KC204 Mine Pool Stabilization Project

By Hedin Environmental
For Trout Unlimited & the Kettle Creek Watershed Association
June 2011

Executive Summary

The goal of this project was the implementation of a priority recommendation made in the "West Side of Lower Kettle Creek AMD Remediation Plan" (2007). During the development of the remediation plan it was discovered that a substantial mine pool containing highly acidic water existed in the abandoned Kettle Creek No. 1 Mine. A large portion of the pool was maintained by collapsed mine entries and clogged mine drains. Several hundred acres of deep mine had only one free flowing drain. If the water were to be suddenly released in a "blowout" event, the acidity and metals would devastate lower Kettle Creek and degrade the West Branch of the Susquehanna River downstream of Westport, PA. The goal of this project was to reestablish water flow through several collapsed mine adits by installing drains into each of the mine openings.

Five drains were installed at collapsed entries into the deep mine complex in Bitumen PA. During excavation of the entries, old drainage pipes were encountered verifying that mine water was intended to discharge at these locations. The drains were reestablished with plastic pipe bedded in non-reactive aggregate and reburied. The five pipes discharge to Milligan Run, a stream that was already highly polluted with AMD. In the first half of 2011 (a very wet period) the pipes discharged as much as 2,683 gpm of flow and averaged 625 gpm of flow containing 400-800 mg/L acidity, 50-130 mg/L Fe, and 25-60 mg/L Al. Previous to installation of the drains most of this AMD would have accumulated in the mines and discharged to Kettle Creek through KC204. The project has successfully diverted a large loading of AMD out of the Kettle Creek watershed and decreased fluctuations in the mine pool which should lessen the risk of a catastrophic mine blowout.

Background

Several deep mines were in operation around the turn of the last century within the ridge that separates Kettle Creek from Milligan Run. Map A shows the project location. The primary entries for the No. 1, 2, and 3 mines were all located in the headwaters of Milligan Run where an inclined plane was used to lower coal down the mountain to a cleaning plant near Crowley Hollow. Mine No. 2 and a portion of No. 3 drain to Milligan Run and are drained through these entries. Mine No. 1 dips to the north away from Milligan Run so two drains were installed in the No. 1 mine that discharge to the north to Kettle Creek. These drains are identified as the KC204 and KC204A discharges. Mine mapping and descriptions included in the Operation Scarlift report suggest that flow from the No. 2 mine as well as the adjacent Bachallette and Stewart Mine discharged through the KC204A drain. The KC204 drain provides drainage for 30-50 acres of mine that is separated from the rest of the mine workings by a structural roll.

When the Operation Scarlift study was conducted in 1972-78, the mines discharged through KC204A and the entries at Milligan Run. Between 1978 and 2002, the KC204A drain became plugged (naturally) and the mine entries on Milligan Run collapsed and stopped carrying substantial flow. The only freely flowing mine drain was KC204. Water impounded behind the blocked drains formed a minepool that fluctuated in depth and extent with precipitation. KC204 is separated from the rest of the mine pool by a structural roll. When the pool rose above the roll it spilled over to the KC204 drain and flowed freely to Kettle Creek. The increased head put pressure on the Milligan Run entries which leaked through the blockages, but never flowed freely.

Since at least 2002, the only free flowing drain for several hundred acres of deep mine workings above Kettle Creek was KC204. If the KC204 discharge were to become obstructed, water levels in the mine would rise and a blowout would likely occur. Or, if the KC204A blockage were to be released, a blowout-like event would occur. Because the water in the mine is highly acidic (> 600 mg/L), a rapid release of a large volume would devastate lower Kettle Creek and the West Branch Susquehanna River below Westport.

To reduce the risk of such an environmental disaster, this project reestablished drainage from two of the entries at the inclined plane above Milligan Run. Reestablishment of flow through the KC204A drain was considered impractical and was not pursued for several reasons. First, the drain is located on a very steep slope that makes access with equipment difficult and expensive. Second, the KC204A drain is located at the base of the mine pool so the pool would have to be pumped down prior to any work on the drain. Pumping would be costly and would not completely eliminate the threat of the release of mine water from isolated pools near the drain. And third, the increased flow of AMD from KC204A that would result from the drain's repair would cause more acidic water to flow to Kettle Creek and deleteriously impact the recovering fishery in lower Kettle Creek.

Drilling

A new monitoring well was installed so that water elevations in the mines could be monitored. The drilling occurred September 24-25, 2009 by Smith Drilling (Brookville, PA) using an air rotary drill. Initially the drilling occurred along Cattaraugus Road. Unfortunately, bedrock fractures caused the drill bit to jam in all of the holes along Cattaraugus Road before the coal seam was reached. It is believed that the fracturing is due to unloading along the edge of the steep slope. When the rig moved west of the road, it was able to drill successfully into the underlying No. 3 mine. The hole was cased and capped for use as a monitoring well (identified as BIT 13). Two monitoring wells that were installed prior to this project (BIT 3 and BIT 9) penetrate the workings of Mine No. 1. Together these three wells allowed for monitoring of mine pool elevations. The location and elevation of the monitoring wells was surveyed by DEM Surveying of Brookville, PA. Map B shows the location of the monitoring wells.

Monitoring Methods

Mine pool elevations and discharge flow rates were measured throughout the project. Water elevations within the mine were measured at three monitoring wells with a down-well water level indicator. Flow rates were measured by the timed volume method using a bucket or 17 gallon tub and stopwatch. Flows greater than 500 gpm, which cannot be reliably measured by timed volume, were measured in the channel below the drain outfall using a Swoffer Model 3000 flow meter. Flow from the KC204 discharge was measured using an H-flume installed just below the outfall.

Reestablishment of Mine Drains

The plugged mine entries at the incline plane were excavated so that drainage could be reestablished. The construction contractor for the work was Smith Excavating and Construction of Renovo, PA. The work was done with an excavator and dozer. Drains were constructed from 10-inch SDR 35 PVC pipe. Bedding, when necessary, was non-calcareous sandstone aggregate. All drains were piped to a point of existing water flow and discharged into energy dissipaters that discharged to existing drainages.

Four drains were installed between December 14, 2009 and January 14, 2010. In October 2010 Smith remobilized and installed a fifth drain. The installation of each of the five mine entry drains is described in the following sections. Map C shows the project work area, including the mine entries and drains.

Mine 1 Drain

The Mine 1 entry was completely excavated and a drain was installed on the mine floor. The mine was dry at the time of excavation and evidence of a wooden box drain was found between the crossties of the railway. The new drain consists of 10-inch PVC perforated pipe in a bed of non-calcareous aggregate. A clay dam was installed across the mine opening immediately downstream of the perforated pipe to prevent leakage along the pipe. Solid 10-inch PVC pipe carried the flow from the mine entry to the discharge location 300 feet downslope to an existing kill zone. An energy dissipater lined with riprap was installed at the outfall to prevent erosion.

Mine 2a Drain

During the excavation of Mine 1 a pipeline was discovered that ran parallel to the coal crop toward the entries of Mine 2. The pipeline was excavated and found to consist of a mixture of 2-inch metal and wooden pipe. In front of the eastern most entry to Mine 2 (Mine 2a) the excavation encountered a large log cribbing that was filled with saturated sediment. The cribbing was located directly beneath an old weir for monitoring flow from the Mine 2a entry. Sediment was excavated from the cribbing which revealed a 12 inch clay pipe that had served as a drain for the mine. The clay pipe was discharging water. The land above the entry was severely subsided so opening the entry to replace the drain properly would involve significant excavation and was considered impractical. Instead, a 10-inch PVC pipe was connected to the existing clay pipe using a Fernco fitting. The PVC pipe was extended downslope to an existing kill zone where an energy dissipater lined with riprap was installed at the outfall to prevent erosion.

Mine 2b Drain

The next entry west of Mine 2a was excavated. It was chosen due to its apparent lack of subsidence upslope of the entry indicating that a clear connection to the main mine workings may exist. Once opened it became clear that it was a primary entry to Mine 2. The roof was heavily timbered and large pillars supported the roof on both sides. No roof subsidence was visible from the exposed entry. During excavation a 24-inch diameter clay pipe was discovered that had served as a drain for the mine. The clay pipe was filled with iron solids and the outlet end was crushed and filled with earth. A new drain was installed on the mine floor. The new drain consists of 10-inch PVC perforated pipe in a bed of non-calcareous aggregate. Just inside the entry a section of perforated pipe was pushed into an adjacent room that was producing significant flow then connected to the main pipe with a wye fitting. A clay dam was installed across the mine opening immediately downstream of the perforated pipe to prevent leakage along the pipe. Solid 10-inch PVC pipe carried the flow from the mine entry to the discharge location 280 feet downslope in an existing channel. An energy dissipater lined with riprap was installed at the outfall to prevent erosion.

Mine 2c Drain

An apparent collapsed drift entry was excavated to provide drainage based on the presence of a small kill zone at its mouth. Once opened, the entry was found to be into a small room cut parallel to the crop that dead-ended 20 to 30 feet to the west of the entry and was blocked by subsidence to the east. No heading was found to the north that would have connected the entry to the main workings. Removal of the subsidence would have involved creating a significant and potentially dangerous highwall during construction so no effort was made to remove it. Instead, a drain was installed on the mine floor which consists of a 10-inch PVC perforated pipe in a bed of non-calcareous aggregate. A clay dam was installed immediately downstream of the perforated pipe across the mine opening to prevent leakage along the pipe. Solid 10-inch PVC pipe carried the flow from the mine entry to the discharge location 270 feet downslope to an existing channel.

Mine 3 Drain

Mine 3 lies west of the inclined plane between Crowley Hollow and Cattaraugus Road. The entry into Mine 3 is perpendicular to the other entries at the inclined plane and about 10 feet of elevation higher than the other entries. Excavation of the mine entry encountered a square clay pipe. The pipe was discharging water at the time of excavation. A Fernco fitting was used to connect a 10-inch PVC pipe to the square clay pipe. Clay was packed around the joint to seal the imperfect fit of the round fitting to the square pipe. The 10-inch PVC was directed to the existing discharge channel.

KC401 Drain

No work was done at the KC401 drain as part of this project. The KC401 drain is a clay pipe located approximately 450 feet southeast of the main entry to the No. 1 mine. Mine maps do not indicate an entry or drain at this location so the pipe was likely installed to drain a localized area in the mine that could not be drained through the primary drains. Though the mapping is unclear, it appears that 25-30 acres of deep mine may drain to KC401.

Monitoring Results and Discussion

All of the re-established mine drains discharge AMD. A total of 36 complete rounds of water level and flow measurements were made in addition to several partial rounds. Average flow and level measurements are shown in Tables 1 and 2. All measurements are included at the end of this report. Two rounds of water quality samples were collected as well as a single sample of Mine 2b during a very high flow event. Table 3 shows the water quality from the June 15, 2011 sampling round which included all of the drains.

Water Elevation (ft)		
Bit 3	**Bit 9**	**Bit 13**
1364.7	1363.9	1373.1

Table 1. Average water elevation from January 8, 2010 to June 15, 2011

Average Flow Rate (gpm)						
KC401	**Mine 1**	**Mine 2a**	**Mine 2b**	**Mine 2c**	**Mine 3**	**KC204**
64.3	104.6	26.0	413.1	23.5	57.6	182.1

Table 2. Average flow rate from January 8, 2010 to June 15, 2011 except Mine 2b which was installed in October 2010 and monitored from November 24, 2010 to June 15, 2011.

Site	**Flow gpm**	**pH**	**Acidity mg/L**	**Fe mg/L**	**Mn mg/L**	**Al mg/L**	**Sulfate mg/L**
KC401	21.0	2.7	295	39	2	16	446
Mine 1	47.6	2.7	399	58	3	26	602
Mine 2a	26.7	2.6	771	133	8	58	1,107
Mine 2b	310	2.7	631	125	7	55	1,045
Mine 2c	3	2.7	508	98	5	35	857
Mine 3	48.5	2.7	351	47	2	26	555
KC204	150	2.6	638	110	6	49	1,050
KC204A*							

*Table 3. June 15, 2011 water quality. *KC204A was dry during the project.*

The two drains that were installed directly into the mine opening (Mine 1 and Mine2b) have had the highest flow rates. Within two weeks of reestablishment of the Mine 1, 2a, 2c and 3 drains (but before the installation of the Mine 2b drain) heavy rains combined with a rapid thaw quickly refilled the mine. Water levels in the mine and flow rates were intensely monitored to characterize the event. Monitoring of water levels in the mine and discharge flow rates showed how the mine fills and how the mine drains and the KC204 discharge responded. Figure 1shows flow rates from the mine during this period.

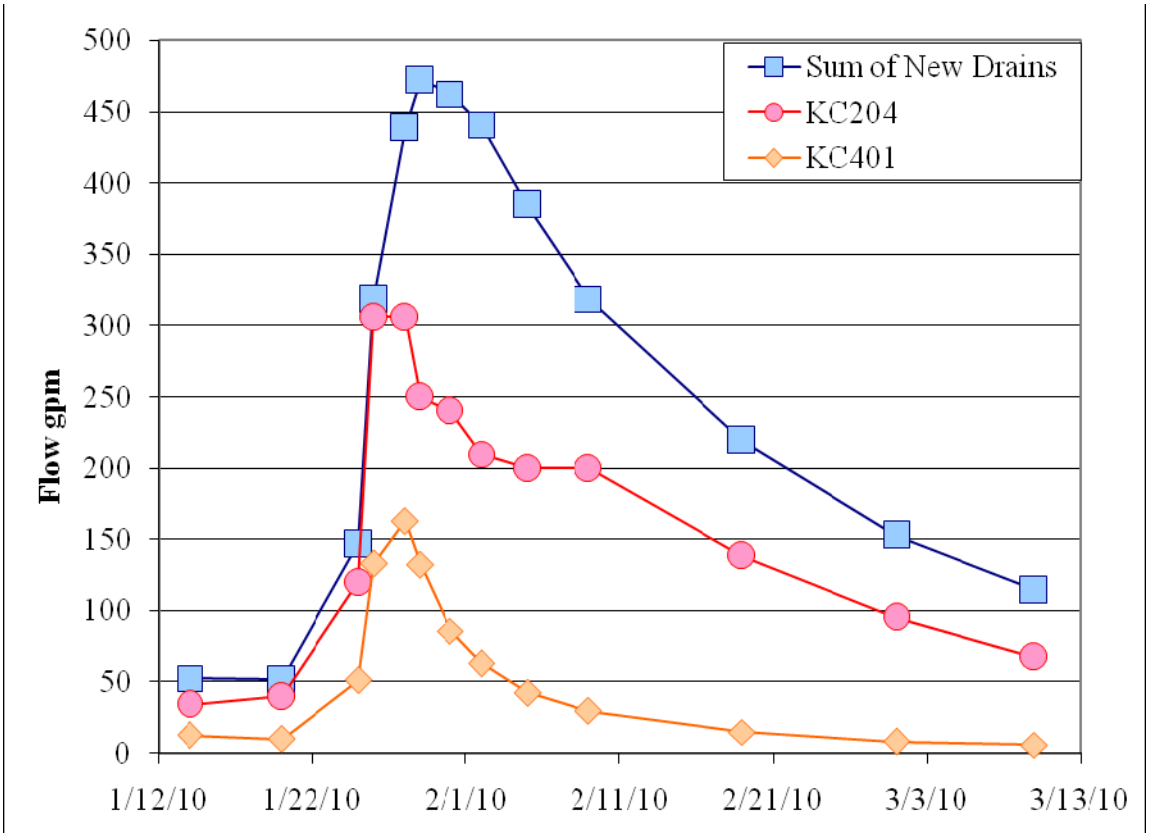


Figure 1 Flow rate from new drains, KC204 and KC401 following heavy rains. Note the irregular curve as the flow declines from KC204. This suggests input from the adjacent pool in Mine No. 1.

Discharge flow from the mine began to increase first at KC204 and KC401. This agrees well with the mine structure indicated on the mine mapping that shows these two discharges have their own minesheds separated from the main mine workings. Once the slug of water from the local mineshed passed, the flow from these two discharges began to quickly decline. However, the rate of decline in flow from the KC204 discharge shows signs of influence from the adjacent No. 1 Mine. The break in the slope of the flow rate decline occurs at about the same time as the peak mine pool elevations were observed. This suggests that the mine pool was contributing to the flow at KC204.

If the new mine drains are connected to the mine pool that contributes flow to KC204 then any flow from the mine drains must be flow that would have ultimately discharged to Kettle Creek via KC204. The available mine maps indicate that the connection exists. Also, the mine water chemistry suggests connectivity as the Mine 2b and KC204 discharges had similar water chemistry in June 2011 (Table 3).

Further evidence for the connectivity between the new mine drains and the mine pool lies in the comparison of the mine pool elevation with the flow rate from the drains. Figure 2 shows the relationship between water elevation in monitoring well BIT 9 and discharge flow rate from Mine 1 and Mine 2b drains. The strong relationship indicates that the two are directly connected and that Mine 1 drain is an unrestricted outlet for the mine. Note

that the highest flow rate for Mine 1 is slightly off the curve established by the other measurements. This can be attributed to either measurement error of such a large flow or the pipe is nearing its capacity.

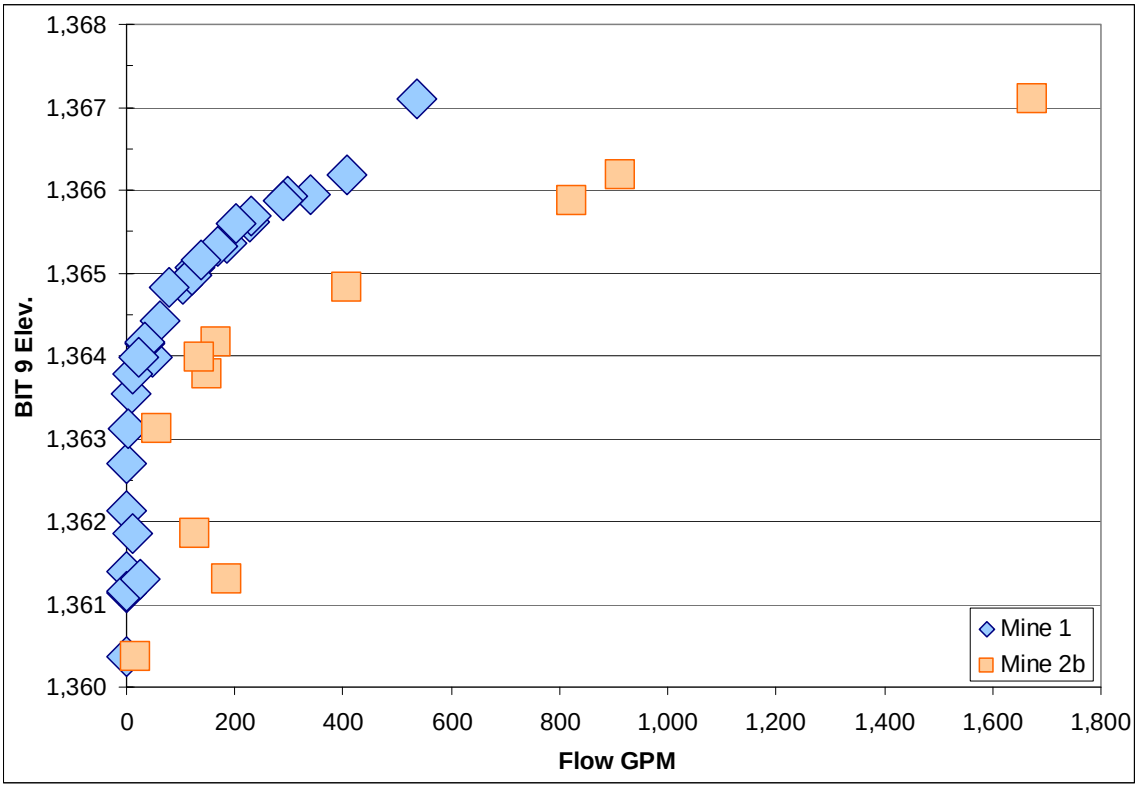


Figure 2 Relationship of flow rate from Mine 1 and 2b drains to water level in monitoring well BIT 9. (Elevation in feet above sea level.)

At mine pool elevations above 1,364 feet the Mine 1 and Mine 2b drains discharge water that would have largely flowed to Kettle Creek. The new mine drains give the mine pool the ability to discharge large flows at lower elevations. As a result the risk of mine pool blowout is reduced because the frequency of high head conditions that would lead to a blowout has been significantly reduced.

A single monitoring round on April 2, 2008 captured a high flow event prior to re-establishment of the mine drains. The measurements from that date show the highest mine pool elevation observed to date. Comparing the discharge from the mine under those conditions before reestablishment of the mine drains provides a means for quantifying the effect of the project. In 2008 the mine pool reached an elevation of 1367.8 feet while discharging a total of 518 gpm from KC401 and the collapsed Mine 1, 2a, 2b and 2c drains. In 2011 these same drains were discharging 558 gpm while the mine pool was at elevation 1366.3 feet. The mine is now capable of discharging the same flow but at a mine pool elevation 1.5 feet lower than before the project.

More than double the normal average precipitation fell during March and April 2011 leading to extremely high flows and high mine pool water elevations. The high flows

were sustained for at least seven weeks and appear to have peaked in late April. During this period the mine pool filled to its highest post-project elevation. The result was a flow rate five times that observed during the previous maximum measured mine pool elevation event (April 2, 2008) but at a mine pool elevation 0.7 feet lower. The project has effectively increased the discharge capacity of the mines by at least a factor of five.

In addition to increasing the discharge capacity of the mines, the project changed where the mines discharged by establishing free flowing drainage from Mines 1 and 2. Flows from these mines was previously limited to the KC204, KC401 (a partially collapsed entry) and leakage during very wet weather through the collapsed entries. Most of the discharge from Mines 1 and 2 would have been through KC204. Since installation of the drains, large flows of water have been consistently produced by Mine 1 and Mine 2b. These flows, which drain to Milligan Run, previously would have largely discharged to Kettle Creek through KC204. Assuming that 90% of the flow from the Mine 1 and Mine 2b drains would have discharged to Kettle Creek rather than Milligan Run on June 15, 2011, the acidity loading to Kettle Creek was reduced by 2,318 ppd (62%) on that day. Extrapolating this calculation back to January 1 suggests that about 400 tons of acidity were diverted out of Kettle Creek in the first six months of 2011.

Conclusions

The project has reduced the environmental hazard posed by the collapsed KC204A mine drain in three ways. First, by reestablishing two drains the mine can now drain freely from three locations. Prior to the project, the collapse of the single free flowing drain (KC204) would have led to a dangerous buildup of water within the mine. Second, the reestablished mine drains reduce the likelihood of a mine pool blowout by allowing the mine to discharge greater flows at lower mine pool elevations. In this way, the probability of excessive mine pool elevations is reduced. Third, since the mine pool is kept at a lower elevation, the total volume of water that could be released if a blowout would occur has been reduced. As a result, the potential damage caused by a blowout is also reduced.

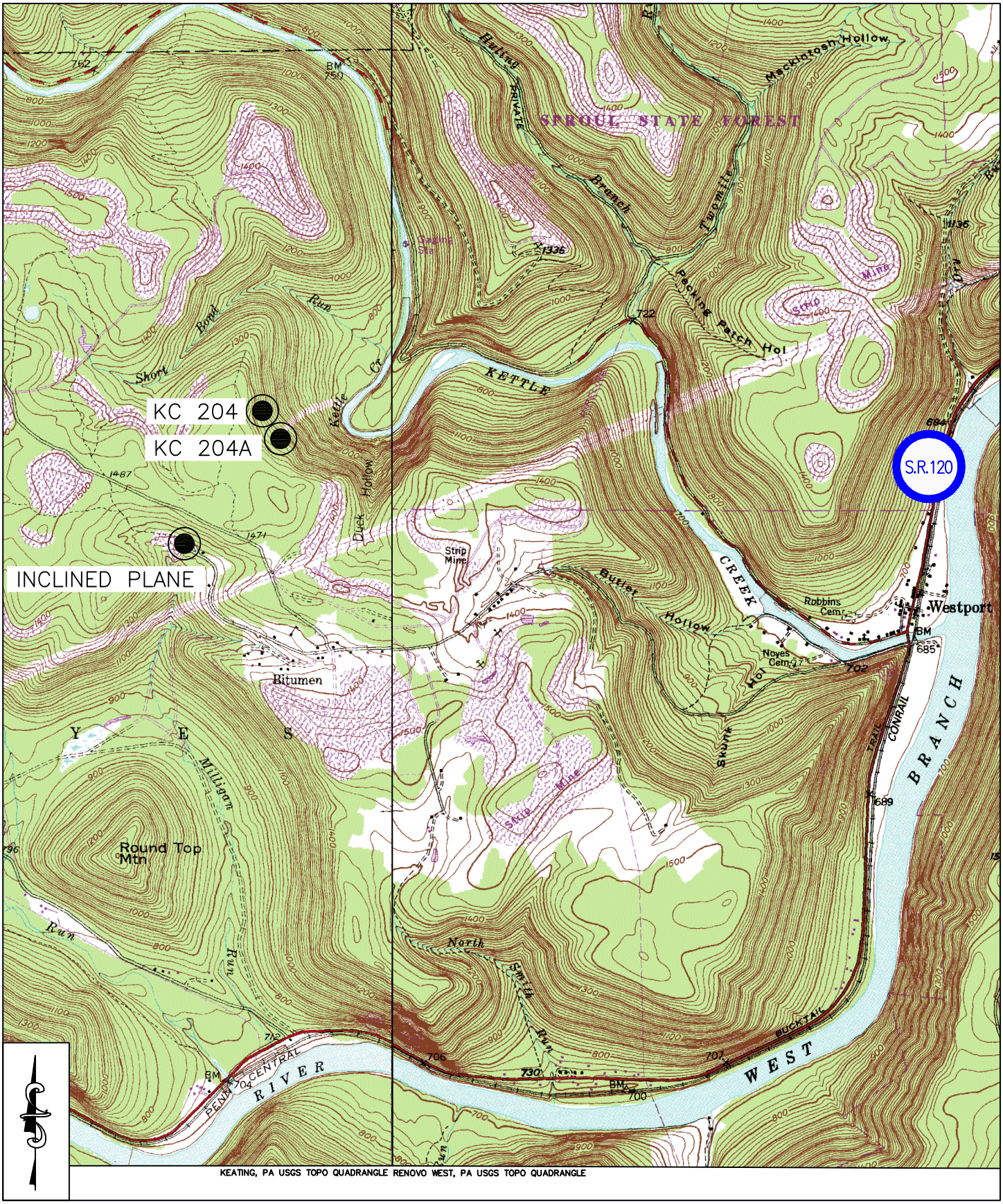
The measurements taken during the high flows of spring 2011 show that the project increased the discharge capacity of the mines by at least a factor of five. It is unclear how the mine would have discharged the extremely high flow rates observed during this period (totaling 2,289 gpm from No. 1 and 2 mines in April 2011) without the reestablished mine drains. The KC204 drain is too small to convey such a large flow without significant head pressure. While it is impossible to prove if a blowout would have occurred under these conditions without the reestablished drains, it is clear that these were exactly the conditions the project was intended to address and the drains performed as intended.

The project produced benefits in addition to lessening the blowout risk. AMD is now diverted flow from Kettle Creek to Milligan Run. This diversion should enhance the ongoing ecological recovery of lower Kettle Creek. The diversion should not substantially affect Milligan Run because the stream was already severely polluted with AMD.

A last benefit of the project is that AMD produced by the Bitumen deep mines is now collected into pipes. Treatment of Crowley Run and Milligan Run AMD has been discussed by several parties. It is now possible to pipe a substantial portion of the AMD to a treatment plant, without dilution by surface water.

Water Elevation (ft)				Flow Rate (gallons per minute)						
Well Name	**Bit 3**	**Bit 9**	**Bit 13**	**KC401**	**Mine 1**	**Mine 2a**	**Mine 2b**	**Mine 2c**	**Mine 3**	**KC204**
Casing Elev	**1473.8**	**1473.2**	**1454.9**							
11/28/2006	1367.5	1366.5								260
4/2/2008	1367.8			350	75	66		27	150	700
9/25/2009			1371.9							3.5
10/8/2009	1363.0		1371.2							2.8
10/30/2009	1362.7	1362.1	1371.6	1.5	0	0		1	0	2.0
11/11/2009										2.0
12/14/2009	1362.5	1361.3	1371.4							3.25
12/31/2009		1362.3	1372.0							
1/6/2010			1372.0							
1/8/2010	1363.1	1362.7	1371.9		1.5	14.8			6.5	31.4
1/12/2010				12.9	1.5	14.2		17.3	5	
1/14/2010	1363.1	1362.7	1372.0	12.5	1.25	13.5		21.5	4	34
1/20/2010	1363.2	1362.8	1372.0	10	2.25	14.1		21.2	4	40
1/25/2010	1363.4	1363.3	1372.6	51.3		15		41.8	38.8	120
1/26/2010	1363.9	1364.0	1372.9	132.9	47.6	18.6		57.5	61.7	306
1/28/2010	1364.6	1365.1	1373.0	162.9	126	32.5		56.7	60.5	306
1/29/2010	1364.9	1365.4	1373.1	132.6	186.4	41.8		54.1	57.4	250
1/31/2010	1365.4	1365.6	1373.2	85.9	227.9	44		44.9	59.8	240
2/2/2010	1365.6	1365.7	1373.2	63.4	231.1	40.7		44.4	61.4	210
2/5/2010	1365.8	1365.6	1373.2	42.7	201.4	42		39	59.4	200
2/9/2010	1365.8	1365.3	1373.2	29.5	167.8	36.9		33.1	51.5	200
2/19/2010	1365.6	1364.9	1373.1	15	103.6	38.8		27.5	34.4	138.6
3/1/2010	1365.2	1364.4	1372.9	8	61.3	38.1		22.6	22.6	95.3
3/10/2010	1364.9	1364.1	1372.9	6	34.9	36.5		21.6	15.6	67.4
3/18/2010	1366.1	1366.0	1373.8	97.5	340.6	42.2		37.3	99	275
4/12/2010	1366.3	1365.9	1374.0	47.1	298.7	39.5		39.2	90	225
5/4/2010	1365.7	1365.0	1373.6	21	121.9	34.8		33.5	48.5	159
6/2/2010	1365.8	1365.2	1373.9	18	136.8	35		35	50	150
7/27/2010	1364.5	1363.5	1372.9	1	7.2	25		27	11	41.1
8/26/2010	1363.9	1362.7	1372.6	0	0.4	18.75		22.1	4.5	23.6
9/16/2010	1363.5	1362.1	1372.4	0	0.1	16.5		20.4	2.75	15
10/8/2010	1363.1	1361.4	1372.2	0	0.1	14		18	2	10
10/19/2010	1362.9	1361.2						18		
10/20/2010	1362.9	1361.1	1372.2	0	0	14		16.2	1.3	7

Water Elevation (ft)				Flow Rate (gallons per minute)						
Well Name	**Bit 3**	**Bit 9**	**Bit 13**	**KC401**	**Mine 1**	**Mine 2a**	**Mine 2b**	**Mine 2c**	**Mine 3**	**KC204**
Casing Elev	**1473.8**	**1473.2**	**1454.9**							
10/21/2010	1363.0	1361.2	1372.2	0	0	13		1.5	1.3	7
11/24/2010	1362.5	1360.4	1371.9	0	0	10.5	16.5	0	1	4.4
12/2/2010	1363.0	1361.3	1372.8	41.3	25	15	184	7.5	71.4	260
12/3/2010	1363.3	1361.9	1372.9	103.6	11	17.5	126.9	4	52.7	250
12/7/2010	1364.0	1363.8	1373.1	72	12	22.5	147.5	3	31.1	175
12/10/2010	1364.4	1364.2	1373.1	45.9	32.5	25	166	3	31.6	150
12/17/2010	1364.8	1364.0	1373.3	27.5	23.8	25.8	134.7	2	36.4	130
1/18/2011	1364.4	1363.1	1373.0	5.5	3.5	22.5	55.8	0.6	15	55
3/15/2011	1367.3	1366.2	1375.0	393	407	22.6	913	10	320	775
4/27/2011	1367.1	1367.1	1375.0	329	537	28	1672.3	52	394	800
5/6/2011	1367.1	1365.9	1374.8	287	288	23	822	11	208	475
6/8/2011	1366.3	1364.8	1374.2	40.3	78.8	27.4	408	3.5	69.2	180
6/15/2011	1366.0	1364.4	1373.8	21	47.6	26.7	310	3	48.6	150



LEGEND:
1" = 2,400'

◉ FEATURE LOCATION

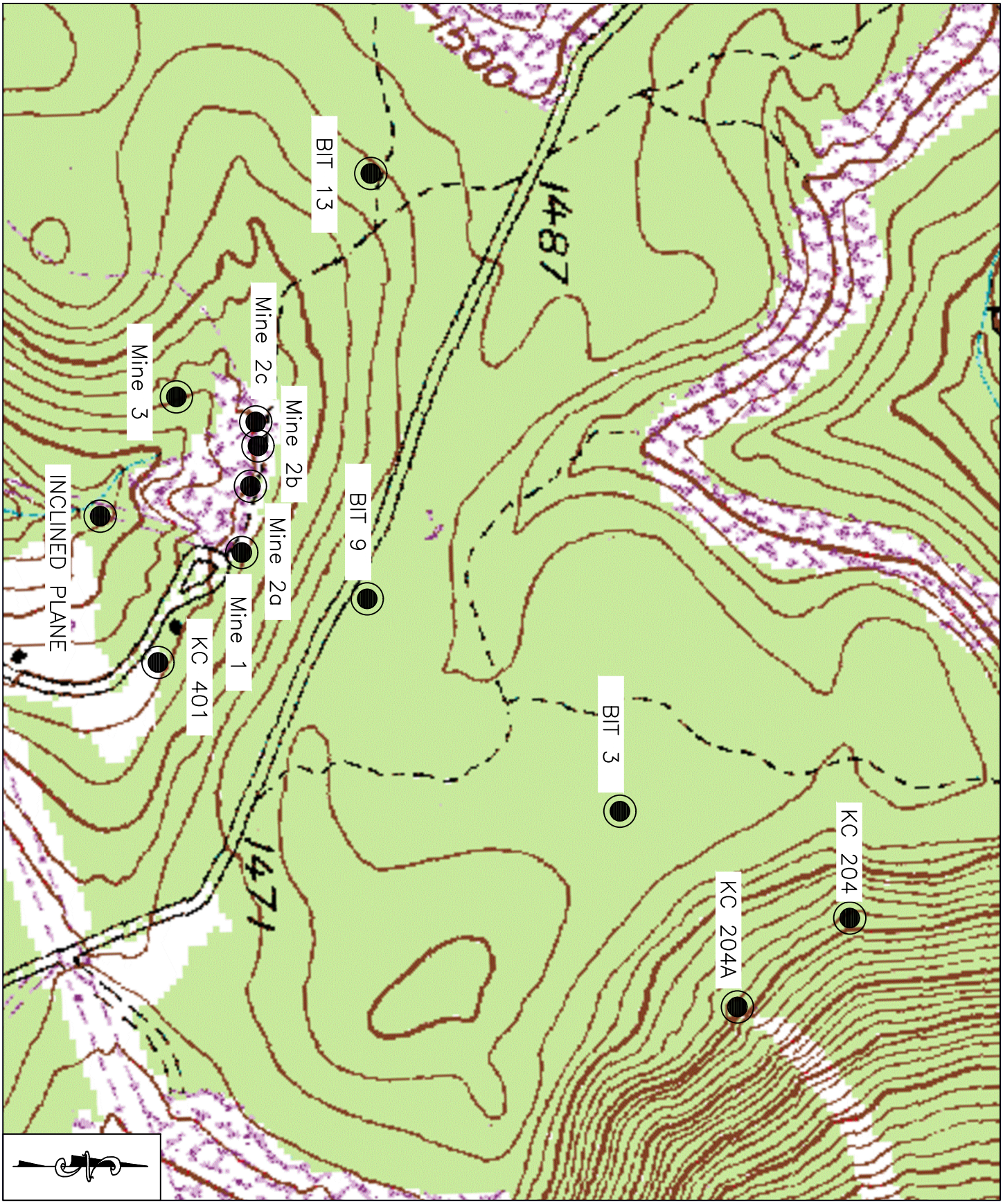
TROUT UNLIMITED

HedinEnvironmental
195 Castle Shannon Blvd.
Pittsburgh, PA 15228
www.hedinenv.com

MAP A

KC 204
PROJECT LOCATION MAP

MUNICIPALITY:	DATE:	FILE NAME:
NOYES TOWNSHIP	JUNE 2011	BIT MAPS.dwg
COUNTY:	DRAWN BY:	SCALE:
CLINTON COUNTY, PA	NAW	AS SHOWN



KEATING, PA USGS TOPO QUADRANGLE

LEGEND:

1" = 500'

◉ Feature Location

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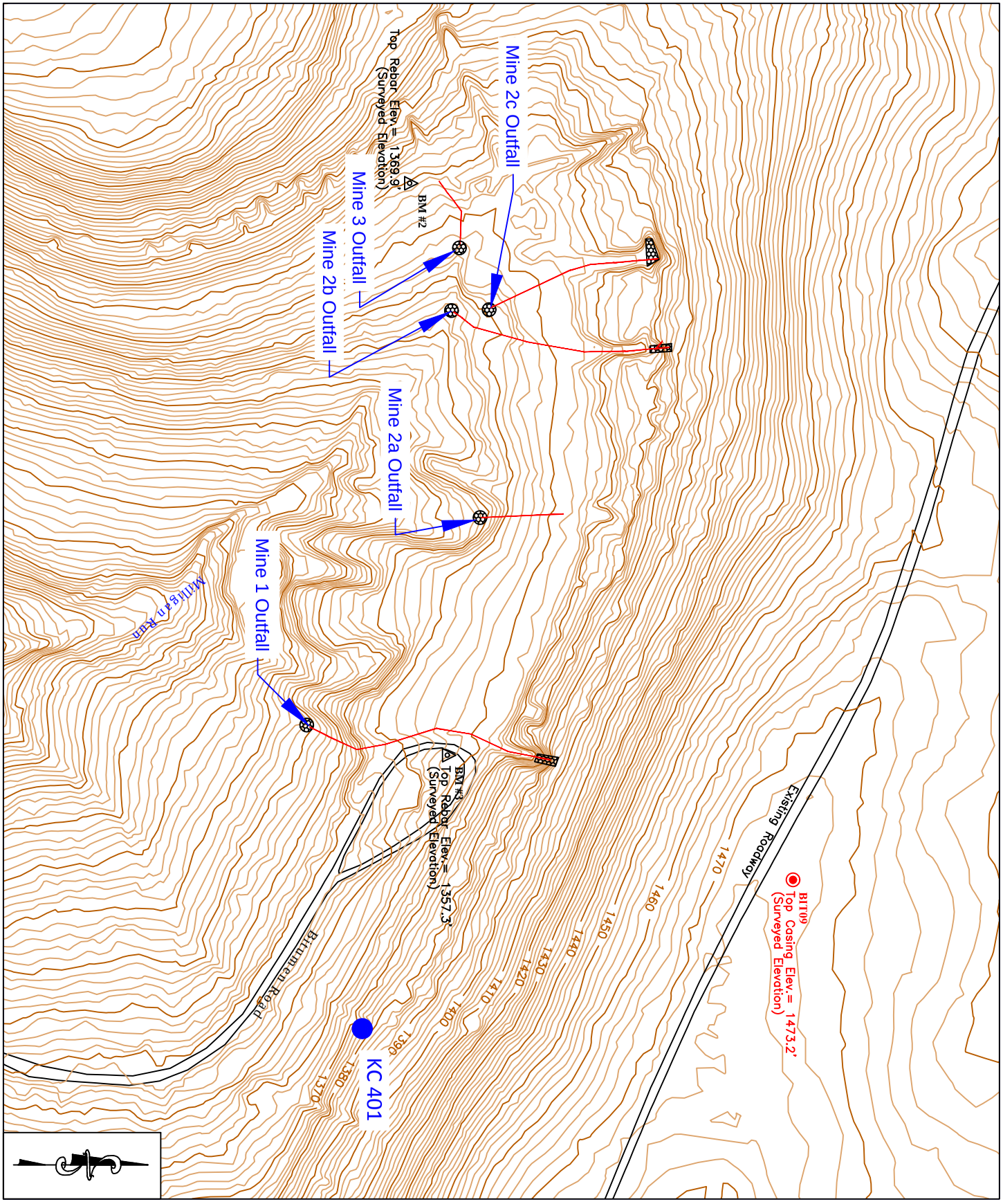
MAP B

DISCHARGE AND MONITORING WELL LOCATION MAP

MUNICIPALITY:	DATE:	FILE NAME:
NOYES TOWNSHIP	June 2011	BIT MAPS.dwg
COUNTY: CLINTON COUNTY, PA	DRAWN BY: NAW	SCALE: AS SHOWN



Mapping Souce: PADNCR PAMAP Program

LEGEND:

1" = 200'

- 10"ø PVC Pipe
- Energy Dissipater
- Perforated Pipe and Aggregate

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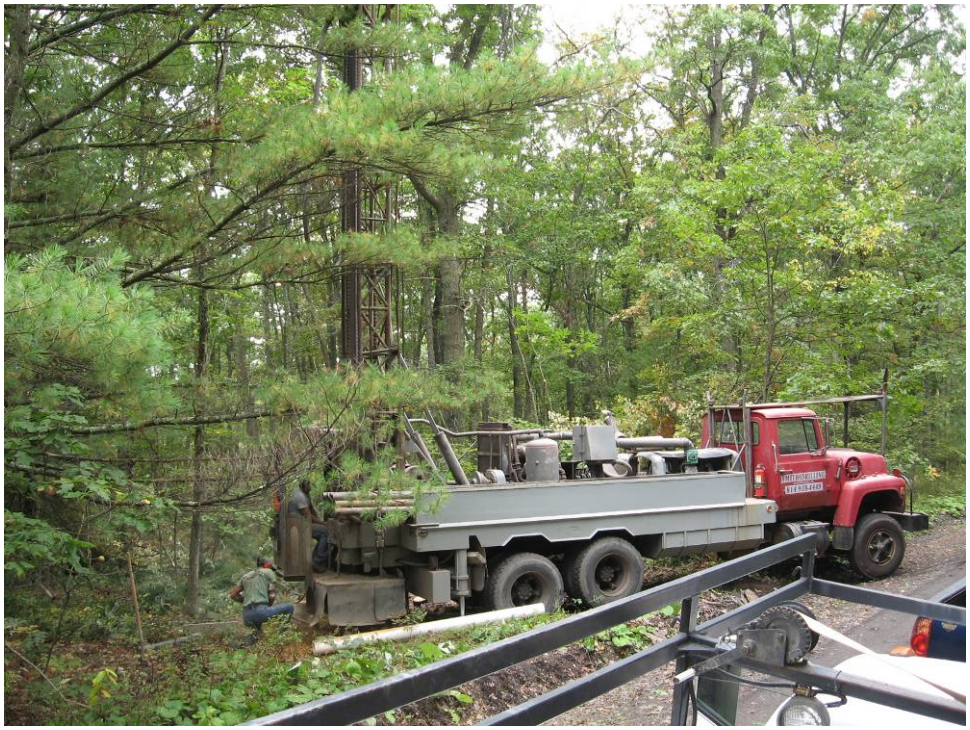
MAP C

KC204
MINE DRAIN PROJECT LOCATOIN MAP

MUNICIPALITY: NOYES TOWNSHIP	DATE: June 2011	FILE NAME: BIT MAPS.dwg
COUNTY: CLINTON COUNTY, PA	DRAWN BY: NAW	SCALE: AS SHOWN



Drilling along Cattaraugus Road

BIT 03 monitoring well casing.

KC204 discharge and H-flume

Collapsed KC204A drain

Mine 1 entry with pipe and aggregate.

Mine 2a drain was connected to the clay pipe near the left center of the photo. The wooden pipe discharging water near the right edge of the photo extended to and past the Mine 1 entry.

Mine 2b entry excavated with pipe and aggregate in place

Compacted clay dam in Mine 2b entry

Mine 2c excavated to the mine floor.

Mine 3 drain uncovered. The PVC was connected to the clay tile using a Fernco fitting and compacted clay.

Mine 2b outfall with energy dissipater

Mine 2b during spring 2011 high flow