Shoup Run Watershed TMDLs:

TMDLs for Shoup Run, Miller Run and Hartman Run
For the Effects of Acid Mine Drainage

Prepared by Pennsylvania Department of Environmental Protection

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Introduction

These Total Maximum Daily Load (TMDLs) calculations have been prepared for the streams in the Shoup Run Watershed. They are done to address the impairments noted for the streams on the 1996 Pennsylvania 303(d) list, required under the Clean Water Act. High levels of metals, and in some areas depressed pH, caused Shoup Run, Miller Run and Hartman Run to be impaired. The impairments are the result of acid mine drainage from abandoned surface and underground coal mines. These TMDLs address the three primary metals associated with acid mine drainage, iron, manganese, and aluminum, as well as pH.

Table 1. 303(d) Sub-List								
State Water Plan (SWP) Subbasin:11-D -Central West Branch Susquehanna River								
Year	Miles	Seg-ment ID	DEP Stream Code	Stream Name	Designated Use	Data Source	Source	EPA 305(b) Cause Code
1996	7.7	6524	13717	Shoup Run	WWF	305(b) Report	Resource Extraction	Metals pH
1998	7.78	6524	13717	Shoup Run	WWF	SWMP	AMD	Metals pH
2000	7.76	6524	13717	Shoup Run	WWF	SWMP	AMD	Metals pH
1996	2.4	LAM -40	13720	Miller Run	WWF	305(b) Report	Resource Extraction	Metals pH
1998	2.4	Part C of 1998 List		Miller Run	WWF	305(b) Report	AMD	AMD
2000	2.4	Part D of 2000 List		Miller Run	WWF	305(b) Report	AMD	AMD
1996	200 ft.	Not Currently on the 303(d) list		Dudley Deep Mine Discharge				
1998	200 ft.	Not Currently on the 303(d) list		Dudley Deep Mine Discharge				
2000	200 ft.	Not Currently on the 303(d) list		Dudley Deep Mine Discharge				
1996	1.1	6529	13737	Hartman Run	WWF	305(b) Report	Resource Extraction	Metals pH
1998	1.19	6529	13737	Hartman Run	WWF	SWMP	AMD	Metals pH
2000		6529	13737	Hartman Run	WWF	SWMP	AMD	Metals pH

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

Directions to Shoup Run Watershed

Take any appropriate road to PA Route 26; then PA Route 26 to Route 913 North into Saxton (1 mile). Follow route 913 through the town of Saxton. At the High School make the left on to the bridge crossing Shoup Run. Sampling Point SR-1 is in the middle of Shoup Run directly upstream of the bridge. The remaining sample points are as shown on Figure 1. Follow route 913 upstream (it parallels Shoup Run) through the towns of Coalmont, Barnettstown and Dudley to locate the various sample points.

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. The distinction between non-point and point sources in this case is determined on the basis of whether or not there is a responsible party for the discharge. Where there is no responsible party the discharge is a non-point source. Each segment on the 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 good representation of the data used for the calculations.

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

Watershed History

The Shoup Run stream basin drains approximately 13,746-acres located in the Appalachian Mountain – Broadtop region of the Valley-Ridge Province. Within this province, the area lies within the northwestern section of the Broad Top Mountain Plateau. This area is characterized by narrow valleys and moderately steep mountain slopes. Shoup Run is located in Huntingdon County, but includes drainage from portions of Bedford County. Shoup Run flows into the Raystown Branch of the Juniata River near the community of Saxton. Miller Run and Hartman Run are both tributaries to Shoup Run (Attachment B). No other tributaries to Shoup Run are on the 303(d) list for acid mine drainage.

Approximately 10% of the surface area of the Shoup Run Stream Basin has been surface mined. Much of the mining activity occurred prior to 1977, with Deep mining taking place around the turn of the century, few of the mines were reclaimed to current specifications. Surface mining activity in this watershed ended in the early 1980s. Approximately 12% of the area has been undermined. Many abandoned deep-mine entries and openings still exist in the Shoup Run Basin. Deep mining was done below the water table in many locations. In order to de-water the mines, drifts were driven into deep mines to allow water to flow down slope and out of many of these mines. The bedrock in this area is folded and faulted. Tunnels were driven through many different lithologies to allow drainage. An extensive network of tunnels has allowed water and air to contact toxic material. Drainage from these mines is discharged through the mine entries and degrades the surface waters (Musser 2000). In a 1981 study sponsored by the Bedford and Huntingdon County Conservation Districts and Planning Commissions, a total of 11 deep mine drainage points were found to be discharging from abandoned mine openings. One such point with a very large discharge is the Dudley Deep Mine Discharge, located near Dudley Borough. Where the Dudley deep mine discharge flows into Shoup Run it comprises a minimum of 40% of the total volume of the stream. Consequently, mine drainage in the Shoup Run Drainage Basin is a problem. Elevated levels of Al, Fe, Mn, and depressed pH are degrading these streams (Groft et al. 1981). There is currently no active mining in the watershed.

As a result of mine drainage, the lower portions of Shoup Run are nearly devoid of life. The upper, less affected areas of Shoup Run and unaffected tributaries to Shoup Run do exhibit healthy aquatic populations. Miller Run was found to be nearly devoid of life at its confluence with Shoup Run. However, it did possess a native population of Brook Trout in its upper expanses before the stream is affected by various non-point sources of mine drainage (Groft et al.1981). No known significant aquatic populations were documented in Hartman Run.

The Shoup Run Basin essentially went unmonitored and unstudied from the early 1980s to last year. The only exception to this was the consistent monitoring of the Dudley Deep Mine Discharge by Musser Engineering Inc. from 1983 through 1998. This monitoring was done as part of the monitoring plan for a Surface Mine Permit (SMP) outside of the Shoup Run Drainage Basin. The L&B Coal Company was operating a site approximately 4 miles to the south of the town of Dudley and selected the deep mine discharge as a monitoring point. This is indicative of the connection between the Dudley Deep Mine Discharge, the vast network of abandoned underground mines, and their hydrologic connection to surface activities

In 1999, the Shoup Run Watershed Association in conjunction with the PA Department of Environmental Protection began a monitoring program to assess the quality of the stream basin. Once the quality of the stream is assessed, methods to treat the stream in order to improve stream quality will be applied.

In March of 2000, Musser Engineers, Inc. developed a report assessing the Dudley Deep Mine Discharge. The report summarized the mining activities in this area and concluded that previous surface mining activities approximately 4 miles to the southeast have some influence on the Dudley Deep Mine Discharge. Surface mining activities have allowed surface water and precipitation to enter the deep mine workings. It concluded that some portion of the volume of the Dudley Deep Mine Discharge is the result of water infiltrating the deep mine as the result of previous surface mining activities. A large source of this water is the remnants of Great Trough Creek approximately 4 miles to the south of the town of Dudley. Great Trough Creek was greatly disturbed by surface mining during which the stream channel was fragmented and in some places incidentally removed. Much of the stream flows into various impoundments, over unconsolidated spoil, and in some cases directly into the underlying deep mine system. The result is a large volume of water infiltrating the deep mine complex. Some unknown portion of this water flows through the deep mine system along structural dip and is re-emerging as part of the Dudley Deep Mine Discharge.

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 acceptable 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 of the nature of the pollution sources in the watershed, most of the TMDLs component makeup will be Load Allocations (LA) that are specified for the watershed above a point in the stream segment. All allocations will be specified as long-term average concentrations. These long-term average concentrations are expected to meet water-quality criteria 99% of the time. PA Title 25 Chapter 93.5(b) specifies that a minimum 99% level of protection is required. All metals criteria evaluated in these TMDLs are specified as total recoverable. 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*	0.1 of the 96 hour LC 50 0.75	Total recoverable
Iron	1.50 0.3	Total recoverable dissolved
Manganese	1.00	Total recoverable
PH**	6 - 9	NA

- *- This TMDL was developed using the value of 0.75 mg/l as the in-stream criterion for aluminum. This is the EPA national acute fish and aquatic life criterion for aluminum. Pennsylvania's current aluminum criterion is 0.1 mg/l of the 96-hour LC-50 and is contained in PA Title 25 Chapter 93. The EPA national criterion was used because the Department has recommended adopting the EPA criteria and is awaiting final promulgation of it.
- ** - 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. These values are typically as low as 5.4 (Pennsylvania Fish and Boat Commission). This condition is met when the net alkalinity is maintained above zero.

Computational Methodology

A TMDL equation consists of a Wasteload Allocation (WLA), Load Allocation (LA) and a Margin of Safety (MOS). The WLA is the portion of the load assigned to Point Sources. The LA is the portion of the load assigned to Non-point Sources (NPS). The MOS is applied to account for uncertainties in the TMDL. The MOS may be expressed implicitly (documenting conservative processes in the computations) or explicitly (setting aside a portion of the allowable load).

Table 3. Correlations	
Parameter	**R-squared**
pH	0.03
Net Alk.	0.00001
Fe	0.02
Mn	0.001
Al	Al did not have enough paired data

Correlations for flow and each parameter (Table 3) were calculated for Dudley Deep Mine Discharge only. The available data for the other streams in this TMDL did not have enough paired flow/parameter data to calculate correlations. There is no significant correlation between source flows and pollutant concentrations. Analyses of the data could not determine a critical flow.

For purposes of this TMDL, point sources are identified as permitted discharge points and nonpoint sources are other discharges from abandoned mine lands which includes tunnel discharges, seeps (although none were specifically identified), and surface runoff. Abandoned and reclaimed mine lands are treated in the allocations as nonpoint sources because there are no NPDES permits associated with these areas. As such, the discharges associated with these lands were assigned load allocations (as opposed to wasteload allocations).

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 (LA) made at that point will be for all of the watershed area that is above that point. For situations where there are only point-source impacts or a combination of point and non-point sources, the same type of evaluation is used. The point-source is mass balanced with the receiving stream, and sources will be reduced as necessary to meet the water quality criteria below the discharge

TMDLs and LAs for each parameter were determined using Monte Carlo simulation. For each source and pollutant, it was assumed that the observed data are log-normally distributed. The lognormal distribution has long been assumed when dealing with environmental data.

Each pollutant source was evaluated separately using @Risk[1]. Five thousand iterations were performed to determine the required percent reduction so that water-quality criteria will be met in-stream at least 99 percent of the time. For each iteration, the required percent reduction is:

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

PR = required percent reduction for the current iteration
Cc = criterion in mg/l

[1] @ Risk - Risk Analysis and Simulation Add-in for "Micorsoft Excel", Palisade Corporation, Newfield , NY, 1990-1997

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
Standard Deviation = Standard deviation of observed data

The overall percent reduction required is the 99th percentile value of the probability distribution generated by the 5000 iterations so that the allowable long-term average (LTA) concentration is:

LTA = Mean * (1-PR_{99}) where (2)

LTA = allowable LTA source concentration in mg/l (the mean of five thousand iterations, from the statistics portion of the @Risk program).

An example calculation, including detailed tabular summaries of the Monte Carlo results is presented for the Lorberry Creek TMDL in Attachment D.

Data

The data used to develop endpoints for each TMDL are presented in Attachment E.
The only data available are the result of joint sampling between the Department and the Shoup Run Watershed Association (SRWA) and the monitoring of the Dudley Deep Mine Discharge by Musser Engineering, Inc. The joint sampling began in the summer of 1999 and continues to the present.

Four separate TMDLs were developed for the Shoup Run Watershed. One was developed for the segment of the watershed formed by Miller Run, one for the segment formed by Hartman Run, one for the Dudley Deep Mine Discharge, and one for the main stem of Shoup Run. The points for which data were collected and used to develop these TMDLs were at the mouths of Miller Run, Hartman Run, Shoup Run and the Dudley Deep Mine Discharge.

The only acidity/alkalinity data available were Net Alkalinity. Net alkalinity can be either negative or positive in value depending on how acidic the sample is. To calculate a reduction the data for net alkalinity were entered as a positive value. The percent reduction listed for net alkalinity is the percent reduction of acidity required to meet the criteria of zero net alkalinity.

Hartman Run

The TMDL for Hartman Run consists of a load allocation to all of the area above sampling point HR-1 (Attachment B). This is the first stream monitoring point downstream of all mining impacts. Addressing the mining impacts above this point addresses the impairment for the entire stream segment to its confluence with Shoup Run.

This segment is listed on the Pa 303(d) list for impairment due to pH and metals. Sample data at point HR-1 shows pH ranging between 3.5 and 4.3. There are no upstream samples available The objective is to reduce acid loading to the stream which will in turn raise the pH to the desired range. The net alkalinity at sampling point HR-1 will be used in the evaluation. The result of this analysis is an acid loading reduction that equates to meeting standards for pH (see Table 2). The method and rationale for addressing pH is contained in Attachment C.

The load allocation for this stream segment was computed using water-quality sample data collected at point HR1. The average flow, measured at sample point HR-1 (0.238 MGD), is used for these computations.

An allowable long-term average in-stream concentration was determined at point HR1 for aluminum, iron, manganese and net alkalinity. The analysis is designed to produce an average daily 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, five thousand 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. Table 4. shows the load allocations for this stream segment.

Table 4. Load Allocations for Hartman Run

HR-1	**Aluminum**	**Iron**	**Manganese**	**Net Alkalinity***
Existing Average Concentration (mg/L)	0.88	1.11	2.13	-26.16
Existing Average Loading (lbs/day)	1.7	2.2	4.2	51.9
Target Criteria (mg/L)	0.75	1.5	1.0	0.0
Percent Reduction Required to maintain criteria with a 99% Confidence Level(%)	71%	13%	86%	100%
Long Term Average Concentration (mg/L)	0.26	0.96	0.30	0.0
Long Term Average Loading (lbs/day)	0.5	1.9	0.6	0.0

*Percent reduction of a negative net alkalinity value is an increase in net alkalinity (reduction in acidity)

The allowable loading values shown in Table 4. represent load allocations made at point HR-1.

Margin of Safety

For this study the margin of safety is applied implicitly. A MOS is built in because the allowable concentrations and loadings were simulated using Monte Carlo techniques and employing the @Risk software. Another margin of safety used for this TMDL analysis results from:

- 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.

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. The average flow for this point was used to derive loading values for the TMDL.

Dudley Deep Mine Discharge

Given that the Dudley Deep Mine Discharge is such a large source of degradation to Shoup Run, it will be treated as a separate entity for this study. The TMDL for The Dudley Deep Mine Discharge consists of a load allocation to all of the area upstream of point Dudley shown in Attachment B. This segment is unnamed and is not on DEPs stream file or in Delorme. It is shown on the map in Attachment B as a dot because of the scale (The deep mine opening is 200 feet from Shoup Run, 0.0426 inch on the map. This is the first stream monitoring point downstream of the deep mine discharge. Addressing the mining impacts above this point addresses the impairment for the discharge to its confluence with Shoup Run.

This segment is not listed on the Pa 303(d) list. We did this TMDL because where the Dudley deep mine discharge flows into Shoup Run it comprises a minimum of 40% of the total volume of Shoup Run. Sample data at point Dudley shows pH ranging between 3.1 and 4.0. There are no upstream samples available. The objective is to reduce acid loading to the stream which will in turn raise the pH to the desired range. The net alkalinity at sampling point Dudley will be used in the evaluation. The result of this analysis is an acid loading reduction that equates to meeting standards for pH (see Table 2). The method and rationale for addressing pH is contained in Attachment C.

The load allocation for this stream segment was computed using water-quality sample data collected at the point Dudley. The average flow, measured at sample point Dudley (3.69 MGD), is used for these computations.

An allowable long-term average in-stream concentration was determined at point Dudley for aluminum, iron, manganese and net alkalinity. The analysis is designed to produce an average daily 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, five thousand 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. Table 5. shows the load allocations for this stream segment.

Table 5. Load Allocations for Dudley Deep Mine Discharge

Dudley	**Aluminum**	**Iron**	**Manganese**	**Net Alkalinity***
Existing Average Concentration (mg/L)	4.78	0.34	3.39	-62.81
Existing Average Loading (lbs/day	147.2	10.5	104.4	1934.7
Target Criteria (mg/L)	0.75	1.5	1.0	0.0
Percent Reduction Required to maintain criteria with a 99% Confidence Level(%)	88%	0%	85%	100%
Long Term Average Concentration (mg/L)	0.57	0.34	0.52	0.0
Long Term Average Loading (lbs/day)	17.6	10.5	16.0	0.0

*Percent reduction of a negative net alkalinity value is an increase in net alkalinity (reduction in acidity)
The allowable loading values shown in Table 5. represent load allocations made at point Dudley

Margin of Safety

For this study the margin of safety is applied implicitly. A MOS is built in because the allowable concentrations and loadings were simulated using Monte Carlo techniques and employing the @Risk software. Another margin of safety used for this TMDL analysis results from:

- 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.

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. The average flow for this point was used to derive loading values for the TMDL

Miller Run

The TMDL for Miller Run consists of a load allocation to all of the area above the point MR-1 shown in Attachment B. This is the first stream monitoring point downstream of all mining impacts. Addressing the mining impacts above this point addresses the impairment for the entire stream segment to its confluence with Shoup Run.

This segment is listed on the Pa 303(d) list for impairment due to pH and metals. Sample data at point MR-1 shows pH ranging between 4.4 and 4.7. There are no upstream samples. The objective is to reduce acid loading to the stream which will in turn raise the pH to the desired range. The net alkalinity at sampling point MR-1 will be used in the evaluation. The result of this analysis is an acid loading reduction that equates to meeting standards for pH (see Table 2). The method and rationale for addressing pH is contained in Attachment C.

The load allocation for this stream segment was computed using water-quality sample data collected at the point MR-1. The average flow, measured at sampling point MR-1 (1.13 MGD), is used for these computations.

An allowable long-term average in-stream concentration was determined at point MR1 for aluminum, iron, manganese and net alkalinity. The analysis is designed to produce an average daily 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, five thousand 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. Table 6. shows the load allocations for this stream segment.

Table 6. Load Allocations for Miller Run				
MR-1	**Aluminum**	**Iron**	**Manganese**	**Net Alkalinity***
Existing Average Concentration (mg/L)	1.31	0.05	0.60	-10.25
Existing Average Loading (lbs/day)	12.3	0.4	5.6	96.4
Target Criteria (mg/L)	0.75	1.5	1.0	0.0
Percent Reduction Required to maintain criteria with a 99% Confidence Level(%)	84%	0%	47%	100%
Long Term Average Concentration (mg/L)	0.21	0.05	0.32	0.0
Long Term Average Loading (lbs/day)	2.0	0.4	3.0	0.0

*Percent reduction of a negative net alkalinity value is an increase in net alkalinity (reduction in acidity)

The allowable loading values shown in Table 6. represent load allocations made at point MR-1.

<u>Margin of Safety</u>

For this study the margin of safety is applied implicitly. A MOS is built in because the allowable concentrations and loadings were simulated using Monte Carlo techniques and employing the @Risk software. Another margin of safety used for this TMDL analysis results from:

- 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.

<u>Seasonal Variation</u>

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. The average flow for this point was used to derive loading values for the TMDL.

Shoup Run

The existing and the allowable loading for point SR1 for all parameters was determined. This was based on the sample data for this point and did not account for any load reductions already specified from upstream sources. The load reductions from points HR1, MR1, and Dudley were summed and represents the upstream load reductions. The upstream load reduction was subtracted from the existing load at point SR1, and was compared to the allowable load at SR1 for each parameter, to determine if any further reductions were needed at this point.

The existing and allowable loading values for this stream segment were computed using water-quality sample data collected at the point SR-1. The average flow, measured at sampling point SR-1 (9 MGD), is used for these computations.

This segment is listed on the Pa 303(d) list for impairment due to pH and metals. Sample data at point SR-1 shows pH ranging between 4.5 and 4.6. There are no upstream Shoup Run samples. The objective is to reduce acid loading to the stream which will in turn raise the pH to the desired range. The net alkalinity at sampling point SR-1 will be used in the evaluation. The result of this analysis is an acid loading reduction that equates to meeting standards for pH (see Table 2). The method and rationale for addressing pH is contained in Attachment C.

An allowable long-term average in-stream concentration was determined at point SR1 for aluminum, iron, manganese and net alkalinity. The analysis is designed to produce an average daily 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, five thousand 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. Table 7. shows the load allocations for this stream segment.

Table 7. Load Allocations for Shoup Run				
SR-1	**Aluminum**	**Iron**	**Manganese**	**Net Alkalinity***
Existing Average Concentration (mg/L)	3.07	0.08	1.72	-23.20
Existing Average Loading (lbs/day)	230.6	6.3	129.2	1742.6
Target Criteria (mg/L)	0.75	1.5	1.00	NA
Percent Reduction Required to maintain criteria with a 99% Confidence Level(%) **	86%	0%	68%	100%
Long Term Average Concentration (mg/L)	0.43	0.08	0.55	0.0
Long Term Average Loading (lbs/day)	32.3	6.3	41.3	0.0

The area upstream of Miller Run is the most affected portion of the Shoup Run watershed. However, the area of Shoup Run watershed downstream of Miller Run may be adversely affected by AMD and one or more allocations may be necessary at SR-1. In an effort to determine if there is a need for any allocations at sampling point SR-1 the following procedure was used.

The loading reductions for points MR-1, HR-1, and Dudley were summed to show the total load that was removed from upstream sources. This value, for each parameter was then subtracted from the existing load at point SR-1. This value was then compared to the allowable load at point SR-1. Reductions at point SR-1 are necessary for any parameter that exceeded the allowable load at this point. Table 8. shows a summary of all loads that affect point SR-1. Table 9. illustrates the necessary reductions at this point SR-1. The results of this analysis show that a reduction for aluminum is necessary at this point.

Table 8. Summary of All Loads that Affect SR-1				
	Al (#/day)	**Fe (#/day)**	**Mn (#/day)**	**Net Alkalinity (#/day)**
Hartman Run (HR-1)				
load reduction=	1.2	0.3	3.6	51.9
Miller Run (MR-1)				
load reduction=	10.3	0.0	2.6	96.4
Dudley Deep Mine Discharge				
load reduction=	129.6	0.0	88.4	1934.7

Table 9. Necessary Reductions at Sample Point SR-1

	Al (#/day)	Fe (#/day)	Mn (#/day)	Net Alkalinity (#/day)
Existing Loads at SR-1	230.6	6.3	129.2	1742.6
Total Load Reduction (Sum of HR-1, MR-1 & Dudley)	141.2	0.3	94.6	2083.0
Remaining Load	89.4	6.0	34.6	NA
Allowable Loads at SR-1	32.3	6.3	41.3	0.0
Percent Reduction	64%	NA	NA	NA

The load allocation for this stream segment was computed using water-quality sample data collected at point SR-1 and the allowable loads from HR-1, Dudley and MR-1. The average flow, measured at sample point SR-1, is used for these computations. The TMDL for Shoup Run consists of a load allocation for Aluminum to all of the area between point SR-1 and the confluence with Miller shown. No additional loading reductions were necessary for iron, manganese, or net alkalinity.

<u>Margin of Safety</u>

For this study the margin of safety is applied implicitly. A MOS is built in because the allowable concentrations and loadings were simulated using Monte Carlo techniques and employing the @Risk software. Another margin of safety used for this TMDL analysis results from.

- 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.

<u>Seasonal Variation</u>

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

<u>Critical Conditions</u>

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. The average flow, measured at sample point SR-1, is used for these computations.

Summary of Allocations

This TMDL will focus remediation efforts on the identified numerical reduction targets for each watershed. As changes occur in the watershed, the TMDL may be re-evaluated to reflect current conditions.

Table 10 presents the estimated reductions identified for all points in the watershed.

Table 10. Summary Table – Shoup Run Watershed

Station		Measured Sample Data		Allowable		Reduction Identified
	Parameter	Conc (mg/l)	load (lbs/day)	LTA Conc (mg/l)	load (lbs/day)	%
HR1	**In-stream monitoring point located on Hartman Run**					
	Al	0.88	1.7	0.26	.5	71%
	Fe	1.11	2.2	.96	1.9	13%
	Mn	2.13	4.2	.03	0.6	86%
	Net Alkalinity	-26.16	51.9	0.00	0.0	100%
Dudley	**In-stream monitoring point located on Dudley Deep Mine Discharge near its mouth**					
	Al	4.78	147.2	0.57	17.6	88%
	Fe	0.34	10.5	0.34	10.5	0%
	Mn	3.39	104.4	0.52	16.0	85%
	Net Alkalinity	-62.81	1934.7	0.0	0.0	100%
MR1	**In-stream sampling point located on Miller Run at its mouth**					
	Al	1.31	12.3	0.21	2.0	84%
	Fe	0.05	0.4	0.05	0.4	0%
	Mn	0.60	5.6	0.32	3.0	47%
	Net Alkalinity	-10.25	96.4	0.0	0.0	100%
SR-1	**In-stream sampling point located on Shoup Run at its mouth**					
	Al	3.07	230.6	NA	32.3	64%
	Fe	0.08	6.3	NA	NA	NA
	Mn	1.72	129.2	NA	NA	NA
	Net Alkalinity	-23.20	1742.6	NA	NA	NA

All allocations are load allocations to non-point sources. The margin of safety for all points is applied implicitly through the methods used in the computations.

Recommendations

Several possibilities exist for the treatment of AMD in the Shoup Run watershed. Methods of both passive and active treatment are possible. Successive Alkaline Producing Systems (SAPS) as well as alkaline producing wetlands are possibilities where the volume of the flow permits. Diversion wells have been discussed as a possibility to treat the Dudley Deep Mine Discharge. Reclaiming abandoned mine workings may also help reduce loading of AMD to the watershed. Active treating, by chemical addition, while not cost effective, is also a possibility to treat the AMD degraded waters. The collection of additional data will be required for any remediation activities undertaken. As technology advances and development of new abatement techniques continue, other treatment systems may also be constructed to implement these TMDLs.

There is currently no mining taking place in the watershed. This fact greatly reduces the chances of any new loading to the watershed. It limits the abatement actions to only reducing the existing loads. The desire to improve the water quality of Shoup Run does exist. Many local residents through the SRWA have begun to monitor and study the watershed with the desire to someday improve the water quality. Currently, a new watershed association for Great Trough Creek is being formed. This association lists among its goals, restoring Great Trough Creek and keeping it from losing such a large fraction of its flow to the underlying deep mines. This should help reduce the volume of the Dudley Deep Mine Discharge. Because of this high level of public awareness and concern, and the lack of new mining activities in the watershed, the TMDL's for the Shoup Run Watershed have a very realistic chance of being implemented.

Public Participation

Public notice of the draft TMDL was published in the Broad Top Bulletin, Saxton, Bedford County, PA and in the Pennsylvania Bulletin upon approval of the draft version of this document to foster public comment on the allowable loads calculated. A public meeting was held on January 16, 2001 beginning at 6:30 p.m. at the Borough Building in Coalmont, Huntingdon County, PA to discuss and accept comments on the proposed TMDL.

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Groft, Eric D, Hoffnar, Bernard R. and Groendaal, Denson, 1981. Broad top soil and water conservation project- final report, Bedford and Huntingdon Counties Conservation and Planning Commissions.

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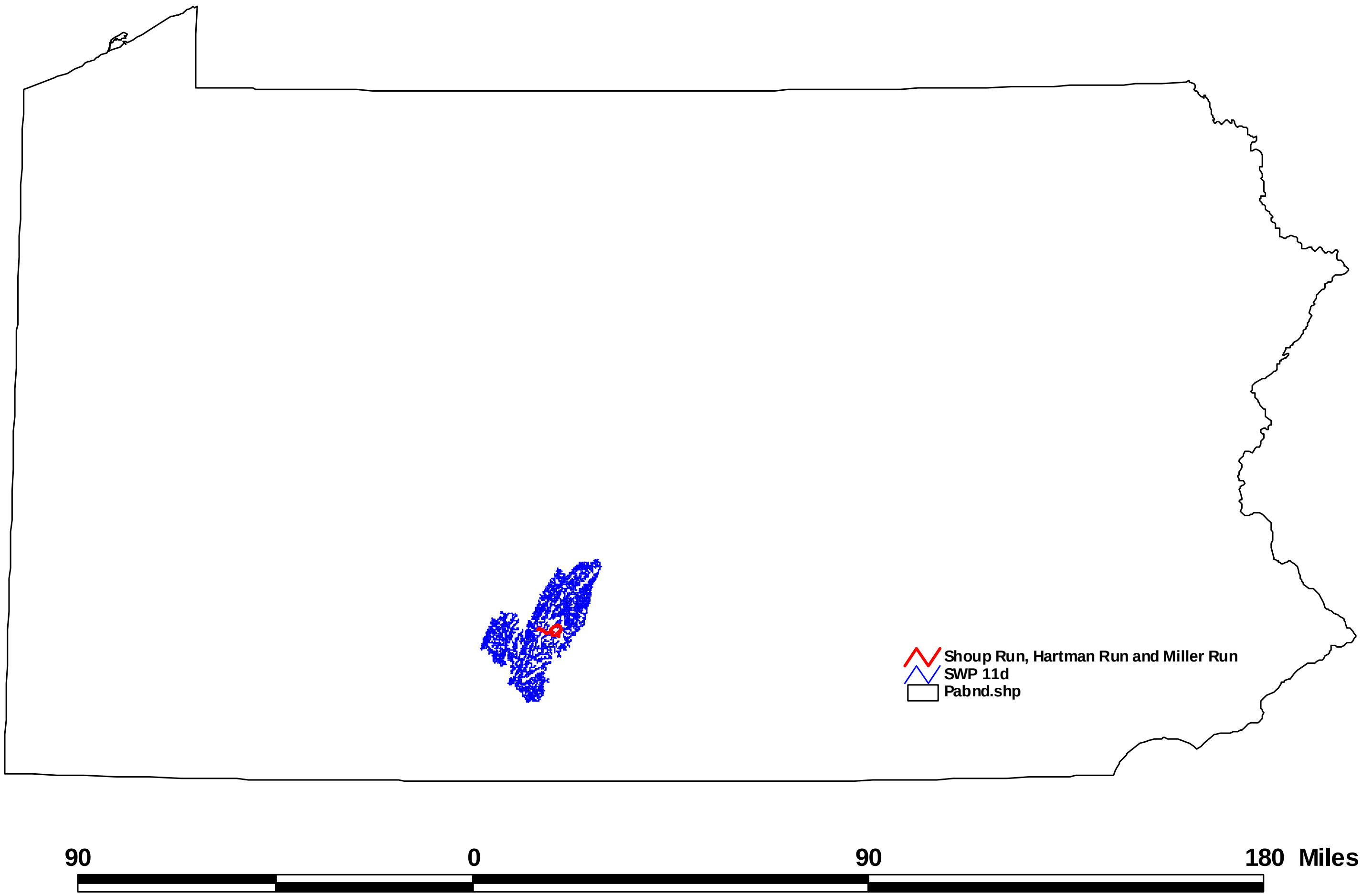
PA Department of Environmental Protection, 1998. Coal mine drainage prediction and pollution prevention in Pennsylvania: chapter 1 – geochemistry of coal mine drainage, Harrisburg, PA 22p.

Attachment A

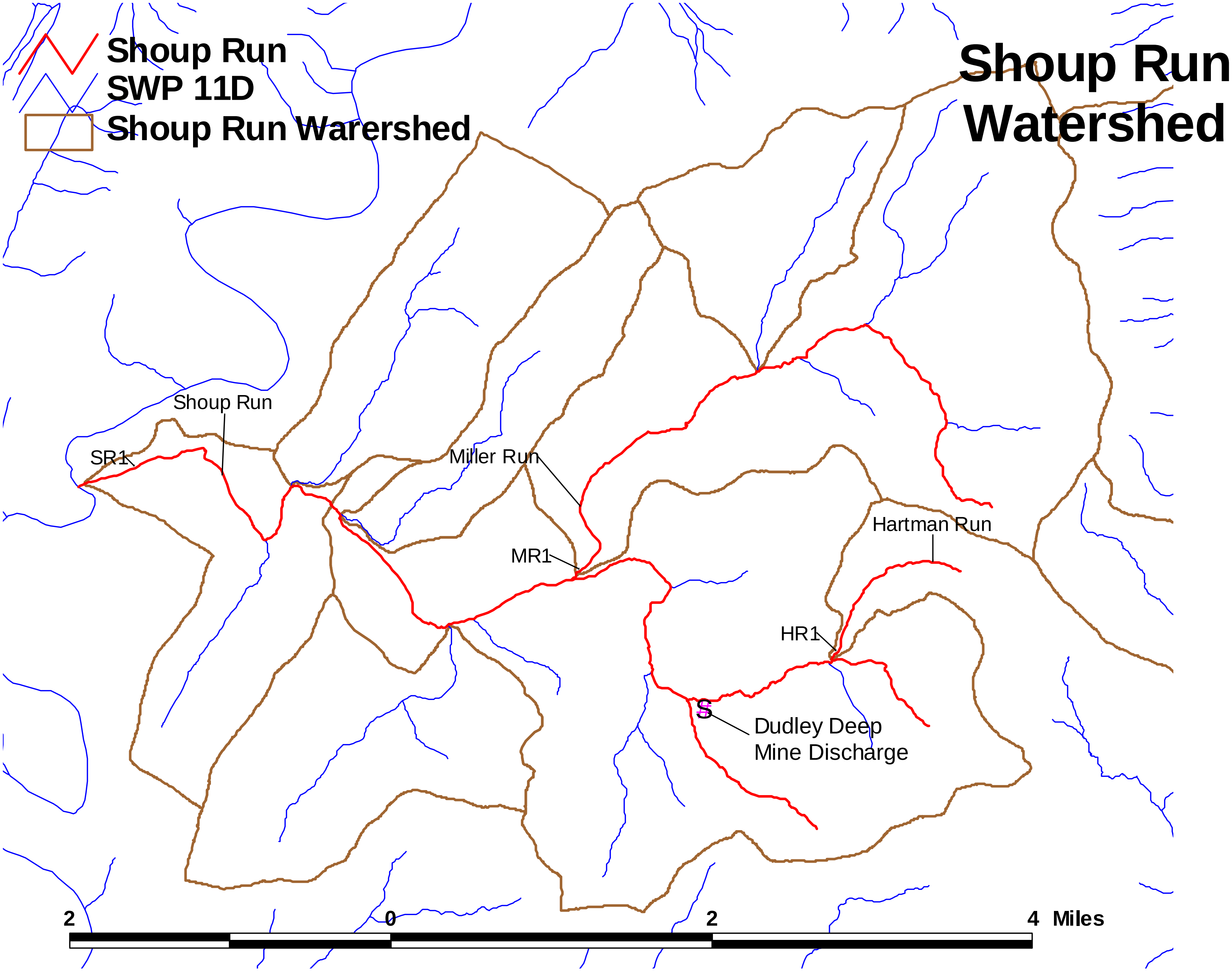
Location of Shoup Run Watershed

Shoup Run, Hartman Run and Miller Run



Attachment B

Shoup Run Watershed



Shoup Run
SWP 11D
Shoup Run Warershed
Shoup Run
Watershed
Shoup Run
SR1
Miller Run
MR1
Hartman Run
HR1
S
Dudley Deep
Mine Discharge
2
0
2
4 Miles

Attachment C

The pH Method

Method for Addressing 303(d) listings for pH

There has been a great deal of research conducted on the relationship between alkalinity, acidity, and pH. Research published[2] by the PA Department of Environmental Protection demonstrates, that by plotting net alkalinity vs. pH for 794 mine sample points, where net alkalinity is positive (greater or equal to zero), the pH range is most commonly 6 to 8, which is within the EPA's acceptable range of 6 to 9, and meets Pennsylvania water quality criteria in Chapter 93. The included graph (page 3) presents the nonlinear relationship between net alkalinity and pH. The nonlinear positive relation between net alkalinity and pH indicates that pH generally will decline as net alkalinity declines and vice versa; however, the extent of pH change will vary depending on the buffering capacity of solution. Solutions having near-neutral pH ($6 < pH < 8$) or acidic pH ($2 < pH < 4$) tend to be buffered to remain in their respective pH ranges.[3] Relatively large additions of acid or base will be required to change their pH compared to poorly buffered solutions characterized by intermediate pH ($4 < pH < 6$) where the correlation between net alkalinity and pH is practically zero.

The parameter of pH, a measurement of hydrogen ion acidity presented as a negative logarithm of effective hydrogen ion concentration, is not conducive to standard statistics. Additionally pH does not measure latent acidity that can be produced from hydrolysis of metals. For these reasons PA is using the following approach to address the stream impairments noted on the 303(d) list due to pH. The concentration of acidity in a stream is partially dependent upon metals. For this reason, it is extremely difficult to predict the exact pH values which would result from treatment of acid 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 able to measure the reduction of acidity. When acidity in a stream is neutralized or is restored to natural levels, pH will be acceptable (>6.0). 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 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 PA'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 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. In other words, if the pH in an unaffected portion of a stream is found to be naturally occurring below 6, then the average net alkalinity for that portion of the stream will

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[2] 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.

[3] Stumm, Werner, and Morgan, J.J., 1996, Aquatic Chemistry--Chemical Equilbria and Rates in Natural Waters (3rd ed.), New York, Wiley-Interscience, 1022p.

become the criterion for the polluted portion. This "natural net alkalinity level" will be the criterion to which a 99% 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 meet a minimum net alkalinity of zero.

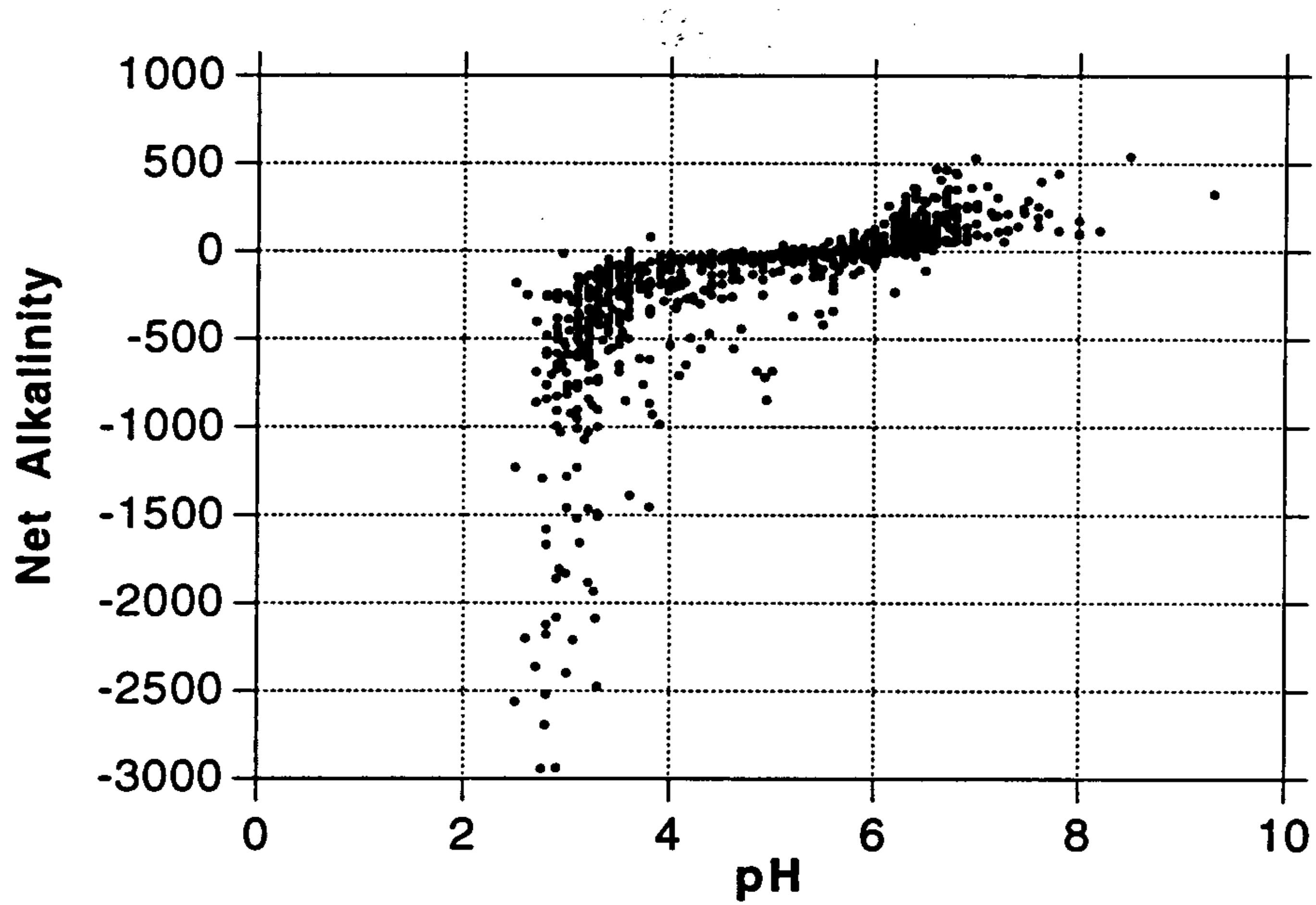

Figure 1.2, Graph C, net alkalinity vs. pH, page 1-5, of Coal Mine Drainage Prediction and Pollution Prevention in PA

Attachment D

Example Calculation: Lorberry Creek

Example Calculation: Lorberry Creek

Lorberry creek was evaluated for impairment due to high metals contents in the following manner. The analysis was completed in a stepwise manner starting at the headwaters of the stream and moving to the mouth. The Rowe Tunnel (Swat-04) was treated as the headwaters of Lorberry Creek for the purpose of this analysis.

1. A simulation of the concentration data at point Swat-04 was completed. This estimated the necessary reduction needed for each metal to meet water quality criteria 99% of the time as a long-term average daily concentration. Appropriate concentration reductions were made for each metal.

2. A simulation of the concentration data at point Swat-11 was completed. It was determined that no reductions in metals concentrations are needed for Stumps Run at this time, and therefore no TMDL for metals in Stumps Run is required at this time.

3. A mass balance of loading from Swat-04 and Swat-11 was completed to determine if there was any need for additional reductions as a result of the combining the loads. No additional reductions were necessary.

4. The mass balance was expanded to include the Shadle discharge (L-1). It was estimated that BAT requirements for the Shadle discharge were adequate for iron and manganese. There is no BAT requirement for aluminum. A wasteload allocation was necessary for aluminum at point L-1.

There are no other known sources below the L-1 discharge. However, there is additional flow from overland runoff and one unnamed tributary not impacted by mining. We believe it is reasonable to assume the additional flow provides assimilation capacity below the L-1 discharge and no further analysis is needed downstream.

The calculations are detailed in the following section and Table 9 shows the allocations made on Lorberry Creek

1. A series of 4 equations were used to determine if a reduction was needed at point Swat-04, and, if so the magnitude of the reduction.

Table 1. Equations Used for Rowe Tunnel Analysis			
	Field Description	**Equation**	**Explanation**
1	Swat-04 initial Concentration Value (equation 1A)	= Risklognorm(mean,StDev)	This simulates the exisitng concentration of the sampled data.
2	Swat-04 % Reduction (from the 99^{th} percentile of PR)	= (input a percentage based on reduction target)	This is the percent reduction for the discharge.
3	Swat-04 Final Concentration Value	= Sampled Value x (1 - %reduction)	This applies the given percent reduction to the initial concentration.
4	Swat-04 Reduction Target (PR)	= maximum(0, 1- Cd/Cc)	This computes the necessary reduction, if needed, each time a value is sampled. The final reduction target is the 99^{th} percentile value of this computed field.

2. The reduction target (PR) was computed taking the 99^{th} percentile value of five thousand iterations of the equation in row 4 of Table 9. The targeted percent reduction is shown, in boldface type, in the following table.

Table 2. Swat-04 Estimated Target Reductions			
Name	Swat-04 Aluminum	Swat-04 Iron	Swat-04 Manganese
Minimum =	0	0.4836	0
Maximum =	0.8675	0.9334	0.8762
Mean =	0.2184	0.8101	0.4750
Std Deviation =	0.2204	0.0544	0.1719
Variance =	0.0486	0.0030	0.0296
Skewness =	0.5845	-0.8768	-0.7027
Kurtosis =	2.0895	4.3513	3.1715
Errors Calculated =	0	0	0
Targeted Reduciton % =	**72.2%**	**90.5%**	**77.0%**
Target #1 (Perc%)=	99%	99%	99%

3. This PR value was then used as the % reduction in the equation in row 3. It was tested by checking that the water quality criterion for each metal was achieved at least 99% of the time. This is how the estimated percent reduction necessary for each metal was verified. The following table shows, in boldface type, the percent of the time criteria for each metal was achieved during five thousand iterations of the equation in row 3 of Table 9.

Table 3. Swat-04 Verification of Target Reductions			
Name	Swat-04 aluminum	Swat-04 iron	Swat-04 manganese
Minimum =	0.0444	0.2614	0.1394
Maximum =	1.5282	2.0277	1.8575
Mean =	0.2729	0.7693	0.4871
Std Deviation =	0.1358	0.2204	0.1670
Variance =	0.0185	0.0486	0.0279
Skewness =	1.6229	0.8742	1.0996
Kurtosis =	8.0010	4.3255	5.4404
Errors Calculated =	0	0	0
Target #1 (value) (WQ Criteria)=	0.75	1.5	1
Target #1 (Perc%)=	**99.15%**	**99.41%**	**99.02%**

4. These same four equations were applied to point Swat-11. The result was that no reduction was needed for any of the metals. The following two tables show the reduction targets computed for, and the verification of, reduction targets for Swat-11.

Table 4. Swat-11 Estimated Target Reductions			
Name	Swat-11 Aluminum	Swat-11 Iron	Swat-11 Manganese
Minimum =	0.0000	0.0000	0.0000
Maximum =	0.6114	0.6426	0.0000
Mean =	0.0009	0.0009	0.0000
Std Deviation =	0.0183	0.0186	0.0000
Variance =	0.0003	0.0003	0.0000
Skewness =	24.0191	23.9120	0.0000
Kurtosis =	643.4102	641.0572	0.0000
Errors Calculated =	0	0	0
Targeted Reduciton % =	**0**	**0**	**0**
Target #1 (Perc%) =	99%	99%	99%

Table 5. Swat-11 Verification of Target Reductions			
Name	**Swat-11 Aluminum**	**Swat-11 Iron**	**Swat-11 Manganese**
Minimum =	0.0013	0.0031	0.0246
Maximum =	1.9302	4.1971	0.3234
Mean =	0.0842	0.1802	0.0941
Std Deviation =	0.1104	0.2268	0.0330
Variance =	0.0122	0.0514	0.0011
Skewness =	5.0496	4.9424	1.0893
Kurtosis =	48.9148	48.8124	5.1358
Errors Calculated =	0	0	0
WQ Criteria =	**0.75**	**1.5**	**1**
% of Time Criteria Achieved =	**99.63%**	**99.60%**	**100%**

5. The following table shows variables used to express mass balance computations.

Table 6. Variable Descriptions for Lorberry Creek Calculations	
Description	**Variable shown**
Flow from Swat-04	Q_{swat04}
Swat-04 Final Concentration	C_{swat04}
Flow from Swat-11	Q_{swat11}
Swat-11 Final Concentration	C_{swat11}
Concentration below Stumps Run	C_{stumps}
Flow from L-1(shadle discharge)	Q_{L1}
Final Conc From L-1	C_{L1}
Concentration below L-1 discharge	C_{allow}

6. Swat-04 and Swat-11 were mass balanced in the following manner.

The majority of the sampling done at point Swat-11 was done in conjunction with point Swat-04 (20 matching sampling days). This allowed for the establishment of a significant correlation between the two flows, the R squared value was 0.85. Swat-04 was used as the base flow and a regression analysis on point Swat-11 provided an equation for use as the flow from Swat-11.

The flow from Swat-04 (Q_{swat04}) was set into an @RISK function so it could be used to simulate loading into the stream. The cumulative probability function was used for this random flow selection. The flow at Swat-04 is as follows

Q_{swat04} = RiskCumul(min,max,bin range,cumulative percent of occurrence)

The RiskCumul function takes 4 arguments: minimum value, maximum value, the bin range from the histogram, cumulative percent of occurrence)

The flow at Swat-11 was randomized using the equation developed by the regression analysis with point Swat-04.

$Q_{swat11} = Q_{swat}04 \times 0.142 + 0.088$

The mass balance equation is as follows:

$Cstumps = ((Q_{swat04} * C_{swat04}) + (Q_{swat11} * C_{swat11}))/(Q_{swat04}+Q_{swat11})$

This equation was simulated through 5000 iterations and the 99^{th} percentile value of the data set was compared to the water quality criteria to determine if standards had been met. The results show there is no further reduction needed for any of the metals at either point. The simulation results are shown in the following table.

Table 7. Verification of Meeting WQ Standards below Stumps Run			
Name	**Below Stumps Run Aluminum**	**Below Stumps Run Iron**	**Below Stumps Run Manganese**
Minimum =	0.0457	0.2181	0.1362
Maximum =	1.2918	1.7553	1.2751
Mean =	0.2505	0.6995	0.4404
Std Deviation =	0.1206	0.1970	0.1470
Variance =	0.0145	0.0388	0.0216
Skewness =	1.6043	0.8681	1.0371
Kurtosis =	7.7226	4.2879	4.8121
Errors Calculated =	0	0	0
WQ Criteria =	**0.75**	**1.5**	**1**
% of Time Criteria Achieved =	**99.52%**	**99.80%**	**99.64%**

7. The mass balance was then expanded to determine if any reductions would be necesssary at the L-1 (Shadle discharge).

   The L-1 discharge originated in 1997 and there is very little data available for it. The discharge will have to be treated or eliminated. It is the current site of a USGS test remediation project. The data that were available for the discharge were collected at a point prior to a settling pond. We currently do not have data for effluent from the settling pond.

   Modeling for iron and manganese will start with the BAT required concentration value. The current effluent variability based on limited sampling will be kept at its present level. There is no BAT value for aluminum, so the starting concentration for the modeling is arbitrary. The BAT values for iron and manganese are 6 mg/l and 4 mg/l. The following table shows the BAT adjusted values used for point L-1

Table 8 Shadle Adjusted BAT Concentrations				
Parameter	**Measured Value**		**BAT adjusted Value**	
	Average Conc.	Standard Deviation	Average Conc.	Standard Deviation
Iron	538.00	19.08	6.00	0.21
Manganese	33.93	2.14	4.00	0.25

The average flow, 0.048 cfs, from the discharge will be used for modeling purposes. There was not any means to establish a correlation with point Swat-04.

The same set of four equations used for point Swat-04 were set up for point L-1. The following equation was used for evaluation of point L-1.

$C_{allow} = ((Q_{swat04}*C_{swat04})+(Q_{swat11}*C_{swat11})+(Q_{L1}*C_{L1}))/(Q_{swat04}+Q_{swat11}+Q_{L1})$

This equation was simulated through 5000 iterations and the 99^{th} percentile value of the data set was compared to the water quality criteria to determine if standards had been met. It was estimated that an 81 % reduction in aluminum concentration is needed for point L-1.

The following table shows the simulation results of the equation above

Table 9. Verification of Meeting WQ Standards Below Point L-1			
Name	**Below L-1 / aluminum**	**Below L-1 / Iron**	**Below L-1 Manganese**
Minimum =	0.0815	0.2711	0.1520
Maximum =	1.3189	2.2305	1.3689
Mean =	0.3369	0.7715	0.4888
Std Deviation =	0.1320	0.1978	0.1474
Variance =	0.0174	0.0391	0.0217
Skewness =	1.2259	0.8430	0.9635
Kurtosis =	5.8475	4.6019	4.7039
Errors Calculated =	0	0	0
WQ Criteria=	**0.75**	**1.5**	**1**
Percent of time achieved=	**99.02%**	**99.68%**	**99.48%**

Table 10 presents the estimated reductions needed to meet water quality standards at all points in Lorberry Creek.

		Table 10. Lorberry Creek				
		Measured Sample Data		Allowable		Reduction Identified
Station	Parameter	Conc (mg/l)	Load (lbs/day)	LTA Conc (mg/l)	load (lbs/day)	%
Swat 04						
	Al	1.01	21.45	0.27	5.79	73%
	Fe	8.55	181.45	0.77	16.33	91%
	Mn	2.12	44.95	0.49	10.34	77%
Swat 11						
	Al	0.08	0.24	0.08	0.24	0%
	Fe	0.18	0.51	0.18	0.51	0%
	Mn	0.09	0.27	0.09	0.27	0%
L-1						
	Al	34.90	9.03	6.63	1.71	81%
	Fe	6.00	1.55	6.00	1.55	0%
	Mn	4.00	1.03	4.00	1.03	0%

All values shown in this table are Long-Term Average Daily Values

The TMDL for Lorberry Creek requires that a load allocation is made to the Rowe Tunnel abandoned discharge for the three metals listed, and that a wasteload allocation is made to the L-1 discharge for aluminum. There is no TMDL for metals required for Stumps Run at this time.

Margin of safety

For this study the margin of safety is applied implicitly. 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:

- None of the data sets were filtered by taking out extreme measurements. The 99% level of protection is designed to protect for the extreme event so we felt it pertinent not to filter the data set.

- Effluent variability plays a major role in determining the average value that will meet water quality criteria over the long term. Our analysis maintained that the variability at each point would remain the same. The general assumption can be made that a treated discharge would be less variable than an untreated discharge. This implicitly builds in another margin of safety.

Attachment E

Data Used To Calculate the TMDLs

Data Table 1 Hartman Run								
Date	**Sampler**	**Sample Point**	**Flow (gpm)**	**pH (su)**	**Fe (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**Net Alkalinity (mg/L)**
07/13/99	RICH	HR-1	11.5	3.5	1.18	4.23	1.72	-46.0
11/13/99	SRWA	HR-1	13.5	3.6	1.04	2.83	0.95	-30.0
12/11/99	SRWA	HR-1	81.0	3.8	1.24	1.50	0.583	-24.0
01/19/99	JLA	HR-1	64.9	3.9	1.33	1.50	0.685	-16.2
04/30/00	SRWA	HR-1	656.0	4.3	0.76	0.602	0.476	-14.6
Mean			165.4	3.82	1.11	2.13	0.88	-26.16
STD Dev			275.9	0.311	0.224	1.417	0.499	12.707

Data Table 2 Miller Run								
Date	**Sampler**	**Sample Point**	**Flow (gpm)**	**pH (su)**	**Fe (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**Net Alkalinity (mg/L)**
07/14/99	RICH	MR 1	36	4.4	0.02	1.00	1.95	-16.4
10/23/99	SRWA	MR 1	583	4.5	0.02	0.82	2.21	-15.6
01/19/00	JLA	MR 1	784	4.7	0.089	0.29	0.65	-1.8
04/30/00	SRWA	MR-1	1731	4.7	0.05	0.27	0.44	-7.2
Mean			783.5	4.575	0.045	0.596	1.313	-10.25
STD Dev			706.33	0.15	0.0327	0.3678	0.8959	7.0036

Data Table 4 Shoup Run								
Date	**Sampler**	**Sample Point**	**Flow (gpm)**	**pH (su)**	**Fe (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**Net Alkalinity (mg/L)**
07/14/99	RICH	SR 1	3254	4.5	0.074	1.90	3.29	-24.0
10/23/99	SRWA	SR-1	5475	4.6	0.037	1.99	3.32	-20.8
01/19/00	JLA	SR-1	5308	4.5	0.067	1.97	3.77	-26.0
04/30/00	SRWA	SR-1	10980	4.5	0.159	1.02	1.91	-22.0
Mean			6254.25	4.53	0.084	1.72	3.07	-23.2
STD Dev			3308.415	0.05	0.052	0.468	0.805	2.286

Data Table 3 Dudley Deep Mine Discharge								
Date	**Sampler**	**Sample Point**	**Flow (gpm)**	**pH (su)**	**Fe (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**Net Alkalinity (mg/L)**
02/08/83	MEI	DUDLEY	1500+	3.50	0.34	2.40		-25.0
03/01/83	MEI	DUDLEY	1500+	4.00				
04/05/83	MEI	DUDLEY	1500+	4.00				
05/16/83	MEI	DUDLEY	1500+	3.30	0.31	2.00		-34.0
06/02/83	MEI	DUDLEY	1000	3.70	0.31	2.00		-22.0
07/01/83	MEI	DUDLEY	500	4.00				
03/07/84	MEI	DUDLEY	500	3.60	0.51	2.70		-48.0
06/05/84	MEI	DUDLEY	500	3.50	0.32	2.30		-22.0
02/08/85	MEI	DUDLEY	1000+	3.40	0.43	2.90		-24.0
05/14/85	MEI	DUDLEY		3.50	0.27	2.20		-21.0
09/11/85	MEI	DUDLEY	300	3.60	0.30	2.60		-22.0
12/10/85	MEI	DUDLEY	4325	3.58	0.40	2.99		-65.6
03/21/86	MEI	DUDLEY	6600	3.54	0.30	2.62		-55.6
05/12/86	MEI	DUDLEY	3000	3.55	0.28	2.48		-60.6
09/30/86	MEI	DUDLEY	9000	3.59	0.38	2.96		-68.8
12/22/86	MEI	DUDLEY	1050	3.55	0.49	3.35		-78.8
03/27/87	MEI	DUDLEY	2000	3.40	0.33	3.48		-60.0
06/13/87	MEI	DUDLEY	1800	3.51	0.37	2.84		-56.3
09/28/87	MEI	DUDLEY	1800	3.56	0.36	3.42		-55.6
12/31/87	MEI	DUDLEY	3000	3.55	0.32	3.69		-59.4
03/16/88	MEI	DUDLEY	2000	3.53	0.31	3.14		-56.2
05/26/88	MEI	DUDLEY	2000	3.52	0.36	2.79		-53.8
08/23/88	MEI	DUDLEY	1500	3.67	0.28	3.37		-59.4
12/30/88	MEI	DUDLEY	1800	3.54	0.42	4.80		-308.8
03/31/89	MEI	DUDLEY	3000	3.53	0.30	3.75		-56.9
06/20/89	MEI	DUDLEY		3.49	0.26	3.44		-55.0
08/29/89	MEI	DUDLEY	1200	3.52	0.31	3.95		-52.5
12/01/89	MEI	DUDLEY	2500	3.57	0.29	4.60		-58.1
03/09/90	MEI	DUDLEY	3000	3.51	0.32	3.90		-67.5
05/21/90	MEI	DUDLEY	3000	3.49	0.29	3.90		-53.1
08/07/90	MEI	DUDLEY	1500	3.55	0.28	3.85		-51.3
12/20/90	MEI	DUDLEY	1750	3.50	0.23	4.10		-71.3
03/27/91	MEI	DUDLEY	2000	3.57	0.26	3.51		-69.4
06/21/91	MEI	DUDLEY	1500	3.39	0.34	3.52		-72.5
10/01/91	MEI	DUDLEY	1200	3.09	0.22	3.54		-62.8
11/26/91	MEI	DUDLEY	800	3.25	0.35	3.80		-60.0
03/24/92	MEI	DUDLEY	1500	3.45	0.51	3.91		-86.3
06/19/92	MEI	DUDLEY	1200	3.24	0.27	3.92		-101.9
09/23/92	MEI	DUDLEY	2000	3.50	0.28	3.94		-100.0
12/22/92	MEI	DUDLEY	3000	3.46	0.32	4.21		-89.4
03/31/93	MEI	DUDLEY	6300	3.47	1.63	3.19		-100.6
06/21/93	MEI	DUDLEY	2700	3.39	0.42	3.77		-26.3

Data Table 3 Dudley Deep Mine Discharge								
Date	**Sampler**	**Sample Point**	**Flow (gpm)**	**pH (su)**	**Fe (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**Net Alkalinity (mg/L)**
09/20/93	MEI	DUDLEY	1000	3.45	0.37	4.16		-106.3
12/20/93	MEI	DUDLEY	3500	3.40	0.51	6.60		-80.6
03/30/94	MEI	DUDLEY	5000+	3.48	0.68	4.20		-87.5
06/23/94	MEI	DUDLEY	1050	3.45	0.27	3.70		-80.0
08/18/94	MEI	DUDLEY	1400	3.52	1.34	4.50		-56.3
11/22/94	MEI	DUDLEY	1800	3.49	0.28	5.10		-77.5
01/18/95	MEI	DUDLEY	4200	3.50	0.59	5.90		-73.1
06/19/95	MEI	DUDLEY	4000	3.53	0.32	3.49		-99.4
08/14/95	MEI	DUDLEY	2300	3.60	0.39	3.44		-53.8
11/28/95	MEI	DUDLEY	2950	3.62	0.36	4.38		-60.0
03/19/96	MEI	DUDLEY	6300	3.55	0.24	2.93		-45.0
06/10/96	MEI	DUDLEY	3700	3.59	0.20	2.14		-50.6
09/25/96	MEI	DUDLEY	4000	3.62	0.31	5.60		-48.8
11/29/96	MEI	DUDLEY	3650	3.62	0.21	2.51		-33.1
03/04/97	MEI	DUDLEY	3800	3.67	0.13	2.59		-52.5
06/04/97	MEI	DUDLEY	4100	3.64	0.17	2.53		-71.3
08/11/97	MEI	DUDLEY	1800	3.72	0.26	2.52		-54.8
11/05/97	MEI	DUDLEY	2450	3.69	0.11	2.81		-56.3
03/31/98	MEI	DUDLEY	3100	3.62	0.14	2.17		-60.0
06/08/98	MEI	DUDLEY	1500	3.45	0.16	2.31		-36.3
07/14/99	RICH	DUDLEY	2314	3.80	0.10	2.58	4.09	-42.8
10/23/99	SRWA	DUDLEY	2468	3.80	0.10	2.91	4.81	-46.0
11/13/99	SRWA	DUDLEY	1885	3.80	0.10	3.01	5.01	-63.4
12/11/99	SRWA	DUDLEY	1904	3.70	0.11	3.14	5.21	-61.6
01/19/00	JLA	DUDLEY	3109	3.70	0.14	3.21	5.23	-52.6
03/18/00	SRWA	DUDLEY	3554	3.70	0.15	3.07	4.96	-53.8
04/16/00	SRWA	DUDLEY	3792	3.70	0.17	2.49	4.13	-50.0
Mean			2564.77	3.56	0.34	3.39	4.78	-62.81
STD Dev			1614.826	0.158	0.237	0.929	0.478	36.784

Attachment F

Comment and Response

DEP received no official comments on this TMDL. Minor language edits may have been made since the draft document was public noticed.