Muddy Run Passive Treatment Conceptual Designs, Beech Creek Township, Clinton County

Technical Report Provided by Hedin Environmental through the Trout Unlimited AMD Technical Assistance Program

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Background

In April of 2009 the Clinton County Conservation District (CCCD) requested technical assistance in the form of conceptual passive treatment system designs for discharges in the Muddy Run watershed. To prepare the conceptual treatment plans a comprehensive sampling round was conducted to verify discharge chemistry and also perform reconnaissance of possible treatment locations. Conceptual treatment plans were then prepared based on a combination of the results of the comprehensive sampling round, existing water quality and quantity data, and existing site conditions. Estimates of materials quantities and construction costs were prepared for the conceptual treatment designs.

Comprehensive Sampling Round

A comprehensive sampling round was conducted on May 21, 2009. Eight discharges were sampled. Sampling locations are shown in Figure 1 and results of the sampling round are shown in Table 1. All discharge flows were measured using a bucket and stopwatch. With the exception of the Pond 1 Kill Zone, all of the discharges sampled had very similar water quality characteristics with aluminum and pH being the major sources of impairment. Pond 1 Kill Zone is unique in that it has the most severe water quality in the study area with 72 mg/L iron. All other discharges sampled had iron concentrations less than 1 mg/L.

Figure 1. Sampling Locations

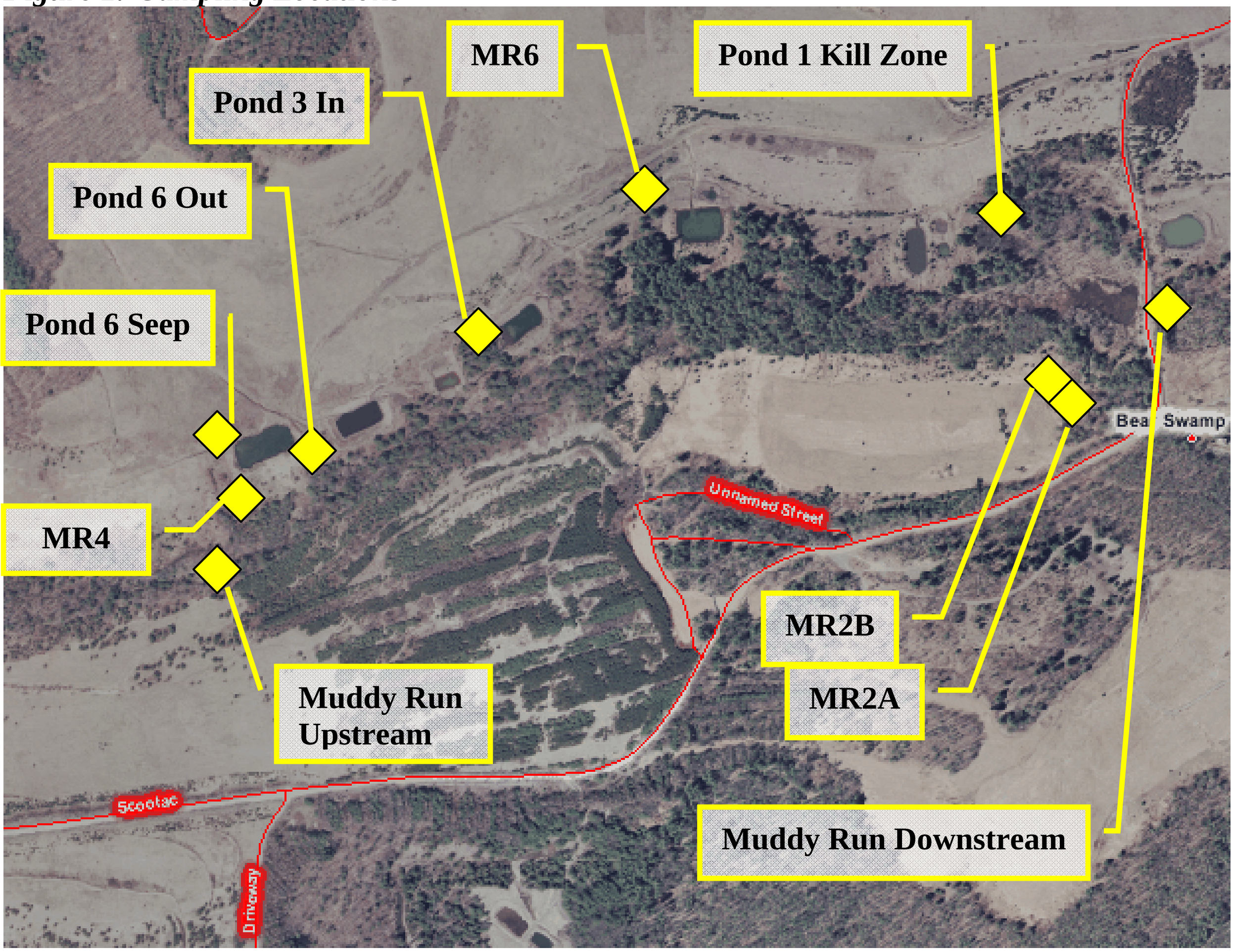


Table 1. May 21,2009 Comprehensive Sampling Results

Sample ID	Flow (gpm)	pH	Acidity (mg/L)	Fe (mg/L)	Mn (mg/L)	Al (mg/L)	SO_4 (mg/L)
Muddy Run Upstream	67	4.37	10	0.3	0.4	0.3	25
MR-4	7	4.13	23	0.2	7.6	1.7	203
Pond 6 Out	16	2.78	113	0.1	6.9	1.1	218
Pond 6 Seep	NM	4.41	22	0.3	6.8	2.1	235
Pond 3 Seep	2	5.03	36	0.1	17.5	2.2	525
MR-6	24	3.91	77	0.6	26.7	4.0	812
MR-2A	9	4.15	58	0.1	13.5	7.0	436
MR-2B	31	4.18	58	0.1	15.2	6.6	493
MR-2C	DRY						
Pond 1 Kill Zone	5	3.23	201	72.2	39.7	4.7	1444
Muddy Run Downstream	211	3.94	26	0.6	9.3	1.8	295

Sample Site Descriptions

Muddy Run Upstream

The Muddy Run Upstream sampling location was located upstream of the MR4 discharge. Flow measurement was made using a bucket and stopwatch. Numerous crayfish were observed in the stream at this location so the water quality was assumed to be unimpaired. However, the sample results suggest that the stream is in fact impaired by depressed pH (4.4) and slightly elevated aluminum (0.3 mg/L). The low sulfate (25 mg/L) suggests that the source of the impairment is not acid mine drainage. The stream is very poorly buffered which makes it exceptionally susceptible to impacts from acid mine drainage.

MR-4

MR-4 is a weir located near the southwest corner of Pond 6. It is also identified in the historical data as Site 097. The discharge emanates from a diffuse seepage area below a breached surface water diversion ditch. The chemistry suggests that the water has the same source as that feeding Pond 6. This is an established monitoring point.

Pond 6 Out and Pond 6 Seep

Pond 6 receives surface seeps from the same horizon as MR-4 and is likely emanating from the same source. The sample collected from the effluent of the pond (Pond 6 Out) had unexpectedly low lab-reported pH. The reason for this is unclear but the result is a significantly higher acidity value for the sample. The Pond 6 Seep sample was a grab sample of one of several small seeps feeding Pond 6. The quality agrees well with the MR-4 site quality but differs from the Pond 6 effluent due to the questionable pH and acidity value. As a result, the water quality from the Pond 6 Seep sample will be used for loading and system sizing calculations.

MR-6

MR-6 is a weir installed in a channel upslope of Pond 2. The discharge flows into Pond 2 before discharging to Muddy Run. This is an established monitoring point.

MR-2A, MR-2B, MR-2C

A group of discharges that represent the only known impacts from the south side of Muddy Run upstream of Peacock Road. The MR-2A and 2C discharges are located at the toe of a reclaimed surface mine. MR-2B appears to be a drift entry into a deep mine that has been surface mined out. These are established monitoring points.

Pond 1 Kill Zone

Just upstream of Peacock Road on the north side of Muddy Run is an iron stained kill zone resulting from a discharge identified as Pond 1 Kill Zone. The severe water quality of this discharge makes it unique in the watershed. The reason for the severe chemistry is unknown.

Muddy Run Downstream

Muddy Run Downstream was collected at the outfall of the Peacock Road culvert. Flow measurement was made using a flow meter. Site conditions made flow measurement difficult and as a result the flow measurement should be considered an estimate. In addition, the impoundment of water upstream of the measurement location likely results in infiltration of stream flow into the shallow groundwater system. This infiltrated flow would not be accounted for in the flow measurement leading to an underestimation of stream flow.

Loading

While Pond 1 Kill Zone had the most severe chemistry it does not contribute a significant amount of pollution loading to the stream. Three discharges; Pond 6 Out, MR6 and MR2B accounted for 77% of the acidity loading contributed by the sampled discharges. Table 2 shows an accounting of pollution loading from the sampled sources.

Table 2. Pollution Loading Accounting

Site*	**Flow (gpm)**	**Acidity (ppd)**	**Fe (ppd)**	**Mn (ppd)**	**Al (ppd)**
Muddy Run Upstream	67	7.8	0.2	0.3	0.2
MR4	7	1.9	0.0	0.6	0.1
Pond 6 Out	16	21.5	0.0	1.3	0.2
Pond 3 Seep	2	0.7	0.0	0.3	0.0
MR6	24	22.5	0.2	7.8	1.2
MR2A	9	6.3	0.0	1.5	0.8
MR2B	31	21.8	0.0	5.7	2.5
Pond 1 Kill Zone	5	10.8	3.9	2.1	0.3

**Flow was not measured for Pond 6 seep so loadings cannot be calculated.*
The accuracy of the flow rate measured at Muddy Run Downstream is questionable so loadings were not calculated for this location.

Treatment Options

Three treatment systems are recommended that will address seven discharges. When in operation, the three systems will dramatically improve water quality in Muddy Run. During normal flow conditions, the stream will be neutral or net alkaline.

MR-4 Treatment System Concept

This system is intended to treat flow from the seepage zone around the westernmost existing pond in the study area (Pond 6). MR-4 and Pond 6 Out represent the discharges to be treated. Treatment of these discharges would address the first impacts to Muddy Run and provide buffering capacity to protect the stream from downstream acidic inputs. A vertical flow pond (VFP) that utilizes the existing ponds on the site is recommended.

The only data available for the Pond 6 discharge is from the sampling round on 5/21/09. Historical data does exist for the MR-4 discharge. It is likely that the historical data predates the construction of Pond 6 and thus the effluent from the pond would have originally been part of the flow monitored at MR-4. As a result, the MR-4 and Pond 6 samples will be treated as a single discharge for comparison to the historical dataset. A total of 35 samples and 39 flow rates were measured between 1988 and 1999. Chemistry and flow data for MR-4 are summarized in Table 3. The 5/21/09 sample fits within the range of observed values for the discharge.

Table 3. MR-4 Discharge

Timeframe	Flow (gpm)	pH	Acidity (mg/L)	Fe (mg/L)	Mn (mg/L)	Al (mg/L)	SO_4 (mg/L)
MR-4 plus Pond 6 5/21/09	23	4.1	22	0.2	7.1	1.3	214
1988-99 Average*	18	4.2	43	0.5	10.6	6.2	292

**Four samples showed exceptionally high Iron values due to elevated TSS and were removed from the dataset.*

Figure 2. MR-4 Treatment System Existing Conditions

The first step in treatment is the collection of the MR-4 seep zone which appears to break out of an eroded ditch to the west of Pond 6 (Photo 1). Once collected, the discharge can be routed to Pond 6 for monitoring and treatment.

Photo 1. MR-4 Seep Zone

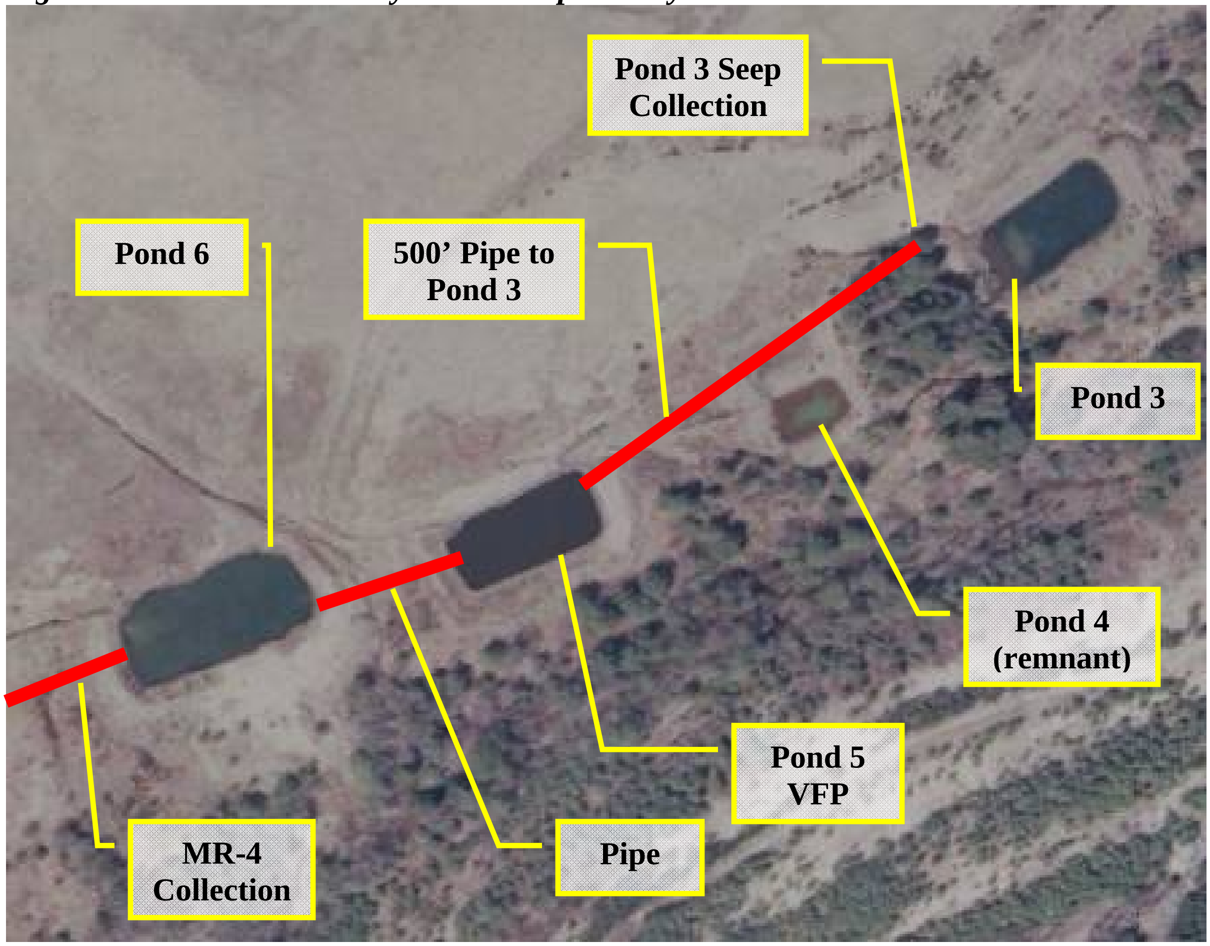
Table 4 summarizes the design criteria for the system. Pond 6 has a water surface area of 2,700 m^2 which is far larger than the required VFP surface area. Simply converting it to a VFP using its current dimensions would be cost-prohibitive. Regrading the pond to a more suitable size consumes construction funds that could be expended on alkaline material. A preferable alternative is to utilize Pond 6 for discharge collection and construct the VFP in the smaller Pond 5. Figure 3 shows the conceptual layout.

Table 4. MR-4 Treatment System Assumptions and Sizing

Item	**Quantity**
Average Flow	18 gpm
90^{th} percentile flow (design flow)	52 gpm
Acidity	42 mg/L
Fe	0.5 mg/L
Al	6.1 mg/L
Existing Pond Size (Pond 5)	1,7340 m^2
Acidity loading at design flow	7 (g/m^2)/day
Limestone required	1,316 tons
Compost required	1,193 yd^3
Limestone for Compost amendment	537 tons
Effluent Net Acidity	-146 to -196 mg/L
Alkalinity contributed to Muddy Run	30 to 40 ppd
In-stream acidity loading reduction*	19% to 25%

**Based on historical average in-stream acidity loading of 158 lbs/day*

Figure 3. MR-4 Treatment System Conceptual Layout



The 1,700 m^2 Pond 5 is still larger than what would theoretically be required but since nearly all of the construction funds go toward treatment media the total cost is still lower than if a smaller system were to be built from scratch. In addition, the added size of the VFP will minimize maintenance costs. Similarly sized VFPs treating similar water quality have functioned with little to no maintenance for nearly a decade.

Converting Pond 5 into a VFP involves draining the pond and removing debris and accumulated sediment. A network of underdrain pipes would then be installed followed by a two foot thick layer of limestone. On top of the limestone would be a two foot thick layer of spent mushroom compost that has been amended with limestone fines. The outlet plumbing would be equipped with a water level control structure and the effluent piped to Pond 3.

The alkaline effluent from the VFP will easily neutralize the minor AMD flow into Pond 3 allowing for additional metals removal and reduced metals loading to Muddy Run.

The estimated cost to construct the system is $101,249. Attached AMDTreat cost worksheets show the breakdown of assumptions and quantities. This does not include engineering costs (design, permitting, construction oversight or post-construction monitoring) which would likely add an additional $20,000 to the cost.

MR-6 Treatment System Concept

The existing pond adjacent to MR-6 (Pond 2) should be utilized for treatment of the MR-6 discharge. Flow and water quality data have been collected at varying intervals since 2004. A total of 16 flow rates and 15 samples have been collected. Interestingly, the chemistry of the discharge improved dramatically in 2005 with iron concentrations falling an order of magnitude. Table 5 compares the 5/21/09 sample with the historical average and the two time periods with differing water quality. The reason for the water quality improvement is unclear. Regardless, the treatment strategy would be the same for either water quality.

Table 5. MR-6 Discharge

Timeframe	N	Flow (gpm)	pH	Acid (mg/L)	Fe (mg/L)	Mn (mg/L)	Al (mg/L)	SO_4 (mg/L)
MR-6 5/21/09	1	24	3.9	77	0.6	26.7	4.0	812
2004-2005 Ave	10	42	4.1	88	6.4	22.5	2.7	842
2005-2009 Ave	6	48	4.0	76	0.7	19.4	3.8	839
2004-2009 Ave	16	44	4.1	83	4.1	21.2	4.1	841

The proposed system will consist of the converting the existing Pond 2 sedimenation pond to a vertical flow pond (VFP). Only Pond 1 is lower in elevation than Pond 2 so it would be the only available existing pond that could accept the effluent from Pond 2 for metals polishing or indirect treatment of additional discharges. However, Pond 1 appeared to have good water quality so there will be no advantage in piping the effluent from the MR-6 VFP to Pond 1. The effluent from the VFP will have very low metals concentrations so settling is not required. As a result, the VFP will discharge directly to Muddy Run. Figure 4 shows the MR-6 treatment system layout.

Figure 4. MR-6 Treatment System Conceptual Layout

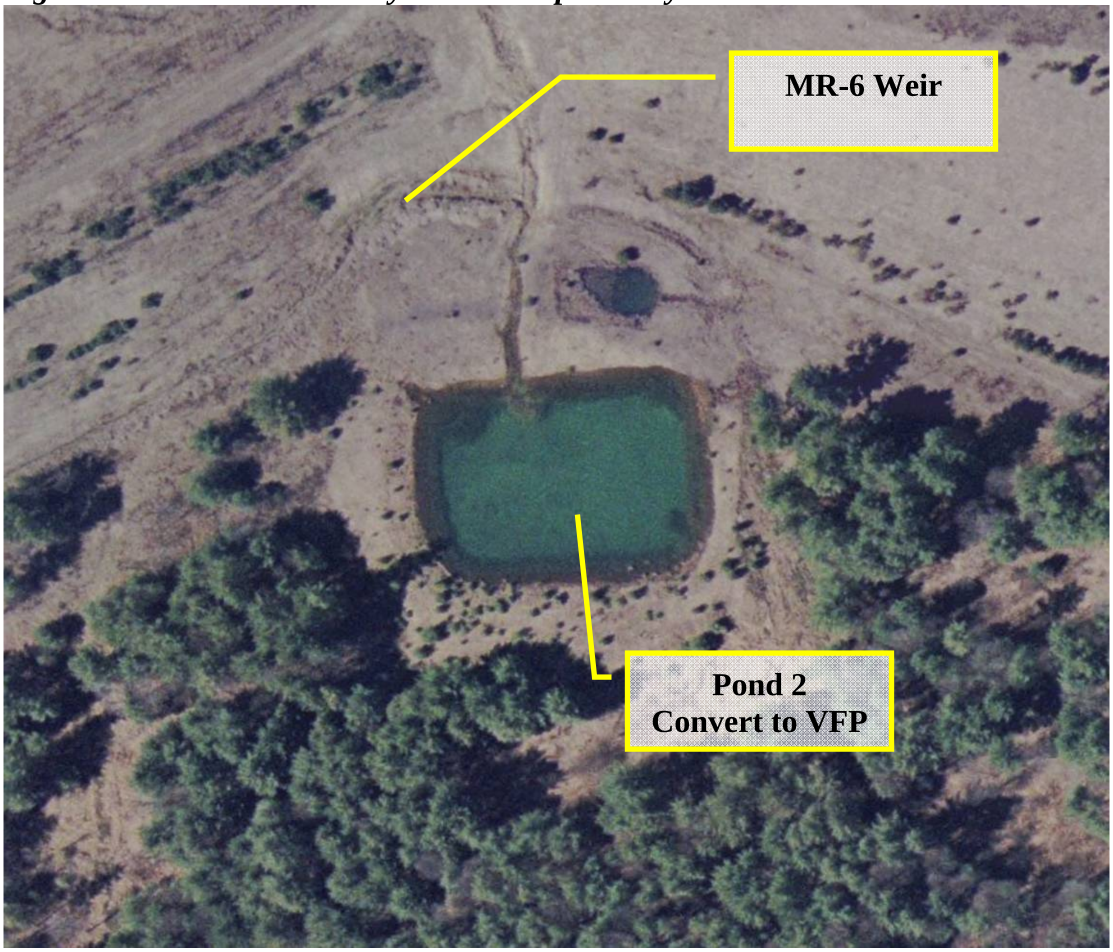


Table 6 shows the design assumptions and quantities for the MR-6 treatment system. The existing pond has a surface area of 21,000 ft^2 which leads to an acidity loading rate of 23 (g/m^2)/day at the design flow rate of 84 gpm. The system will be under-loaded but as a result will require little to no maintenance. Similarly sized VFPs treating similar water quality have functioned with little to no maintenance for nearly a decade.

Table 6. MR-6 Treatment System Assumptions and Sizing

Item	**Quantity**
Average Flow	43 gpm
90th percentile flow (design flow)	84 gpm
Acidity	83 mg/L
Fe	3.9 mg/L
Al	3.2 mg/L
Existing Pond Surface Area	1,673 m^2
Acidity loading at design flow	23 (g/m^2)/day
Limestone required	2,194 tons
Compost required	1,926 yd^3
Limestone for Compost amendment	753 tons
Effluent Net Acidity	-94 to -144 mg/L
Alkalinity contributed to Muddy Run	62 to 88 ppd
In-stream acidity loading reduction*	39% to 56%

**Based on historical average in-stream acidity loading of 158 lbs/day*

The estimated cost to construct the system is $138,750. Attached AMDTreat cost worksheets show the breakdown of assumptions and quantities. This does not include engineering costs (design, permitting, construction oversight or post-construction monitoring) which would likely add an additional $20,000 to the cost.

<u>MR-2A, MR-2B and MR-2C Treatment System Concept</u>

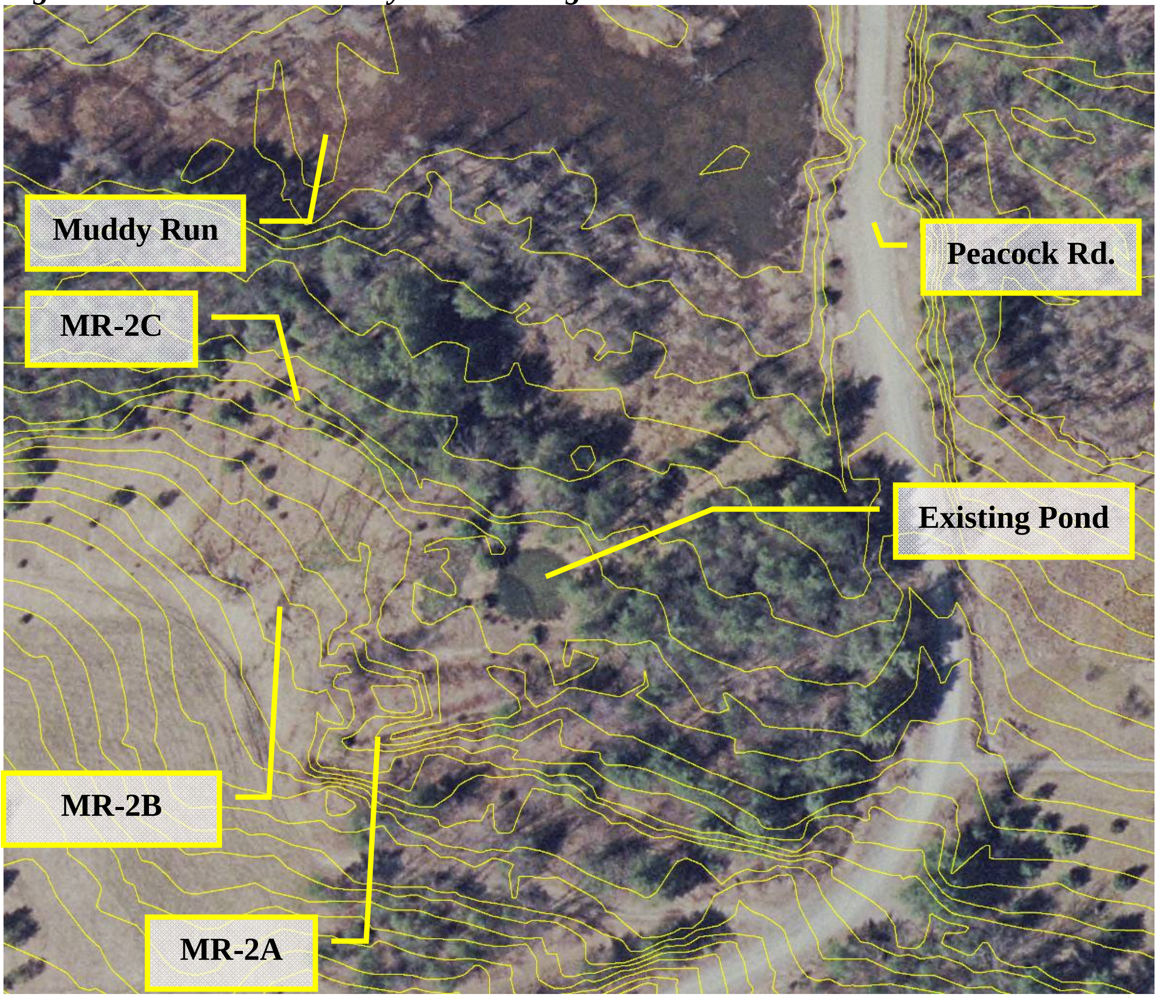
The MR-2 treatment system will treat all three discharges at the site which have essentially identical chemistry. The discharge was sampled at varying intervals between 1998 and 2005. The results of the 5/21/09 sample are compared to the existing averages in Table 7.

Table 7. MR-2 Discharges

Timeframe	**N**	**Flow (gpm)**	**pH**	**Acidity (mg/L)**	**Fe (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**SO_4 (mg/L)**
MR-2A 5/21/09	1	9	4.2	58	0.1	13.5	7.0	436
1998-2005 Ave	17	6	4.0	97	0.4	18.2	9.2	561
MR-2B 5/21/09	1	31	4.2	58	0.1	15.2	6.6	493
1998-2005 Ave	16	36	4.1	98	0.1	20.6	8.6	570
MR-2C 5/21/09	1	0	DRY					
1998-2005 Ave	15	6	4.0	96	0.1	21.4	8.0	577

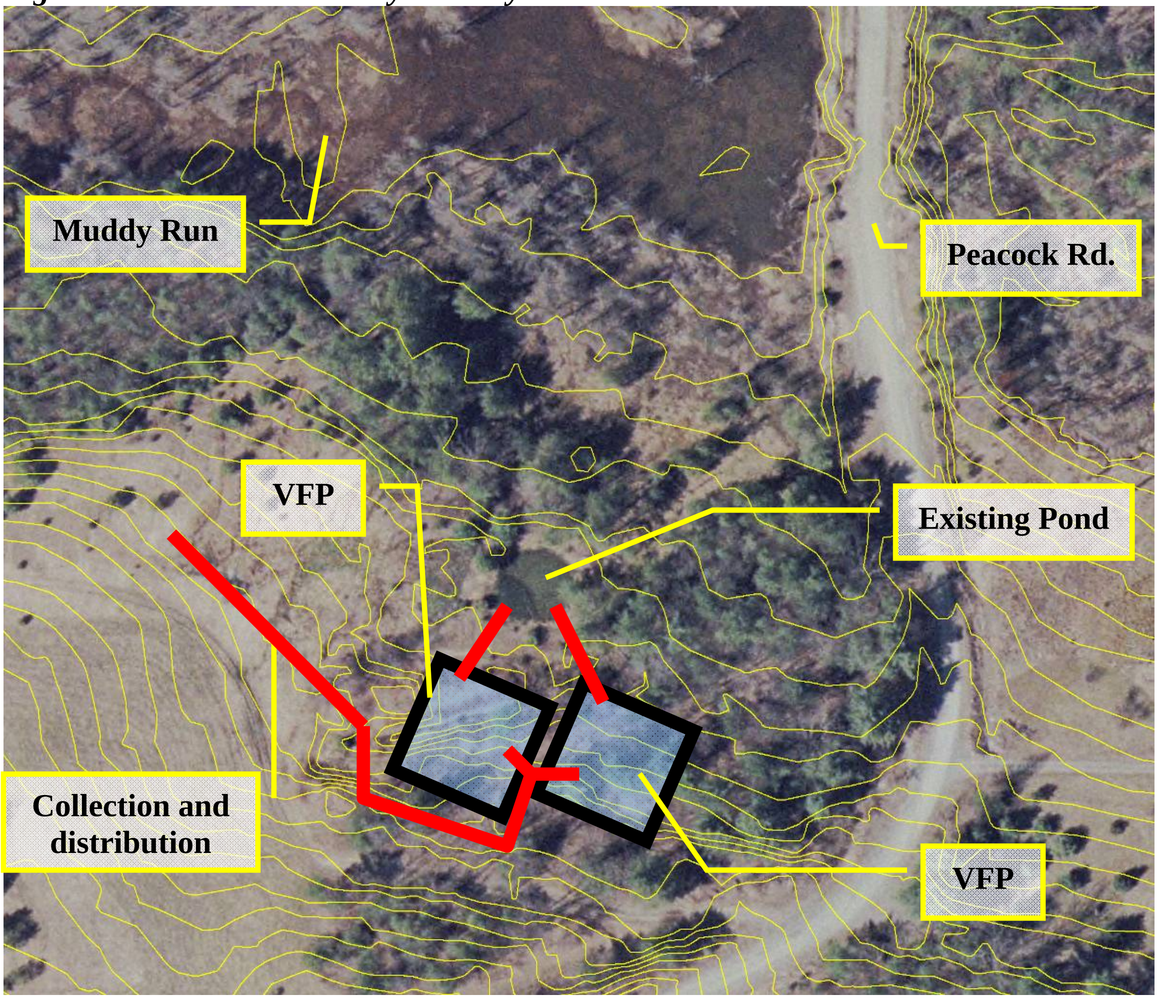
The discharges presently emerge from the toe of an abandoned strip mine as a somewhat diffuse seepage area. All three discharges arise from a common source and an effort should be made to collect all three into a single point. This will likely result in a discharge elevation lower than the current MR-2B discharge elevation reducing the available area for treatment. Figure 5 shows the existing conditions and Figure 6 shows the proposed treatment system.

Figure 5. MR-2 Treatment System Existing Conditions



Yellow lines are topographic contours on 2 foot interval

Figure 6. MR-2 Treatment System Layout



Yellow lines are topographic contours on 2 foot interval

The system will consist of two vertical flow ponds (VFPs) arranged in parallel to allow treatment to continue during maintenance operations. The combined chemistry of the three discharges and the 90th percentile flow rate were used as a basis for the design. Design criteria are summarized in Table 8.

Table 8. MR-2 Treatment System Assumptions and Sizing

Item	**Quantity**
Average Flow	47 gpm
90th percentile flow (design flow)	86 gpm
Acidity	95 mg/L
Fe	0.2 mg/L
Al	8.5 mg/L
Acidity loading at design flow	30 (g/m^2)/day
VFP water surface area (total)	1,480 m^2
Limestone required	1,038 tons
Compost required	954 yd^3
Limestone for Compost amendment	429 tons
Effluent Net Acidity	-100 to -150 mg/L
Alkalinity contributed to Muddy Run	86 to 115 ppd
In-stream acidity loading reduction*	54% to 73%

**Based on historical average in-stream acidity loading of 158 lbs/day*

The site is adjacent to known wetlands and additional wetlands may exist in the proposed construction area. As a result the concept system was arranged at the highest elevation possible in an effort to avoid wetland impacts. However, it may not be possible to avoid wetland encroachment on this site.

The estimated cost to construct the system is $115,662 which includes $20,000 for wetland mitigation. Attached AMDTreat cost worksheets show the breakdown of assumptions and quantities. This does not include engineering costs (design, permitting, construction oversight or post-construction monitoring) which would likely add an additional $35,000 to the cost.

Summary

Three treatment systems are proposed which will address 7 of the 8 known discharges impacting Muddy Run. Two of the systems will utilize existing ponds on the site while the third will require pond construction. Table 10 summarizes the cost of the systems and the pollution loading to be treated. Under most hydrologic conditions, Muddy Run will be net neutral to net alkaline once the projects are in operation. The total cost of all three systems, built individually is estimated at $430,661. Savings in design, construction, and construction management would be realized by installing projects simultaneously. Savings of 5-10% are possible by doing multiple projects simultaneously.

Table 10. Summary of pollution loading reductions and costs

System	Avg. Flow (gpm)	Acidity Loading (lbs/day)	Aluminum Loading (lbs/day)	Iron Loading (lbs/day)	Cost
MR-4	18	10	1.3	0.1	$121,249
MR-6	43	83	3.2	3.9	$158,750
MR-2	47	54	4.8	0.1	$150,662
TOTAL	**108**	**147**	**9.3**	**4.1**	**$430,661**
Muddy Run Downstream (MR-1)*	295	158	5.9	5.9	

**Historical averages.*