is the same as that used for other parameters such as iron, aluminum, and manganese that have numeric water quality criteria.

Each sample point used in the analysis of pH by this method must have measurements for total alkalinity and total acidity. Net alkalinity is alkalinity minus acidity, both being in units of milligrams per liter (mg/l) $CaCO_3$. The same statistical procedures that have been described for use in the evaluation of the metals is applied, using the average value for total alkalinity at that point as the target to specify a reduction in the acid concentration. By maintaining a net alkaline stream, the pH value will be in the range between six and eight. This method negates the need to specifically compute the pH value, which for mine waters is not a true reflection of acidity. This method assures that Pennsylvania's standard for pH is met when the acid concentration reduction is met.

There are several documented cases of streams in Pennsylvania having a natural background pH below six. If the natural pH of a stream on the Section 303(d) list can be established from its upper unaffected regions, then the pH standard will be expanded to include this natural range. The acceptable net alkalinity of the stream after treatment/abatement in its polluted segment will be the average net alkalinity established from the stream's upper, pristine reaches added to the acidity of the polluted portion in question. Summarized, if the pH in an unaffected portion of a stream is found to be naturally occurring below six, then the average net alkalinity for that portion (added to the acidity of the polluted portion) of the stream will become the criterion for the polluted portion. This "natural net alkalinity level" will be the criterion to which a 99 percent confidence level will be applied. The pH range will be varied only for streams in which a natural unaffected net alkalinity level can be established. This can only be done for streams that have upper segments that are not impacted by mining activity. All other streams will be required to reduce the acid load so the net alkalinity is greater than zero 99% of time.

Reference: *Rose, Arthur W. and Charles A. Cravotta, III 1998. Geochemistry of Coal Mine Drainage. Chapter 1 in Coal Mine Drainage Prediction and Pollution Prevention in Pennsylvania. Pa. Dept. of Environmental Protection, Harrisburg, Pa.*

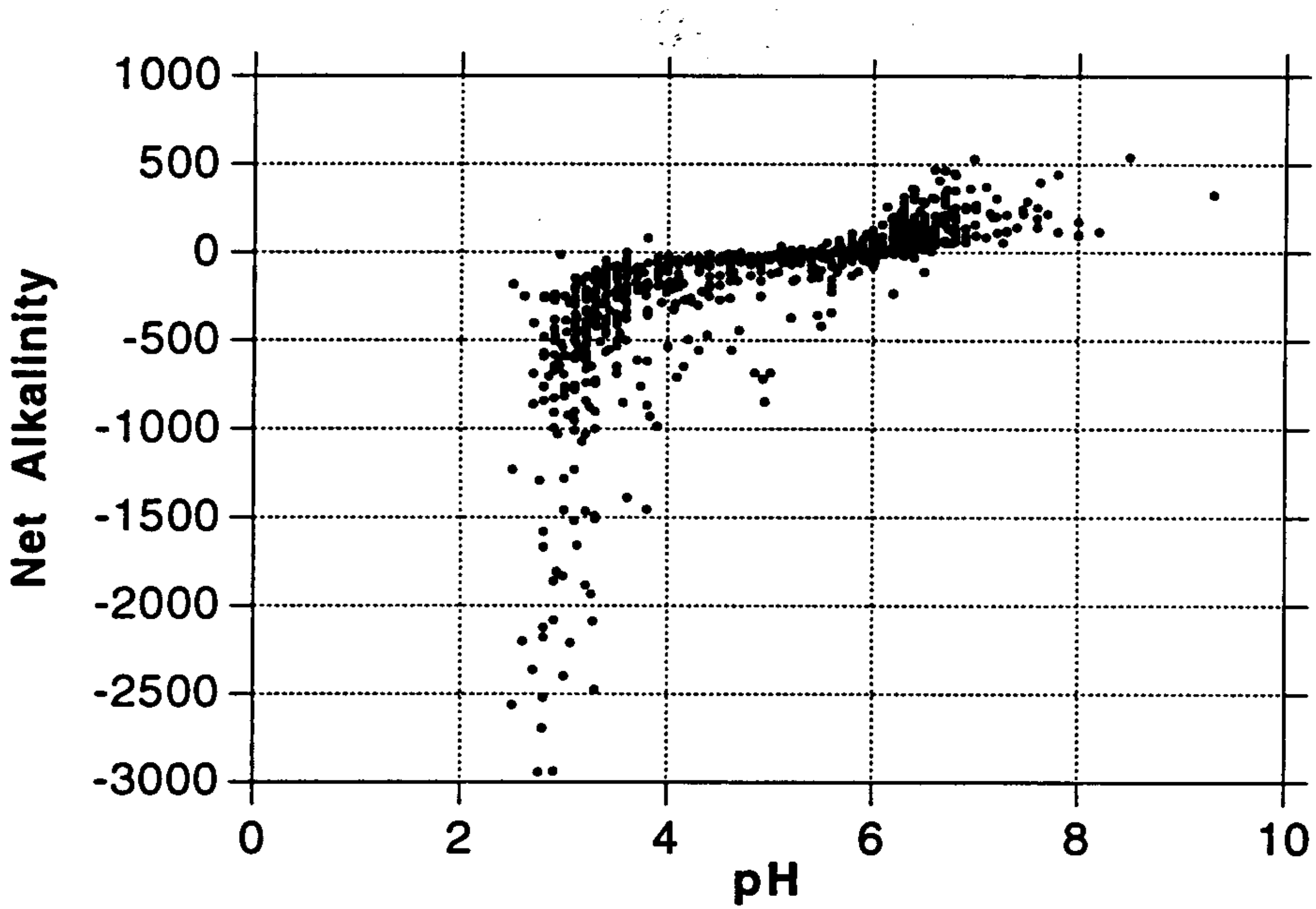


Figure 1. Net Alkalinity vs. pH. Taken from Figure 1.2 Graph C, pages 1-5, of Coal Mine Drainage Prediction and Pollution Prevention in Pennsylvania

Attachment C

TMDLs By Segment

Moon Run

The TMDL for Moon Run consists of load allocations of one tributary and two sampling sites along the stream. There are no waste load allocations in the watershed because there are no active NPDES mining permits in the watershed. Analysis completed at two additional points in the watershed determined that water quality standards are met under current conditions and therefore no TMDLs are necessary.

Moon Run is listed as impaired on the PA Section 303(d) list by both high metals and low pH from AMD as being the cause of the degradation to the stream. Suspended solids is listed as a cause of impairment from AMD on the 1996 PA Section 303(d) list, but was removed from subsequent lists. Suspended solids impairments are metal precipitate and will be remedied with the removal of the metals impairment. For pH, the objective is to reduce acid loading to the stream that will in turn raise the pH to the acceptable range. The result of this analysis is an acid loading reduction that equates to meeting standards for pH (see TMDL Endpoint section in the report, Table 2). The method and rationale for addressing pH is contained in Attachment B.

Data indicates that Moon Run is impaired upstream of MOON03. Sampling downstream of this showed that the stream is meeting water quality standards. The impairments in Moon Run are a result of abandoned mine discharges located upstream of MOON03 and into the headwaters.

TMDLs are not necessary at MOON02 and MOON01 because analysis shows that water quality standards are being met 99% of the time at both points for all parameters.

An allowable long-term average in-stream concentration was determined at each sample point for aluminum, iron, manganese, and acidity. The analysis is designed to produce an average value that, when met, will be protective of the water-quality criterion for that parameter 99% of the time. An analysis was performed using Monte Carlo simulation to determine the necessary long-term average concentration needed to attain water-quality criteria 99% of the time. The simulation was run assuming the data set was lognormally distributed. Using the mean and standard deviation of the data set, 5000 iterations of sampling were completed, and compared against the water-quality criterion for that parameter. For each sampling event a percent reduction was calculated, if necessary, to meet water-quality criteria. A second simulation that multiplied the percent reduction times the sampled value was run to insure that criteria were met 99% of the time. The mean value from this data set represents the long-term average concentration that needs to be met to achieve water-quality standards.

TMDL Calculations - Sample Point MOON05, Moon Run upstream of Unnamed Tributary 36737

The TMDL for sample point MOON05 consists of a load allocation to all of the area above the point (Attachment A). The load allocation for this segment was computed using water-quality sample data collected at point MOON05. The average flow of 0.74 MGD, measured at point MOON05, is used for these computations.

This segment was included on the 1996 and 1998 PA Section 303(d) lists for metals impairments from AMD. In 1999 a new assessment was completed on the segment and pH was added as a cause of impairment. Sample data at point MOON05 shows pH ranging between 5.9 and 7.4; pH will be addressed as part of this TMDL because of the mining impacts.

Table C1. TMDL Calculations at Point MOON05				
Flow = 0.74 MGD	Measured Sample Data		Allowable	
Parameter	Conc. (mg/l)	Load (lbs/day)	LTA Conc. (mg/l)	Load (lbs/day)
Fe	1.44	8.9	0.52	3.2
Mn	1.07	6.6	0.58	3.6
Al	3.89	24.0	0.19	1.2
Acidity	9.63	59.3	4.24	26.1
Alkalinity	40.80	251.2		

Table C2. Calculation of Load Reduction Necessary at Point MOON05				
	Fe (lbs/day)	Mn (lbs/day)	Al (lbs/day)	Acidity (lbs/day)
Existing Load	8.9	6.6	24.0	59.3
Allowable Load	3.2	3.6	1.2	26.1
Load Reduction	5.7	3.0	22.8	33.2
% Reduction Segment	64	46	95	56

TMDL Calculations - Sample Point MOON04, mouth of Unnamed Tributary 36737

The TMDL for sample point MOON04 consists of a load allocation to all of the area above the point (Attachment A). The load allocation for this tributary was computed using water-quality sample data collected at point MOON04. The average flow of 0.17 MGD, measured at point MOON04, is used for these computations.

This segment is not included on the PA Section 303(d) list for impairments from AMD. Sample data at point MOON04 shows pH ranging between 6.3 and 7.9 and that the stream is net alkaline; pH will not be addressed as part of this TMDL.

Table C3. TMDL Calculations at Point MOON04				
Flow = 0.17 MGD	Measured Sample Data		Allowable	
Parameter	Conc. (mg/l)	Load (lbs/day)	LTA Conc. (mg/l)	Load (lbs/day)
Fe	0.62	0.9	0.49	0.7
Mn	1.15	1.6	0.53	0.7
Al	2.38	3.4	0.14	0.2
Acidity	6.53	9.3	6.53	9.3
Alkalinity	102.53	145.3		

Table C4. Calculation of Load Reduction Necessary at Point MOON04				
	Fe (lbs/day)	Mn (lbs/day)	Al (lbs/day)	Acidity (lbs/day)
Existing Load	0.9	1.6	3.4	9.3
Allowable Load	0.7	0.7	0.2	9.3
Load Reduction	0.2	0.9	3.2	0.0
% Reduction Segment	22	54	94	0

TMDL Calculations - Sample Point MOON03, Moon Run downstream of Unnamed Tributary 36372

The TMDL for sample point MOON03 consists of a load allocation to all of the area between points MOON05, MOON04, and MOON03. The load allocation for this segment was computed using water-quality sample data collected at point MOON03. The average flow of 1.53 MGD, measured at point MOON03, is used for these computations.

This segment was included on the 1996 and 1998 PA Section 303(d) lists for metals impairments from AMD. In 1999 a new assessment was completed on the segment and pH was added as a cause of impairment. Sample data at point MOON03 shows pH ranging between 7.0 and 7.9 and that the stream is net alkaline; pH is not addressed as part of this TMDL.

Water quality analysis determined that the existing and allowable iron loads are equal. Because the WQS is met, a TMDL for iron is not necessary. Although a TMDL for iron is not necessary, the loading is considered at the next downstream point. All data for manganese fell below the criterion of 1.0 mg/L. The simulation, however, determined that standards would not be met 99% of the time based on the existing data set and a reduction is needed.

Table C5. TMDL Calculations at Point MOON03				
Flow = 1.53 MGD	Measured Sample Data		Allowable	
Parameter	Conc. (mg/l)	Load (lbs/day)	LTA Conc. (mg/l)	Load (lbs/day)
Fe	0.45	5.8	0.45	5.8
Mn	0.47	6.0	0.40	5.1
Al	1.50	19.2	0.17	2.1
Acidity	0.00	0.0	0.00	0.0
Alkalinity	71.80	918.1		

The calculated load reductions for all the loads that enter point MOON03 must be accounted for in the calculated reductions at the sample point shown in Table C6. A comparison of measured loads between points MOON03, MOON04 and MOON05 shows that there is a loss of loading for all parameters. The loss of loading indicates that instream processes, such as settling, are taking place within the segment. To determine the total segment load, the percent decrease in existing loads between MOON03, MOON04 and MOON05 is applied to the upstream loads entering the segment.

Table C6. Calculation of Load Reduction Necessary at Point MOON03				
	Fe (lbs/day)	Mn (lbs/day)	Al (lbs/day)	Acidity (lbs/day)
Existing Load at MOON03	5.8	6.0	19.2	0.0
Difference in Existing Load between MOON05, MOON04 & MOON03	-3.9	-2.2	-8.1	-68.6
Load tracked from MOON04 & MOON05	3.9	4.3	1.4	35.4
% Load lost due to instream process	40	26	30	100
% Load tracked through segment	60	74	70	0
Load tracked between points MOON03, MOON04 & MOON05	2.3	3.2	1.0	0.0
Allowable Load at MOON03	5.8	5.1	2.1	0.0
Additional Reduction at MOON03	0.0	0.0	0.0	0.0
% Reduction required at MOON03	0	0	0	0

TMDL Calculations - Sample Point MOON02, mouth of Unnamed Tributary 36731

This segment is not included on the PA Section 303(d) list. TMDLs for MOON02 are not necessary because water quality standards are met for all parameters at MOON02.

Table C7. TMDL Calculations at Point MOON02				
Flow = 0.17 MGD	Measured Sample Data		Allowable	
Parameter	Conc. (mg/l)	Load (lbs/day)	LTA Conc. (mg/l)	Load (lbs/day)
Fe	0.31	0.4	0.31	0.4
Mn	0.06	0.1	0.06	0.1
Al	ND	ND	NA	NA
Acidity	0.00	0.0	0.00	0.0
Alkalinity	138.23	194.2		

Table C8. Calculation of Load Reduction Necessary at Point MOON02				
	Fe (lbs/day)	Mn (lbs/day)	Al (lbs/day)	Acidity (lbs/day)
Existing Load	0.4	0.1	ND	0.0
Allowable Load	0.4	0.1	NA	0.0
Load Reduction	0.0	0.0	0.0	0.0
% Reduction Segment	0	0	0	0

TMDL Calculations - Sample Point MOON01, mouth of Moon Run

This segment was included on the 1996 and 1998 PA Section 303(d) lists for metals impairments from AMD. In 1999 a new assessment was completed on the segment and pH was added as a cause of impairment.

TMDLs for MOON01 are not necessary because water quality standards are met for all parameters at MOON01 under the current loading. Upstream iron loads are not considered at MOON01 because values are below the detection limit. There is a loss in manganese and aluminum loading between points MOON01, MOON02, and MOON03. The percent of load lost is applied to the upstream loads entering the segment to determine the amount of load tracked through the segment.

Table C9. TMDL Calculations at Point MOON01				
Flow = 2.02 MGD	Measured Sample Data		Allowable	
Parameter	Conc. (mg/l)	Load (lbs/day)	LTA Conc. (mg/l)	Load (lbs/day)
Fe	ND	ND	NA	NA
Mn	0.11	1.8	0.11	1.8
Al	0.50	8.5	0.50	8.5
Acidity	0.00	0.0	0.00	0.0
Alkalinity	87.07	1467.0		

Table C10. Calculation of Load Reduction Necessary at Point MOON01				
	Fe (lbs/day)	Mn (lbs/day)	Al (lbs/day)	Acidity (lbs/day)
Existing Load at MOON01	ND	1.8	8.5	0.0
Difference in Existing Load between MOON01, MOON02 & MOON03	-	-4.3	-10.7	0.0
Load tracked from MOON02 & MOON03	-	3.3	1.0	0.0
% Load lost due to instream process	-	70	56	-
% Load tracked through segment	-	30	44	-
Load tracked between points MOON01, MOON02 & MOON03	-	1.0	0.4	0.0
Allowable Load at MOON01	NA	1.8	8.5	0.0
Load Reduction at MOON01	0.0	0.0	0.0	0.0
% Reduction required at MOON01	0	0	0	0

Margin of Safety

For this study the margin of safety is applied implicitly. A MOS is implicit because the allowable concentrations and loadings were simulated using Monte Carlo techniques and employing the @Risk software. Other margins of safety used for this TMDL analysis include the following:

- Effluent variability plays a major role in determining the average value that will meet water-quality criteria over the long-term. The value that provides this variability in our analysis is the standard deviation of the dataset. The simulation results are based on this variability and the existing stream conditions (an uncontrolled system). The general assumption can be made that a controlled system (one that is controlling and stabilizing the pollution load) would be less variable than an uncontrolled system. This implicitly builds in a margin of safety.
- An additional MOS is provided because the calculations were done with a daily Fe average instead of the 30-day average

Seasonal Variation

Seasonal variation is implicitly accounted for in these TMDLs because the data used represents all seasons.

Critical Conditions

The reductions specified in this TMDL apply at all flow conditions. A critical flow condition could not be identified from the data used for this analysis.

Attachment D

Excerpts Justifying Changes Between the 1996, 1998, and 2002 Section 303(d) Lists

The following are excerpts from the Pennsylvania DEP Section 303(d) narratives that justify changes in listings between the 1996, 1998, and 2002 lists. The Section 303(d) listing process has undergone an evolution in Pennsylvania since the development of the 1996 list.

In the 1996 Section 303(d) narrative, strategies were outlined for changes to the listing process. Suggestions included, but were not limited to, a migration to a Global Information System (GIS), improved monitoring and assessment, and greater public input.

The migration to a GIS was implemented prior to the development of the 1998 Section 303(d) list. As a result of additional sampling and the migration to the GIS some of the information appearing on the 1996 list differed from the 1998 list. Most common changes included:

1. mileage differences due to recalculation of segment length by the GIS;
2. slight changes in source(s)/cause(s) due to new EPA codes;
3. changes to source(s)/cause(s), and/or miles due to revised assessments;
4. corrections of misnamed streams or streams placed in inappropriate SWP subbasins; and
5. unnamed tributaries no longer identified as such and placed under the named watershed listing.

Prior to 1998, segment lengths were computed using a map wheel and calculator. The segment lengths listed on the 1998 Section 303(d) list were calculated automatically by the GIS (ArcInfo) using a constant projection and map units (meters) for each watershed. Segment lengths originally calculated by using a map wheel and those calculated by the GIS did not always match closely. This was the case even when physical identifiers (e.g., tributary confluence and road crossings) matching the original segment descriptions were used to define segments on digital quad maps. This occurred to some extent with all segments, but was most noticeable in segments with the greatest potential for human errors using a map wheel for calculating the original segment lengths (e.g., long stream segments or entire basins).

Attachment E

Water Quality Data Used In TMDL Calculations

Monitoring Point	Date	Flow (gpm)	pH	Alk (mg/L)	Acidity (mg/L)	Fe (mg/L)	Mn (mg/L)	Al (mg/L)
MOON05	6/28/2002	125	5.9	14.2	57.8	1.5	1.44	4.78
Latitude:	6/6/2003	705	7	49.2	0	1.38	1.17	5.22
40 27' 45"	7/3/2003	894	6.6	27	0	2.95	1.26	8.67
Longitude:	8/4/2003	599	7.1	48.6	0	1.04	0.991	2.1
80 06' 44"	9/9/2003	300	7.2	53.4	0	0.96	0.712	1.47
	10/1/2003	453	7.4	52.4	0	0.81	0.851	1.11
	Average	512.66667	6.86667	40.80000	9.63333	1.44000	1.07067	3.89167
	St Dev	278.90261	0.54283	16.26481	23.59675	0.78417	0.27032	2.90511
MOON04	06/28/02	175	6.3	30	39.2	1.24	1.39	0.0301
Latitude:	06/06/03	55	7.6	99	0	0.359	1.17	5.01
40 27' 52"	07/03/03	110	7.6	85.4	0	0.434	1.45	5.27
Longitude:	08/04/03	175	7.7	117.8	0	1.04	1.37	2.97
80 06' 39"	09/09/03	45	7.7	146	0	0.365	0.698	0.5
	10/01/03	148	7.9	137	0	0.3	0.797	0.5
	Average	118.00000	7.46667	102.53333	6.53333	0.62300	1.14583	2.38002
	St Dev	57.89646	0.58195	42.13667	16.00333	0.40765	0.32410	2.37520
MOON03	6/28/2002	1050	7	54	0	0.3	0.259	0.544
Latitude:	6/6/2003	1617	7.7	72.6	0	0.812	0.718	3.02
40 28' 51"	7/3/2003	1043	7.6	56	0	0.626	0.745	3.34
Longitude:	8/4/2003	1236	7.8	78.8	0	0.387	0.468	1.1
80 07' 16"	9/9/2003	700	7.7	81.4	0	0.3	0.281	0.5
	10/1/2003	742	7.9	88	0	0.3	0.363	0.5
	Average	1064.66667	7.61667	71.80000	0.00000	0.45417	0.47233	1.50067
	St Dev	338.29198	0.31885	13.93356	0.00000	0.21605	0.21391	1.32438
MOON02	6/28/2002	30	7.7	148	0	0.3	0.093	<0.5
Latitude:	6/6/2003	223	8	118.8	0	0.346	0.054	<0.5
40 30' 00"	7/3/2003	177	8.1	143	0	0.3	0.063	<0.5
Longitude:	8/4/2003	119	8.1	138.4	0	0.3	0.05	<0.5
80 07' 16"	9/9/2003	84	8.1	140.8	0	0.3	0.056	<0.5
	10/1/2003	69	8.1	140.4	0	0.3	0.05	<0.5
	Average	117.00000	8.01667	138.23333	0.00000	0.30767	0.06100	ND
	St Dev	71.83592	0.16021	10.07048	0.00000	0.01878	0.01640	NA
MOON01	6/28/2002	1200	7.1	62	0	<0.3	0.25	0.521
Latitude:	6/6/2003	2883	8	85.4	0	<0.3	0.2	0.5
40 30' 31"	7/3/2003	1222	7.7	75.8	0	<0.3	0.052	0.5
Longitude:	8/4/2003	1190	7.8	95	0	<0.3	0.05	0.5
80 08' 13"	9/9/2003	700	8	100.6	0	<0.3	0.05	0.5
	10/1/2003	1223	8	103.6	0	<0.3	0.05	0.5
	Average	1403.00000	7.76667	87.06667	0.00000	ND	0.10867	0.50350
	St Dev	753.17302	0.35024	15.98433	0.00000	NA	0.09149	0.00857

Attachment F

Comment and Response

Comments/Responses on the Moon Run Watershed TMDL

EPA Region III Comments (Received 09/08/2004)

Comment:
Page 7 & 9 – formatting of equation numbers

Response:
Corrected.

Comment:
Page 26, Table C10 – slight error in numbers.

Response:
The numbers in Table C10 are correct.