West Virginia Mine Drainage Task Force Symposium

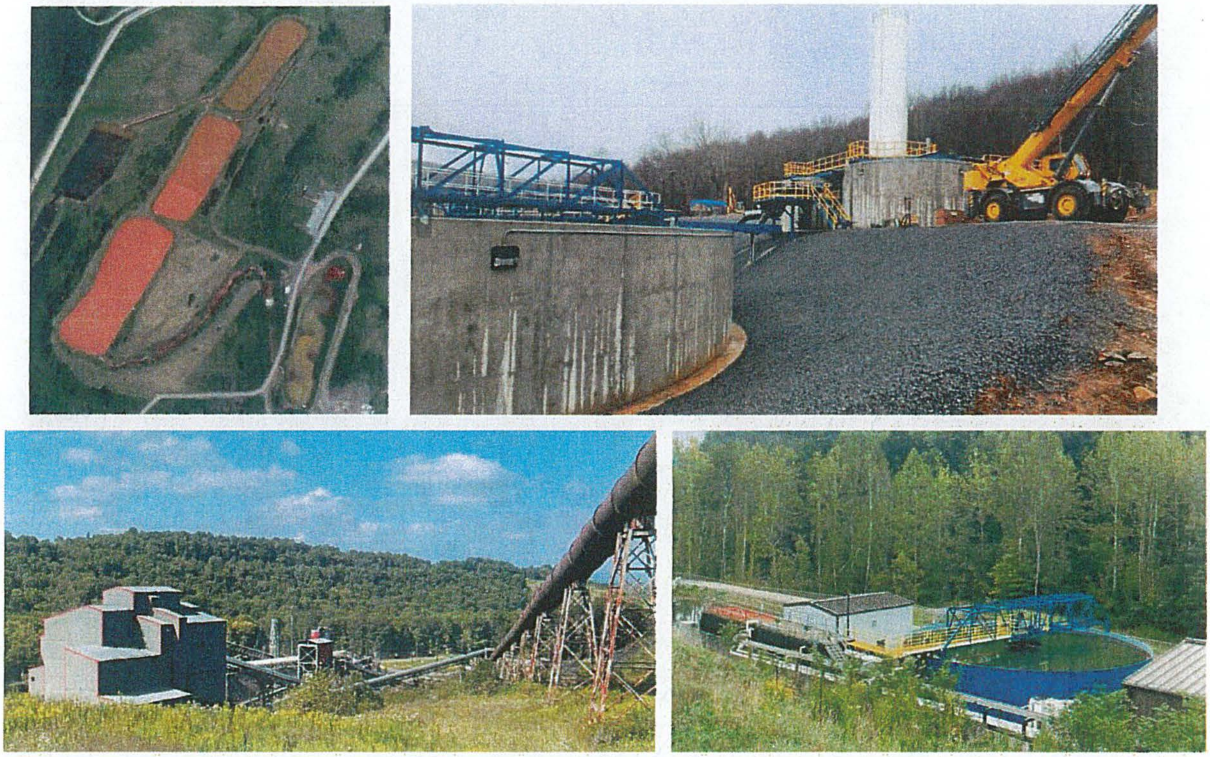
&

15th International Mine Water Association Congress

WVTF IMWA 2024

2024 Post Conference Tour

April 26 – 29



Tour Guides:

- Brent Means (1-717-919-3982, bmeans@osmre.gov) Emergency Contact
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WVTF | IMWA 2024 – Post Congress Field Trip

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Tour Itinerary

Friday, April 26	**2:00pm (14:00):** Depart Morgantown and travel 160km to: _Holiday Inn Express_ _1140 Scalp Ave. Johnstown, PA 15904_ _(40° 16’ 17” N, 78° 51’ 33” W)_
	6:00pm (18:00): Optional group dinner at: _The Fifth Alehouse (next to hotel)_ _*Cost of dinner not included in the tour cost (meals ~ $15-$20 USD)_
Saturday, April 27	**8:00am (8:00):** Depart Holiday Inn Express and travel 48km to Flight 93 Memorial. _United States National Park Service, Flight 93 Memorial_ _6424 Lincoln Hwy. Stoystown, PA 15563_ _(40° 04’ 41” N, 78° 53’ 30.73” W)_
	TOUR STOP #1 **8:45am (8:45):** Arrive at Flight 93 Memorial _(*Restrooms on site)_ Stop Highlights: • Review mining history at the Memorial • Discuss enhanced iron removal using wetland • Visit manganese removal bed (passive treatment) • Visit Memorial visitor center and points of interest • Eat provided box lunch at Memorial **1:45pm (13:45):** Depart and travel 48km to St. Michael, PA _Rosebud Mining, St. Michael Treatment Plant_ _St. Michael, PA 15951_ _(40° 19’ 53” N, 78° 46’ 13” W)_
	TOUR STOP #2 **2:30pm (14:30):** Arrive at St. Michael Treatment Plant _(*Very limited or nonexistent restrooms on site)_ Stop Highlights: • Discuss unique public/private partnership • Showcase Bethlehem Steel treatment system layout • Showcase Bethlehem Steel high density sludge treatment process • Review the treatment geochemistry • Highlight 1 minute retention time decarbonation unit, dual 64-meter welded steel Westech clarifiers, unique gravity-feed lime slaking system **4:00pm (16:00):** Depart and travel 12km back to Holiday Inn Express on Scalp Ave. in Johnstown, PA. **6:00pm (18:00):** Optional group dinner at: _Pappy’s Family Pub (next to hotel)_ _*Cost of dinner not included in the tour cost (meals ~ $15 USD)_

Sunday, April 28	**8:00am (8:00):** Depart Holiday Inn Express and travel 8km Winder, PA *Rosebud Mining, Mine 78 Coal Mining Facility* *879 Centennial Dr., Winder, PA 15963* *(40° 14' 18" N, 78° 47' 23" W)*
	TOUR STOP #3 **8:20am (8:20):** Arrive at Rosebud Mining Mine 78 *(*No restrooms)* <u>Stop Highlights:</u> • See underground coal mining surface facilities • View a coal preparation plant • Visit a coal refuse disposal facility (waste coal, sulfur, and rock pile, similar to a tailings pile for metal mining) • Learn how coal refuse piles are constructed and the ground and surface water protection strategy • Learn about the coal refuse pile reclamation plan • Visit coal refuse treatment facilities **1:45pm (13:45):** Depart and travel 48 km to Blacklick Treatment Plant *Pennsylvania Department of Environmental Protection* *Bureau of Abandoned Mine Lands* *Blacklick Treatment Plant* *Vintondale, PA 15961* *(40° 29' 4.26" N, 78° 56' 3.78" W)*
	TOUR STOP #4 **2:30pm (14:30):** Arrive at Blacklick Treatment Plant *(*Restrooms on site)* <u>Stop Highlights:</u> • Pump three mine pools to a single treatment plant • Visit a treatment plant at the 90% construction phase • See plant equipment redundancy • Review the treatment geochemistry **4:00pm (16:00):** Depart and travel 100km back to hotel in Pittsburgh, PA *Hyatt Place Pittsburgh – North Shore* *260 N Shore Dr. Pittsburgh, PA 15212*
	5:15pm (17:15): Arrive at Hyatt Place Pittsburgh hotel **Tour attendees have dinner options in area surrounding hotel*

Monday, April 29	**9:50am (9:50):** Depart Hyatt Place and travel 0.2km to National Aviary _National Aviary_ _700 Arch St. Pittsburgh, PA 15212_ _(40° 27' 12.05" N, 80° 00' 34.90" W)_
	TOUR STOP #5 **10:00am (10:00):** Arrive at National Aviary _(*Restrooms on site)_ Stop Highlights: • Mine Water and the Environment Editor in Chief, Dr. Bob Kleinmann, will be our tour guide. • View facilities and a lot of birds **12:00pm (12:00):** Eat lunch at the Aviary **1:00pm (13:00):** Depart and travel 27km to Gladden Treatment Plant _Pennsylvania Department of Environmental Protection_ _Bureau of Abandoned Mine Lands_ _Gladden Treatment Plant_ _Cuddy, PA 15031_ _(40° 20' 22.69" N, 80° 10' 12.05" W)_
	TOUR STOP #6 **1:45pm (13:45):** Arrive at Gladden Treatment Plant _(*Restrooms on site)_ Stop Highlights: • Pumps Gladden Mine Pool located in Pittsburgh Coal Seam • Net alkaline mine drainage • 50% by wt. hydrogen peroxide used to oxidize iron • External flocculation tank • Enhanced flocculation, produces 4% solids by wt. • Review the treatment geochemistry **3:30pm (15:30):** Depart and travel 15 min to hotels near Pittsburgh International Airport and then to the conference hotel in Morgantown.

TABLE OF CONTENTS

In Back of Binder

Day 1 Stop 1

U.S. National Park Service

Flight 93 National Memorial

(Lat: 40º 03’ 56.58 N, Long: 78º 53’ 21.8 W)

Stoystown, Pennsylvania

United States Department of the Interior

**OFFICE OF SURFACE MINING
RECLAMATION AND ENFORCEMENT**

Flight 93 Mining and Site History

- The Flight 93 Memorial Grounds are positioned on top of an extensive coal mining complex that started in the 1950s and ended soon after the crash of Flight 93. The complex consists of several surface and underground mines.

- Surface mining started on the Flight 93 Memorial grounds in the late 1950’s. Five (5) seams were mined (Lower, Middle, and Upper Kittanning and Lower and Upper Freeport coal seams). Maximum highwall was 325 ft. approximately 1100 acres were surface mined in and adjacent to the memorial.

- In the early 1990s, the Diamond T underground mine complex operated on the Middle and Lower Kittanning seams. The Diamond T complex ceased operations on 9/1/1998 (seals installed).

- In 1992, another underground mine was permitted on the property called the Longview mine and mined the Lower Kittanning coal seam. This mine was operating at the time Flight 93 crashed. The last coal mined in Longview occurred in July 2002. The complex was reclaimed in 2004.

- By September of 2001 site <u>surface mine</u> reclamation was mostly complete however equipment remained on site. If you remember seeing early photos of the crash site and temporary memorial, you may recall a large American flag suspended from the boom of one of the two electric draglines that remained on site. The draglines were eventually dismantled and sold however one of the dragline buckets was shipped to a foundry in Newport News VA where it was melted down and eventually incorporated into the hull metal of the USS Somerset. This U.S. Navy San Antonio Class Warship was built to honor the passengers and crew of Flight 93. The ship was commissioned on March 1, 2014 at the Philadelphia Navel Shipyard.

- In 2003 two pumping wells were installed into the Diamond T Underground Mine Middle and Lower Kittanning mine pool complex to prevent an uncontrolled surface discharge near the Flight 93 impact site. Both Diamond T mine pools are connected via a borehole. Each well pumps 900 gpm, (3,407 l/min) or a total flow of 1,800 gpm.

- A hydrated lime system was initially installed by the mining company but was replaced with a passive pond aeration system with a theoretical retention time of 1.0 week (see photo below for active vs. passive treatment comparison)

- Passive treatment oxidized all of the iron but settling the iron to less than 1.0 mg/L was problematic, especially in the winter.

- In 2012, the U.S. Office of Surface Mining awarded a grant of $312,000 to construct a 1.2 acre (0.49 Ha) polishing wetland to remove the suspended iron and a small Manganese removal bed.

- A sludge disposal line was installed into the Longview mine and a manure pump attached to a tractor is used slurry the sludge and pump it to the underground mine.

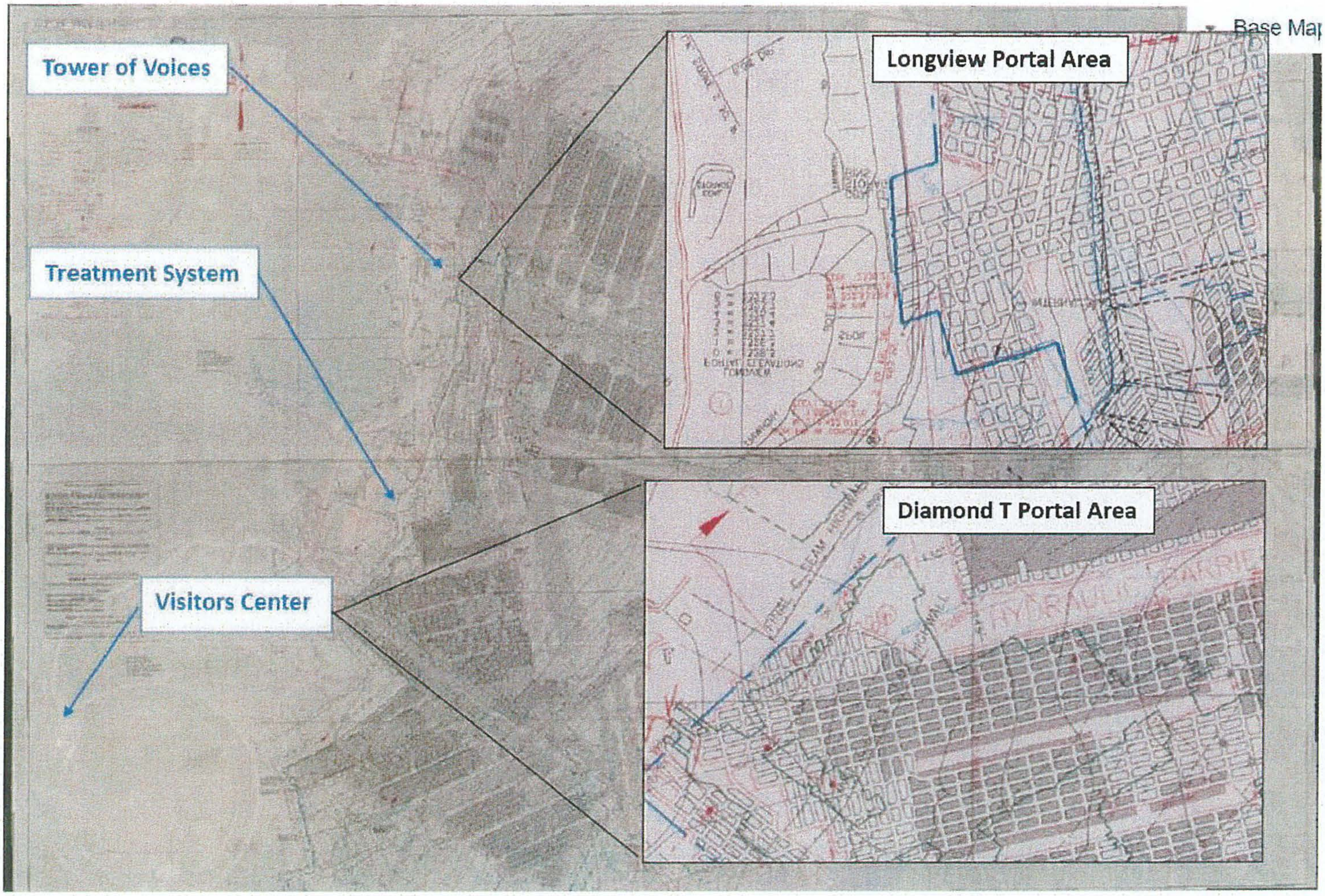
	Value	Units
pH	6.5	s.u.
Calcium	361	mg/L
Aluminum	<0.38	mg/L
Iron	47.4	mg/L
Chloride	5.7	mg/L
Magnesium	220	mg/L
Manganese	10.5	mg/L
Sodium	6.2	mg/L
Sulfate	1945	mg/L
Alkalinity	226	mg/L as CaCO3
Hot Acidity	-138	mg/L as CaCO3

Raw Water of Flight 93 Pumped Well Discharge

September 1967 PASDA Imagery

April 1994 Google Earth Imagery

September 2016 Google Earth Imagery


Base Map
Tower of Voices
Treatment System
Visitors Center
Longview Portal Area
Diamond T Portal Area
HYDRAULIC BARRIE

Diamond T Deep Mines Portal Area

Longview and Diamond T Mine Area near FL 93 Treatment System

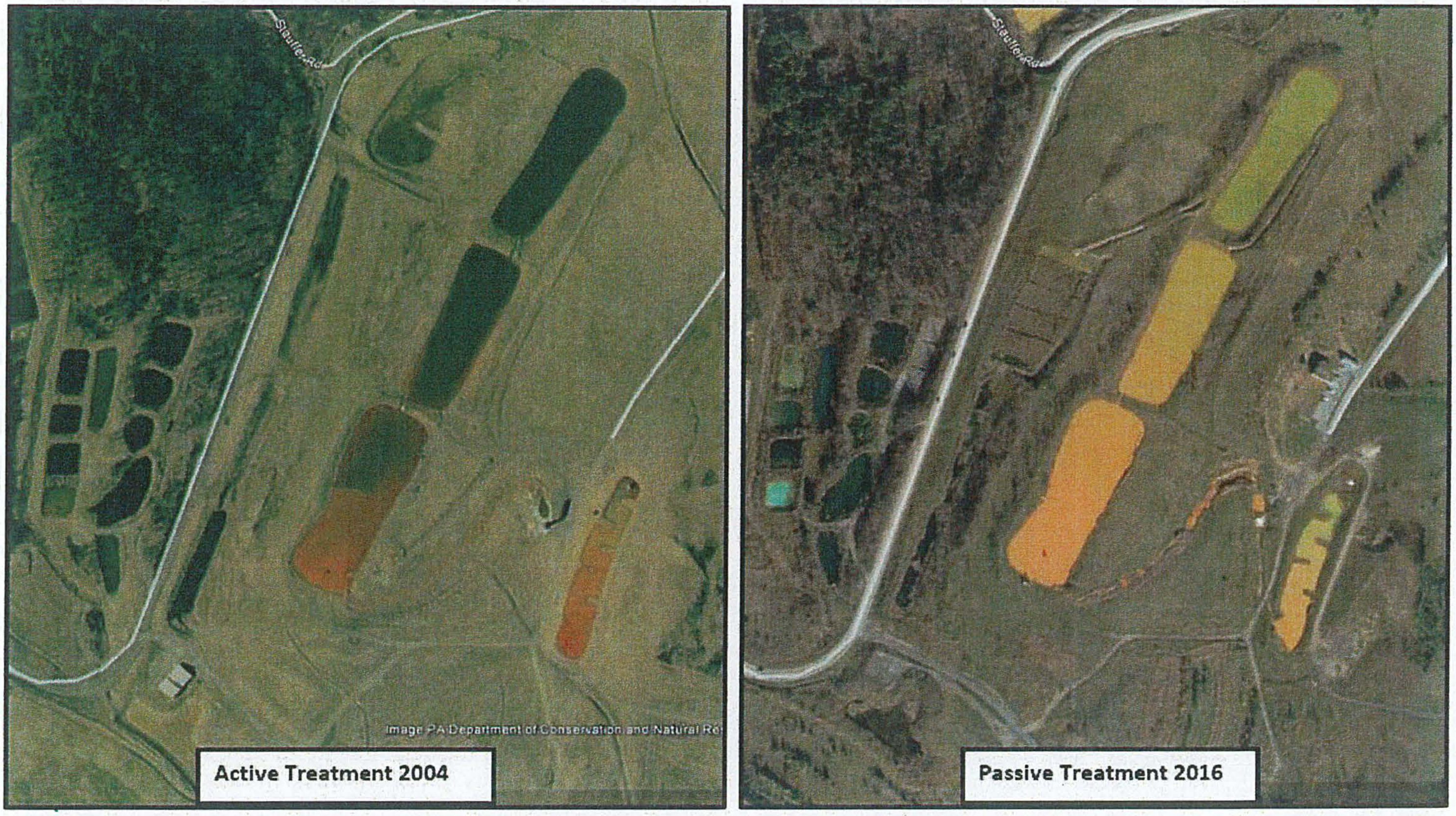


Image PA Department of Conservation and Natural Re

Active Treatment 2004

Passive Treatment 2016

FL 93 Treatment System – Active vs. Passive Treatment

Photo showing the use of lime to remove iron (left photo) compared to natural aeration (right photo).

L

Photo showing the effectiveness of polishing wetland at removing suspended iron to below detection on Hach testing kit.

Raw Water Flight 93

Date of Issue: 04/10/2024 07:36:28

DEP Bureau of Laboratories - Harrisburg
P.O. Box 1467
2575 Interstate Drive
Harrisburg, PA 17105-1467

Contact Phone Number: (717) 346-7200

NELAP - accredited by

NJ DEP - Laboratory Number: PA059
PA DEP LAP - DEP Lab ID: 22-00223

Analytical Report For
Abandoned Mine Reclamation

Sample ID: 7219 900 **Date Collected:** 03/27/2024 01:00:00 PM **Lab Sample ID:** I2024005435 **Status:** Completed

---

Name of Sample Collector: Brent Means
Date Received: 03/28/2024

County: NOT INDICATED **State:**
Municipality: NOT INDICATED

Location: NOT INDICATED
Reason: Routine Sampling
Project: NOT INDICATED
Standard Anlysis: 764
Matrix: Water

Stream Condition:

Test Codes / CAS # - Description	Reported Results	Date And Time Analyzed	Approved by	Test Method
00410M ALKALINITY AS CaCO3 @ pH 3.9	284.2 mg/L	03/28/2024 12:16 PM	JAHOGUE	SM 2320B
** Comment ** Sample bottle had headspace present before analysis				
01106A ALUMINUM, DISSOLVED (WATER & WASTE) BY ICP	<300. ug/L (U)	04/01/2024 10:05 AM	ESPAUGH	EPA 200.7
01105A ALUMINUM, TOTAL (WATER & WASTE) BY ICP	<300. ug/L (U)	04/01/2024 10:05 AM	ESPAUGH	EPA 200.7
00915A CALCIUM, DISSOLVED (WATER & WASTE) BY ICP	254.00 mg/L	04/01/2024 10:05 AM	ESPAUGH	EPA 200.7
00916A CALCIUM, TOTAL (WATER & WASTE) BY ICP	253.000 mg/L	04/01/2024 10:05 AM	ESPAUGH	EPA 200.7
01046A IRON, DISSOLVED (WATER & WASTE) BY ICP	22400.00 ug/L	04/01/2024 10:05 AM	ESPAUGH	EPA 200.7

Analytical Report For
Abandoned Mine Reclamation

Sample ID: 7219 900 **Date Collected:** 03/27/2024 01:00:00 PM **Lab Sample ID:** I2024005435 **Status:** Completed

Test Codes / CAS # - Description	Reported Results	Date And Time Analyzed	Approved by	Test Method
01045A IRON, TOTAL (WATER & WASTE) BY ICP	22500.00 ug/L	04/01/2024 10:05 AM	ESPAUGH	EPA 200.7
00925A MAGNESIUM, DISSOLVED (WATER & WASTE) BY ICP	154.00 mg/L	04/01/2024 10:05 AM	ESPAUGH	EPA 200.7
00927A MAGNESIUM, TOTAL (WATER & WASTE) BY ICP	153.00 mg/L	04/01/2024 10:05 AM	ESPAUGH	EPA 200.7
01056A MANGANESE, DISSOLVED (WATER & WASTE) BY ICP	6850.00 ug/L	04/01/2024 10:05 AM	ESPAUGH	EPA 200.7
01055A MANGANESE, TOTAL (WATER & WASTE) BY ICP	6790.00 ug/L	04/01/2024 10:05 AM	ESPAUGH	EPA 200.7
00945M Mine Drainage Total Sulfate-Colorimetric*	1118.2 mg/L	04/03/2024 05:40 PM	ALELANG	EPA 375.2
00403M pH Reported with 3.9 alk	6.2 pH units	03/28/2024 12:16 PM	JAHOGUE	SM 4500-H+ B
** Comment ** Holding time exceeded				
00935A POTASSIUM, DISSOLVED WATER & WASTE) BY ICP	5.840 mg/L	04/01/2024 10:05 AM	ESPAUGH	EPA 200.7
00937A POTASSIUM, TOTAL (WATER & WASTE) BY ICP	5.82 mg/L	04/01/2024 10:05 AM	ESPAUGH	EPA 200.7
00955A SILICA, DISSOLVED (WATER & WASTE) BY ICP	8.09 mg/L	04/01/2024 10:05 AM	ESPAUGH	EPA 200.7
00956A SILICA, TOTAL (WATER & WASTE) BY ICP*	8.05 mg/L	04/01/2024 10:05 AM	ESPAUGH	EPA 200.7
00930A SODIUM, DISSOLVED (WATER & WASTE) BY ICP	4.49 mg/L	04/01/2024 10:05 AM	ESPAUGH	EPA 200.7
00929A SODIUM, TOTAL (WATER & WASTE) BY ICP	4.49 mg/L	04/01/2024 10:05 AM	ESPAUGH	EPA 200.7
00095 SPECIFIC CONDUCTIVITY @ 25.0 C	1970.00 umhos/cm	03/30/2024 12:42 AM	MTUZINSKI	SM 2510B
00403T Temperature at which pH is measured	18.88 C	03/28/2024 12:16 PM	JAHOGUE	SM 4500-H+ B
70508 Total Acidity as CaCO3 @ pH 8.3	-197.20 mg/L	03/28/2024 01:20 PM	JANJOHN	SM 2310B
** Comment ** Sample bottle had headspace present before analysis				
00940A Total Chloride-Colorimetric	7.1 mg/L	04/03/2024 03:03 PM	MTUZINSKI	SM 4500-CL- E
70300U TOTAL DISSOLVED SOLIDS @ 180C BY USGS-I-1750	1910 mg/L	03/29/2024 10:51 AM	CLONTZ	USGS I-1750-85
** Comment ** SPC failed to compare with TDS after re-analysis				
00620A Total Nitrate Nitrogen-Colorimetric	<0.04 mg/L (U)	03/28/2024 10:25 AM	TBEAR	EPA 353.2
00530 TOTAL SUSPENDED SOLIDS	<20 mg/L (U)	03/29/2024 12:13 PM	JULLEHMAN	USGS I-3765-85
01092A ZINC, TOTAL (WATER & WASTE) BY ICP	<30.0 ug/L (U)	04/01/2024 10:05 AM	ESPAUGH	EPA 200.7

The results of the analyses provided in this laboratory report relate only to the sample(s) identified therein. Unless otherwise noted, the results presented on this laboratory report meet all requirements of the 2016 TNI standard. Sample was in acceptable condition when received by the Laboratory. Any exceptions are noted in the report.
* denotes tests that the laboratory is not accredited for

U - Indicates analysis was performed for the test but it was not detected. The sample quantitation limit is reported.

J - Indicates an estimated value, reported between Reporting Limit (RL) and Minimum Detection Limit (MDL).

Jennifer Fesler, Technical Director, Bureau of Laboratories

Into Wetland

Date of Issue: 04/10/2024 07:36:06

DEP Bureau of Laboratories - Harrisburg
P.O. Box 1467
2575 Interstate Drive
Harrisburg, PA 17105-1467

Contact Phone Number: (717) 346-7200

NELAP - accredited by

NJ DEP - Laboratory Number: PA059
PA DEP LAP - DEP Lab ID: 22-00223

Analytical Report For
Abandoned Mine Reclamation

Sample ID: 7219 901 **Date Collected:** 03/27/2024 01:20:00 PM **Lab Sample ID:** I2024005436 **Status:** IN PROCESS

Name of Sample Collector: Brent Means
Date Received: 03/28/2024

County: NOT INDICATED
State:
Municipality: NOT INDICATED

Location: NOT INDICATED
Reason: Routine Sampling
Project: NOT INDICATED
Standard Anlysis: 764
Matrix: Water

Stream Condition:

Test Codes / CAS # - Description	Reported Results	Date And Time Analyzed	Approved by	Test Method
00410M ALKALINITY AS CaCO3 @ pH 3.9	218.0 mg/L	03/28/2024 12:25 PM	JAHOGUE	SM 2320B
01106A ALUMINUM, DISSOLVED (WATER & WASTE) BY ICP	<300. ug/L (U)	03/29/2024 12:15 PM	CREITMEYER	EPA 200.7
01105A ALUMINUM, TOTAL (WATER & WASTE) BY ICP	<300. ug/L (U)	03/29/2024 12:15 PM	CREITMEYER	EPA 200.7
00915A CALCIUM, DISSOLVED (WATER & WASTE) BY ICP	255.00 mg/L	03/29/2024 12:15 PM	CREITMEYER	EPA 200.7
00916A CALCIUM, TOTAL (WATER & WASTE) BY ICP	258.000 mg/L	03/29/2024 12:15 PM	CREITMEYER	EPA 200.7
01046A IRON, DISSOLVED (WATER & WASTE) BY ICP	<100. ug/L (U)	03/29/2024 12:15 PM	CREITMEYER	EPA 200.7
01045A IRON, TOTAL (WATER & WASTE) BY ICP	547.00 ug/L	03/29/2024 12:15 PM	CREITMEYER	EPA 200.7
00925A MAGNESIUM, DISSOLVED (WATER & WASTE) BY ICP	154.00 mg/L	03/29/2024 12:15 PM	CREITMEYER	EPA 200.7

Analytical Report For
Abandoned Mine Reclamation

Sample ID: 7219 901 **Date Collected:** 03/27/2024 01:20:00 PM **Lab Sample ID:** I2024005436 **Status:** IN PROCESS

Test Codes / CAS # - Description	Reported Results	Date And Time Analyzed	Approved by	Test Method
00927A MAGNESIUM, TOTAL (WATER & WASTE) BY ICP	156.00 mg/L	03/29/2024 12:15 PM	CREITMEYER	EPA 200.7
01056A MANGANESE, DISSOLVED (WATER & WASTE) BY ICP	3450.00 ug/L	03/29/2024 12:15 PM	CREITMEYER	EPA 200.7
01055A MANGANESE, TOTAL (WATER & WASTE) BY ICP	3460.00 ug/L	03/29/2024 12:15 PM	CREITMEYER	EPA 200.7
00403M pH Reported with 3.9 alk	7.6 pH units	03/28/2024 12:25 PM	JAHOGUE	SM 4500-H+ B
00935A POTASSIUM, DISSOLVED WATER & WASTE) BY ICP	5.630 mg/L	03/29/2024 12:15 PM	CREITMEYER	EPA 200.7
00937A POTASSIUM, TOTAL (WATER & WASTE) BY ICP	5.68 mg/L	03/29/2024 12:15 PM	CREITMEYER	EPA 200.7
00955A SILICA, DISSOLVED (WATER & WASTE) BY ICP	6.24 mg/L	03/29/2024 12:15 PM	CREITMEYER	EPA 200.7
00956A SILICA, TOTAL (WATER & WASTE) BY ICP*	6.35 mg/L	03/29/2024 12:15 PM	CREITMEYER	EPA 200.7
00930A SODIUM, DISSOLVED (WATER & WASTE) BY ICP	4.54 mg/L	03/29/2024 12:15 PM	CREITMEYER	EPA 200.7
00929A SODIUM, TOTAL (WATER & WASTE) BY ICP	4.58 mg/L	03/29/2024 12:15 PM	CREITMEYER	EPA 200.7
00095 SPECIFIC CONDUCTIVITY @ 25.0 C	1909.00 umhos/cm	03/30/2024 12:45 AM	MTUZINSKI	SM 2510B
00403T Temperature at which pH is measured	18.80 C	03/28/2024 12:25 PM	JAHOGUE	SM 4500-H+ B
70508 Total Acidity as CaCO3 @ pH 8.3	-187.60 mg/L	03/28/2024 01:24 PM	JANJOHN	SM 2310B
00940A Total Chloride-Colorimetric	6.3 mg/L	04/03/2024 03:05 PM	MTUZINSKI	SM 4500-CL- E
70300U TOTAL DISSOLVED SOLIDS @ 180C BY USGS-I-1750	1870 mg/L	03/29/2024 10:51 AM	CLONTZ	USGS I-1750-85
00620A Total Nitrate Nitrogen-Colorimetric	1.07 mg/L	03/28/2024 10:27 AM	TBEAR	EPA 353.2
00530 TOTAL SUSPENDED SOLIDS	<20 mg/L (U)	03/29/2024 12:13 PM	JULLEHMAN	USGS I-3765-85
01092A ZINC, TOTAL (WATER & WASTE) BY ICP	<30.0 ug/L (U)	03/29/2024 12:15 PM	CREITMEYER	EPA 200.7

The results of the analyses provided in this laboratory report relate only to the sample(s) identified therein. Unless otherwise noted, the results presented on this laboratory report meet all requirements of the 2016 TNI standard. Sample was in acceptable condition when received by the Laboratory. Any exceptions are noted in the report.
* denotes tests that the laboratory is not accredited for

U - Indicates analysis was performed for the test but it was not detected. The sample quantitation limit is reported.

J - Indicates an estimated value, reported between Reporting Limit (RL) and Minimum Detection Limit (MDL).

Jennifer Fesler, Technical Director, Bureau of Laboratories

Out of Wetland

Date of Issue: 04/10/2024 07:35:44

DEP Bureau of Laboratories - Harrisburg
P.O. Box 1467
2575 Interstate Drive
Harrisburg, PA 17105-1467

Contact Phone Number: (717) 346-7200

NELAP - accredited by

NJ DEP - Laboratory Number: PA059
PA DEP LAP - DEP Lab ID: 22-00223

Analytical Report For
Abandoned Mine Reclamation

Sample ID: 7219 902 **Date Collected:** 03/27/2024 01:40:00 PM **Lab Sample ID:** I2024005437 **Status:** Completed

---

Name of Sample Collector: Brent Means
Date Received: 03/28/2024

County: NOT INDICATED **State:**
Municipality: NOT INDICATED

Location: NOT INDICATED
Reason: Routine Sampling
Project: NOT INDICATED
Standard Anlysis: 764
Matrix: Water

Stream Condition:

Test Codes / CAS # - Description	Reported Results	Date And Time Analyzed	Approved by	Test Method
00410M ALKALINITY AS CaCO3 @ pH 3.9	202.4 mg/L	03/28/2024 12:34 PM	JAHOGUE	SM 2320B
** Comment ** Sample bottle had headspace present before analysis				
01106A ALUMINUM, DISSOLVED (WATER & WASTE) BY ICP	<300. ug/L (U)	03/29/2024 12:26 PM	CREITMEYER	EPA 200.7
01105A ALUMINUM, TOTAL (WATER & WASTE) BY ICP	<300. ug/L (U)	03/29/2024 12:26 PM	CREITMEYER	EPA 200.7
00915A CALCIUM, DISSOLVED (WATER & WASTE) BY ICP	251.00 mg/L	03/29/2024 12:26 PM	CREITMEYER	EPA 200.7
00916A CALCIUM, TOTAL (WATER & WASTE) BY ICP	255.000 mg/L	03/29/2024 12:26 PM	CREITMEYER	EPA 200.7
01046A IRON, DISSOLVED (WATER & WASTE) BY ICP	<100. ug/L (U)	03/29/2024 12:26 PM	CREITMEYER	EPA 200.7

Analytical Report For
Abandoned Mine Reclamation

Sample ID: 7219 902 **Date Collected:** 03/27/2024 01:40:00 PM **Lab Sample ID:** I2024005437 **Status:** Completed

Test Codes / CAS # - Description	Reported Results	Date And Time Analyzed	Approved by	Test Method
01045A IRON, TOTAL (WATER & WASTE) BY ICP	<100.0 ug/L (U)	03/29/2024 12:26 PM	CREITMEYER	EPA 200.7
00925A MAGNESIUM, DISSOLVED (WATER & WASTE) BY ICP	151.00 mg/L	03/29/2024 12:26 PM	CREITMEYER	EPA 200.7
00927A MAGNESIUM, TOTAL (WATER & WASTE) BY ICP	153.00 mg/L	03/29/2024 12:26 PM	CREITMEYER	EPA 200.7
01056A MANGANESE, DISSOLVED (WATER & WASTE) BY ICP	217.00 ug/L	03/29/2024 12:26 PM	CREITMEYER	EPA 200.7
01055A MANGANESE, TOTAL (WATER & WASTE) BY ICP	214.00 ug/L	03/29/2024 12:26 PM	CREITMEYER	EPA 200.7
00945M Mine Drainage Total Sulfate-Colorimetric*	1067.0 mg/L	04/03/2024 05:56 PM	ALELANG	EPA 375.2
00403M pH Reported with 3.9 alk	7.2 pH units	03/28/2024 12:34 PM	JAHOGUE	SM 4500-H+ B
** Comment ** Holding time exceeded				
00935A POTASSIUM, DISSOLVED WATER & WASTE) BY ICP	5.690 mg/L	03/29/2024 12:26 PM	CREITMEYER	EPA 200.7
00937A POTASSIUM, TOTAL (WATER & WASTE) BY ICP	5.73 mg/L	03/29/2024 12:26 PM	CREITMEYER	EPA 200.7
00955A SILICA, DISSOLVED (WATER & WASTE) BY ICP	5.79 mg/L	03/29/2024 12:26 PM	CREITMEYER	EPA 200.7
00956A SILICA, TOTAL (WATER & WASTE) BY ICP*	5.85 mg/L	03/29/2024 12:26 PM	CREITMEYER	EPA 200.7
00930A SODIUM, DISSOLVED (WATER & WASTE) BY ICP	4.54 mg/L	03/29/2024 12:26 PM	CREITMEYER	EPA 200.7
00929A SODIUM, TOTAL (WATER & WASTE) BY ICP	4.53 mg/L	03/29/2024 12:26 PM	CREITMEYER	EPA 200.7
00095 SPECIFIC CONDUCTIVITY @ 25.0 C	1898.00 umhos/cm	03/30/2024 12:48 AM	MTUZINSKI	SM 2510B
00403T Temperature at which pH is measured	18.95 C	03/28/2024 12:34 PM	JAHOGUE	SM 4500-H+ B
70508 Total Acidity as CaCO3 @ pH 8.3	-176.20 mg/L	03/28/2024 01:28 PM	JANJOHN	SM 2310B
** Comment ** Sample bottle had headspace present before analysis				
00940A Total Chloride-Colorimetric	6.6 mg/L	04/03/2024 03:06 PM	MTUZINSKI	SM 4500-CL- E
70300U TOTAL DISSOLVED SOLIDS @ 180C BY USGS-I-1750	1846 mg/L	03/29/2024 10:51 AM	CLONTZ	USGS I-1750-85
** Comment ** SPC failed to compare with TDS after re-analysis				
00620A Total Nitrate Nitrogen-Colorimetric	0.64 mg/L	03/28/2024 10:30 AM	TBEAR	EPA 353.2
00530 TOTAL SUSPENDED SOLIDS	<20 mg/L (U)	03/29/2024 12:13 PM	JULLEHMAN	USGS I-3765-85
01092A ZINC, TOTAL (WATER & WASTE) BY ICP	<30.0 ug/L (U)	03/29/2024 12:26 PM	CREITMEYER	EPA 200.7

The results of the analyses provided in this laboratory report relate only to the sample(s) identified therein. Unless otherwise noted, the results presented on this laboratory report meet all requirements of the 2016 TNI standard. Sample was in acceptable condition when received by the Laboratory. Any exceptions are noted in the report.
* denotes tests that the laboratory is not accredited for

U - Indicates analysis was performed for the test but it was not detected. The sample quantitation limit is reported.

J - Indicates an estimated value, reported between Reporting Limit (RL) and Minimum Detection Limit (MDL).

Jennifer Fesler, Technical Director, Bureau of Laboratories

Day 1 Stop 2

Rosebud Mining

St. Michael Mine Dewatering
and
Treatment Plant Project

St. Michael, Pennsylvania

Treatment Plant Facts:

- Project Objectives:
  - Install vertical turbine pumps into ~ 213 meter deep (~700 ft) St. Michael shaft and dewater the Maryland # 1 mine pool to facilitate active coal mining in the Mine 78 mine operated in the overlying seam
  - Perpetually treat the St. Michael discharge to remove 30% of the pollution load to the Conemaugh River Watershed to facilitate restoration
  - Effluent Limits
- Project Cost: ~ $15,000,000 USD in 2012
- Design Flow = 37,850 Liter/min (10,000 gpm)
- Maelstrom Oxidizers remove 91% of $CO_{2(aq)}$ in 1.0 minute retention time using 60 HP blowers
- Dual 120 tons silos store Pebble Quicklime (CaO).
- Prior to installing decarbonation units the facility consumed one truck of lime per day (~ 23 tons) when treating at 37,850 liters/min
- Dual slakers are used to convert pebble quicklime to hydrated lime
- Treatment plant modeled after Bethlehem Steel's treatment plant design (gravity flow of materials)
- Uses Bethlehem Steel High Density Sludge process
- Reaction tank ~ 15 min of retention time
- Two- 64 meter (210 ft) diameter Westech welded steel conventional clarifiers with rake lifts
- Manual Polymer make down system with 60,566 liters (16,000 gal) of storage
- Passive flocculation via mixing in clarifier conveyance trough and center well
- Prior to decarbonation sludge density was ~ 35% solids by wt.
- Post decarbonation sludge density is ~ 1.2 % solids by wt.

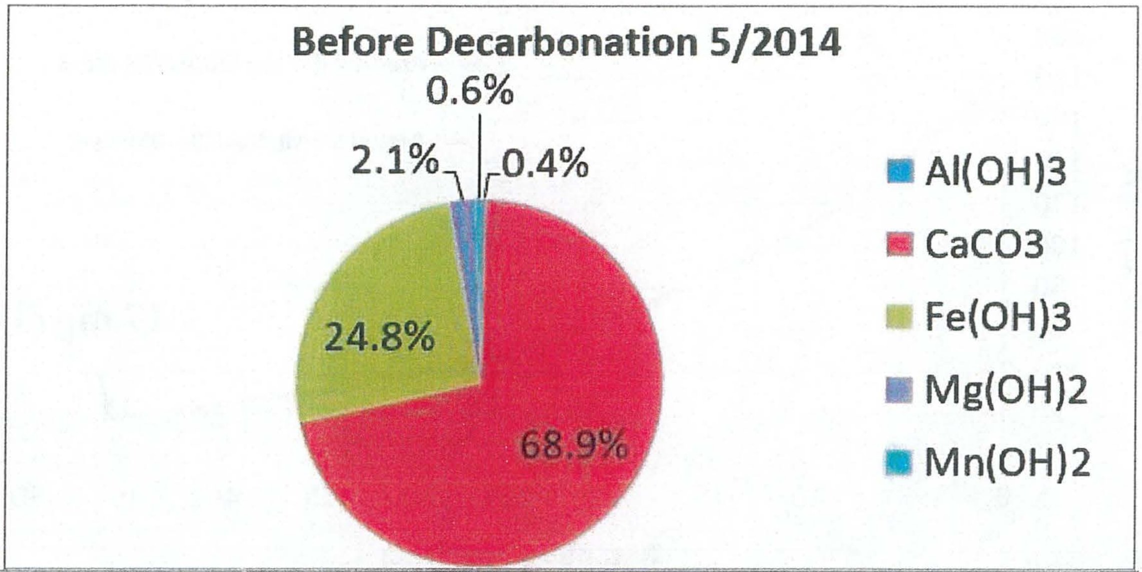
- **Centrifugal Sludge Wasting (200 hp) and Recirculation (20 hp) Pumps**

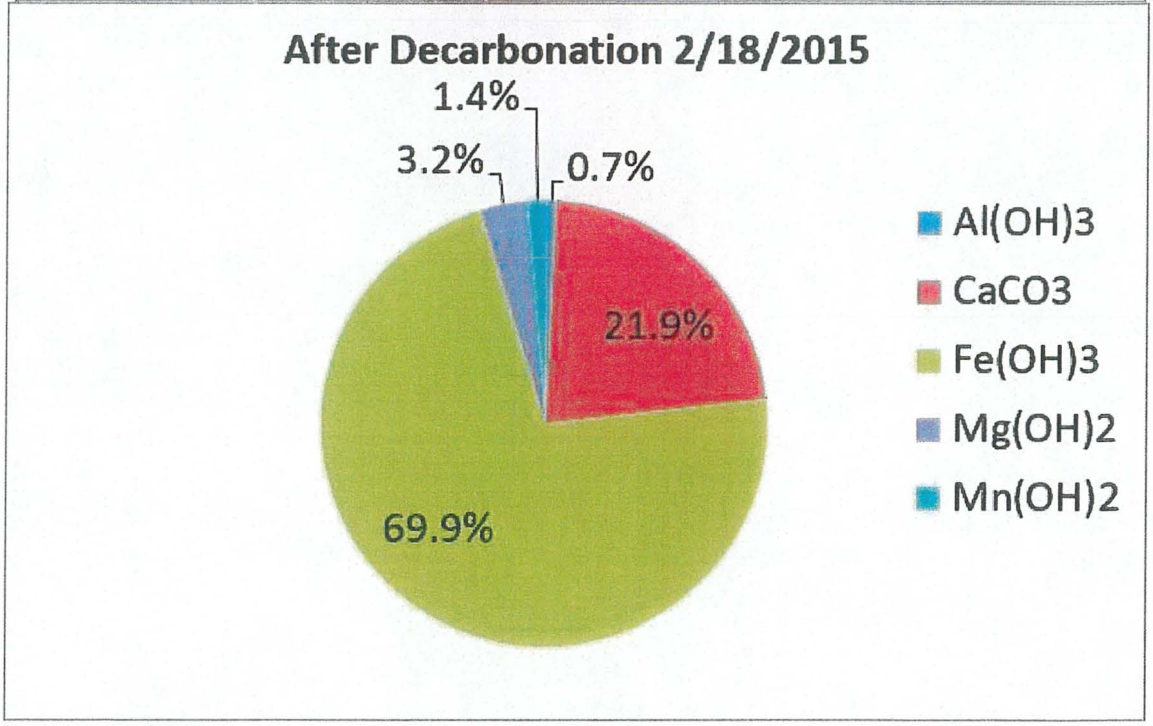
Rosebud Mining St. Micheal Treatment Plant

	Raw Water	Decarb Out	Clarifier Effluent
Date	2/18/2015		
Flow*	28768	14384	28768
Field pH	5.65	6.7	7.78
Temp	13.7	13	11.8
Alkalinity*	41.6	41	41.2
$CO_{2(aq)}$	144.3	13.05	
D-Ca	254	243	363
T-Ca	250	245	366
D-Fe	166	158	0.112
T-Fe	163	160	1.281
D-Mg	99.2	95.2	89
T-Mg	97.8	95.8	89.5
D-Mn	4.058	3.7	0.592
T-Mn	4.249	4.1	0.607
Lab pH	6	6	8.4
D-Si	17.1	15.69	1.5
T-Si	18	17.58	1.624
T-Na	28.4	29.1	27.1
SP@25	1920	1900	1953
D-Zn	0.073	0.065	<.01
T-Zn	0.088	0.088	<.01
Cl-	43.2	42.6	42.5
Sulfate			
TDS	1910	1868	1768
Hot Acidity	238.8	240	-41

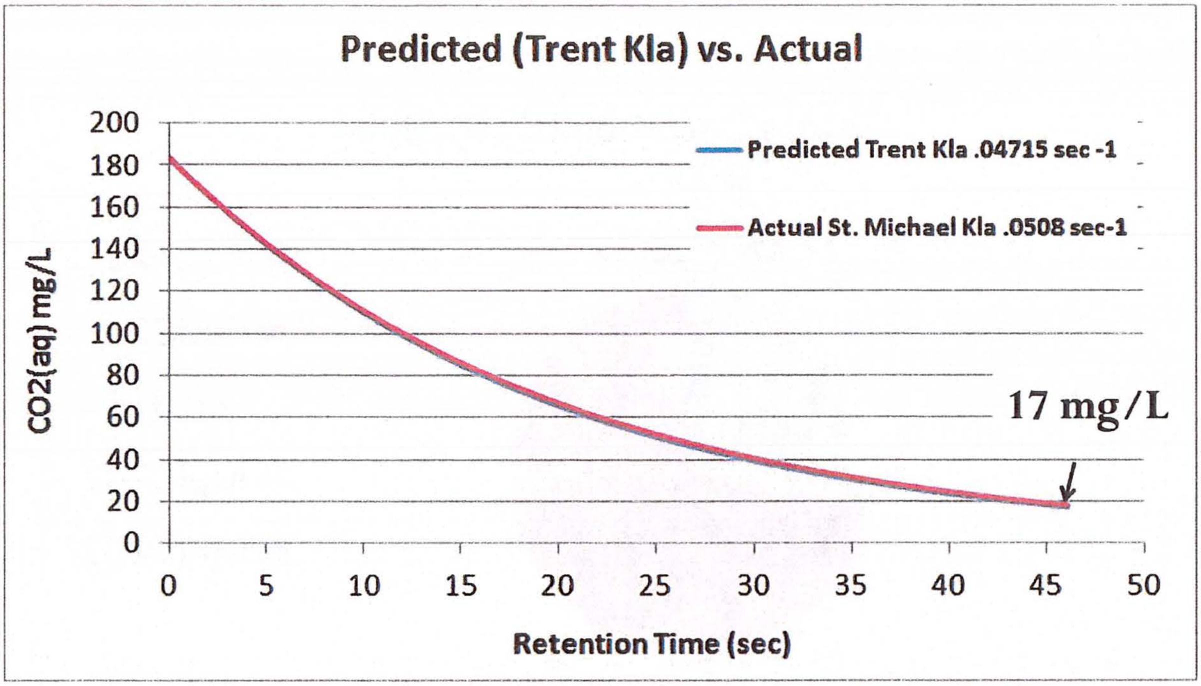
* Flow = Liters/min, Concentrations = mg/L, Alkalinity and Acidity = mg/L as $CaCO_3$

St. Michael Treatment Plant Sludge before and after decarbonation


Before Decarbonation 5/2014


After Decarbonation 2/18/2015

Prediction of Decarbonation Performance at St. Michael Treatment Plant



Overview of St. Michael Project

Welcome to the Rosebud Mining Company's St. Michael Treatment Plant, the former site of the St. Michael AML underground mine discharge. The stream receiving the treated effluent is called Topper Run, and it is a tributary of the South Fork of the Little Conemaugh River. Topper Run flows for about a quarter of a mile before entering the SFLC.

A little over a mile downstream is the confluence of the South Fork of the Little Conemaugh River with the Little Conemaugh River and at that point is roughly 9 miles upstream of the City of Johnstown. At Johnstown the Little Conemaugh River basin has a drainage area of approximately 183 square miles. The majority of this area is severely impacted by AML discharges, particularly abandoned underground mine discharges. Most of those mines were active beginning around and before the turn of the 20th century and extending through World War II. The Lower Kittanning Coal seam, a very high-quality metallurgical grade coal, was the primary seam mined.

While there are undoubtably more than several hundred mine discharges present in the basin, watershed studies and evaluations identified seven (7) large underground mine discharges as accounting for over 90% of the mine drainage pollution load in the basin. Locally they became known as and signified as the "Super Seven". The St. Michael discharge was, and it's nice to past tense was rather than is, the largest of the super seven discharges. It accounted for 30% of the pollution load in the basin.

Prior to Rosebud's efforts, the discharge flowed from a vertical mine shaft directly to Topper Run at an average flow rate of about 3500 gallons per minute. The mine shaft was a primary access point and coal extraction point for the Maryland #1 underground mine on the Lower Kittanning Coal Seam. Pumps for the treatment plant are now withdrawing water from that shaft. Here at this location, the shaft and the coal seam are about 700 feet below the surface. Geologically speaking, within this general area rock units and associated coal seams exist with what is termed a syncline or synclinal basin. This particular syncline is called the Wilmore Syncline. If you can visualize that beneath us and within the surrounding 50 or so square mile area the rock units and coal seams are shaped into a large U shaped basin or, for lack of a better term, bathtub shaped formation you can then begin to rationalize how a discharge can occur at the surface from a mine that exists 700 feet beneath our feet. The Maryland #1 mine and a number of adjacent mines throughout the Wilmore basin extend up the sides of that basin and are interconnected to form a very large underground pool of flooded abandoned mine workings. Head pressure in the workings is enough to force a discharge of mine water to surface.

That is the "in a nutshell" version of the site history, but the most interesting part of this treatment plant is that it is a private / public partnership effort. The back story is super interesting.

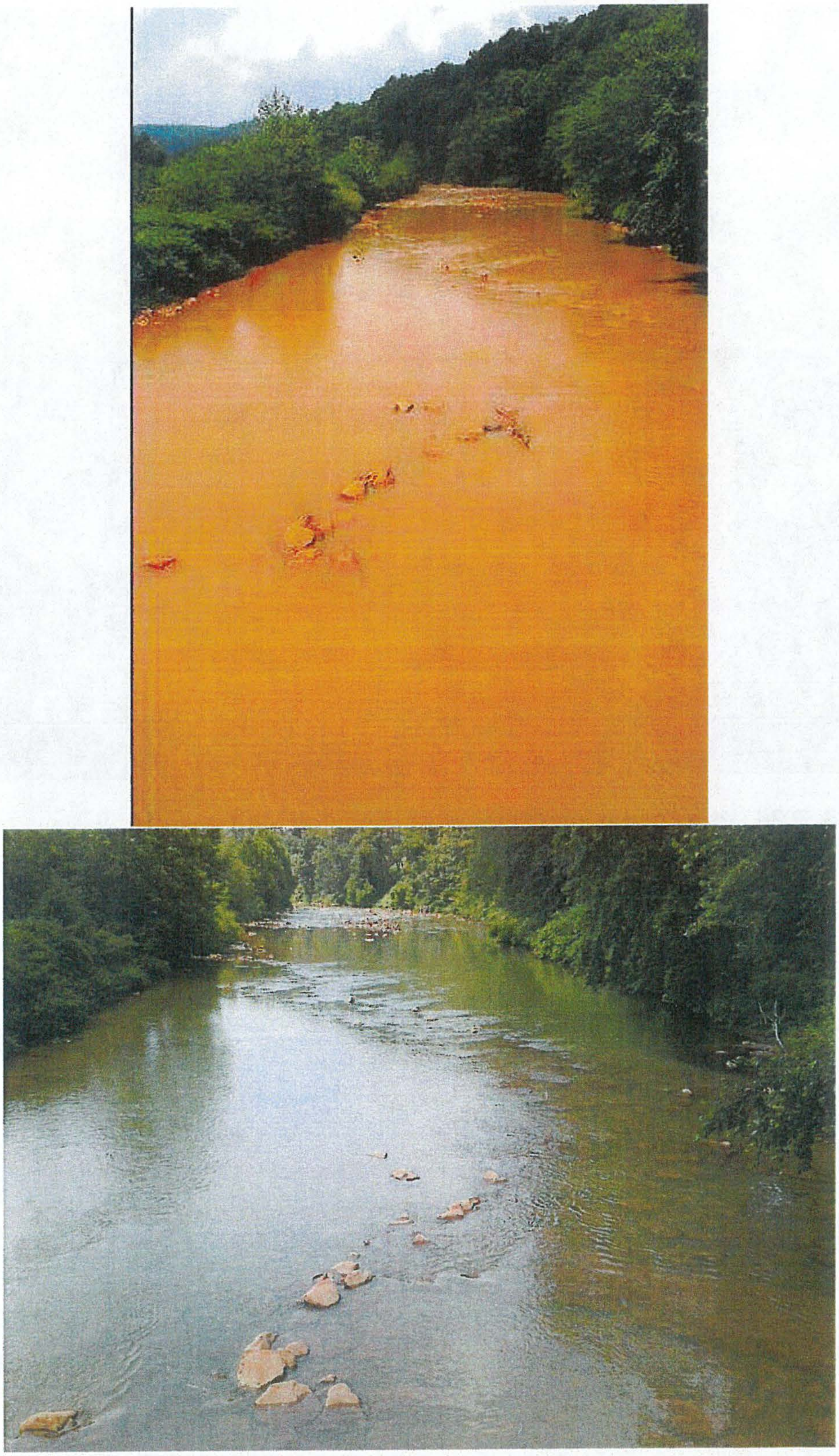
Since the onset of the AMD Set-Aside program in Pennsylvania, the AML program and local organizations were very interested in developing watershed restoration projects for the Little Conemaugh. The watershed is located in the 20th most populated city in the State of Pennsylvania so the pollution affected many people. The problem was that given the quality and magnitude of the "super seven" discharges and the fact that several large-scale active treatment facilities would be needed to achieve restoration the overall cost was prohibitive in terms of limited available AML Program funds. In terms of a cost benefit analysis many other impaired watersheds offered a more substantial resource recovery for a significantly smaller expenditure.

The St. Michael discharge and flooded mine workings in the Wilmore Basin was the cause of a very different but no less significant problem for Rosebud Mining Company. Rosebud was and is currently mining a different metallurgical grade coal seam in the basin, the Upper Kittanning Coal seam which is located about 110 feet above the abandoned Lower Kittanning Coal seam mine workings. A large portion of Rosebud's coal reserves was saturated and unable to be mined because of the flooded mine workings and associated head pressure.

Rosebud mining proposed that they would pay for the construction of the treatment plant (~ $16 - 20 million in 2012) and use the plant to dewater and treat the abandoned mine to desaturate their metallurgical coal reserves so they could continue their mining operation. In addition to paying for the treatment plant to gain access to their reserves, they offered to pay for the treatment costs for the life of their mine (~30 years) and place $15 million into a trust fund that Pennsylvania could use to help pay for treatment when their mine closed. All of this was contingent on them only having to treat the abandoned mine drainage for the duration of their mine and the $15 million trust fund could grow for the next 30 years to generate enough annual income (interest) to pay for the continued operation and maintenance of the facility. PA DEP, with concurrence from OSM and EPA, entered into a consent agreement with Rosebud to that effect. Rosebud would not be responsible for treatment after their mine closed and that PA DEP would take over the responsibility for using the trust fund money to pay for the perpetual operation and maintenance costs. Keep in mind that Rosebud didn't create the St. Michael discharge, but needed to dewater the abandoned mine to gain access to coal reserves in a seam above the flooded mine. Consequently, it didn't seem just to make the company perpetually responsible for the treatment of a discharge they didn't create.

This project clearly demonstrates how private and public ventures can be mutually beneficial and address serious environmental concerns. Pennsylvania's Abandoned Mine Land program couldn't have afforded to address the AMD problems in this watershed without assistance from private industry. Furthermore, and most importantly Rosebud's involvement at St. Michael has made additional water treatment efforts feasible. The AMD Set-aside program is currently finalizing development and beginning the design process for the Little Conemaugh Treatment Plant. This facility will treat three more of the "super seven" discharges located in the headwaters of the main stem of the Little Conemaugh. Treated effluent from this new facility and the St. Michael plant will restore main stem of the river. The before and after photo montage provided in your handout signifies the profound impact that the St. Michael plant has had on the lower sections of the river. The location is about five miles downstream at Mineral Point PA. The after photo was taken about 1 week after plant startup and is clearly worth at least 1000 words.

Handouts Below



Before and after photos of the Little Conemaugh River at Mineral Point, Pa.

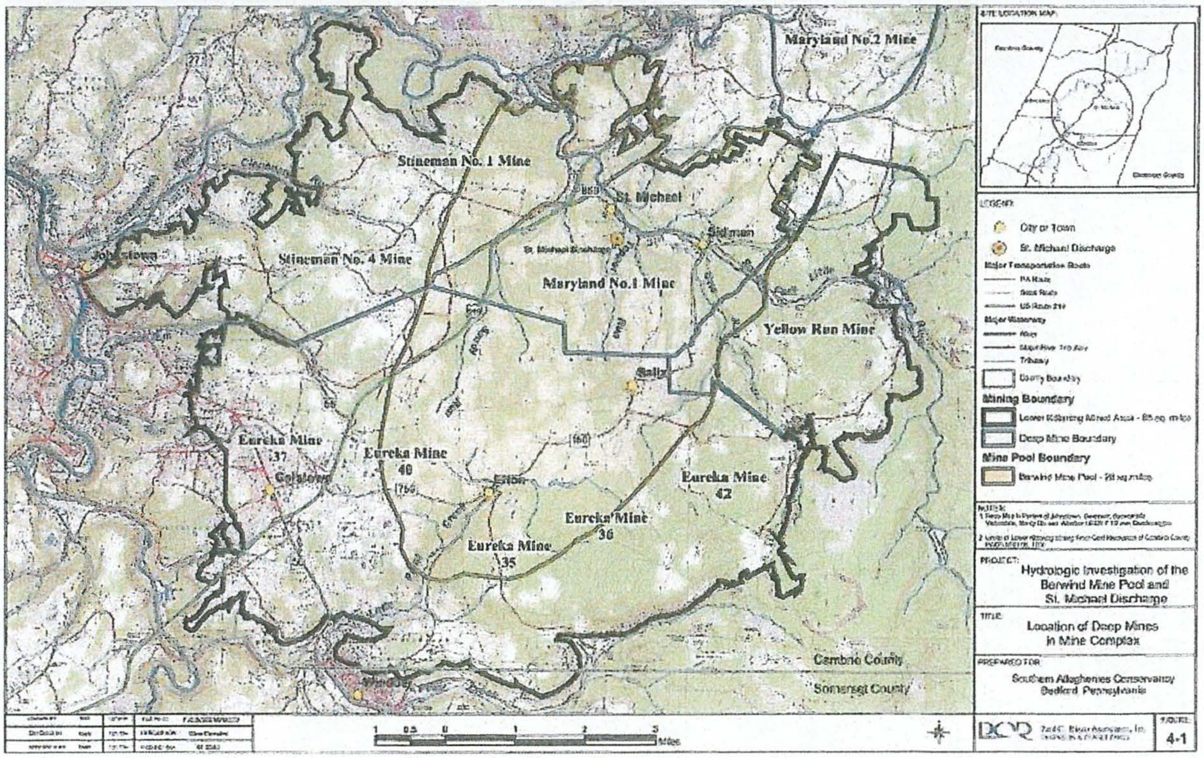
October 23, 2020 Little Conemaugh River at Mineral Point, PA

ROSEBUD MINING COMPANY
SAINT MICHAEL
WATER TREATMENT PLANT
ADAMS TOWNSHIP, CAMBRIA COUNTY, PA

Presented to

ROSEBUD MINING COMPANY

in appreciation for their
continued support of the community,
and to the St. Michael Fire Company.



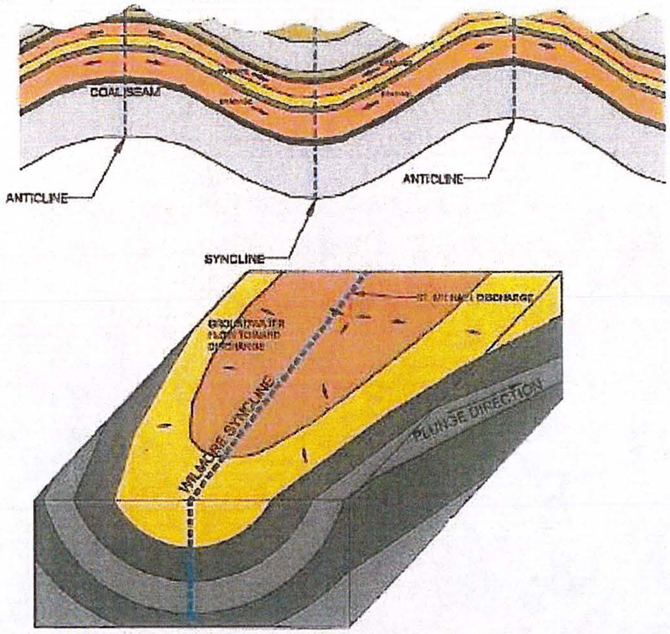
PROJECT:
Hydrologic Investigation of the
Berwind Mine Pool and
St. Michael Discharge

TITLE:
Location of Deep Mines
in Mine Complex

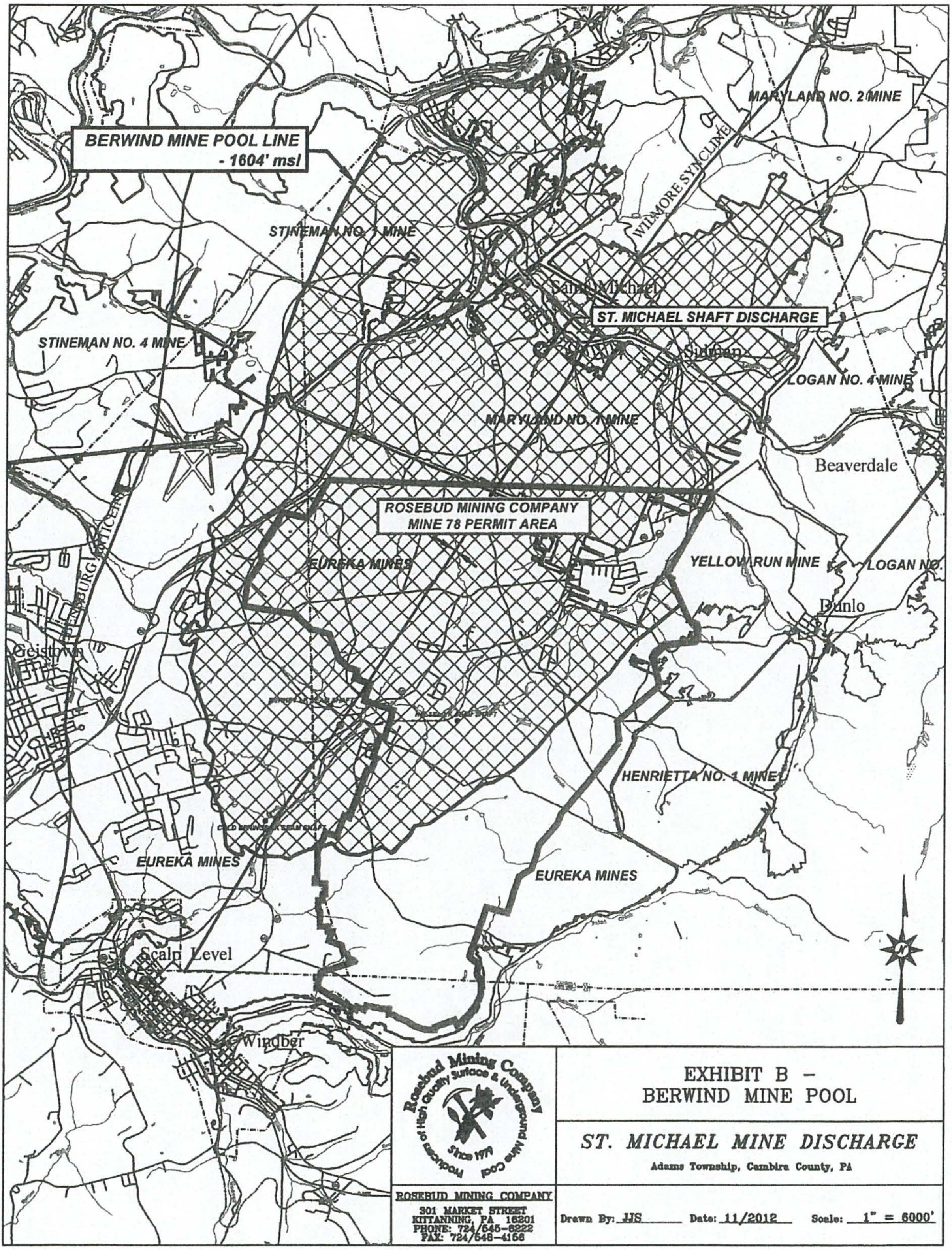
PREPARED FOR:
Southern Alleghenies Conservancy
Bedford, Pennsylvania

FIGURE:
4-1

Figure: ANTICLINE AND SYNCLINE FOLDS



- Water enters the subsurface near stratigraphic high areas known as anticlines. Groundwater then travels down gradient toward the axis of stratigraphic lows known as synclines. The Wilmore Syncline plunges toward the St. Michael Shaft were the groundwater fills a bowl like structure to form the Berwind Mine Pool. St. Michael Shaft is the discharge point of the mine pool.



ROSEBUD MINING COMPANY

301 MARKET STREET
KITTANNING, PA 16201
PHONE: 724/545-6222
FAX: 724/548-4156

EXHIBIT B –
BERWIND MINE POOL

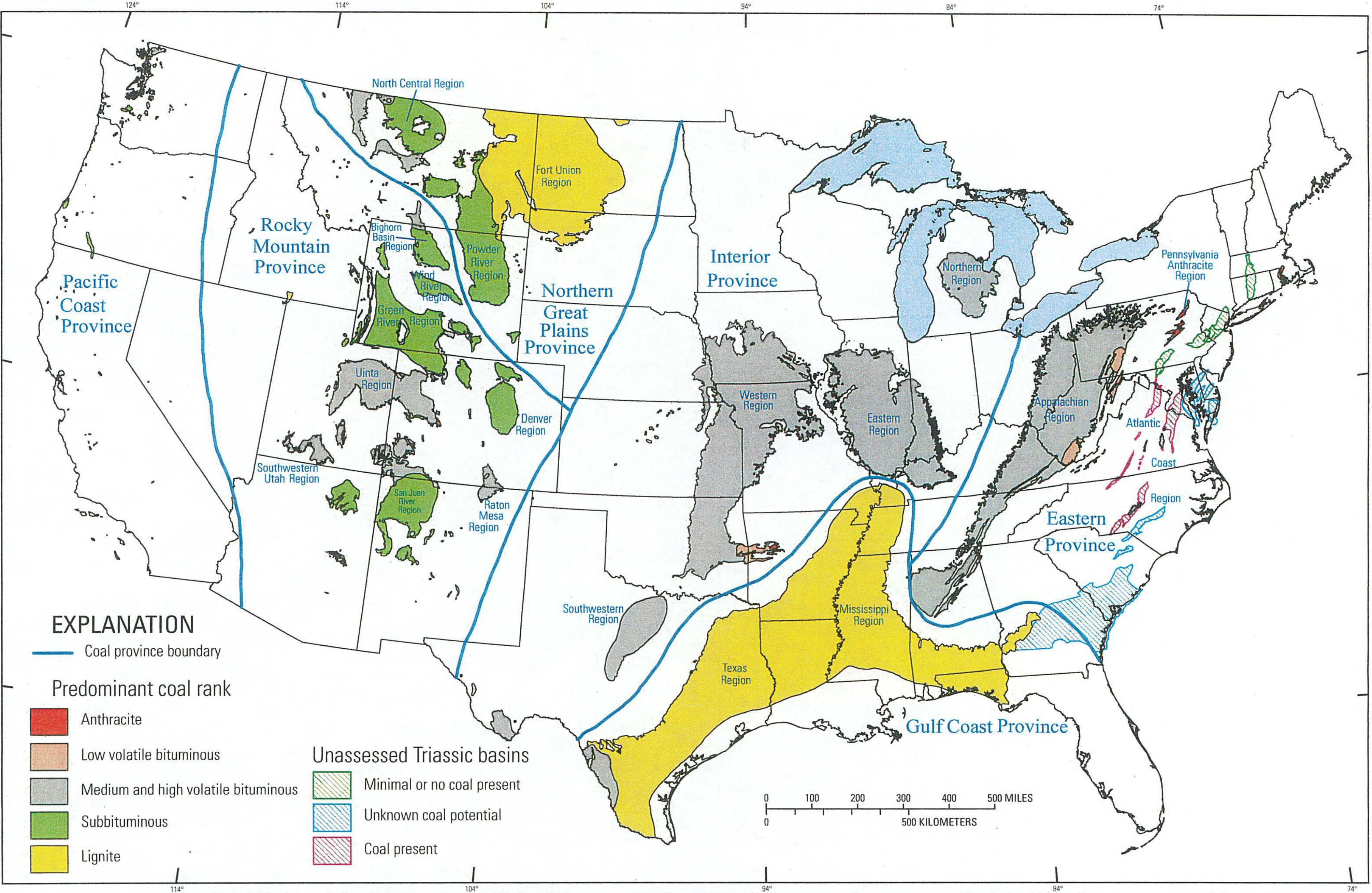
ST. MICHAEL MINE DISCHARGE

Adams Township, Cambira County, PA

Drawn By: JJS Date: 11/2012 Scale: 1" = 6000'

U.S. Department of the Interior
U.S. Geological Survey

To accompany Open-File Report 2012-1205

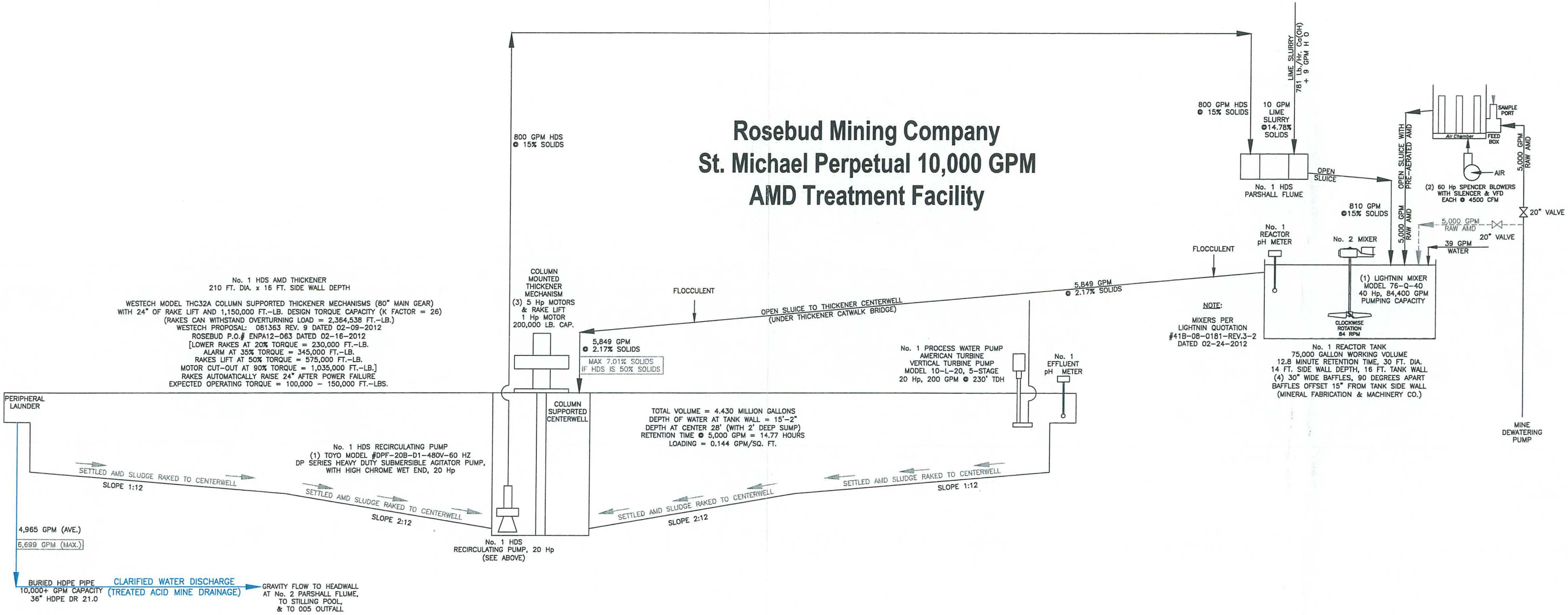


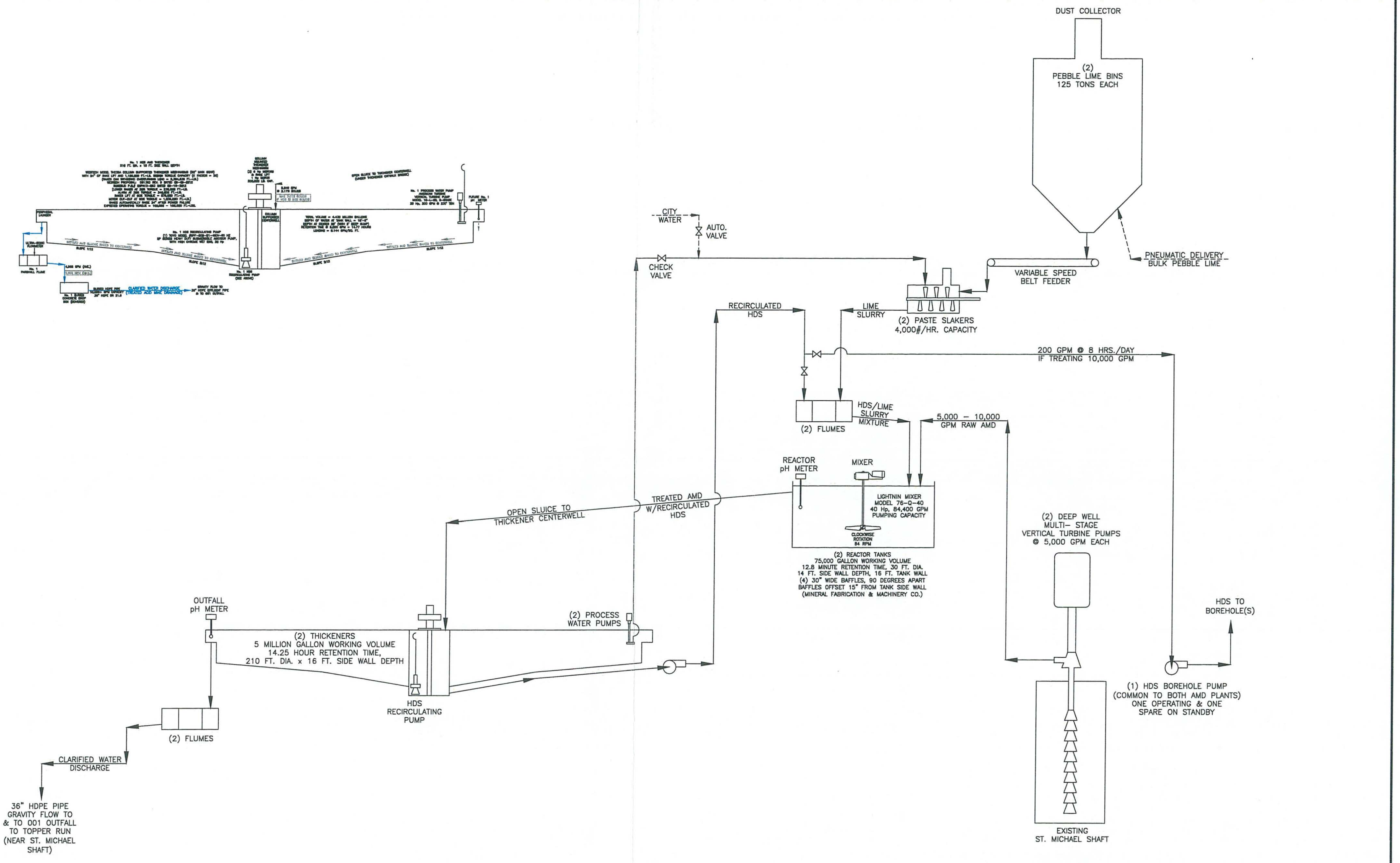
Coal Fields of the Conterminous United States—National Coal Resource Assessment Updated Version in Simplified Presentation Format

By
Joseph A. East

Map in original format and companion digital files are available at https://doi.org/10.3133/ofr20121205.

Rosebud Mining Company
St. Michael Perpetual 10,000 GPM
AMD Treatment Facility





AMD = ACID MINE DRAINAGE, HDS = HIGH DENSITY SLUDGE

NOTE: SITE IS SECLUDED, EASILY ACCESSIBLE, AND AT A BROWNFIELD LOCATION.

NOTE: NOT TO SCALE

ALL RIGHTS RESERVED

ISSUE	DATE	REVISION	BY	CHK'D
1	01/05/10	ORIGINAL	BP	

ROSEBUD MINING COMPANY

Producers of High Quality Surface and Underground Coal
Since 1979

TITLE
St. Michael Perpetual 10,000 GPM AMD Treatment Facility
Flowsheet - (2) Parallel 5,000 GPM Circuits each
Utilizing a High Density Sludge (HDS) System

SCALE	DWG. NO.	ISSUE
NONE	FS-1P	ORG

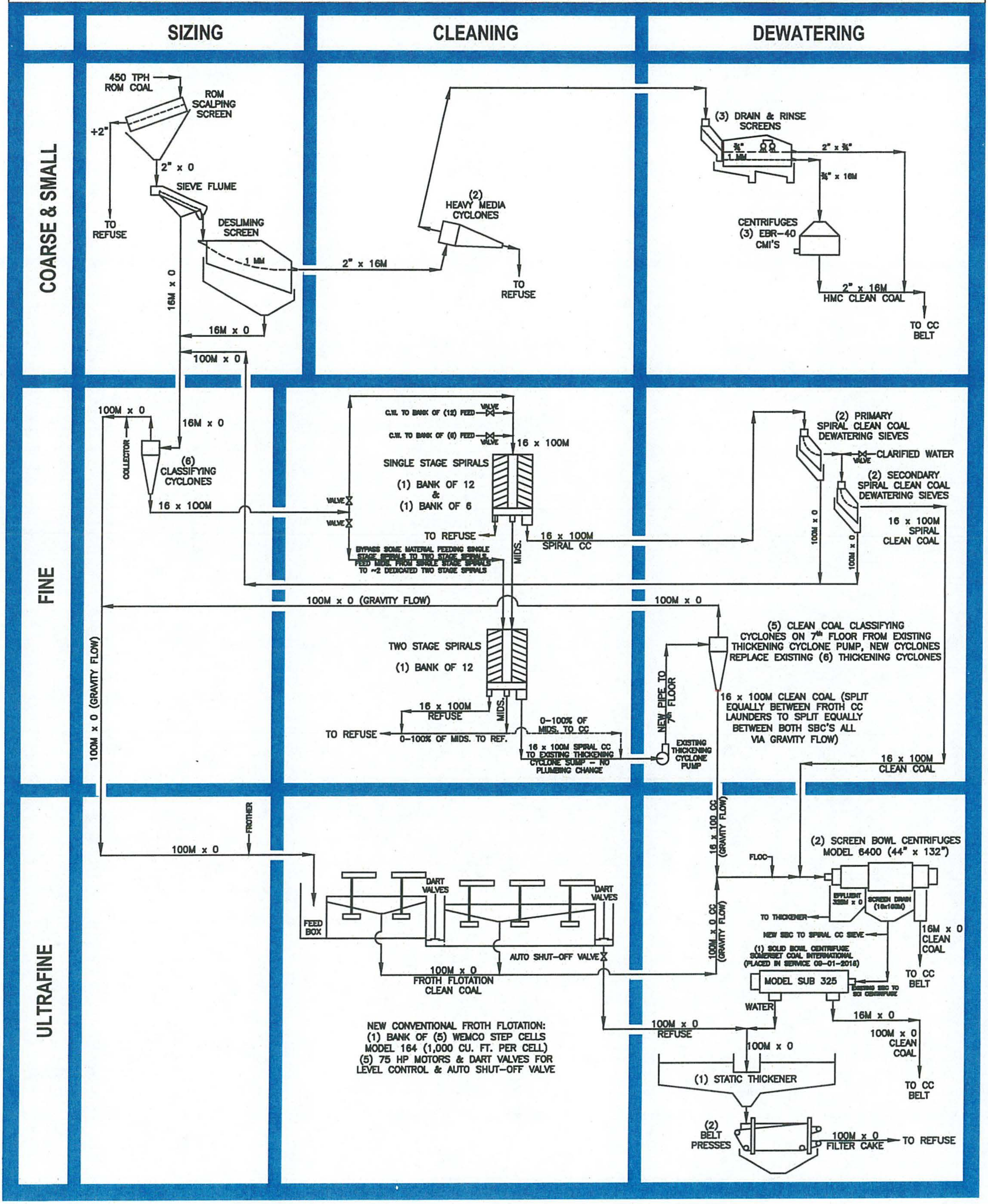
Day 2 Stop 1

Rosebud Mining

Mine 78 Underground Coal Mine, Coal Preparation Plant, and Coal Refuse Disposal Facility

Windber, Pennsylvania

GENERAL SCHEMATIC - PLANT PROCESS FLOW
ROSEBUD MINING COMPANY - MINE 78 PREPARATION PLANT - UPDATED 08-17-2021



Day 2 Stop 2

Pennsylvania Department of Environmental Protection
Bureau of Abandoned Mine Lands

Blacklick Creek Treatment Plant

Vintondale, Pennsylvania

	Redmill Dsg	**Vinton 6 (3 sisters) Dsg**	**Wehrum Shaft Dsg.**
Flow	**5488**	**8138**	**5299**
Lab pH	3.9	4.8	3.2
Lab Alkalinity	0	16	0
SC	914	2220	1196
TIC	24.90	45.4	24.5
TDS	694	2184	848
TSS	12	5	5
CO2(aq)	91	162	89.7
Al - D	6.018	6.567	21.030
Al - T	5.965	6.417	20.740
Ca - D	63.59	94.89	61.48
Ca - T	63.52	91.31	60.04
Fe - D	41.00	37.49	55.24
Fe - T	41.50	35.92	56.04
K - D	3.562	6.768	3.965
K - T	3.510	6.530	3.000
Mg - D	25.55	44.05	25.74
Mg - T	25.51	41.72	25.29
Mn - D	1.505	2.884	2.042
Mn-T	1.494	2.734	2.002
Na - D	38.49	168.50	39.71
Na - T	38.34	161.80	37.79
Si-D	21.935	23.219	27.649
Si-T	22.448	22.748	27.542
Zn - D	0.156	0.172	0.320
Zn - T	0.149	0.160	0.303
Nitrate-N	0.04	0.10	0.04
Sulfate	443.2	1451	610.3
Cl-	8.8	10.4	34.8
Hot Acidity	129.6	674	263

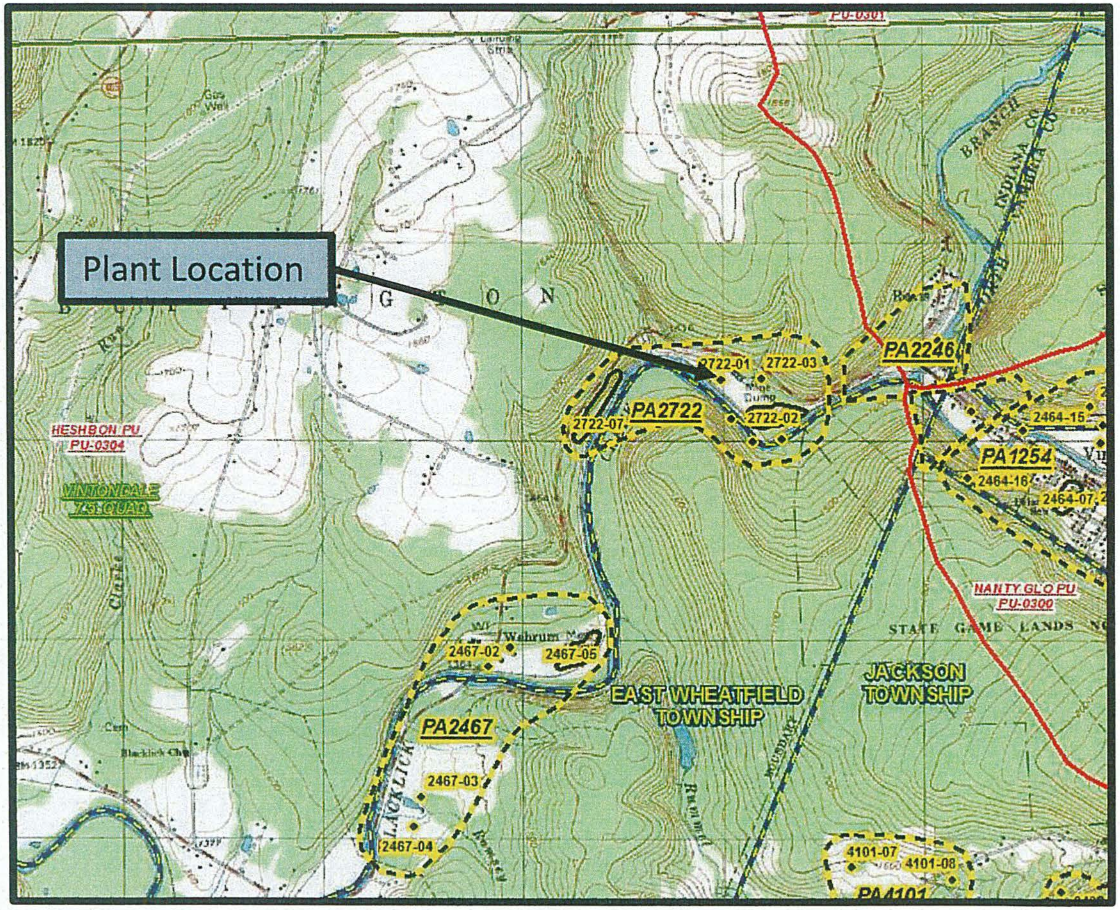
All concentrations are mg/L, Acidity and Alkalinity = mg/L as CaCO3, Flow = Liters/min

Treatment Plant Facts:

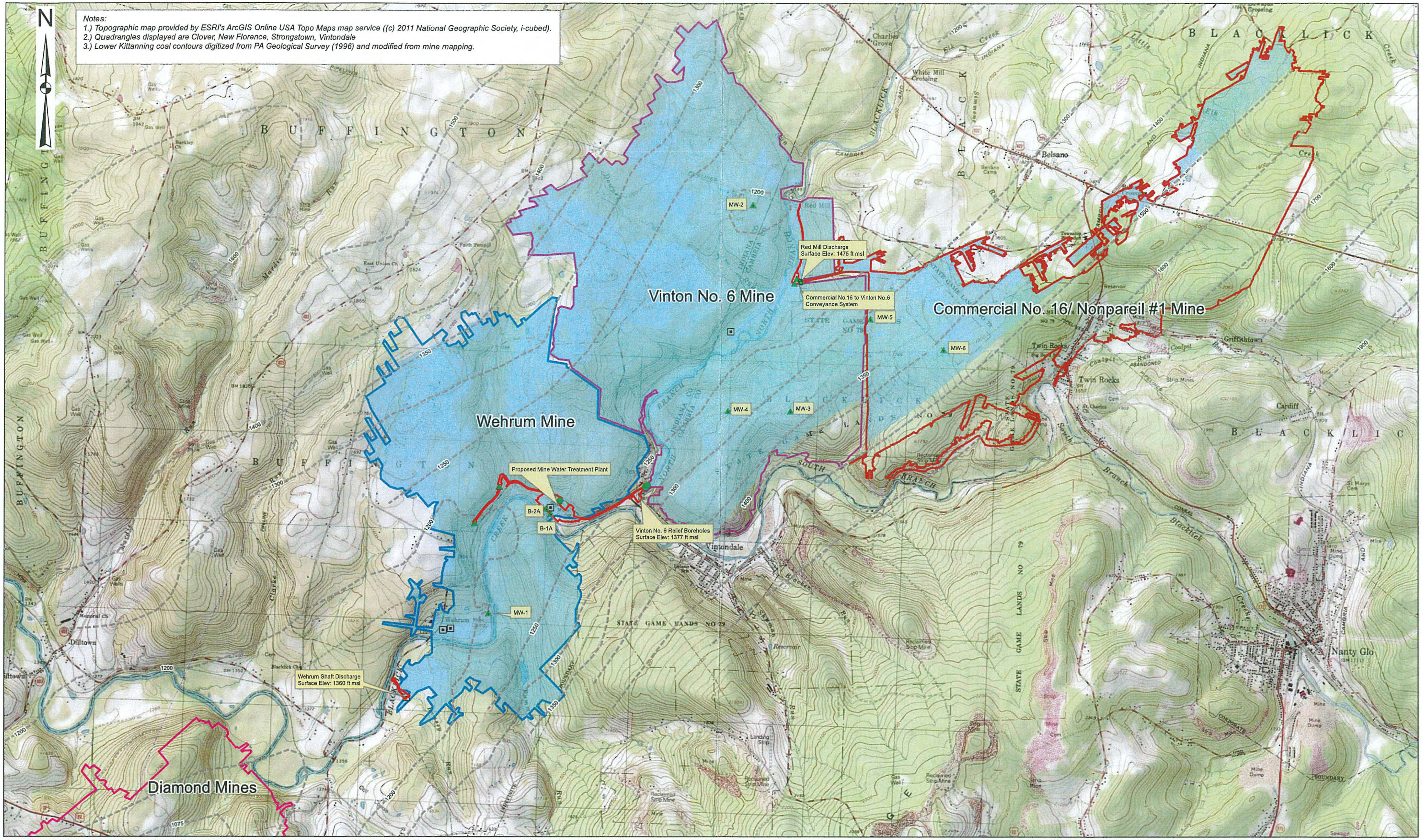
- Objective = Collect and convey three mine pool to a single treatment plant and restore 35.4 km (22 miles) of the North Branch and main stem of Blacklick Creek
- Project Cost: ~ $27,000,000 USD
- Design Flow = 18,925 Liter/min (5,000 gpm)
- All three discharges will be mixed in a equalization tank to form a homogenized solution before being conveyed to decarbonation step
- Maelstrom Oxidizers used to decarbonate mine drainage with a 1.0 minute retention time
- A 100 ton silo will hold Hydrated lime and will produce a 36% solids by wt. hydrated lime slurry for pH adjustment
- Underflow from Clarifier will be recycled back to reaction tank for Enhanced Flocculation
- Two 27.4 meter (90 ft) shaft drive conventional clarifiers with density baffles for solids liquid separation. The clarifiers have a flocculating center well.
- Sludge is expected to be between 1.0 – 2.0 % solids by wt.
- Centrifugal Sludge Wasting (60 hp) and Recirculation (20 hp) Pumps

Blacklick Creek Treatment Facility

- **Located in Buffington Township, Indiana County**
  (AML Problem Area, PA 2722)
- **Facility Design Initiated in May 2017**
  Planned completion date Spring 2019
  - **Project Number AMD 11(2722)102.1**
  - **Design Firm: Tetra Tech**
- **Receiving Stream Sequence:**
  - **North Branch Blacklick Creek _ Blacklick Creek _ Conemaugh River**


Plant Location

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION



Notes:
1.) Topographic map provided by ESRI's ArcGIS Online USA Topo Maps map service ((c) 2011 National Geographic Society, i-cubed).
2.) Quadrangles displayed are Clover, New Florence, Strongstown, Vintondale
3.) Lower Kittanning coal contours digitized from PA Geological Survey (1996) and modified from mine mapping.

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PITTSBURGH, PA 15220
T: (412) 921-7090 I F: (412) 921-4040

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DEPARTMENT OF ENVIRONMENTAL PROTECTION

Legend
- ▲ PADEP_MW_2016
- - - Lower Kittanning Bottom of Coal Elevation
- ● Proposed Mine Water Extraction
- Proposed Mine Water/Sludge Injection ▲
- ☐ Project Areas
- ▨ Approx. Extent of Mine Pool

Date: February 2, 2021	Project No.: 112C07166
Drawn by: HAT	Checked by: TAG

Scale: 1 inch = 1,500 feet
0 1,000 2,000 4,000 Feet

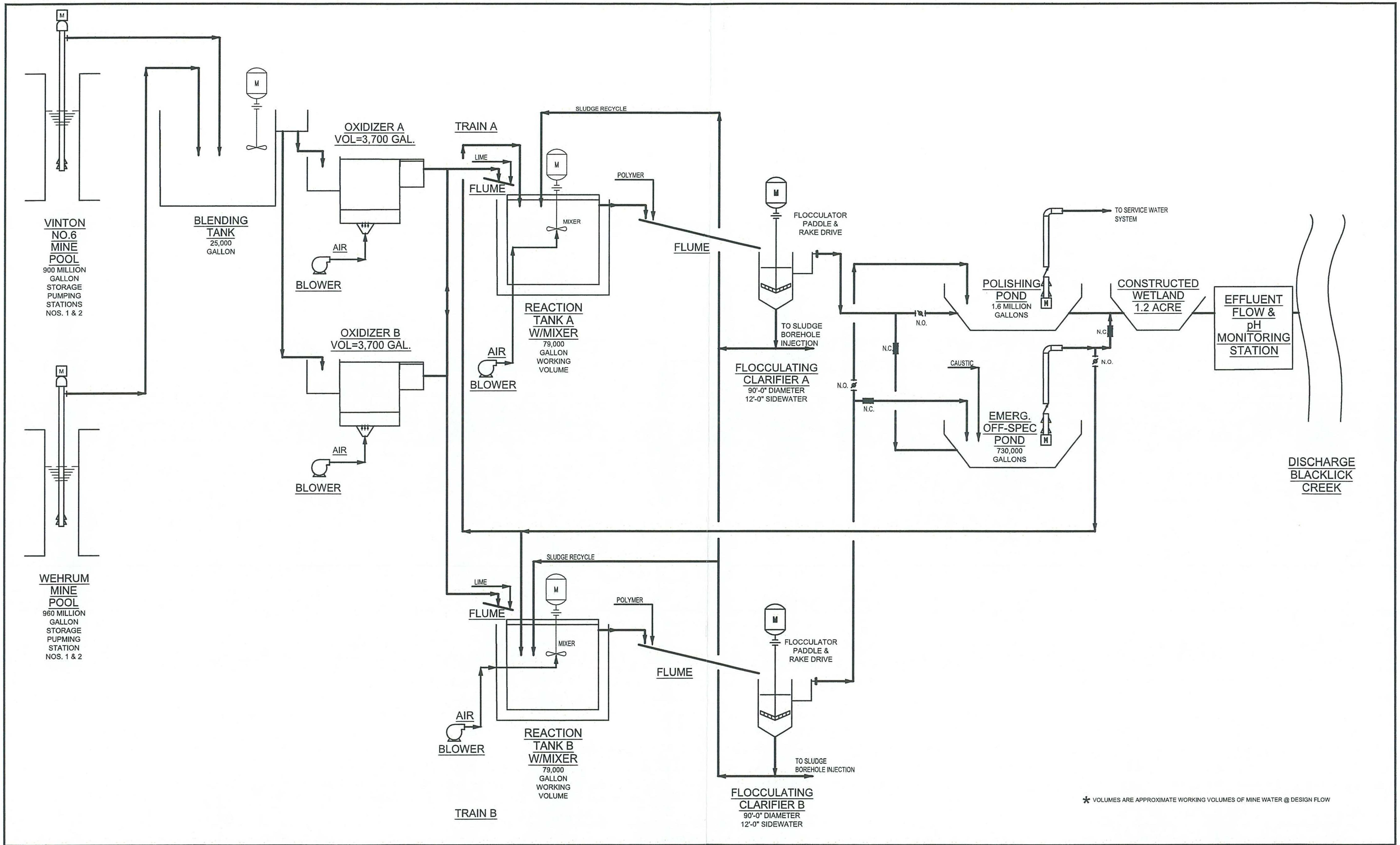
BUREAU OF CONSERVATION AND RESTORATION
BLACKLICK CREEK TREATMENT FACILITY
BLACKLICK, BUFFINGTON, & EAST WHEATFIELD TOWNSHIPS
CAMBRIA & INDIANA COUNTIES

Task No. AMD 32(2246)101.1

PROJECT LOCATION MAP

FIGURE B-1

Path: S:\Tom Gray Files - Tom Gray\PADEP BOM Programs\Blacklick Creek AMD Facility 112C07166\GIS\Blacklick Project site.mxd



* VOLUMES ARE APPROXIMATE WORKING VOLUMES OF MINE WATER @ DESIGN FLOW

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DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF ABANDONED MINE RECLAMATION
HARRISBURG OFFICE

NO.	BY	DATE	DESCRIPTION
D	JDC/GPK	09/04/2020	100% FINAL DESIGN SUBMISSION
C	JDC/GPK	12/12/2019	95% DESIGN SUBMISSION
B	JDC/GPK	2/22/2019	65% DESIGN SUBMISSION
A	JDC	10/25/2018	35% DESIGN SUBMISSION

REVISIONS

GEORGE P. KAY

SUBMITTED BY:
TETRA TECH, INC.

APPROVED BY:
BAMR PROJECT MANAGER TITLE AND OFFICE

DATE: 8/22/2018
PLOT DATE: 12/11/2018
SCALE: NONE
DRAWN BY: RWA
CHECKED BY: JDC
ACAD FILE NAME:

ALL EXISTING CONDITIONS SHALL BE CHECKED AND VERIFIED BY THE CONTRACTOR AT THE SITE

ACID MINE DRAINAGE ABATEMENT PROJECT
BLACKLICK CREEK TREATMENT FACILITY
BLACKLICK, BUFFINGTON, EAST WHEATFIELD TOWNSHIPS
CAMBRIA AND INDIANA COUNTIES
CONTRACT NO. AMD 32(2722)102.1
RECOMMENDED PROCESS
DRAWING NUMBER: FIGURE 5-1

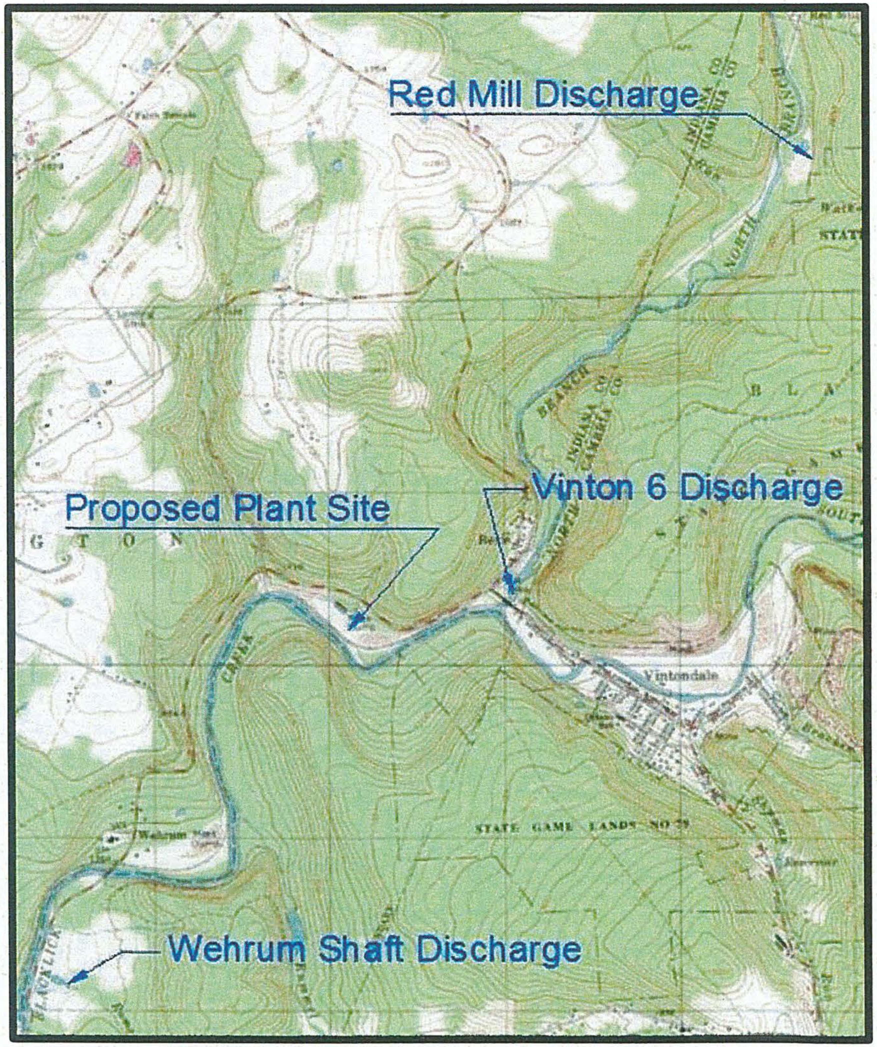
P:\Projects (After 8-23-13)\2018 Projects\PA DEP Blacklick\212C-PB-00814\Engineering\Electrical & Instrumentation\CAD\Design\212C-PB-00814 P&ID.dwg PIT ROBERT.ANGELO 9/9/2020 2:24:34 PM

Blacklick Creek Treatment Plant Project

Restoration Goals:

- Treatment of AMD to eliminate three major AMD discharges to Blacklick Creek and restore approximately 22 miles of the North Branch and main stem of Blacklick Creek to a Trout Stocked fishery

- Funding Sources:
    - Construction
        - Capital Budget Funding - $14 Million
        - AMD Set-Aside Program (As Needed)
    - Operation and Maintenance
        - AMD Set-Aside Program



pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

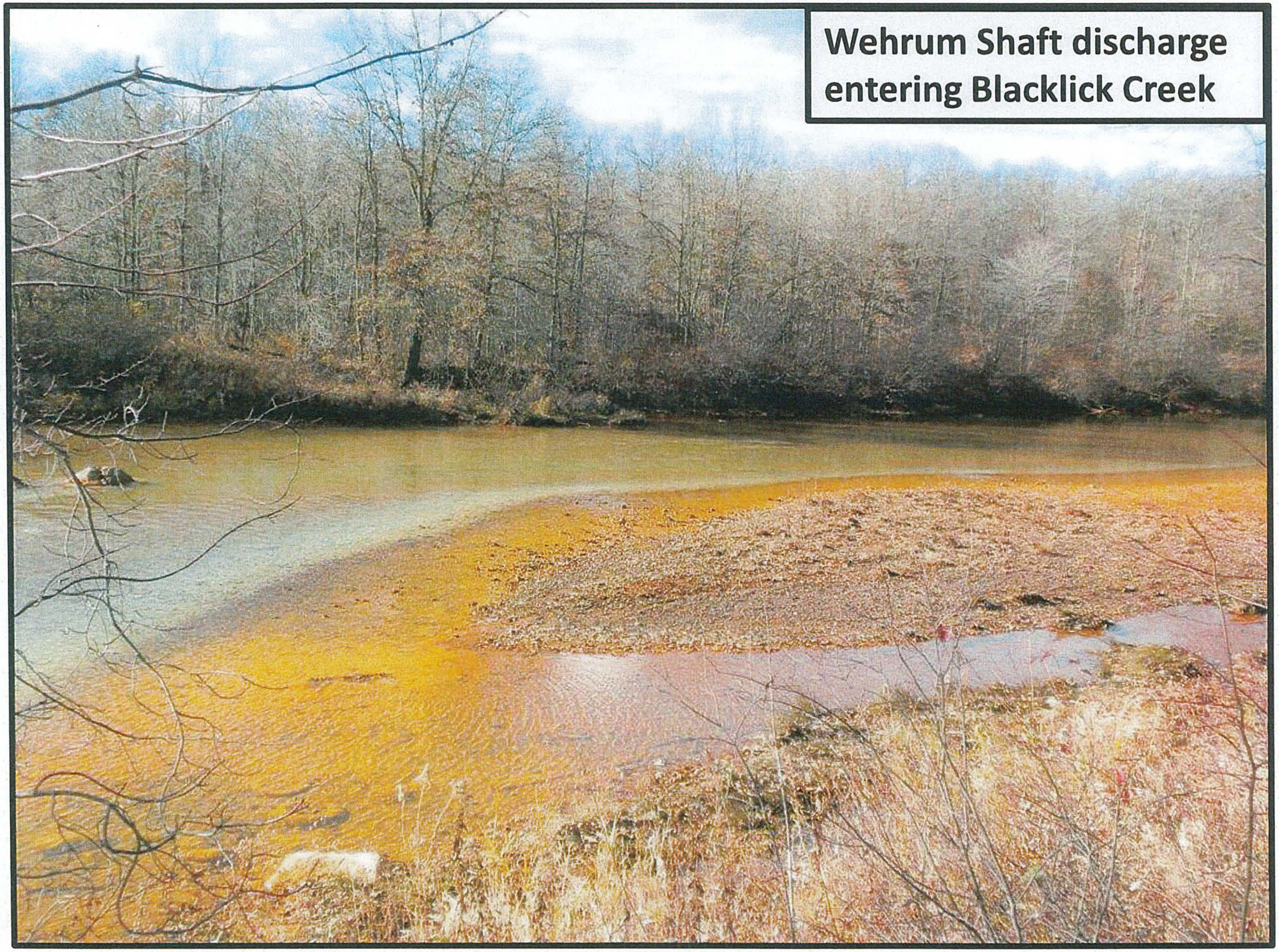
Blacklick Creek Treatment Plant Project

- **Red Mill (Commercial No. 16)** – 744 gpm average flow into the North Branch of Blacklick Creek

- **Vinton No. 6 Boreholes** – 1,080 gpm average flow into the North Branch of Blacklick Creek

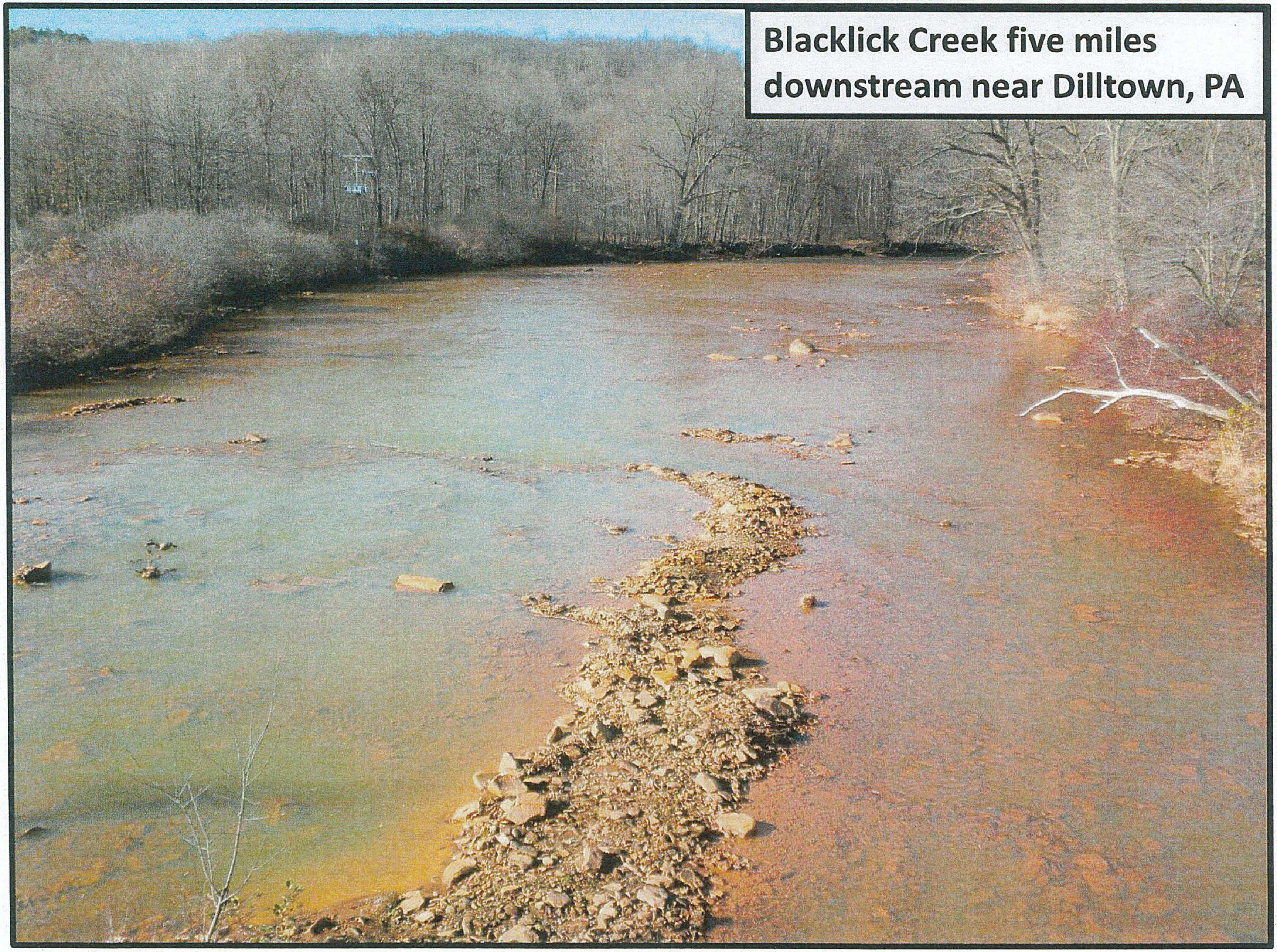
- **Wehrum Shaft** – 711 gpm average flow into the main stem of Blacklick Creek

Blacklick Creek Treatment Plant Project



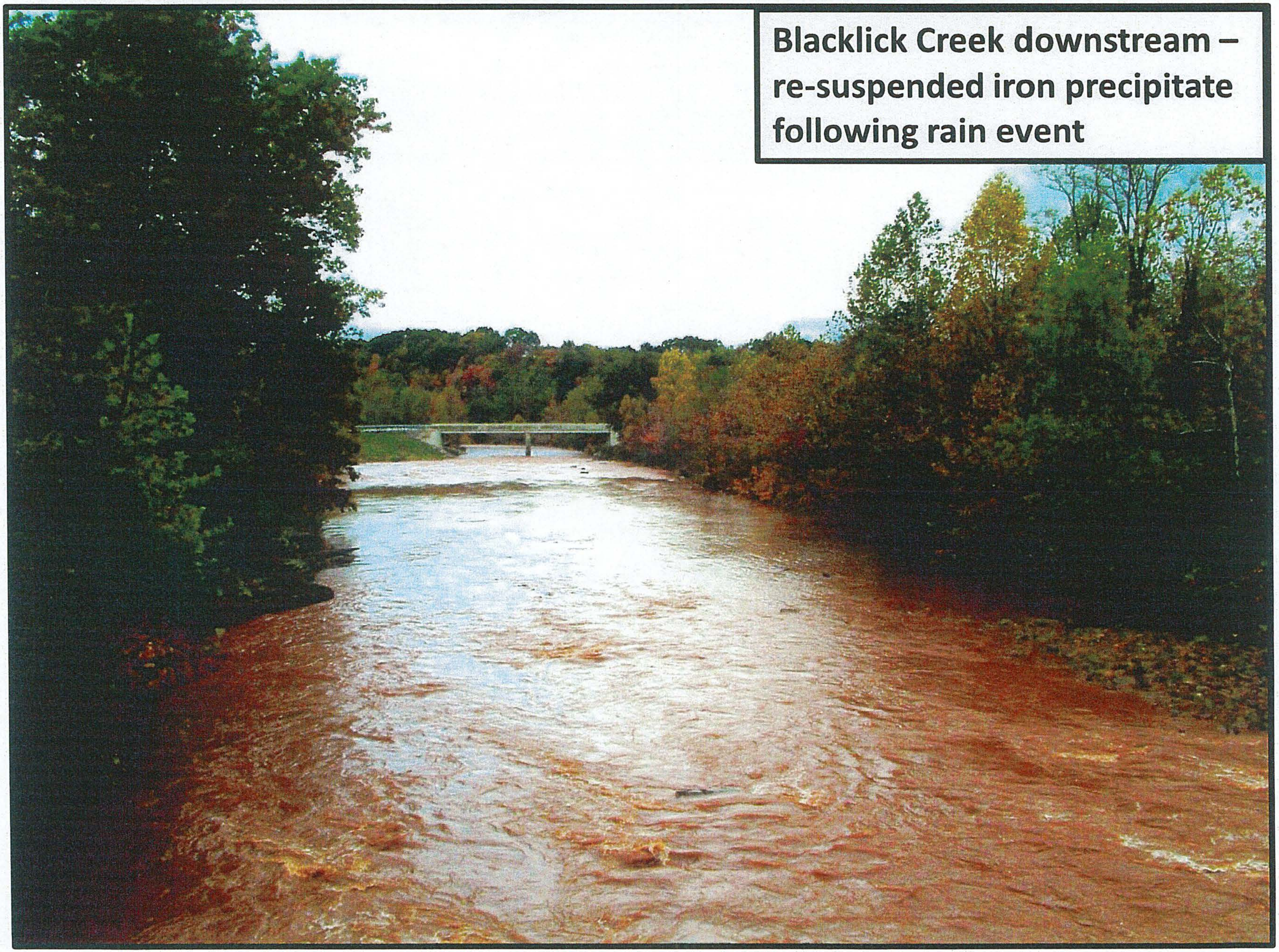
Wehrum Shaft discharge entering Blacklick Creek

Blacklick Creek Treatment Plant Project



Blacklick Creek five miles downstream near Dilltown, PA

Blacklick Creek Treatment Plant Project



Blacklick Creek downstream – re-suspended iron precipitate following rain event

Blacklick Creek Treatment Plant Project

Pollution Loading to be Removed (lbs/day)

	Acidity	Aluminum	Iron	Manganese
Red Mill	1,532	72	484	17
Vinton No. 6	5,423	42	3,098	30
Wehrum Shaft	1,832	146	416	13

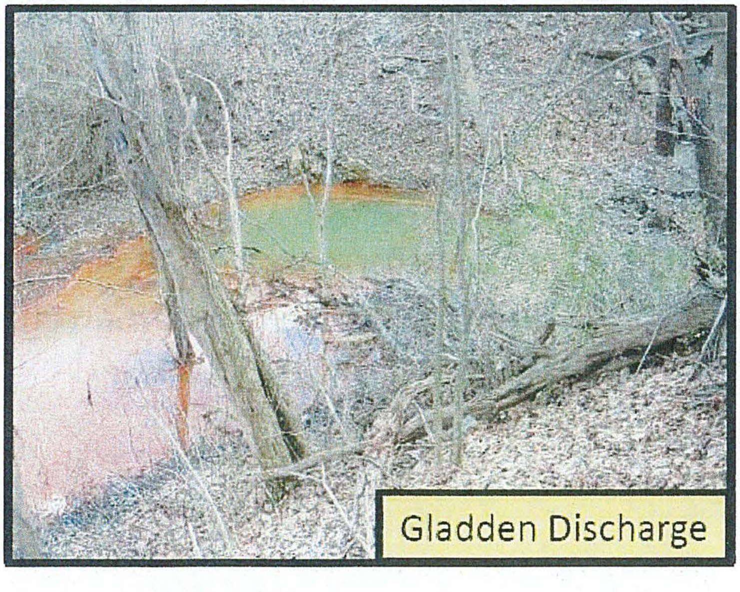
pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

Day 3 Stop 2

Pennsylvania Department of Environmental Protection
Bureau of Abandoned Mine Lands

Gladden Treatment Plant

Cuddy, Pennsylvania
(Lat: 40° 20' 23.45'' N, Long: 80° 10' 11.3'' W)



Gladden Discharge

Parameter	Unit	Influent	Decarbonation Effluent	Final Effluent
pH	S.U.	6.0	6.4	7.8
Alkalinity (T)	mg/l as CaCO3	135.2	100.2	168.2
Al (D)	mg/l	<0.3	<0.3	<0.3
Al (T)	mg/l	<0.3	<0.3	<0.3
Ca (D)	mg/l	79.46	78.55	83.72
Ca (T)	mg/l	78.08	76.34	87.37
Fe (D)	mg/l	60.21	52.02	<0.1
Fe (T)	mg/l	59.42	57.64	1.92
Mg (D)	mg/l	32.02	31.75	35.00
Mg (T)	mg/l	31.41	30.71	36.44
Mn (D)	mg/l	0.721	0.703	0.353
Mn (T)	mg/l	0.706	0.692	0.386
K (D)	mg/l	5.134	5.142	5.713
K (T)	mg/l	5.020	4.96	5.93
Si (D)	mg/l	18.03	17.12	9.73
Si (T)	mg/l	17.77	17.37	10.53
Na (D)	mg/l	193.6	201.6	271.3
Na (T)	mg/l	193.6	194.3	278.5
Spec. Cond.	umhos/cm	1524	1505	1731
Hot Acidity	mg/l as CaCO3	-22	-22.2	-158.0
Cl (T)	mg/l	110.3	107.4	118.5
TDS	mg/l	1122	1064	1204.0
N(T)	mg/l	<0.04	<0.04	<0.04
TSS	mg/l	8	62	6.0
Zn (D)	mg/l	<0.03	<0.03	<0.03
Zn (T)	mg/l	<0.03	<0.03	<0.03
SO_4	mg/l	544.7	541.8	552.5
Temp	C	12.9	12.9	
CO2 (aq)	mg/l	325.2	95.9	

Gladden Water Quality and Performance using both 50% hydrogen peroxide and 50% sodium hydroxide by wt. (Currently only use hydrogen peroxide for treatment)

Treatment Plant Facts:

- Objective = Pump Gladden mine pool to eliminate shaft discharge and restore 6.4 km of Miller Run (~ 4.0 miles) and 6.4 km of Chartiers Creek
- Construction Year: 2020
- Project Cost: ~ $13,000,000 USD (2020)
- Design Flow = 6,056 Liter/min (1,600 gpm),
- Decarbonation followed by reaction tank, flocculation tank, and clarifier.
- 50% by wt. Hydrogen Peroxide used to oxidize Fe2+
- 21,198 liter (5,600 gallon) Stainless Steel Tank to storage peroxide
- A 4.5% solids sludge is recycled back to reaction tank for enhanced flocculation
- A single 19.8 meter (65 ft) shaft drive conventional clarifier with density baffles
- Centrifugal Sludge Wasting and Recirculation Pumps

Gladden Treatment Plant Summary

The Gladden mine drainage treatment plant, located just west of Pittsburgh Pennsylvania in the Chartiers Creek watershed, South Fayette Township, Allegheny County, represents a mutli-decades effort to address and ameliorate the impacts of abandoned underground coal mine drainage in the local community. Project partners in this newly completed active mine drainage treatment facility include state agencies, such as the PA Department of Environmental Protection Bureau of Abandoned Mine Reclamation (PA DEP BAMR), The PA Fish and Boat Commission (PA FBC), local government agencies such as the South Fayette Township and local municipal authorities and most importantly local entities and citizens groups including the South Fayette Conservation Group (SFCG), Chartiers Valley Conservancy, the Allegheny Land Trust, and local landowners.

The Gladden underground mine discharge existed in the Millers Run sub watershed of Chartiers Creek for almost a century. The discharge resulted from the abandonment of the Pittsburgh Coal Company's Montour mine, which had mined the Pittsburgh coal seam throughout the area and had closed prior to the second world war. The mine discharge impacted the 4.5 miles of Millers Run and impaired an equivalent downstream section of Chartiers Creek. Because of the discharge, Millers Run's downstream segments were devoid of aquatic life. Upstream of the discharge Millers Run supported a diverse aquatic community and has been trout stocked annually by the PA FBC for more than 30 years. Upstream of the discharge, the recreational value of Millers Run was very important and somewhat unique to the local community as it was one of only a handful of streams that can support trout in Allegheny County PA.

The recently constructed facility which can treat up to 2.1 million gallons per day (MGD) of mine drainage signifies a number of notable achievements. First of all, because the discharge raw water quality is net alkaline, a chemical oxidizer can be used as a treatment reagent for iron removal rather than traditional pH adjusting chemicals such as lime or other caustic chemicals. Industrial grade Hydrogen Peroxide is used at this facility as a chemical oxidizer, and this results in a much more cost effect approach than traditional treatment methods with the added benefit of not increasing the Total Dissolved Solids (TDS) concentration in the treated effluent. Gladden is the first facility in PA that was designed from inception to be a Hydrogen Peroxide treatment plant. In the preceding decade six (6) other Commonwealth of PA owned or controlled mine drainage treatment plants have been converted from traditional pH adjustment treatment strategies to peroxide treatment achieving significant operation and maintenance (O&M) savings but the Gladden plant is the first uniquely designed facility. Secondly, a variety of project funding sources were combined to facilitate project design and construction. Primary funding sources include both the PA DEP BAMR's 30% AMD Set-aside fund, and the project also qualified for funding under the AMLER program. Subsequent support work, including stream sealing and surface water diversion, both aimed at reducing mine pool infiltration and lowering the quantity of water requiring treatment, are proposed to be funded through both PA's Growing Greener Program and OSMRE's WCAP program. A companion PA Growing Greener application has been submitted by SFCG to fund annual plant operations. Lastly, the entire plant design and construction methodology was facilitated by a PA DEP BAMR grant contracting process that was awarded to the local project sponsor, the South Fayette Conservation Group (SFCG). SFCG, through a competitive bid process, retained design engineering services, construction contractors and plant operators through the PA DEP BAMR reimbursement grant process. This methodology results in the plant being designed, constructed and placed in operation within only a 14-month time frame, despite the fact that construction occurred during the height of the global Covid pandemic.

Gladden Mine Pool Stage Storage Analysis – R.L. Beam P.G.

This document summarizes the assumptions, findings, and conclusions of the above referenced analysis of the Gladden Mine Pool. The evaluation included a detailed review of available mine mapping, an analysis of mine discharge flow information and the current mine pool fluctuations observed during plant operations to date. An ancillary Excel spreadsheet, gladden operations.xlsx, contains more detailed information. 100-scale mine mapping of the mine pool limits from elevation 880 to 900 msl were developed by Joy Scabilloni and can be found at the following server location <R:_212 - OGA\Commercial\PA DEP\00875 - Gladden\Mine Pool, pumping>. The mapping and area calculations performed by Joy defined the mine pool extent and determined the areas of Main Heading, Room and Pillar, Retreat Mined and Solid Coal respectively. I determined a mined seam thickness value of 9.0 feet based on the drill logs of the pumping well boreholes P-401 and P-402 and the results of the PA Turnpike roadway drilling data that was available at the following server location \\tts010fs2.tt.local\shared\DEP - GLADDEN 00875 WOOD\14 Operations\Turnpike Mine Grouting. These data were used to calculate available storage. Table 1 below summarizes relevant data used for the analysis.

Pool Interval	Storage Volume (gal)	Pool acres	Pool Acres Available to Pumps P-401 & P-402	Adjusted Storage Volume (gal)
895 – 900	145,302,000	197.3	197.3	145,302,000
890 – 895	111,660,000	172.6	9.1	5,918,300
885 – 890	87,842,500	135.2	4.6	2,986,600
880 – 885	77,256,300	133.9	2.8	1,622,400

Table 1; Storage volume estimates

Mine water withdraw wells P-401 and P-402 are situated such that a pool drawdown to elevations 879.4 and 893.5, respectively, is possible (based on as constructed drawings). It should be noted that the mining limits shown on map H-5112 combined with the geologic structure imply that below a coal elevation of approximately 893, the southwestern portion of the mine pool will become isolated from withdraw wells P-401 and P-402. Figure 1 below illustrates the particular area of likely separation.

Figure 1; Portion of mine map H- 5112

Coincidentally, the above-mentioned mining and geologic separation area is also contiguous with the area which the PA Turnpike Commission conducted mine grouting for the new highway construction. The files presently contained on the server contain exploratory drill hole information for this area and a map indicating hole locations and indications of where mine voids were encountered. No information is contained therein which denotes the limit of mine grouting and no drilling data is provided which confirms grout placement. It has been reported that grouting extended from elevation 895 and below. My current assumption is that case. Clearly the behavior of the mine pool thus far during the initial plant operations supports the assumption that the portions of the pool between 898 to 900 appear to be in good communication with the entire pool area. Mine pool drawdown data contained in the spreadsheet support this conclusion.

Figure 2 shows the storage graph which was developed using the above information and considering the range of potential recharge scenarios that are likely given expected seasonal variations in recharge.

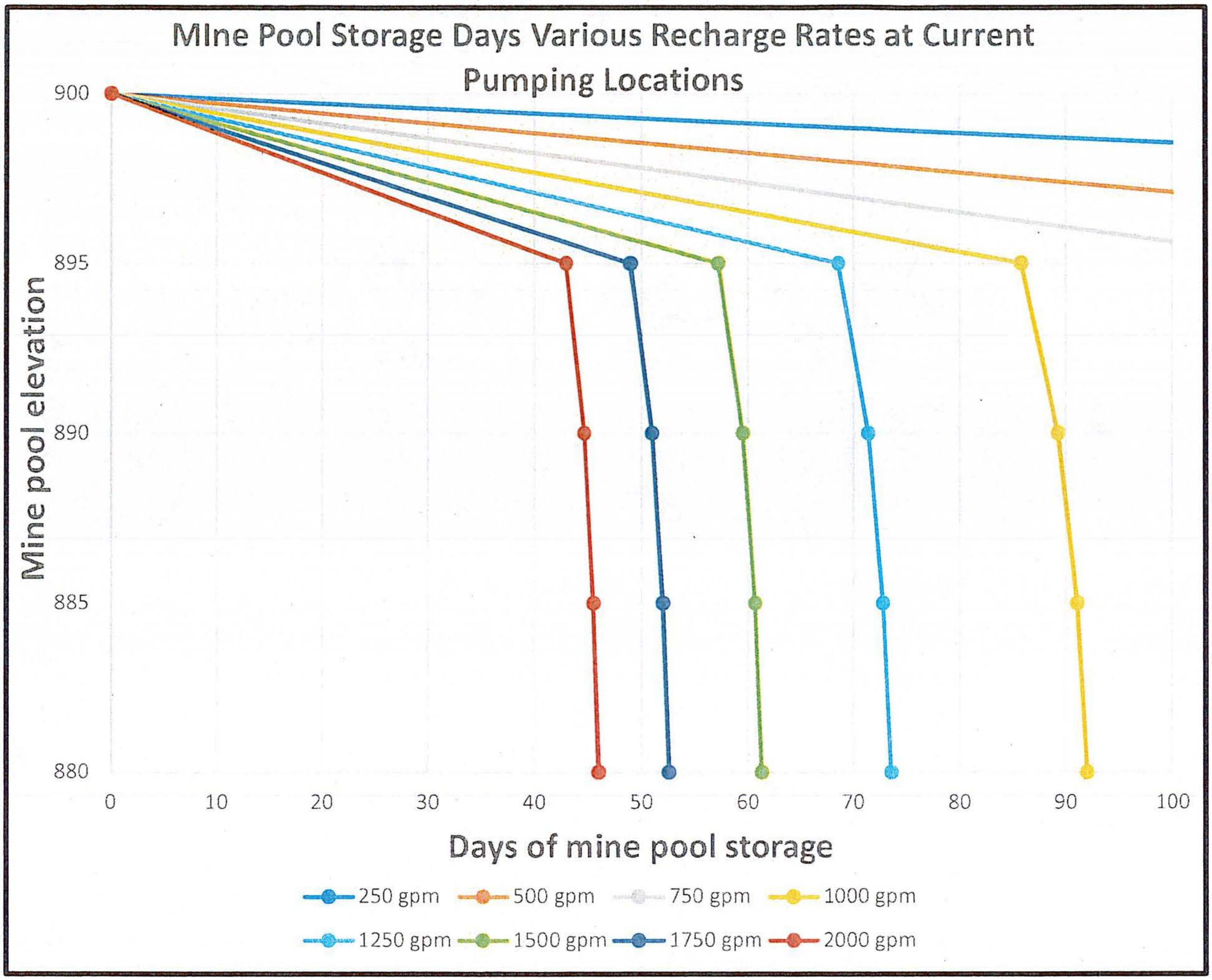


Figure 2; Mine pool stage storage estimates

As indicated in the graph above, even under conditions where sustained recharge events of 2000 gpm are experienced an operational mine pool level at 895 will provide over 40 days of storage before pumping and treatment operations would need to resume to prevent a breakout of untreated water. Also evident is that establishing a targeted operational mine pool below elevation 895 to 893 with the current withdraw pump locations will not provide any significant additional storage volume based on the assumption that the southwestern portions of the pool below an elevation of 893 are not likely to be directly connected to the withdraw well locations. An added and more important consideration for not targeting a lower than elevation 893 operating pool elevation is the risk of substantially altering influent mine water quality perhaps to the point where influent water would no longer be net alkaline. Should that occur treatment costs would substantially increase. A large portion of this mine complex exists above the mine pool and contributes recharge water that is most likely net acidic. Consequently, maintaining adequate mixing with the mine pool is critical for maintaining existing water quality.

As part of the evaluation I also examined available discharge records for the Gladden outfall that were collected after the completion of the initial Fishing Run Reclamation project in 2007. Continuous recorder data for the discharge is available from Jan 2008 through Apr 2011. Figure 3 and Table 2 below summarize the results of this analysis and additional data is available as part of the aforementioned spreadsheet. The season flow variation and response to precipitation is as would be expected for this type of shallow underground mine setting and these data also support the conclusion that extended periods of recharge above 2000 gpm are very unlikely.

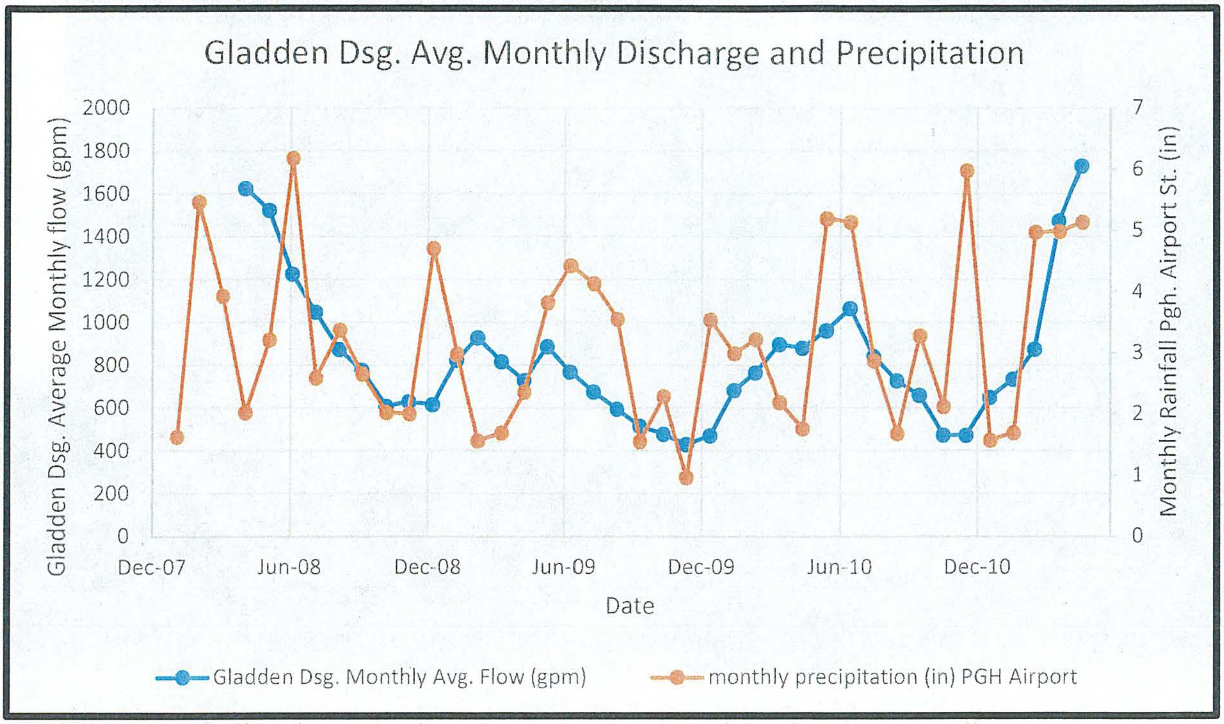


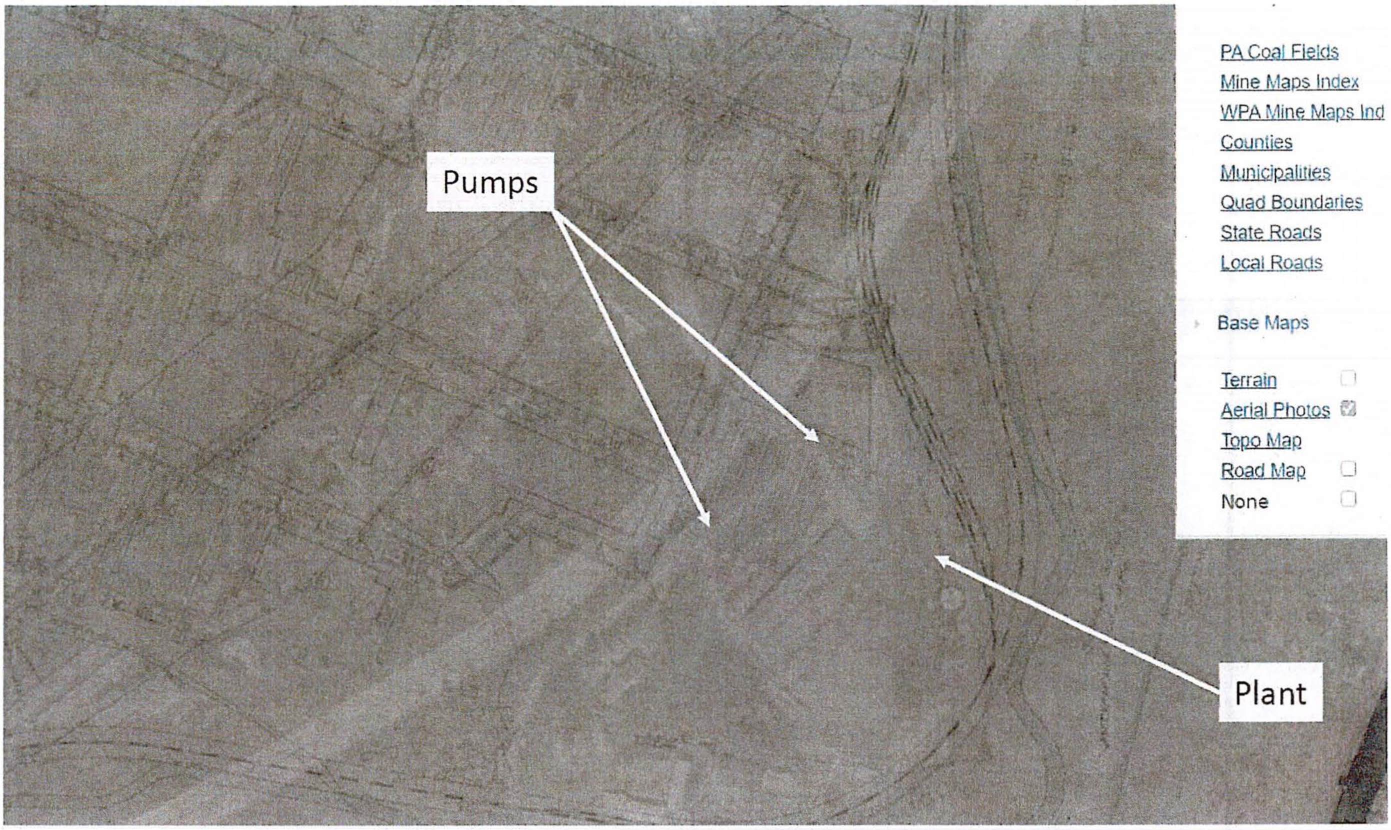
Figure 3; Gladden Discharge average monthly flow and average monthly precipitation

Period	Feb. - May	June – Sept.	Oct. – Jan.
Expected Range (gpm)	800 - 1800	600 - 1000	400 - 900

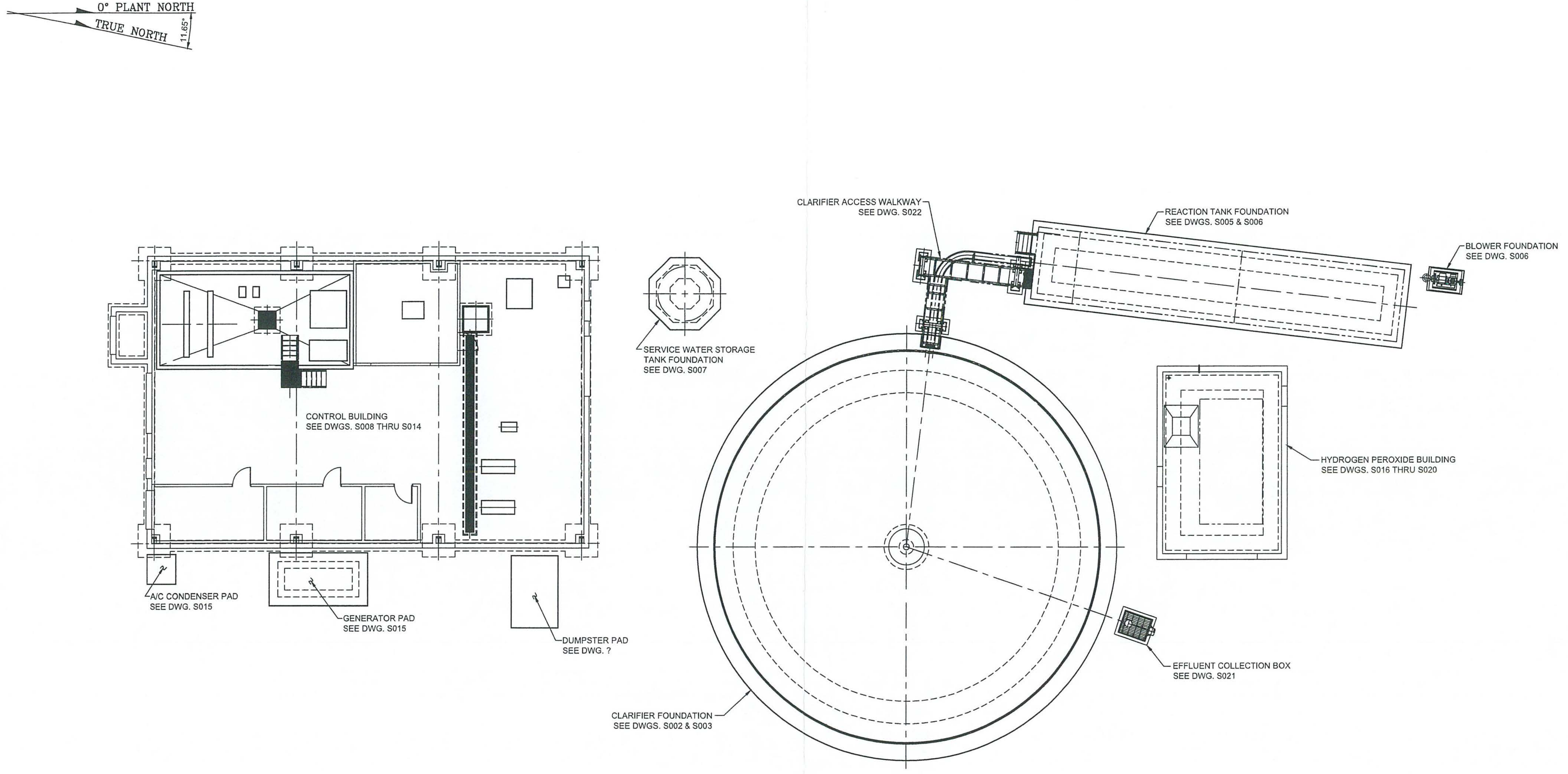
Table 2; Range of expected season recharge rates (gallons per minute)

Conclusions

Based on the above discussion and summary information, even under conditions where sustained recharge events of 2000 gpm are experienced an operational mine pool level at 895 will provide over 40 days of storage before pumping and treatment operations would need to resume to prevent a breakout of untreated water. Also evident is that establishing a targeted operational mine pool below elevation 895 to 893 with the current withdraw pump locations will not provide any significant additional storage volume based on the assumption that the southwestern portions of the pool below an elevation of 893 are not likely to be directly connected to the withdraw well locations. An added and more important consideration for not targeting a lower than elevation 893 operating pool elevation is the risk of substantially altering influent mine water quality. Lastly, obtaining additional mine grouting information may provide additional verification.



Portion of Mine Map showing plant location and withdraw wells



FOUNDATION KEY PLAN

SCALE: 1/8" = 1'-0"

ISSUED FOR CONSTRUCTION

BY G.G.G. DATE 06/03/2020

TETRA TECH

www.tetratech.com

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF ABANDONED MINE RECLAMATION
HARRISBURG OFFICE

NO.	BY	DATE	DESCRIPTION
0	RPB	06-03-2020	ISSUED FOR CONSTRUCTION

REVISIONS

GEORGE G GRACHEN

SUBMITTED BY:
TETRA TECH, INC.

APPROVED BY:
BAMR PROJECT MANAGER TITLE AND OFFICE

DATE:	PLOT DATE:	SCALE:
03/31/2020	03/31/2020	AS NOTED
DRAWN BY: RPB	CHECKED BY: GGG	

ACAD FILE NAME:

ALL EXISTING CONDITIONS SHALL BE CHECKED AND VERIFIED BY THE CONTRACTOR AT THE SITE

BUREAU OF ABANDONED MINE RECLAMATION
GLADDEN ACID MINE DRAINAGE
TREATMENT PLANT

SOUTH FAYETTE TOWNSHIP
ALLEGHENY COUNTY

CONTRACT NO. AMD 02(0441)101.1

FOUNDATION KEYPLAN

DRAWING NUMBER:
S001.2

SOUTH FAYETTE CONNECT

SUMMER 2021 • VOLUME 6, ISSUE 3 • FREE

THE OFFICIAL MAGAZINE OF SOUTH FAYETTE TOWNSHIP

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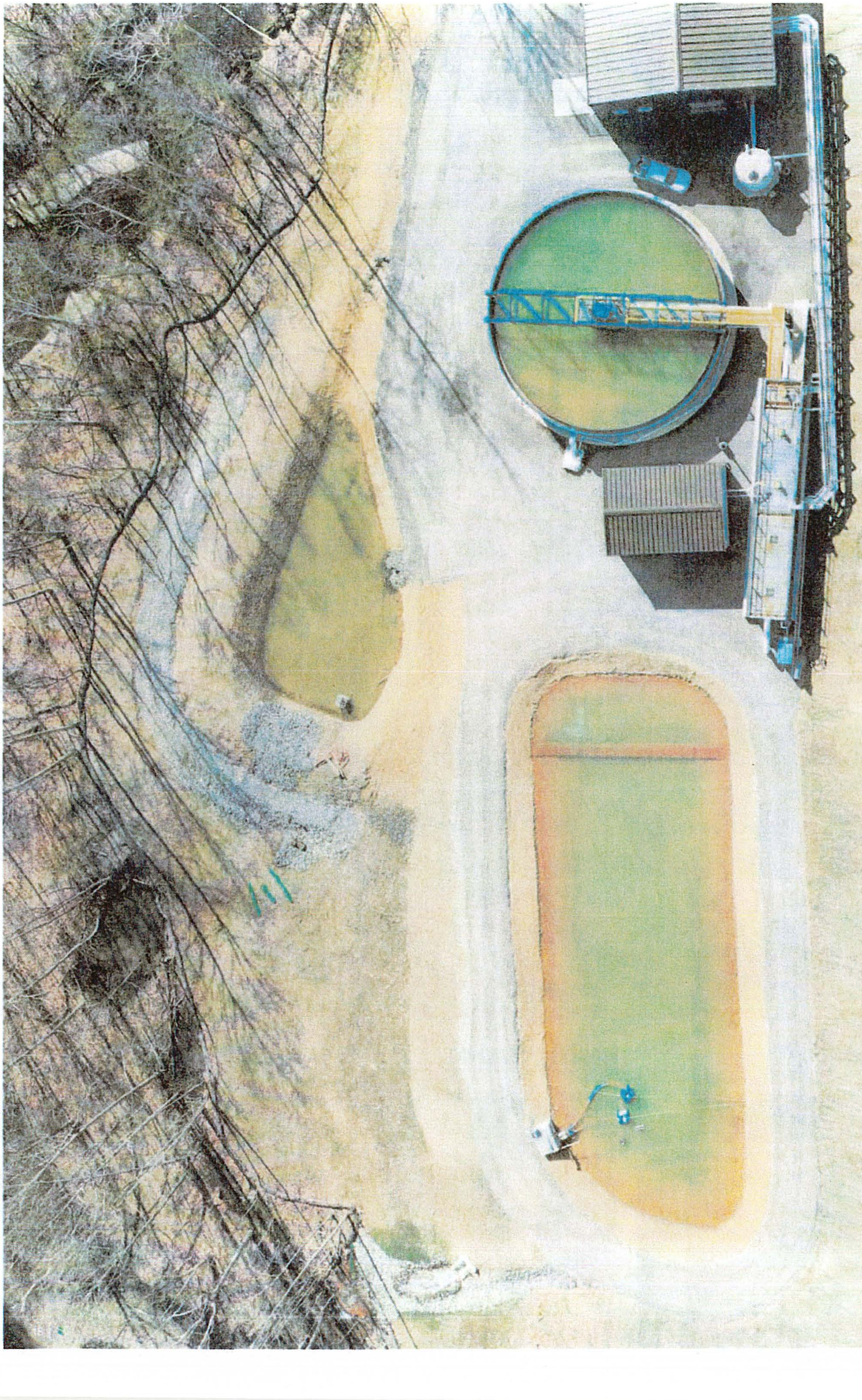


◄ The Gladden Acid Mine Drainage Treatment Plant in South Fayette cleans 1 million to 2 million gallons a day of polluted mine water.

Image courtesy of Tetra Tech

CLEAN CREEKS

$13 million treatment plant in South Fayette turns orange water blue

by Andrea Iglar

Lifelong South Fayette resident John Alan Kosky grew up with Millers Run in his backyard.

The creek was tinted orange from coal mine pollution—proof to his mother that her children had been playing in the water.

"Your fingernails are orange, your clothes are orange, everything is stained," Mr. Kosky recalled.

"Needless to say, you couldn't [hide] if you were playing in the 'crick.' I think it wasn't long after that my parents bought a swimming pool."

While the local creeks still may not be suitable for swimming, trout fishing could be on the slate, thanks to a new water treatment plant in South Fayette that is helping turn the water in Millers Run and Chartiers Creek from orange to blue.

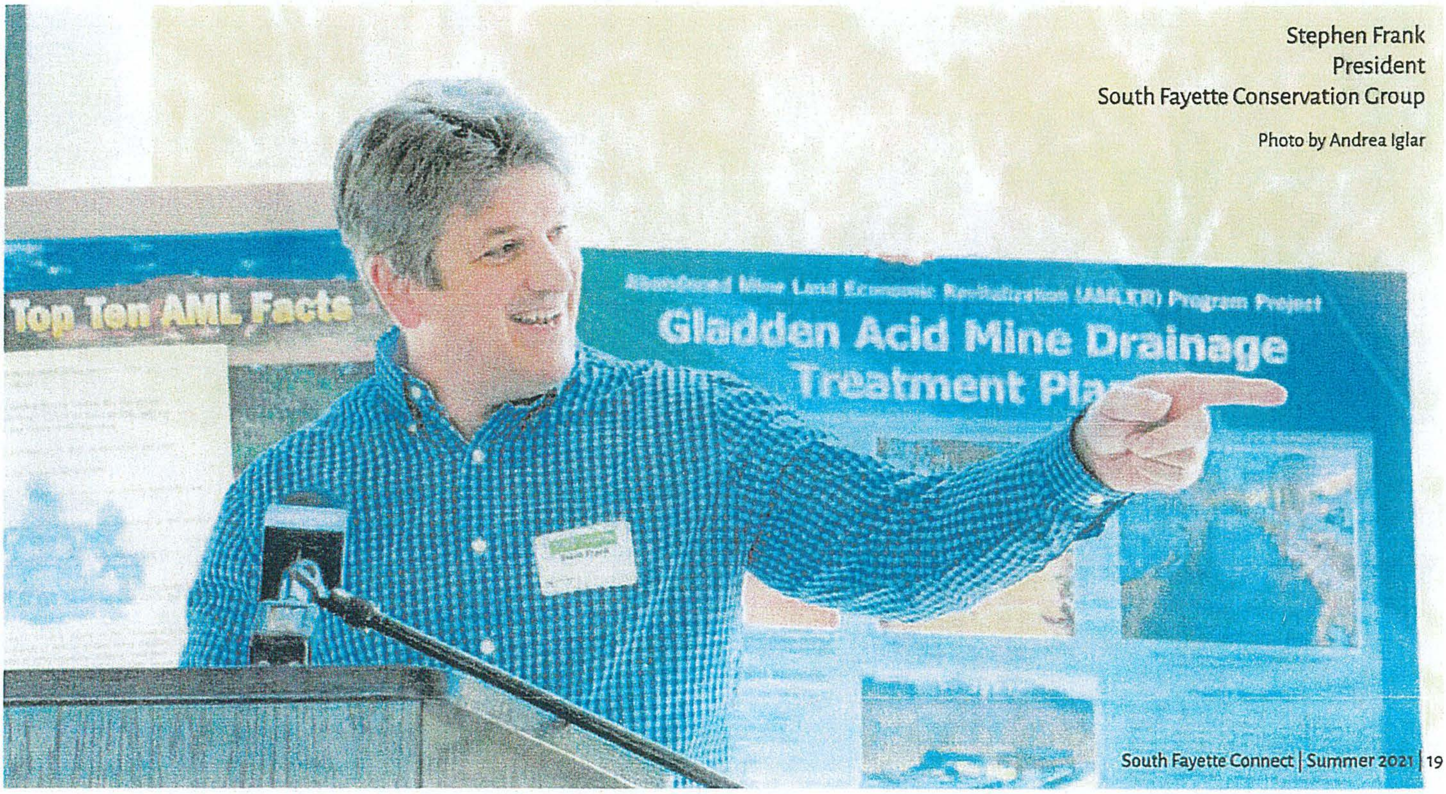
Mr. Kosky discussed the legacy of South Fayette's orange creeks during a dedication ceremony April 27 for the $13 million Gladden Acid Mine Drainage Treatment Plant.

Mr. Kosky and his sisters, Lynn Janocha and Marsha Schwab, donated land to build the plant behind the Original Farmers Market pavilion on Parks Road, in the Gladden neighborhood of South Fayette Township.

The dedication event featured federal and state leaders, underscoring the broad importance of the treatment plant.

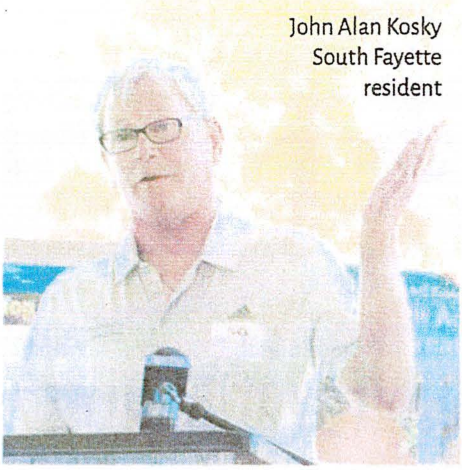
"Projects like this are important for the present and the future of Pennsylvania," state Department of Environmental Protection Secretary Patrick McDonnell said.

"They represent not just environmental revitalization [but also] economic revitalization."



Stephen Frank
President
South Fayette Conservation Group

Photo by Andrea Iglar


John Alan Kosky
South Fayette
resident


Patrick McDonnell
Secretary
PA DEP


Katie Pugh
Environmental Scientist
Tetra Tech, Inc.

Clean creeks will expand recreational opportunities, stimulate business and attract transportation infrastructure projects, said Thomas Shope of the U.S. Department of Interior's Office of Surface Mining Reclamation and Enforcement.

"People want, demand and desire clean water," he said, noting the creek cleanup will have "a profound impact on this area for many, many years to come."

The treatment plant began operating in January to remove about 690 pounds a day of orange-hued iron from 4 miles of Millers Run and, by extension, 3 ½ miles of Chartiers Creek, which eventually flows into the Ohio River.

Trout stocking could start in Millers Run next year.

The plant actively treats between 1 million and 2 million gallons a day of mine discharge, and already there is a clear difference in the water quality of the streams.

The Pennsylvania Fish and Boat Commission will monitor the water quality in Millers Run, and if the creek can support aquatic life, trout stocking could start in 2022.

South Fayette Township officials are considering plans to add creek access in Morgan Park along Millers Run Road, said Paula Willis, the parks and recreation director.

"We wouldn't have the opportunity to use the creek for recreation if it weren't for this cleanup project," she said.

The nonprofit, citizen-led South Fayette Conservation Group worked on the project for more than 10 years, eventually securing a $13 million federal grant—awarded through the state Bureau of Abandoned Mine Reclamation—to fund construction of the plant and complete other stream restoration activities.

The core volunteers were Cindy Cox, Holly Bomba, David Pope, Bob Milacci and Stephen Frank, president of the conservation group.

"It's nice that the work is done, but there is a lot more to do in the next few months," Mr. Frank said.

Next steps are to secure funding for the plant's long-term


◂ South Fayette Township commissioners Gwen Rodi (back left) and Rebecca Sray (back right) view the treatment plant with South Fayette Conservation Group members (clockwise from back) Holly Bomba, Cindy Cox, David Pope and Steve Frank.

Photo courtesy of Tetra Tech

◄ The treatment plant removes solids from mine water and pumps sludge into an abandoned dry mine for disposal.

► Plant visitors—including, at front, Mike Nerrozi of the Pennsylvania Fish and Boat Commission—cross the 350,000-gallon clarification tank during a tour in April.

Photos by Andrea Iglar

operation, address flooding and erosion issues downstream, and increase recreational and educational opportunities in Millers Run, Mr. Frank said.

Next year, ownership of the treatment facility will transfer to the Kentucky-based Clean Streams Foundation, via the Pennsylvania Department of Environmental Protection.

In general, no organization is specifically responsible for cleaning up abandoned mine drainage, the result of decades of coal mining in the region.

Mines in and around the Chartiers Creek watershed were producing more than 24 million tons of coal a year by 1922.

Now abandoned, many underground mines have flooded with water that is highly acidic. When the water surfaces, it flows into rivers, streams and other waterways, negatively affecting water quality, water appearance, recreational use and wildlife habitats.

The Gladden-area mine discharge is the most significant source of iron pollution in the lower Chartiers watershed, according to engineer Tom Gray of Tetra Tech, Inc., the firm that designed the treatment plant.

"We could not clean up Chartiers Creek unless we tackled this discharge," Mr. Gray said.

The discharge gushes at a rate of at least 750 gallons per minute from the abandoned Montour No. 2 deep mine.

As part of the cleanup project, the polluted water is piped underneath Route 50 to the Gladden plant, treated with chemicals and pumped into a 350,000-gallon clarification tank to separate water from iron solids.

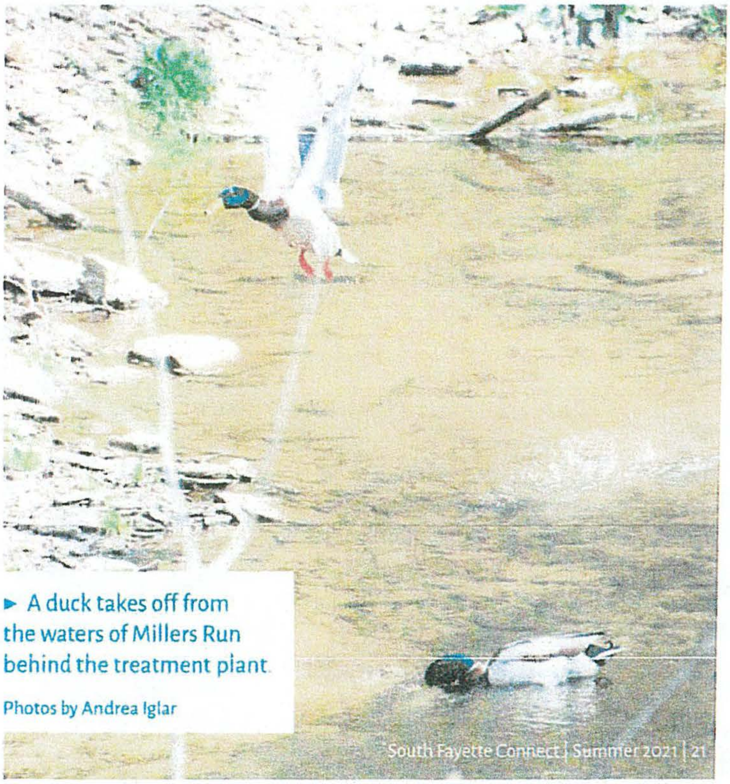
From there, the water is filtered through another pond and then discharged into Millers Run, where geese, ducks and other wildlife are commonly spotted. The sludge is pumped into a dry mine for disposal.

As long as the plant operates, the creeks will continue turning from orange to blue.

"It's been pretty exciting," Mr. Frank said. "Everybody is like, hey, look how good the stream is looking."

Connect with the South Fayette Conservation Group: **southfayetteconservation.com**; *Facebook @sfconservationgroup.*

◄ A flow monitor shows 50 gallons per minute of water being released back into Millers Run after being cleaned at the Gladden Acid Mine Drainage Treatment Plant.

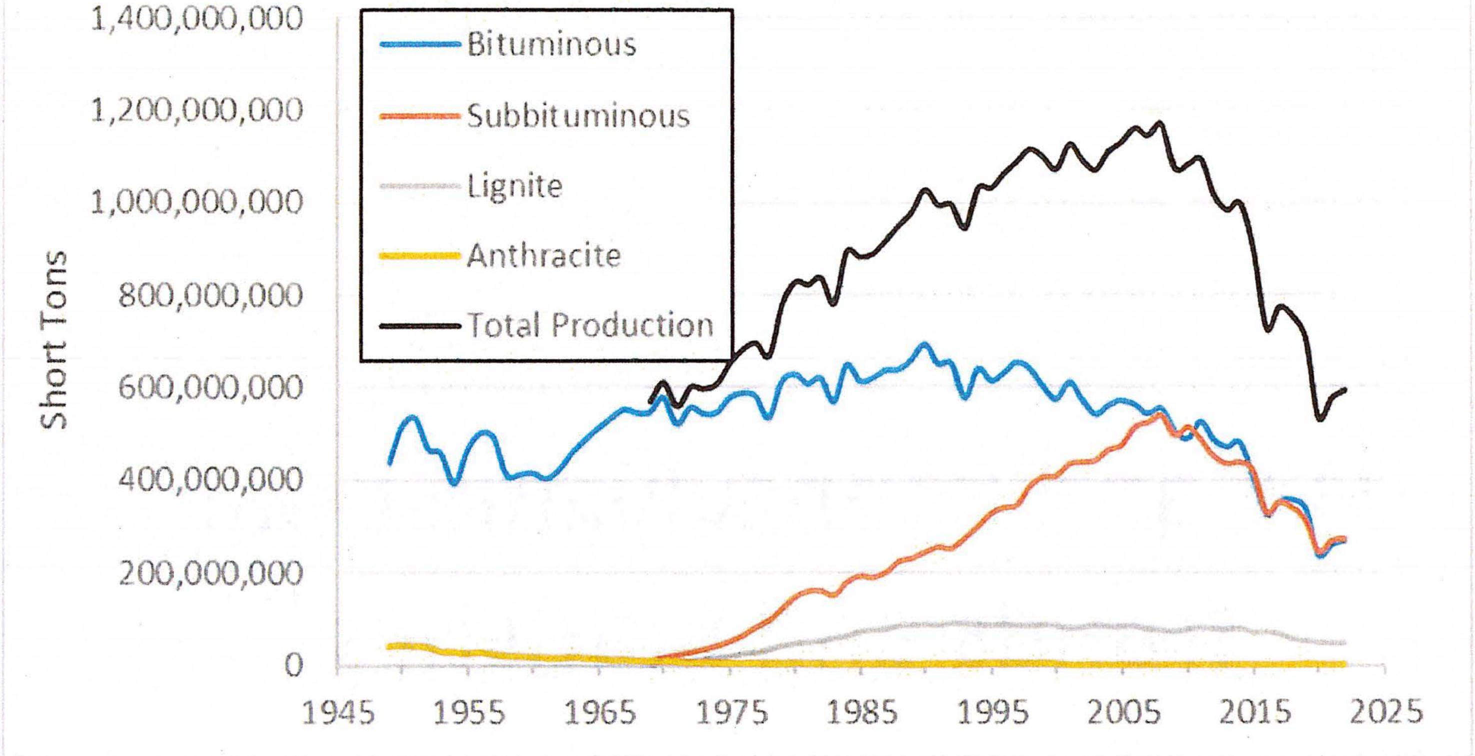


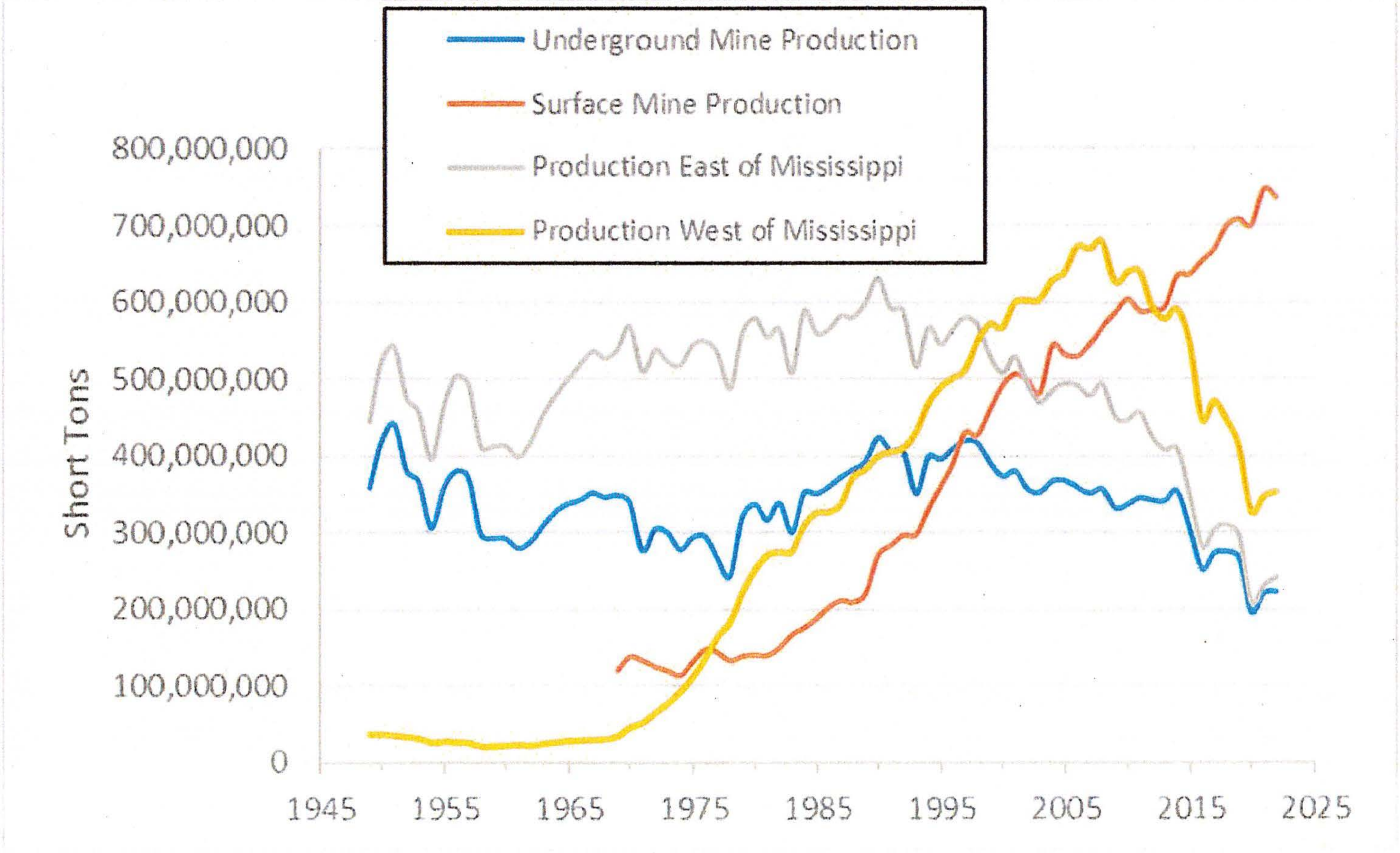
► A duck takes off from the waters of Millers Run behind the treatment plant.

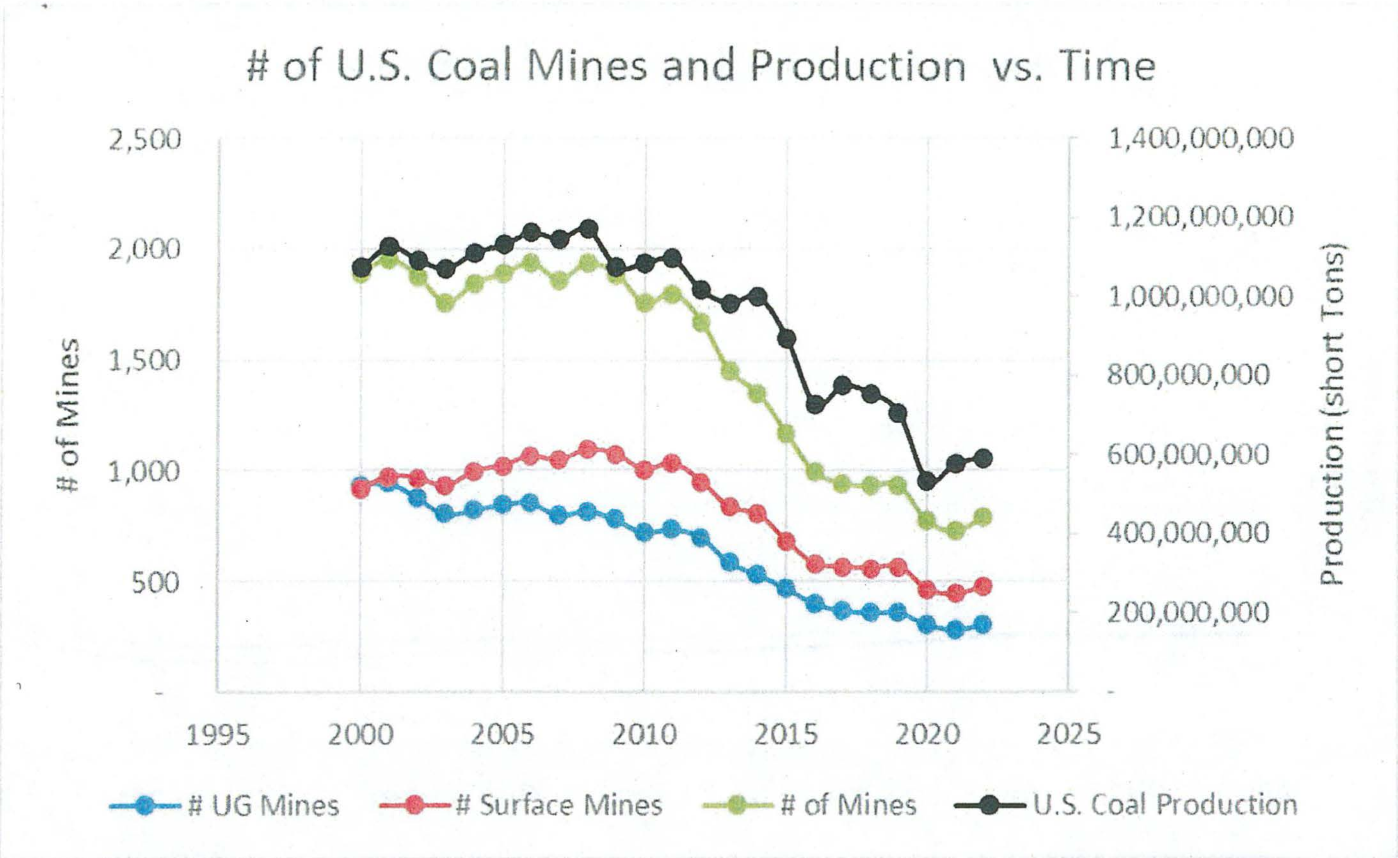
Photos by Andrea Iglar

U.S and Pennsylvania Coal Trends and Statistics

U.S. Coal Production by Coal Type






# of U.S. Coal Mines and Production vs. Time
# of Mines
2,500
2,000
1,500
1,000
500
-
Production (short Tons)
1,400,000,000
1,200,000,000
1,000,000,000
800,000,000
600,000,000
400,000,000
200,000,000
-
1995
2000
2005
2010
2015
2020
2025
UG Mines
Surface Mines
of Mines
U.S. Coal Production


# of Employees in Coal Industry
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
-
Production (short Tons)
1,400,000,000
1,200,000,000
1,000,000,000
800,000,000
600,000,000
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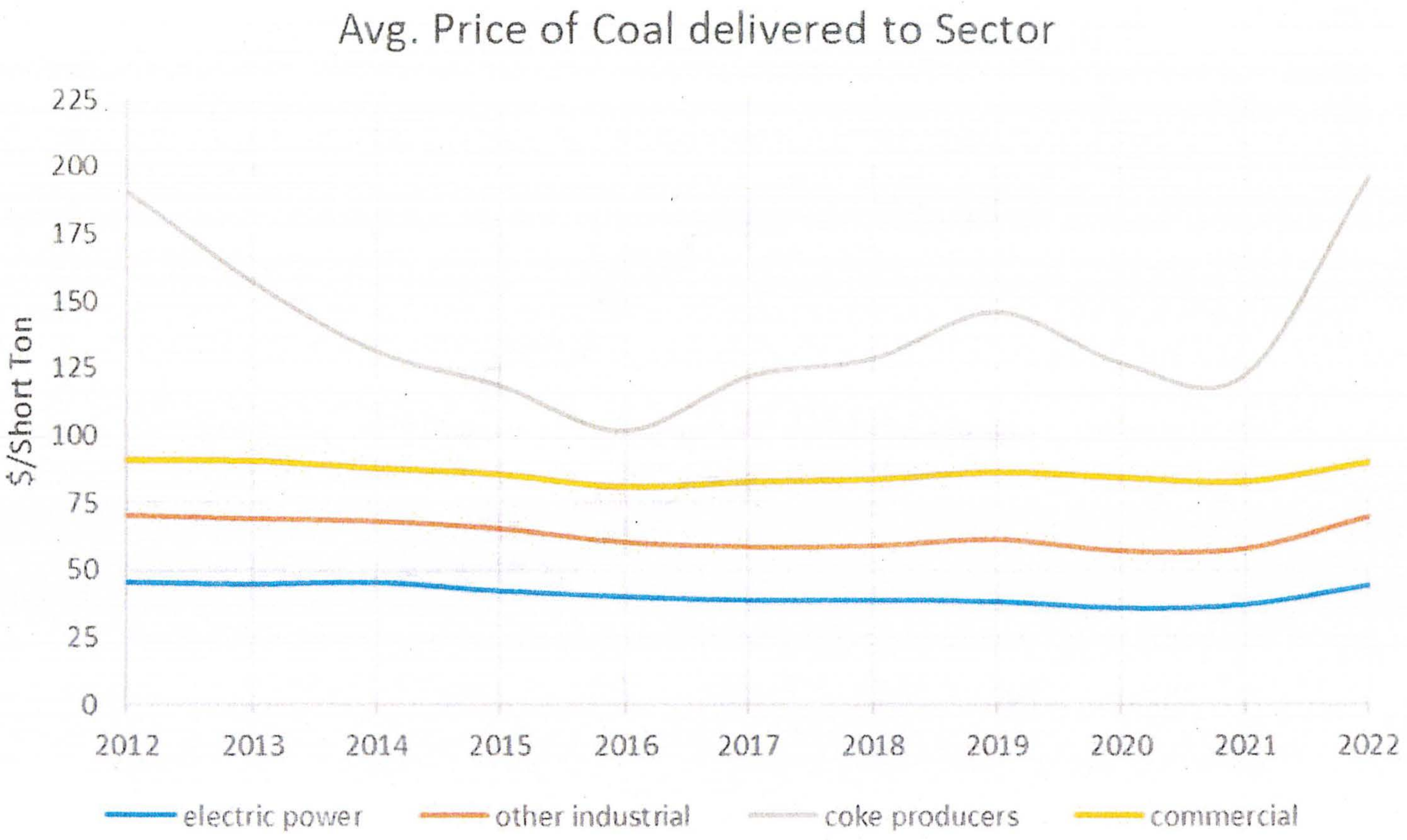
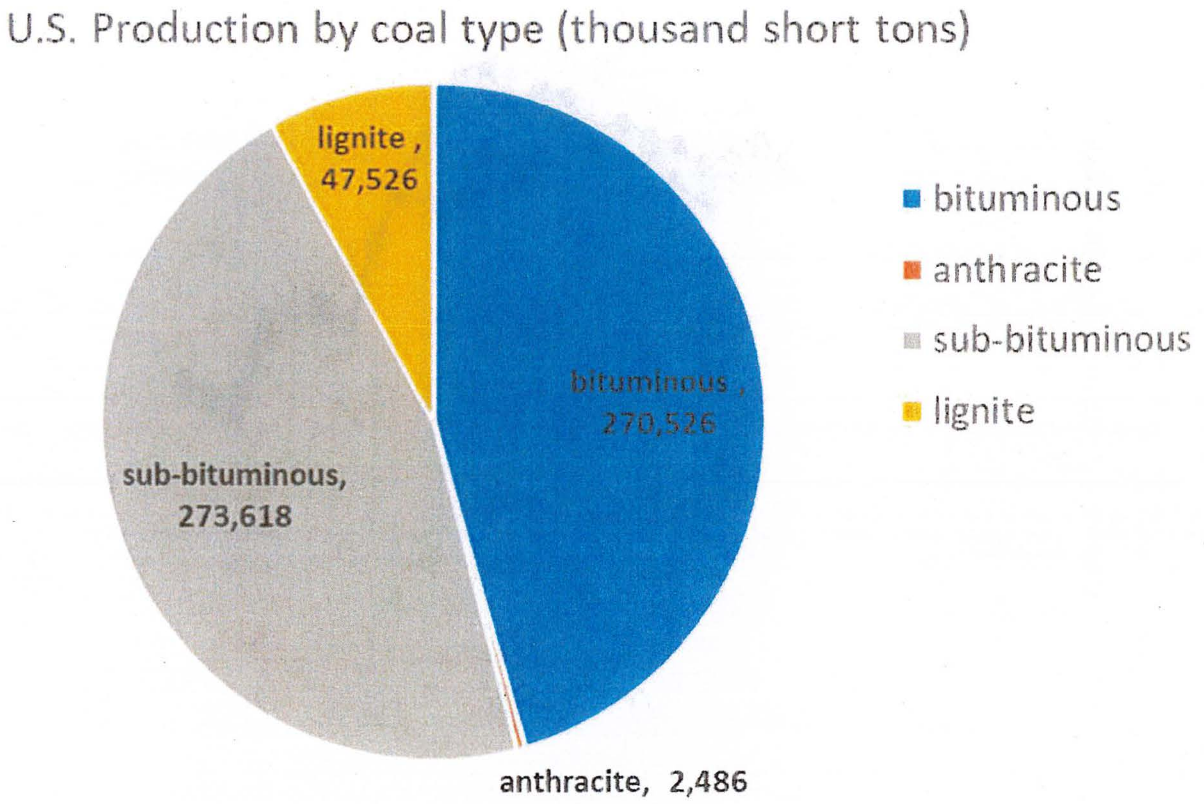
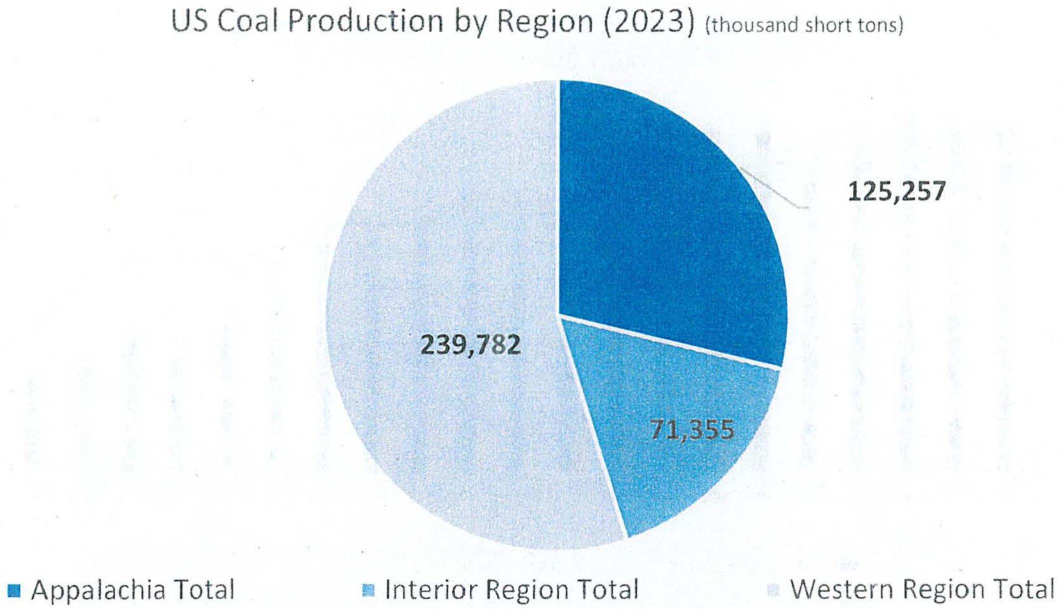
2020
2025
Employees
U.S. Coal Production



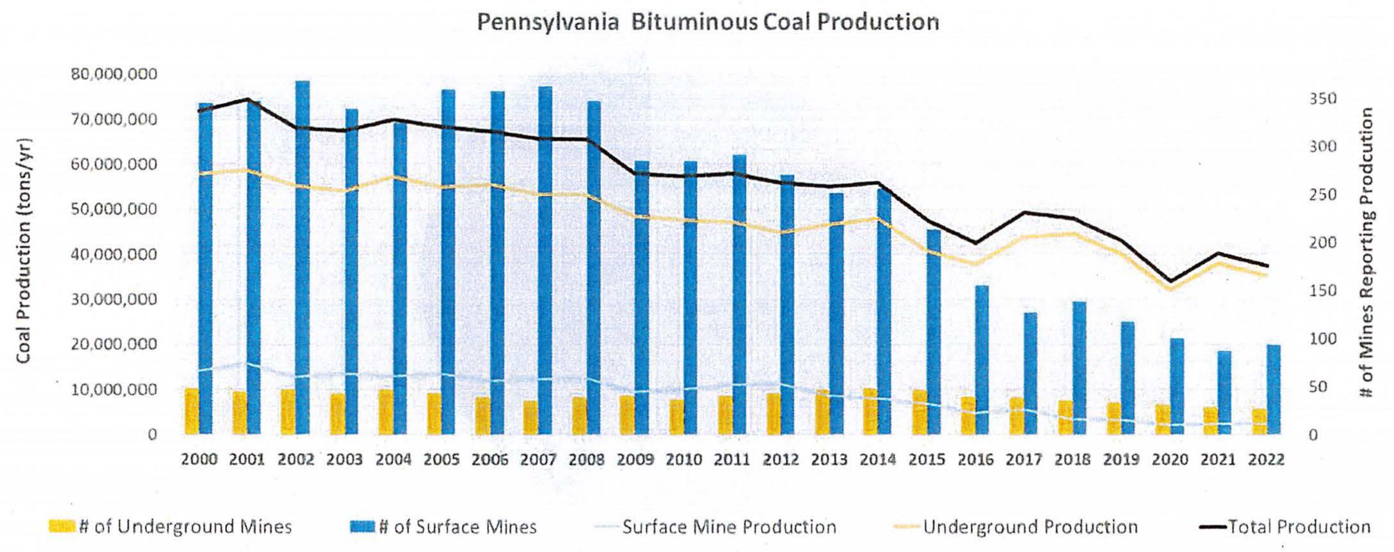
Avg. Price of Coal delivered to Sector

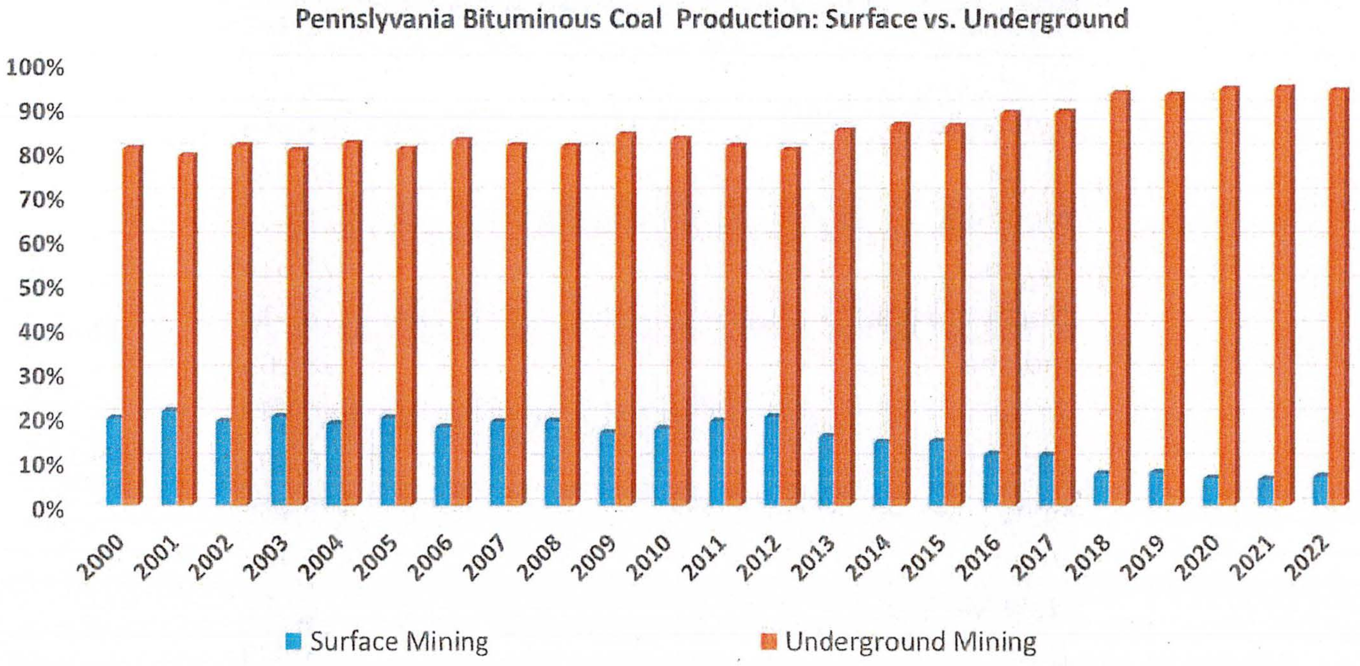


U.S. Production by coal type (thousand short tons)



State	2023 Production (thousand short tons)
Wyoming	178,321
West Virginia	64,941
Pennsylvania	31,528
Illinois	28,175
Montana	21,661
Kentucky	21,614
North Dakota	18,312
Indiana	18,268
Texas	10,445
Alabama	8,892
Colorado	8,736
Virginia	8,164
New Mexico	6,585
Utah	5,389
Mississippi	1,827
Ohio	1,433
Maryland	986
Alaska	778
Louisiana	233
Missouri	106
Oklahoma	1
Tennessee	0
Total Production	**436,395**


Pennsylvania Bituminous Coal Production


Pennsylvania Bituminous Coal Production: Surface vs. Underground

Four Underground Longwall Mines Produce 78% of Pennsylvania Coal (2022)

Mine Name	Surface Permit (acres)	Underground Permit Acres	Production (tons)	# of Employees
Consol Bailey	625	26,620	11,567,919	655
Consol Enlow Fork	18,245	17,159	6,291,939	421
Consol Harvey	162	3,068	6,074,719	288
Contura Cumberland	213	22,532	5,381,422	585
4 Mine Total	**19,245**	**69,379**	**29,315,999**	**1,949**

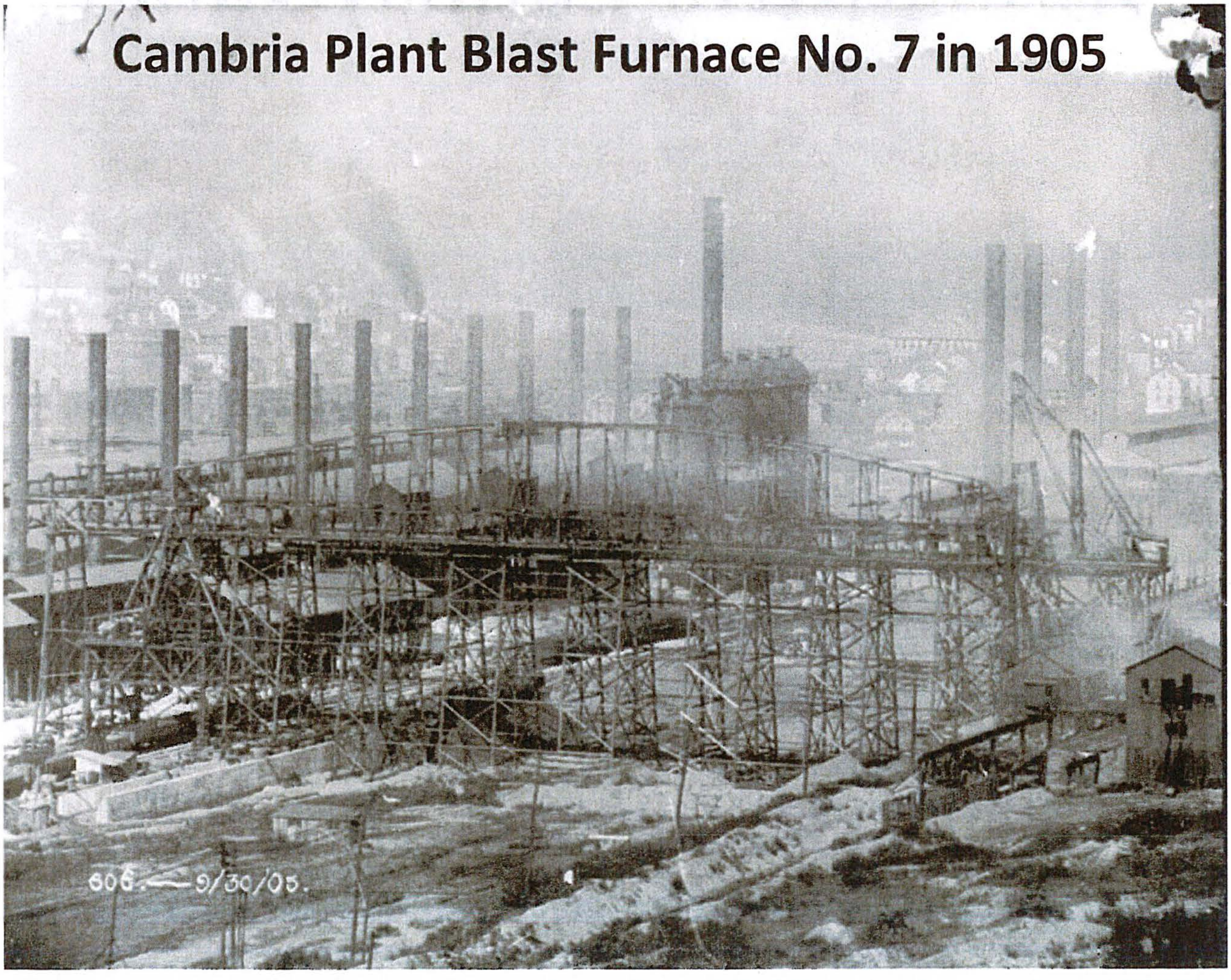
History of the Steel and Coal Industries in Johnstown, Pennsylvania

History of Steel & Coal in Johnstown

Johnstown, PA was an important transportation hub for the railroad connecting Philadelphia and Pittsburgh. The railroad allowed for raw materials to be transported to factories, and the products to be sent all over the United States. It was no coincidence that the Cambria Iron Company started in 1852, the same year that the railroad connecting Philadelphia and Pittsburgh was completed.

Steel

The first railroads used iron rails, which sometimes bent or twisted under the weight of moving trains. Steel was much stronger, but in the 1850-60s, steel was too expensive to make in large batches required for railroads. In 1857, a Pennsylvanian named William Kelly determined that blowing air through the molten iron superheated it, burning away impurities and allowing for large-scale steel production. The "Kelly Converter" was built at the Cambria Iron Works in Johnstown. In 1861, Cambria produced the first American-made steel rails, and was the leading steel producer in the nation by 1876. The Steel mills ran 24 hours a day, seven days a week, both to keep up with demand and to keep the furnaces burning - if they were allowed to go cold, it took days for them to reach the temperature required to melt iron ore. By 1900, all of Pennsylvania's steel mills together made half of the nation's steel. Bethlehem Steel bought Cambria Iron and Steel in 1923, the same decade that Johnstown's population reached its peak because of the steel boom - the population rose from 15,000 in 1880 to over 65,000 in the 1920s where it stayed for 30 years.

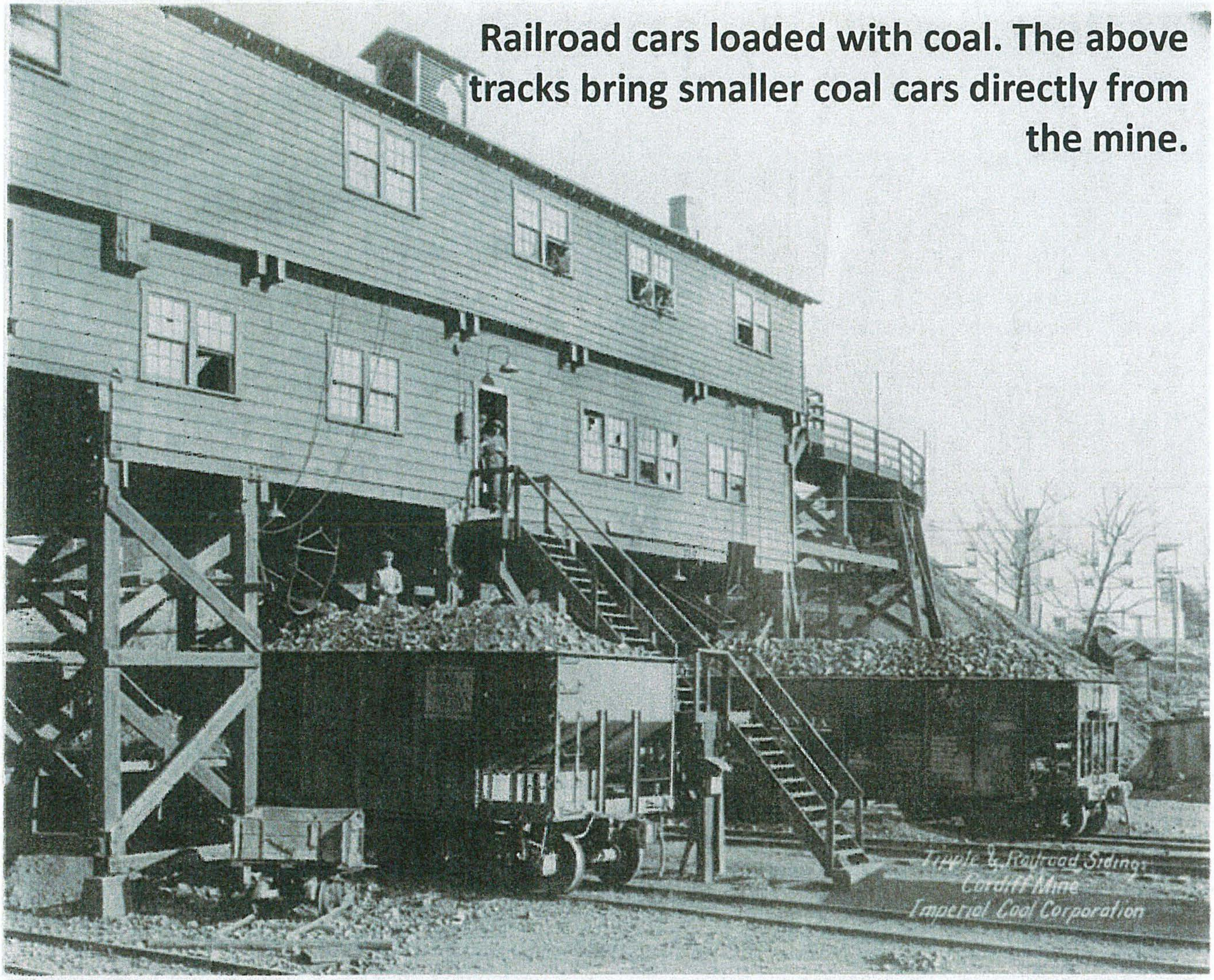


Cambria Plant Blast Furnace No. 7 in 1905

This information was gathered from the Johnstown Area Heritage Association website: jaha.org

Coal

The early iron furnaces used wood charcoal for heat, because extracting large batches of coal from the ground was challenging. The development of the steam engine allowed for miners to dig deeper for coal, and thus led to it's use in steel production. Coal was converted to "coke" in a special oven that heated and quickly cooled the coal, which allowed it to burn hotter. The Rolling Mill Mine was opened in 1856 and provided the bulk of coal used in the iron and steel making process, producing an average of 3,000 tons per day in 1902. In total, Cambria and Somerset counties had 137 mines, which produced over 10.5 million tons of coal and employed nearly 15,000 workers.



Railroad cars loaded with coal. The above tracks bring smaller coal cars directly from the mine.

Industries fuel each other

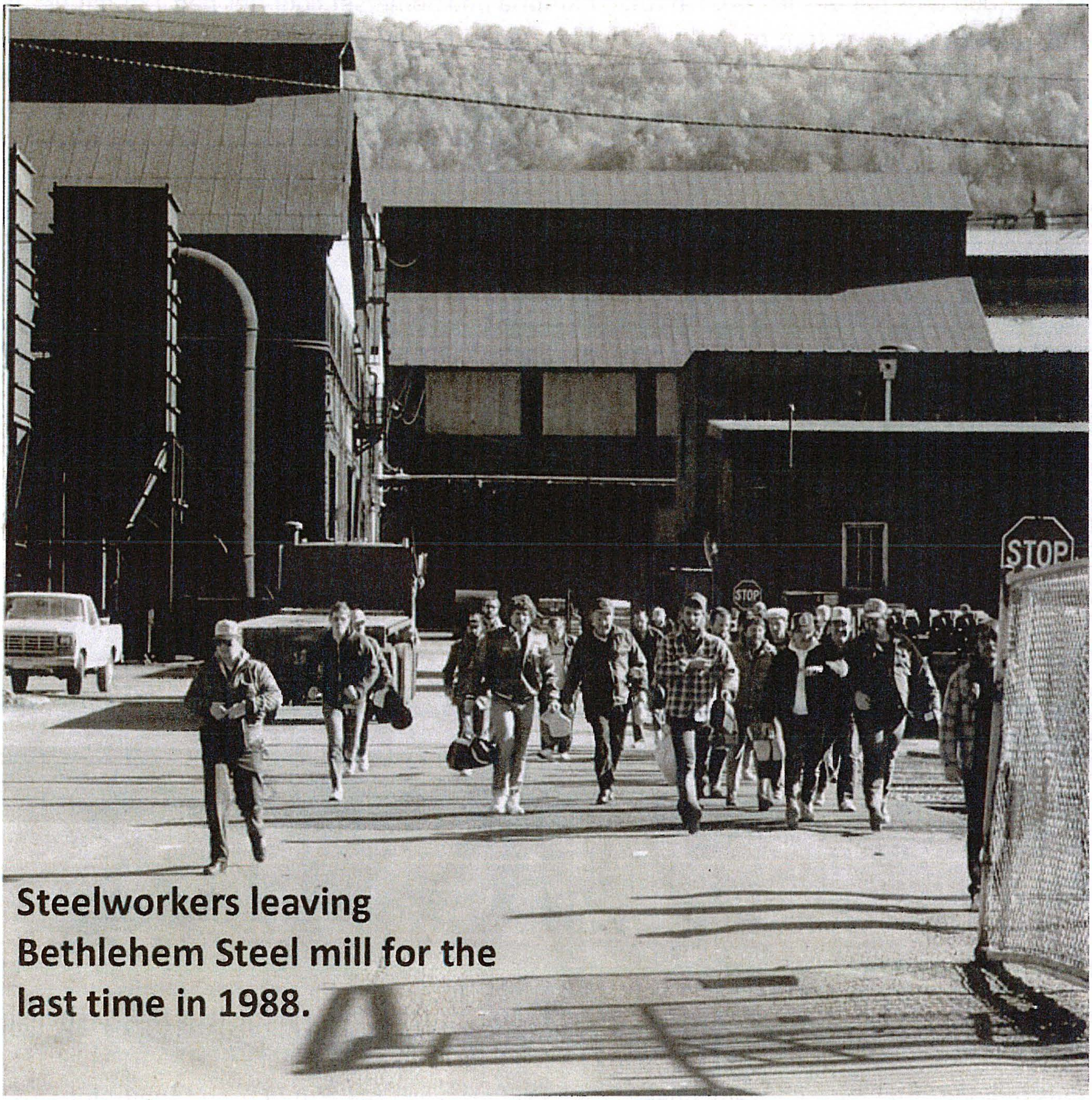
Railroads, steel, and coal came together at the right time for Johnstown in the late 1800s. Though they were each powerful industries, they relied on each other to prosper.

Railroads needed steel for rails, train wheels, cars, bridges; and **coal** as fuel to run the trains and as one of its biggest customers
Steel companies needed railroads to bring iron ore, coal and coke, limestone to them; to send steel products to their customers; as their biggest customer for steel; and **coal** to run the furnaces to make steel.
Coal companies needed steel as its main customer; and **railroads** as customers and to help them reach their markets in cities and mills.

This information was gathered from the Johnstown Area Heritage Association website: jaha.org

Decline of Coal and Steel

By the 1980s, the steel and coal industries in Pennsylvania could not compete with modern steel mills in other states and countries. In addition, coal was being replaced by natural gas and oil for heating and nuclear plants, rather than coal, were producing one-third of the state's electricity. The mines and mills began to close and thousands of workers lost their jobs and between 1973-1983 Bethlehem Steel went from employing 11,800 workers to 2,100 workers, and went out of business by 1988.



Steelworkers leaving Bethlehem Steel mill for the last time in 1988.

Coal and Steel in Johnstown Today

Include some information about the current production of coal/steel in this area? Are there additional mines other than Rosebud? Any steel mills still in the area?

This information was gathered from the Johnstown Area Heritage Association website: jaha.org

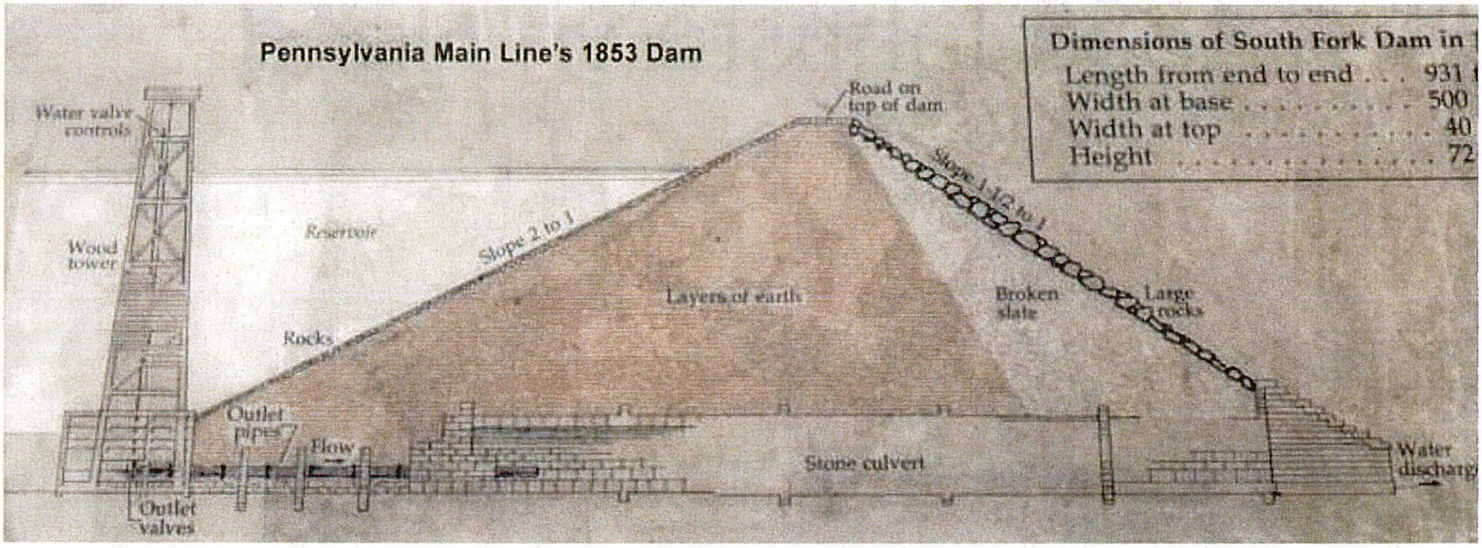
History of the
1889 Johnstown Flood

1889 Johnstown Flood

On May 31, 1889, two days after record heavy rain began, the South Fork Dam that held back the waters of Lake Conemaugh broke, sending a wall of water 14 miles (22.5 km) down the valley towards the city of Johnstown, Pennsylvania. Over 2,200 people were killed in the ensuing disaster, which remains the deadliest flood in American history and the third deadliest flood in the world due to a dam collapse.

The South Fork Dam

The South Fork Dam was constructed in 1853 to supply water to a canal that ran from Johnstown to Pittsburgh. The earthen dam was built in a triangular shape that was 72 ft (22 m) tall, with a 500 ft (152 m) base that tapered to 10 ft (3 m) at the top. Five large, cast iron sluice pipes were set into a stone culvert that ran underneath the dam so that excess water from heavy rains could escape. An emergency overflow spillway was also constructed 10 ft (3 m) lower than the top of the dam to prevent failure when water could not exit the sluice pipes fast enough.



Drawing of a probable construction plan for the 1853 South Fork Dam

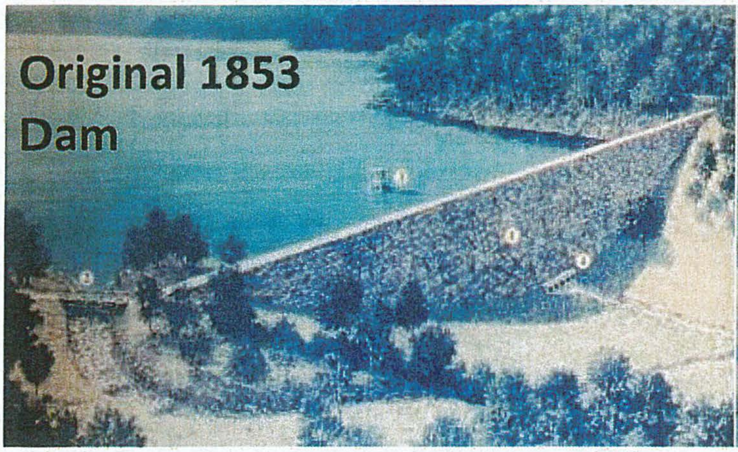
The 1862 Collapse

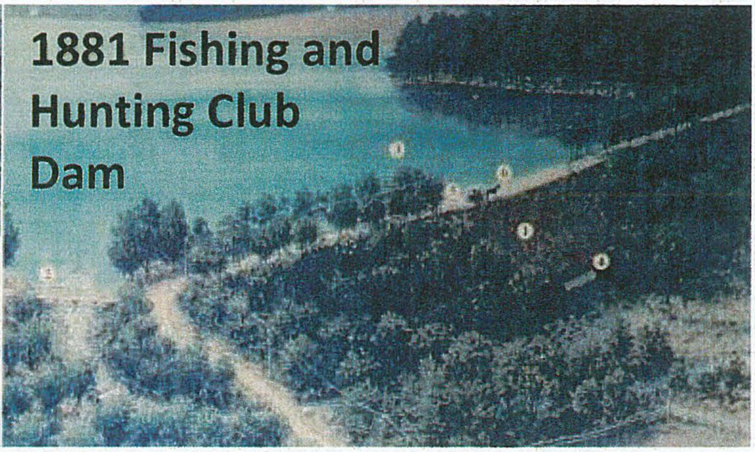
The South Fork Dam was used by the Pennsylvania Main Line canal until its demise in 1857, after which it was purchased by the Pennsylvania Railroad (the same industry that put the canal out of business due to its ability to haul goods faster and cheaper). The railroad had no real interest in maintaining the reservoir, and it collapsed in 1862, sending water down the valley towards Johnstown. Luckily, the reservoir was not full - the drainage pipes and spillway had released much of the water and the rivers and streams were running low at the time. While Johnstown was flooded with about three feet of water, no lives were lost, and property damage was minimal. The dam was left abandoned for the next 17 years.

This information was gathered from the National Park Planner website: npplan.com

The South Fork Fishing and Hunting Club

In 1875 the dam was purchased by U.S. Congressman John Reilly, who eventually sold the entire property to Benjamin Ruff in 1879. Ruff used the property to form an exclusive hunting and fishing resort for the wealthy tycoons of Pittsburgh, which had members including Andrew Carnegie, Andrew Mellon, and Henry Clay Frick. Ruff's original plan was to construct a new dam from the ground up, but after learning the cost, opted to repair the existing dam. Unfortunately, his solution was to plug the hole left by the 1862 flood with whatever materials were available, including brush, hay, and manure. In later years, these materials would compact and cause the center portion of the dam to sag. In addition, the sluice pipes that were originally used for draining the dam were never reinstalled, leaving the emergency overflow spillway as the only exit for excess water. The new dam was also much thinner: only 270 ft (82 m) at the base versus 500 ft (152 m) of the original dam. Further compounding the inadequacies of the repairs, the dam was lowered by 3 ft (0.9 m) to make the top wider so carriages could pass over it during tours of the grounds. In March 1881, after the dam repairs had been halted twice due to failures, the lake was finally deep enough to stock with fish. To keep them from escaping downstream, a metal screen was placed at the mouth of the spillway, a decision that would play heavily in the 1889 disaster.





The Morning of the Flood

On the morning of May 31, 1889, the current president of the club, Elias Unger, who replaced Ruff after his death, woke up to see the lake had taken on a significant amount of water over night, and the rain was still coming down. "It looked as if the whole valley were under water", Unger would later say. Creeks and streams that flowed into the lake were now rushing with water, carrying with them fallen trees and other debris, all of which flowed towards the spillway. This presented a catastrophic problem in that the screen that kept the fish in would not let the debris out, and the buildup was blocking the flow of excess water through the spillway. Unger attempted to remove the screen from the spillway, but the debris were now so tightly packed against the screen that it could not be removed. Unger enlisted Italian immigrants who were camped nearby to dig a new spillway, but the men retreated to higher ground realizing that the dam could collapse at any minute. Meanwhile, a young engineer on hand, John Parke, was tasked with sending a telegram to Johnstown warning of the possible danger. Whether or not the message was ever received, and what was done with it, is still unclear to this day. It is only safe to say that the warning was never delivered to the people of Johnstown.

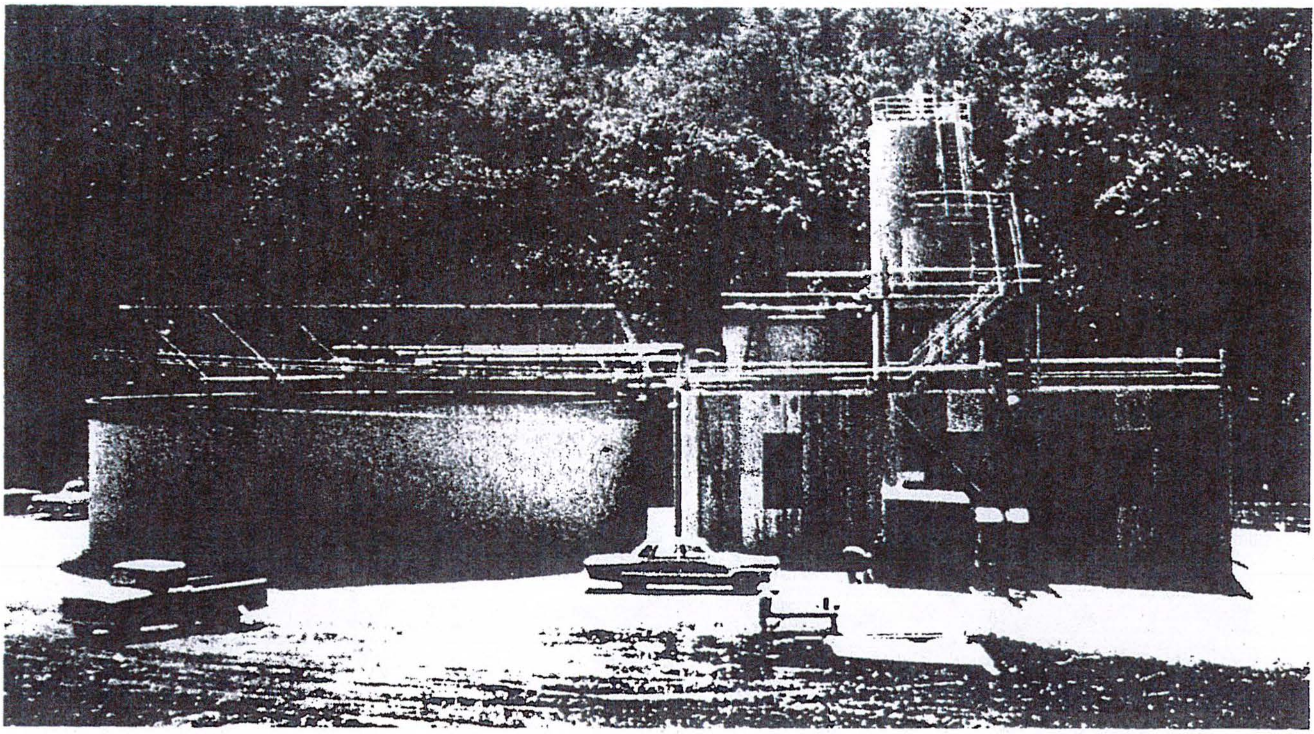
This information was gathered from the National Park Planner website: npplan.com

The Dam Collapses

Around 3pm the water began flowing over the top of the dam, setting in motion its collapse, and soon a 300-ft (91 m) gap had been created. Within 40 minutes, the entire lake had emptied, sending 20 million cubic tons of water rushing down the valley toward Johnstown. It took one hour for the water to reach Johnstown, and on the way, it washed away the towns of South Fork, Mineral Point, East Conemaugh, and Woodvale. The residents of Johnstown were caught by surprise when the water and debris hit the city at 40 mph (64 kph) with waves topping 60 ft (18 m). As debris piled up at the Stone Bridge just north of the city, it created a dam of its own, sending water back into Johnstown and forming a lake over the city. To make matters worse, the debris caught fire and burned for three days, and taking another 3 months to be completely cleared. Nearly 2,200 people were killed because of the flood, many burned and disfigured beyond recognition. Nearly 800 of the dead were never identified and are now buried in Grandview Cemetery in a field of blank tombstones. In the aftermath, lawsuits were filed against members of the South Fork Fishing and Hunting Club, but no one person was found guilty of negligence. In all cases the judged ruled the disaster "an act of God".

Debris at the Stone Bridge after the flood

This information was gathered from the National Park Planner website: npplan.com



High-density sludge demonstration plant at Mine 32 tested process and developed optimum operating conditions.

High-density sludge treats acid

P. D. Kostenbader, Engineer
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Homer Research Laboratories
Bethlehem Steel Corp.
Bethlehem, Pa.

For the past several years the Bethlehem Steel Corp.'s research department and Bethlehem Mines Corp., a subsidiary of Bethlehem Steel, have cooperated in extensive test programs to find economical and technically feasible methods for treating the acid mine drainage (AMD) often associated with coal-mining operations. Particular emphasis was given to finding methods that could be applied successfully to the AMD discharges from coal mines at Bethlehem's Ellsworth and Cambria Divs. to meet Pennsylvania's effluent criteria for iron, pH, and acidity. These investigations of methods for treating acidic metal wastes covered a wide span of technology, ranging from conventional cold-lime neutralization to countercurrent continuous ion exchange. Among the other methods investigated were:

- Deep-well disposal
- Assimilation in a coal-cleaning circuit
- Neutralization and oxidation using reactors in series
- Moving-bed reactor
- Inhibition of pyrite oxidation by protective coatings
- Limestone neutralization
- Modified lime neutralization or high-density sludge

Since only the results from conventional lime neutralization are germane to the development of the high-density sludge process described, we need not discuss all the methods here. Because the moving-bed-reactor process offered a novel and possibly effective approach, it will be interesting to at least define its basic operating principles, as follows: Lime slurry and AMD are fed into a fluidized bed of inert material where neutralization occurs and where the cations are precipitated on the surfaces of the material. The physical characteristics of the precipitated solids are such that a thickener is not required to obtain solids-liquid separation, and rather than a watery sludge the result is waste solids having the consistency and draining qualities of wet sand. However, scale-up of this process has not been developed sufficiently to meet state deadlines for Beth-

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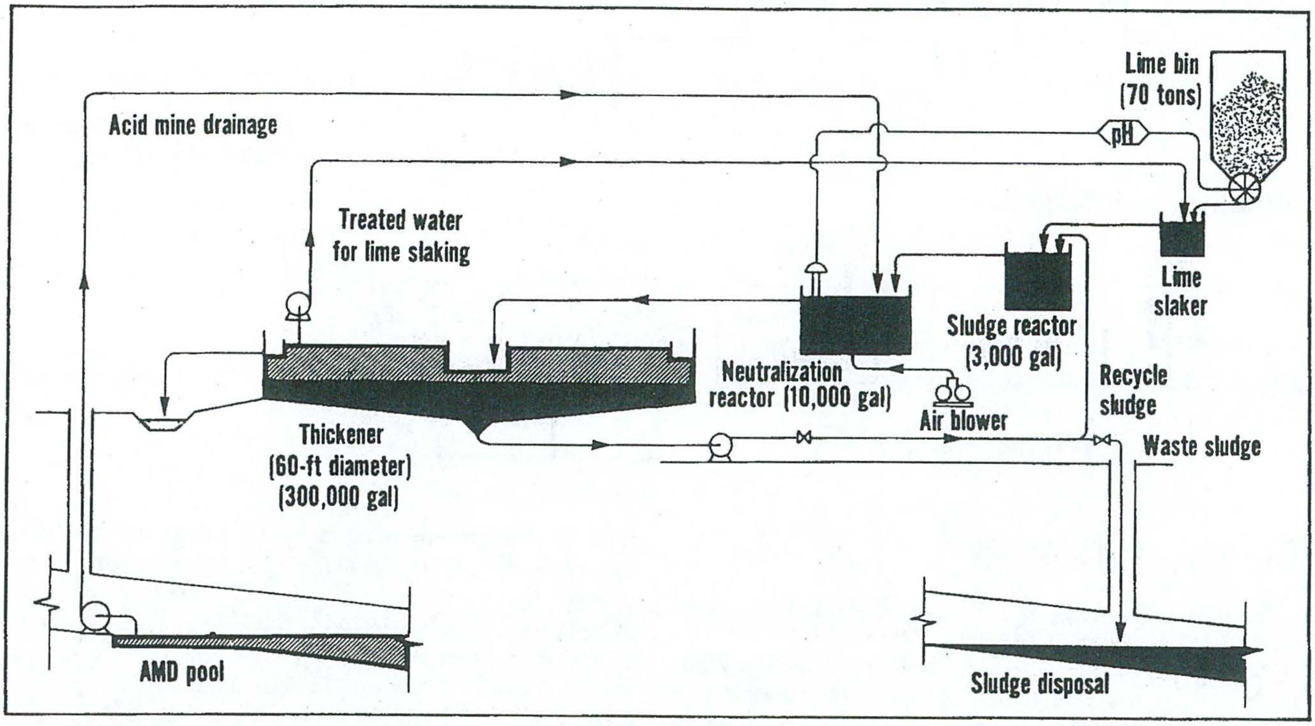
Adapted from a paper presented at the Third Symposium on Coal Mine Drainage Research, Pittsburgh, Pa., May 19-20, 1970.



Flow diagram, HDS demonstration plant at Mine 32. Method involves recycling of part of settled sludge.

mine drainage

lehem's acid mine drainage discharges in Pennsylvania.

Both conventional lime neutralization and assimilation in a coal-cleaning circuit were successfully applied by Bethlehem in full-scale treatment of AMD from mines in the high-volatile Pittsburgh seam in the Ellsworth Div. in southwestern Pennsylvania. However, neither of these treatment methods was considered to be satisfactory for the AMD discharges from the low volatile Lower Kittanning seams at Bethlehem's mines in Cambria County, Pennsylvania (Nos. 31, 32, 33 and 77), where the total flow from three discharges is presently over 9 million gal per day (mgd). Conventional lime neutralization would have presented the formidable problem of storing or disposing of more than 700 acre-feet per year of sludge containing about 1% solids. Furthermore, since two of Cambria's mines are in a fairly early stage of development, the flow to be dealt with in the future may be even greater. As for assimilation in coal-cleaning circuits, the problem was not only the magnitude of the AMD flows from the Cambria mines but also the lack of sufficient alkalinity in the refuse to neutralize the acid water.

Although conventional lime neutralization is certainly adequate for many applications, our research efforts were directed toward improving both the settling characteristics of the neutralized slurries and the solids concentration of sludges normally obtained from the conventional process. The outgrowth of these efforts led to the development of a modified lime-neutralization process characterized by a high-density sludge that requires only a fraction of the storage space needed when the conventional process is used. For brevity, the modified process is known as the high-density sludge process.

Conventional lime neutralization, illustrated in the top half of Fig. 1, consists of:

Mixing high-calcium or dolomitic lime with water to produce a lime slurry;

Neutralizing the AMD with the lime slurry at ambient temperature in a stirred reaction tank, either with or without aeration;

Settling the solids precipitated from the AMD in a clarifier, thickener, or settling pond;

Disposing of the thickened residual sludge.

As the schematic in the bottom half of the figure shows, the HDS process differs from conventional lime neutralization in that provisions are made for:

Recycling a controlled volume of the settled sludge, and

Mixing the recycled sludge with lime slurry in a reaction tank prior to the neutralization and separation steps.

(Continued)

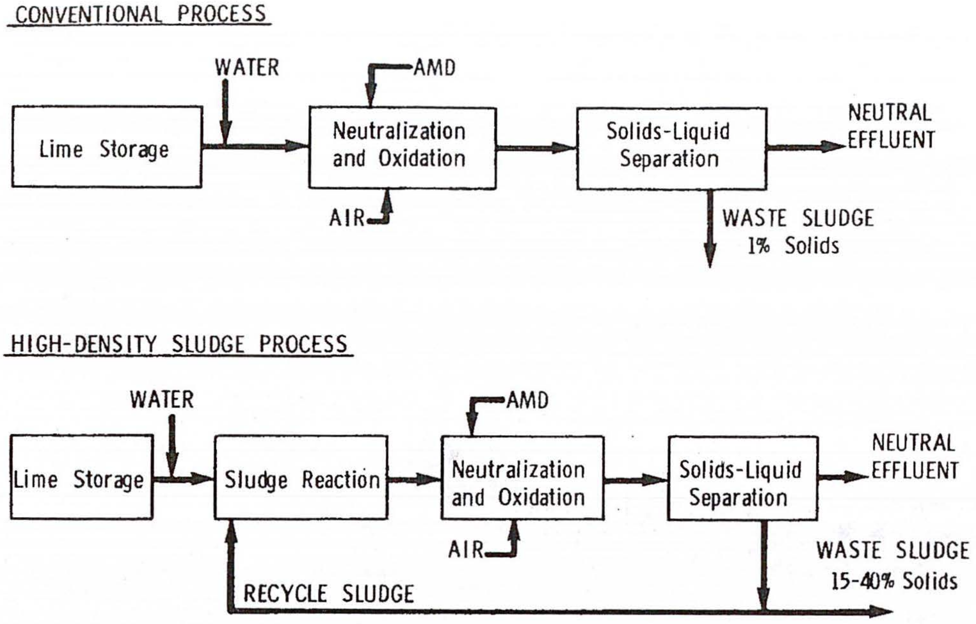


Fig. 1—Lime neutralization of acid mine drainage.

Researching the problem

Research efforts to develop an HDS process were initiated at Bethlehem's Homer Research Laboratories (HRL) in 1966 after it was demonstrated during pilot-plant testing that conventional lime neutralization of the AMD from the Cambria Div. mines resulted in settled sludges containing a maximum of 1% solids and thickener area requirements of 1,000-2,000 sq ft per ton of solids precipitated per day. Using bench-scale equipment, it was shown during exploratory testing of the HDS process that neutralization of a synthetic AMD having nearly all of the contained iron in the ferrous state could result in settled sludges containing a minimum of 40% solids and a thickener area requirement of about 500 sq ft per ton of solids precipitated per day. To take one example, this would mean that the predicted settling area requirements could be reduced for the 4.2 million gal per day of AMD from the Mines 32 and 33 complex by a factor of four and that the volume of sludge requiring final disposal could be reduced from 210,000 gal per day to about 5,000 gal per day, or from 5% of the AMD flow to one-eighth of 1%.

On the basis of the laboratory results, we proceeded to on-site pilot-plant testing of a natural mine discharge to obtain design data for full-scale treatment plants, followed later by bench-scale testing to study the effects of mine water chemistry and operating parameters. The return to more fundamental studies in the laboratory was required after it was determined during the pilot-plant tests that a settled sludge containing 15% solids was the maximum that could be produced from an AMD discharge having an average of 30% of the contained iron in the ferrous state. These pilot-plant results indicated that the chemical differences of individual mine discharges would affect sludge quality and therefore present corresponding design problems.

Although the early laboratory and pilot-plant tests were not conclusive for some of the variables, particularly mine water chemistry, the data were useful for expediting the design and construction, in 1967, of an HDS demonstration plant at Mine 32 to test the process on a ferrous iron AMD and develop optimum operating conditions before proceeding with a full-scale installation. During the 2½-yr period of plant operations, more than one billion gallons of AMD was processed. Tests to determine the effects of operating parameters were conducted at processing rates ranging from 400 to 2,100 gpm, and settled sludges were produced that contained a maximum of 40% solids, with a normal range of 30 to 35% solids. The discharge of excess sludge via a borehole to an area adjacent to the underground mine-water pool proved to be a satisfactory disposal method. The construction of a full-scale HDS plant for treating the present and projected AMD flow from the Mines 32 and 33 complex is scheduled for 1970. Upon completion of this plant, underground disposal of sludge will be continued under present plans.

Later bench-scale tests designed to study the variables affecting the HDS process were conducted at the research laboratories both before and during the operation of the demonstration plant. These tests, detailed later in this article, were successful in:

- Defining variables having major and minor effects on the process.
- Providing operating guidelines and accurately predicting the results obtained in demonstration plant operations.
- Providing engineering design data for treatment plants at Mines 77 and 31, where most of the iron in the AMD is present in the ferric state. An HDS treatment plant for Mine 77 was completed in November, 1969, and a plant for Mine 31 is scheduled for 1970.

Process benefits

The successful development and application of a high-density sludge process to replace conventional lime neutralization for treating AMD has produced the following beneficial results:

- New technology has been developed that results in sludges denser than could be obtained previously by proven and practical processes. Depending mainly on the oxidation state of the iron in the mine water, the sludges contain 15 to 40% solids. Storage requirements for sludges are thus reduced by a factor of anywhere from 15 to 40.

- The higher solids concentrations make further dewatering via filtering or centrifuging a practical possibility if future developments should require these steps.
- The HDS process is inherently well-suited to treating AMD discharges with high ferrous to ferric iron ratios, previously considered the most difficult to treat.
- The effectiveness of the improved lime-neutralization process underscores the built-in advantage of inexpensive processing by lime and air, as contrasted with more sophisticated processes.

Table 1—Chemical analysis of AMD concentration, ppm

Component	Synthetic AMD (pH = 2.8-3.1)	Mine 32 Supply shaft AMD (pH = 2.8-2.9)
Fe^{+2}	300	60-120
Fe^T	300	200-320
Al_2O_3	200	170-330
CaO	250	230-270
MgO	50	10-120
Mn	—	7-9
SiO_2	—	40-70
$SO_4^=$	2,100	1,900-2,200

Laboratory and pilot-plant studies

The first AMD chosen for HDS studies was from a minor discharge at a supply shaft of Mine 32 for which design data had been developed previously for a conventional lime-neutralization system. For the initial, or exploratory, laboratory studies we used a synthetic mixture of the approximate composition of the mine water from the supply shaft of Mine 32 (Table 1). This was done to avoid the cumbersome and time-consuming problem of transporting daily samples from the mine to the research laboratories in Bethlehem. At this stage in the program no attempt was made to duplicate the ferrous to ferric iron ratio.

These initial laboratory tests of the HDS process in a bench-scale pilot unit showed that, without forced aeration, neutralization of the synthetic AMD to pH 8.0-8.3 with high-calcium hydrated lime could result in settled sludges containing 45% solids. When forced aeration was used to completely oxidize the iron in the neutralized slurry, a settled sludge containing 50% solids was produced at a neutralization pH of 7.0-7.2. The volume and area requirements for settling the neutral slurries and thickening the sludge were reduced by a minimum factor of four as compared with the results from the conventional lime neutralization of the same synthetic AMD.

To determine whether these results could be duplicated on a natural mine-water discharge, a pilot plant, shown in Fig. 2, was operated for about 20 days at the supply shaft at Mine 32. Scaled-down equipment based on this flow sheet was used for all bench-scale testing. With operating conditions comparable to those used in laboratory tests, the rate of density increase was much slower than the rates experienced using synthetic AMD, and the maximum settled solids concentration obtained was 15%. Changes in equipment and operating parameters had no apparent effect on either the rate of increase in density or the final concentration of the settled sludge. On-site bench-scale tests, conducted concurrently with the pilot-plant tests, confirmed the pilot-plant results and showed that the problems could not be attributed to scale-up considerations. The increase in solids concentrations as a function of operating time during these tests is shown in Fig. 3.

Although these initial tests of the HDS process could not provide a basis for complete design solutions at this stage of the program, the results did reveal the sludge densification possibilities of the process and, in particular, provided the following findings:

- A conventional lime neutralization system could be modified to an HDS process by the rather simple

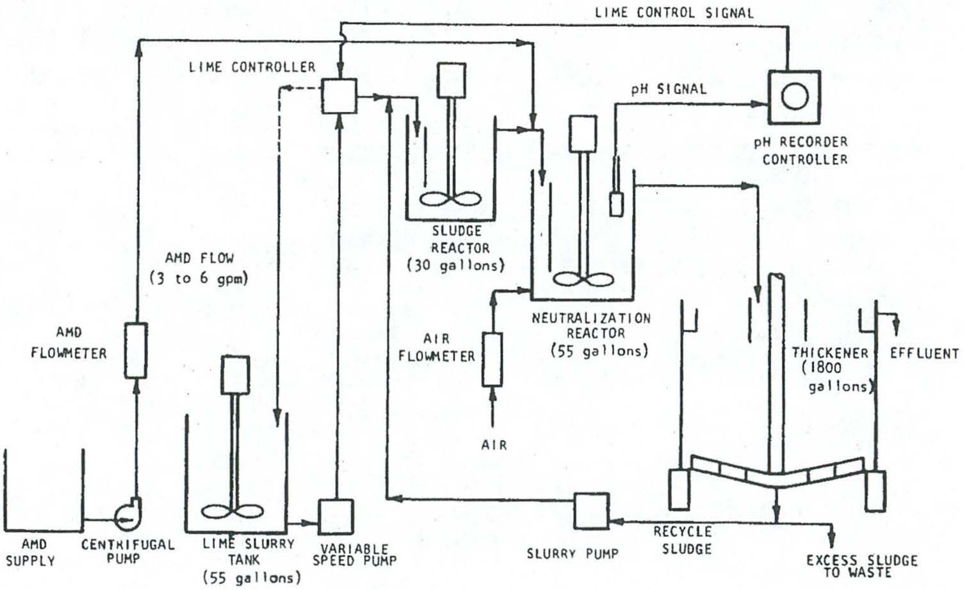


Fig. 2—Flow diagram for high-density sludge pilot plant at Mine 32 supply shaft.

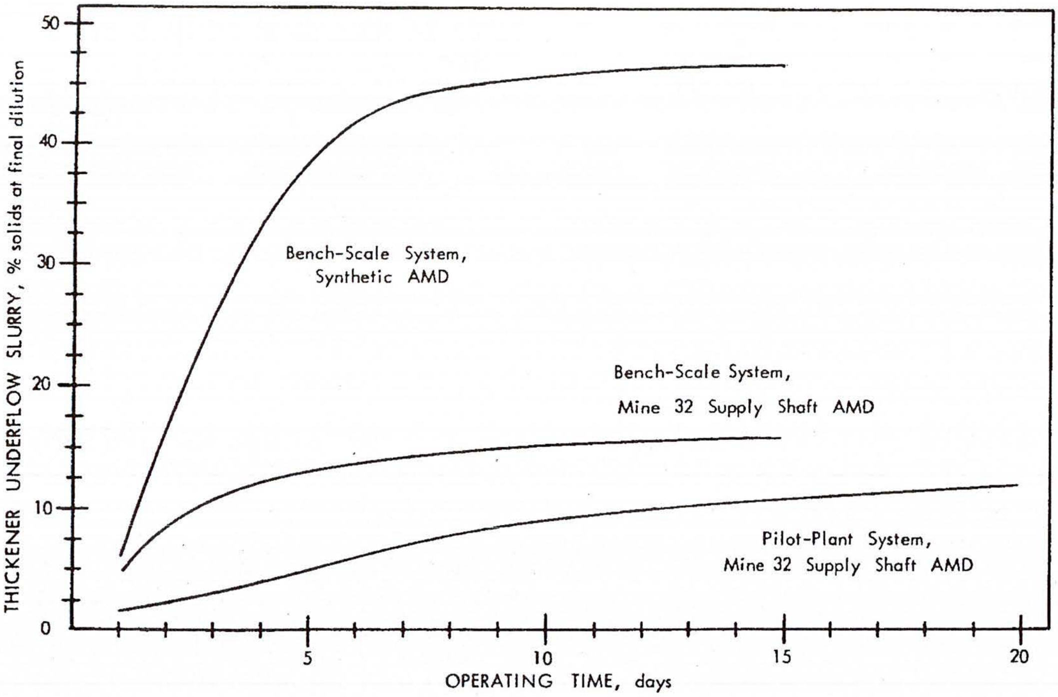


Fig. 3—High-density sludge tests, showing sludge density as a function of time.

Table 2—Flow rates and average chemical analysis of AMD from the Cambria Div. mines

	Mine 32 (Supply shaft)	Mine 31	Mines 32-33 (combined)	Mine 77
Flow, mgd	0.4	4.5	4.2	0.5
pH	2.9	3.0	3.2	3.2
Concentration, ppm				
Fe^{+2}	90	30	140	10
Fe^T	300	250	150	80
Al_2O_3	230	150	80	20
SiO_2	60	60	40	30
Mn	10	5	5	5
CaO	250	220	170	220
MgO	70	10	10	80
$SO_4^=$	2,100	2,000	1,400	1,200
Acidity ($CaCO_3$)	1,800	1,200	500	300

changes of adding a second reaction tank and a return system for thickener underflow slurry.

- The HDS process, when compared with conventional lime neutralization, would increase the solids concentration of settled sludges from 1% to a range of 15 to 50%.
- The maximum solids concentration obtainable was apparently related to the chemical composition.

Expanded program

These initial laboratory and pilot-plant findings furnished the basis for an expanded laboratory bench-scale program at the HRL. In this expanded program we made a more detailed study of the variables and operating parameters affecting sludge density. At the same time, to meet a mandated time schedule for implementing treatment facilities for the Mines 32 and 33 discharge, the data from testing the supply-shaft water were used to expedite the design and construction of a demonstration plant at Mine 32.

For the expanded program we first developed basic design data from Mines 32 and 33 water shipped in on a daily basis. This was done to minimize the possible effects of chemical changes and to eliminate errors that might be attributed to the use of synthetic mine-water mixtures. In the next phase of the expanded study we obtained design data for the HDS treatment of AMD from Mine 31, where the soluble iron in the mine water was more than 85% oxidized. Again, AMD samples were shipped from the mine on a daily schedule. However, even with the precaution of daily shipments of mine water from both sources, the oxidation of iron occurred to varying degrees and was found to affect sludge density, particularly in tests on AMD from Mines 32 and 33. That is, the ferrous to ferric ratio of the AMD emerged as an important factor to be taken into account in developing HDS design principles. Table 2 includes data on the AMD discharges used in the test, as well as data for Mine 77 where a full-scale HDS plant is in operation.

The results of the tests on AMD from Mines 31, 32 and 33, as well as pertinent data from the initial pilot-plant tests, tests on natural and synthetic steelplant wastes, and the demonstration plant, are summarized in the following sections on: ferrous to ferric iron ratios, ratio of solids recirculated to solids precipitated, point of alkalinity addition, neutralization pH, and detention time in reaction tanks.

Ferrous to ferric iron ratios

All test work showed that the ratio of ferrous to

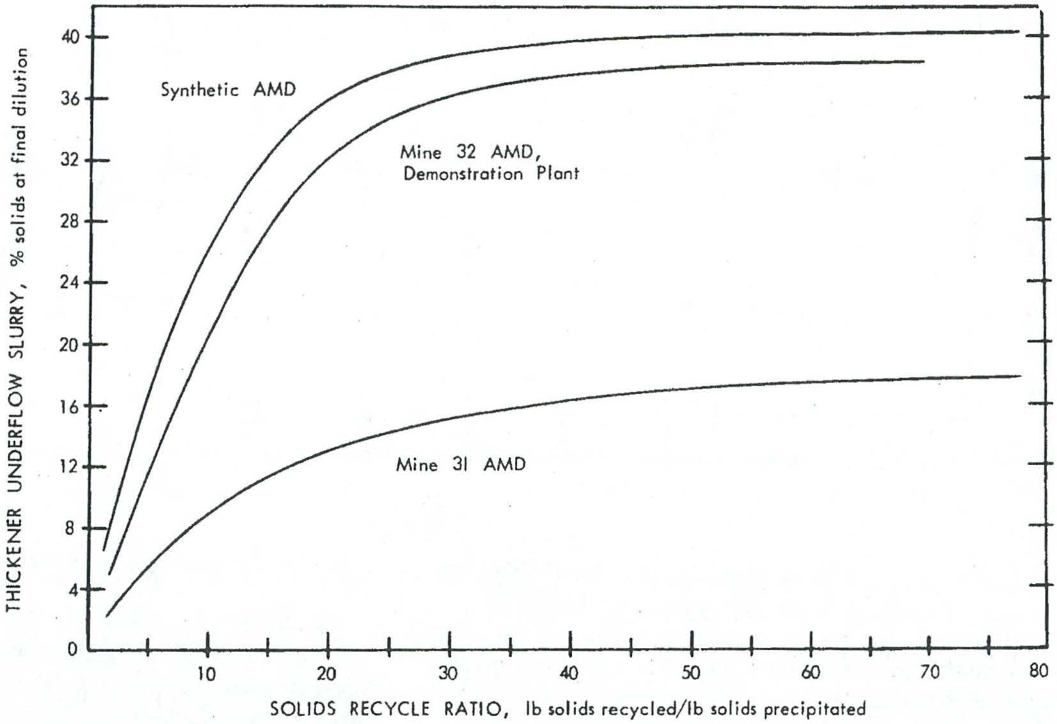


Fig. 4—High-density sludge treatment of AMD, solids concentration of settled sludges as a function of solids recycle ratios.

ferric iron in the wastes acted as an inherent control on the maximum concentration of settled solids that could be produced by HDS treatment. The effect of this ratio on the concentration of settled sludges is summarized in the following table:

Water source	Ferrous iron, Avg. % of total iron	Maximum concentration of settled solids, %
Mines 32-33 AMD (source discharge)	90	40
Synthetic AMD	>95	50
Synthetic steel plant waste	>95	45
Steel plant waste	>95	45
Mines 32-33 AMD (shipped samples)	70 (range 45-90)	22
Mine 32, supply-shaft AMD	30	15
Mine 31 AMD (shipped samples)	2	18

These data show the strong effect of the iron ratios at the upper and lower limits. There is a general proportionality between increasing iron ratios and solids concentrations, with the curve undergoing a break as the highest ratios are approached. This conclusion is supported by the test data on Mines 32-33 AMD, which showed an approximately 100% increase in solids concentration when the percentage of ferrous iron increased from a nonequilibrium oxidation state averaging 70% ferrous iron (45 to 90% range) to a near-steady 90%. However, we have not conducted the precise and lengthy tests that would be required to precisely document the relationship throughout the full range from zero to 100% ferrous iron. Our test data do not indicate that the species or concentrations of anions or cations other than iron had any appreciable effects on sludge density.

Ratio of solids recirculated to solids precipitated

The ratio of solids recirculated within the system to the solids precipitated from the AMD by the neutralization reaction, which is a discretionary operating control and affects thickener sizes because of total solids loadings, was determined to be of primary importance in controlling sludge density. The effect of this ratio on the solids concentration of settled sludges for a synthetic AMD and for AMD from Mine 31 and from Mines 32 and 33 is shown in Fig. 4. The curves for synthetic AMD and Mine 31 AMD were drawn from averaged bench-scale test data at recirculation ratios from 20:1 to 80:1 and from the extrapolation of data at ratios below 20:1. The curve for Mines 32 and 33 AMD was drawn from demonstration plant operating data. The three curves show that the solids concentration increased rapidly as the recirculation ratio was increased to 20:1, the rate of increase in concentration decreased in the ratio range of about 20:1 to 30:1, and the percentage increase in concentration was relatively small in the ratio range of 30:1 to 80:1. The optimum range was 25:1 to 30:1, consistent with good process control, the production of near-maximum sludge densities, and minimum area requirements for sludge settling and thickening. It is of interest to note that this optimum ratio range was the same for both ferrous and ferric waters.

The combined effects of solids concentrations and recycle ratios on the size requirements for a thickener for Mine 31 AMD are shown in Fig. 5. These curves show that within the range of optimum recycle ratios the predicted thickener area requirement would be 2,100 sq ft per ton of solids precipitated per day, or about 20% higher than was determined for con-

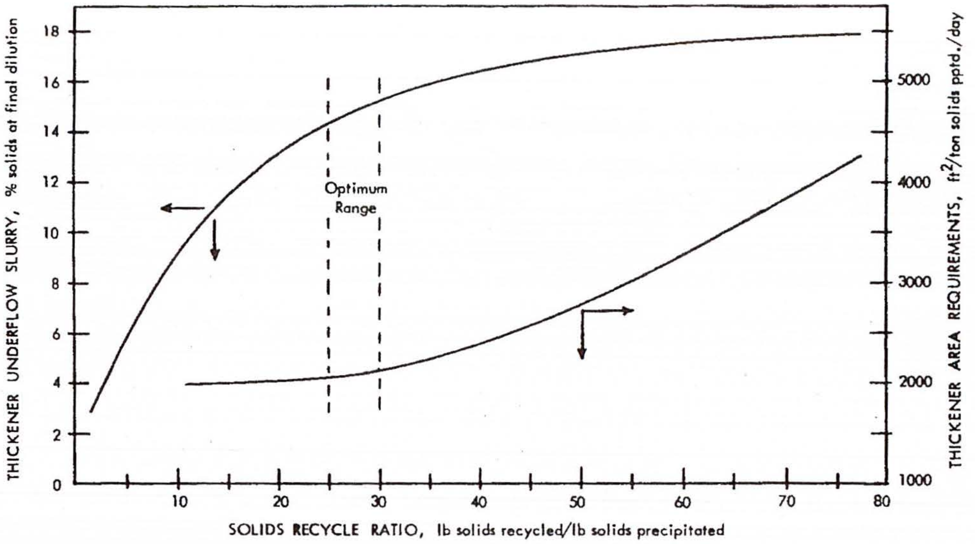


Fig. 5—High-density sludge treatment of Mine 31 AMD, solids concentration of settled sludges and thickener area requirements as a function of solids recycle ratios.

ventional lime neutralization of this AMD. The advantage of treating Mine 31 AMD by the HDS process would accordingly be predicated on a 15-fold increase in sludge concentration rather than on any reduction in thickener size.

Point of alkalinity addition

In the HDS process developed by Bethlehem, the ability to produce maximum-density sludges is based on the practice of mixing lime slurry with recycle slurry before reacting the high pH mixture with AMD. The effects of changing the point of alkalinity addition were determined in bench-scale tests and were later confirmed during demonstration plant operations. In a short-term test, it was shown that mixing lime slurry, recycle slurry, and AMD in a single reaction tank resulted in process failure, i.e., a 50% decrease in settled solids concentration and a 100% increase in thickener area requirements were experienced. Similarly poor results were obtained when the AMD and recycle slurry were mixed in the sludge reactor and the alkalinity was added to the mix in the neutralization reactor.

Neutralization pH

Bench-scale tests and tests at the demonstration plant showed that the neutralization pH had very significant effects on the physical characteristics of the neutralized slurry and on the thickener areas required for sludge settling. These effects are summarized as follows:

- The optimum pH range from overall process considerations was 7.2 to 7.7. Within this range, the oxidation rate of the ferrous iron was satisfactory, sludges of maximum density were produced, and thickener area requirements were at a minimum.
- A neutralization pH range of 6.0 to 6.5 reduced the alkalinity requirements, but the oxidation and precipitation rate of the iron was not satisfactory for practical consideration in sizing the neutralization reactor.
- An average neutralization pH of 8.5 reduced the turbidity of the clarified effluent but decreased the settled solids concentration from 35 to 20% and increased the thickener area requirements by a factor of 1.6.
- A pH range of 9.0 to 9.5 resulted in the production of a rubbery sludge that could not be pumped and that increased torque on the thickener rakes to the extent that the rakes became inoperative.

Detention time in reaction tanks

The HDS process utilizes separate reaction tanks for the sequential steps of mixing lime slurry with recycle slurry and for the combined reactions involving neutralization, oxidation of ferrous iron, and precipitation of cations. In considering reactor sizes for design purposes, it was recognized that the rates of reaction and precipitation are complex functions of numerous variables that can affect the detention times required for completing the chemical reactions. It was not considered necessary to devote detailed research studies to a rigorous or quantitative definition of these variables, since for design purposes it was sufficient to simply specify conservative detention times.

The effects of detention time on over-all process results were determined during laboratory testing of the HDS process. These tests showed that a detention time of 1 min in the sludge reaction tank was sufficient to produce and maintain sludges of maximum density and that a detention time of 10 min in the neutralization-oxidation tank ensured oxidation and precipitation of the ferrous iron at any pH value above 7.2. A maximum detention time of 1 min in the sludge reaction tank is considered to be a valid design number for an HDS system, but detention time in the neutralization tank would be a function of both the initial ferrous iron concentration and the neutralization pH.

Demonstration plant

Our findings about the effects of the above-described variables on the HDS process were incorporated into the operation of the demonstration plant which we had constructed in Mine 32 to treat the AMD from Mines 32 and 33. Before describing the design and operation of our demonstration plant it will be useful to briefly note some highlights of the steps preceding the construction of the plant.

In 1966 the Pennsylvania Sanitary Water Board approved a request by Bethlehem to construct and operate a demonstration plant at Mine 32, to test the HDS process, and to develop firm engineering design data before proceeding with full-scale treatment facilities at the Cambria Div. mines. This request was approved on the basis that the HDS process represented new and improved technology. At the same time, it was understood that the technology was still in the developmental stage and that our early laboratory and pilot-plant programs provided only primary guidance in terms of designing full-scale plants. The demonstration plant was approved by Bethlehem management in the fall of 1966, site preparation and construction were started in January, 1967, and a target startup date of early July was met. The capital cost of the plant, including equipment changes and plant modifications from 1966-69, was approximately $350,000.

Based on the results of the exploratory pilot-plant tests of the HDS process, a conservative estimate of the expected AMD processing rate was 300 gpm, and it was predicted that the settled sludge would contain at least 15% solids. This design flow was exceeded immediately after startup, and during the following 2½-yr period of plant operation the effects of operating parameters on process results were evaluated at flow rates ranging from 400 to 2,100 gpm. The solids concentrations of settled sludges were as high as 40% but ranged from 30 to 35% under operating conditions that were established for scale-up. An AMD rate of 800 gpm to the 60-ft-diameter thickener at the demonstration plant was established as a maximum design number for consistently meeting or bettering the state criterion of 7 ppm iron in the clarified effluent, while at the same time providing a 100% safety or efficiency factor for sludge settling and thickening—an efficiency factor of 100% is generally specified in conservative engineering design.

Plant operation at AMD rates up to about 1,400 gpm was satisfactory with respect to solids settling and thickening. However, the iron limit of 7 ppm could not be met because the higher hydraulic loadings and decreased detention times in the thickener resulted in an increase in the concentration of the very fine solids that accounted for nearly all of the iron in the clarified effluent. Test programs designed to find methods for improving clarification efficiency showed that either tube settlers installed in the thickener or a high-rate filter used for polishing the thickener effluent were effective in reducing the concentration of suspended solids. Methods found to be ineffective were secondary clarification in a settling pond and the use of flocculants. There are no present plans to implement the methods employing the tube settlers or a high-rate filter, because the capital cost to benefit ratio far exceeds that provided by the thickener capacity obtainable with conservative design for settling and thickening sludge.

Operation of the demonstration plant for a 2½-yr period proved the technical feasibility of the HDS process and provided firm design data for a full-scale AMD treatment plant for the Mines 32 and 33 complex. Utilizing the demonstration plant as a large-scale pilot unit over an extended period gave these benefits:

- Provided operating experience and solutions to problems associated with seasonal changes.
- Substantiated laboratory test data that had defined the effects of variables on the process.
- Resulted in modifications to the original plant design that simplified full-scale plant layout and reduced capital costs.
- Resulted in a discovery that reduced the costs for alkalinity for treating Mines 32 and 33 AMD.
- Proved the feasibility of disposing of thickened sludges in an abandoned area of the mine.

With reference to alkalinity costs, it was determined during early tests at the demonstration plant that the alkalinity requirements were substantially higher than was predicted from neutralization curves. This apparent anomaly was solved by Mines' personnel when it was determined that CO_2 in the mine water was responsible for the excessive lime demand and that the CO_2 could be readily stripped by aerating the AMD. Aeration of the mine water prior to introducing it into the neutralization reactor was incorporated as standard plant practice and resulted in reducing the lime demand by 25%.

Two of the bases used for choosing the site for the demonstration plant were that company-owned land was adjacent to the AMD boreholes and that discharging sludges directly underground from the plant to abandoned workings near the mine-water pool could be tested as a possible method for final disposal of thickened sludge. This sludge disposal method was found to be satisfactory during the entire period of plant operation. There was no evidence that sludge was either solubilized by contact with the acid water or short-circuited to the AMD pumps, and examination of the sludge underground showed further dewatering to 55% solids. Although it is expected that underground disposal will prove satisfactory for the foreseeable future, tests were conducted that showed that the sludge could be dewatered by either a filter or centrifuge to produce a cake suitable for handling and transport by truck.

Extensive and cooperative research conducted by Bethlehem Mines Corporation and Bethlehem Steel Corporation to develop practical processes for treating acid mine drainage (AMD) has covered the range from simple lime neutralization to sophisticated ion exchange. A modification of a conventional lime-neutralization process, referred to as a high-density sludge (HDS) process, which was developed in the laboratory and tested in a pilot plant, proved technically successful during a 2½-yr operating period of a 1-million-gal-per-day demonstration plant.

Compared with the 1% solids concentration of sludges obtained from conventional lime neutralization of three AMD discharges, the HDS process produced settled sludges containing 30 to 40% solids for a discharge having a high ferrous to ferric iron ratio and 15 to 18% solids for two discharges containing mainly ferric iron. A full-scale plant utilizing the HDS process was completed in 1969, and two plants are planned for 1970. Upon completion of these units, more than 9 million gal per day of AMD will be treated, the built-in design capacity being sufficient to handle expected increases. ■

United States Patent [19]

Kostenbader

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[45] **June 12, 1973**

[54] **METHOD FOR TREATING ACID WATER CONTAINING METALLIC VALUES**

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[51] **Int. Cl.** **C02c 5/04**
[58] **Field of Search** 210/50, 46, 59, 63, 210/61, 60

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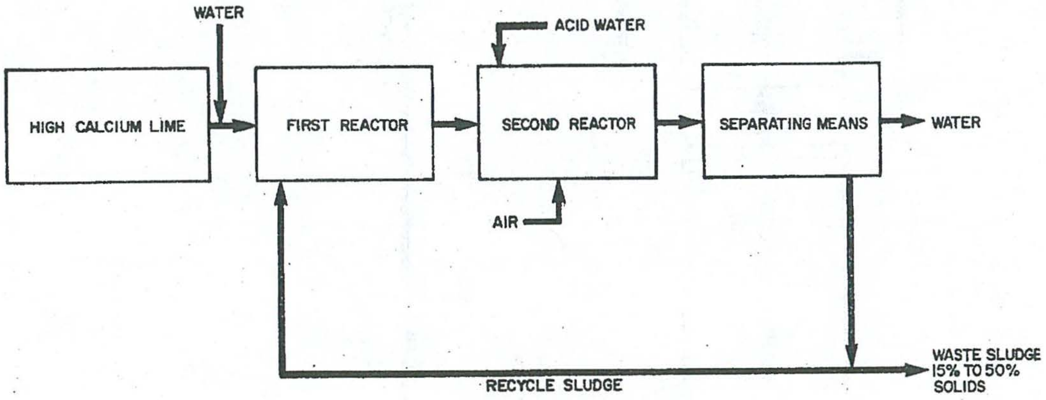
[57] **ABSTRACT**

Method for treating acid water containing metallic values, for example AMD and diluted waste pickle liquor, in which the acid water is treated with an alkali-water slurry, for example, high calcium lime, mixed with a portion of the sludge formed in the method. The alkali-water slurry and sludge are mixed in a first reactor for a time to obtain a uniform mix, prior to treating the acid water. The alkali-water slurry and sludge mix and the acid water flow to a second reactor. Air can be introduced into the second reactor. The acidity of the water is neutralized and a substantial portion if not all of the metallic values are oxidized and precipitated as solids. The mixture in the second reactor flows to a separating means wherein the precipitated solids settle out and form a sludge. The sludge contains about 15 percent to about 50 percent solids. To achieve the results of the invention it is necessary to recycle a portion of the sludge formed in the method. About 20 pounds of solids in the sludge are required for each pound of solids precipitated from the acid water. The treated water can be recycled in the plant or can be discharged into environmental surface water without danger of polluting same.

13 Claims, 1 Drawing Figure



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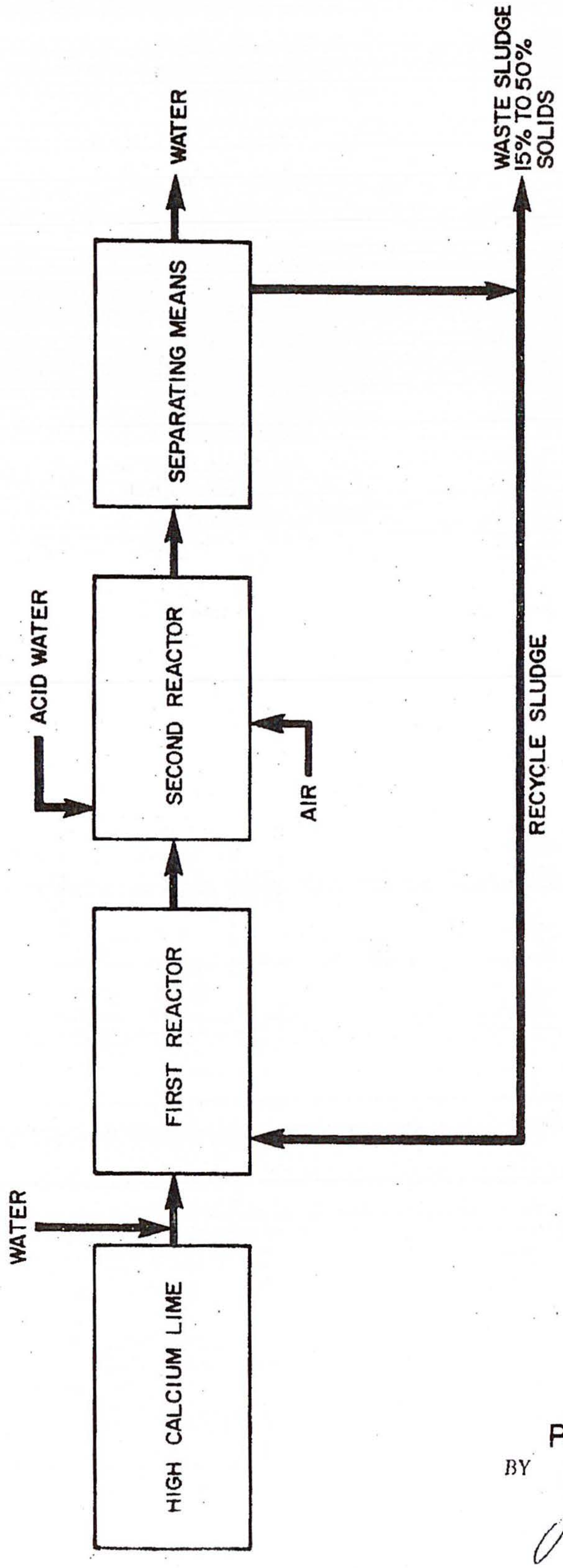

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METHOD FOR TREATING ACID WATER CONTAINING METALLIC VALUES

BACKGROUND OF THE INVENTION

This invention is directed to a method for treating acid water containing metallic values, whereby the acidity of the water is neutralized and a substantial portion of the metallic values are precipitated and settle-out as solids. More specifically, the invention is directed to a method for treating acid water, such as, AMD (acid mine drainage) and diluted waste pickle liquor, which contain metallic values, such as ferrous and ferric iron and compounds of aluminum, calcium, magnesium, zinc, manganese, silicon and the like which compounds can be sulfates and/or chlorides, with a high calcium lime-water slurry mixed with a portion of the sludge formed in the method. The acidity of the water is neutralized and a substantial portion, if not all, of the metallic values are precipitated as solids in a reactor and settle-out as a densified sludge in a separating container. In the method, a specified portion of the sludge is recycled and mixed with high calcium lime-water slurry for specified reaction times and within a specified pH range.

Acid water, for example, AMD from coal mines and diluted waste pickle liquor in steel plants and the like, which contain metallic values, for example ferrous and ferric iron and compounds of aluminum, zinc, calcium, magnesium, manganese, silicon and the like which compounds are sulfates and/or chlorides, must be treated to neutralize the acidity of the water and to remove the metallic values therefrom, before the water can be passed to waste. Prior art methods to treat the acid water are directed to mixing the acid water with an alkali, such as, high calcium lime or dolomitic lime in a water slurry with or without aeration to neutralize the acidity and to precipitate insoluble solids. The mixture is allowed to stand for a period of time to allow the precipitated insoluble solids to settle-out to form a residual sludge. The residual sludge is passed to waste.

Unfortunately, the precipitated solids produced in the above described method form a sludge containing only about 1 to 2 percent solids when allowed to settle-out. As a result, it is impossible to economically dispose of the sludge thus formed.

SUMMARY OF THE INVENTION

It is the primary object of this invention to provide a method for treating acid water containing metallic values wherein the acidity of the water is neutralized and the metallic values are precipitated as solids which settle-out to form a densified sludge.

It is another object of this invention to provide a method for treating acid water containing metallic values wherein the acid water is mixed with a mix containing an alkali-water slurry and a portion of the sludge formed in the method to neutralize the acidity of the water and to precipitate the metallic values as solids which settle-out to form a densified sludge.

It is another object of this invention to provide a method for treating acid water containing metallic values including ferrous iron values wherein the acid water is mixed with a mix containing an alkali-water slurry and a portion of the sludge formed in the method in the presence of an oxygen-bearing fluid to neutralize the acidity of the water, to oxidize the ferrous iron values and to precipitate the metallic values as solids which settle-out as a densified sludge.

It is another object of this invention to provide a method for treating acid water containing metallic values in which substantially all the iron values are in the ferric state wherein the acid water is mixed with a mix containing an alkali-water slurry and a portion of the sludge formed in the method to neutralize the acidity of the water and to precipitate the metallic values as solids which settle-out to form a densified sludge.

It is another object of this invention to provide a method for treating AMD wherein a portion of the densified sludge is recycled in the system.

It is another object of this invention to provide a method for treating AMD whereby the acidity of the AMD is neutralized and the metallic values therein are oxidized to form solids and to increase the solids concentration of precipitates which are formed.

It is another object of this invention to provide a method for treating acid water containing metallic values wherein said acid water is treated with a mix containing an alkali-water slurry and recycled sludge in a reactor with or without the presence of air to neutralize the acidity of the water and to precipitate the metallic values as solids.

It is another object of this invention to provide a method for treating acid water containing metallic values with a mix containing a high calcium lime-water slurry and recycled sludge in a reactor with or without the presence of air wherein the metallic values are precipitated as insoluble solids and the solids are allowed to settle-out to form a sludge containing 15 to 50 percent solids and the acidity of the water is neutralized.

It is another object of this invention to provide a method for treating acid water containing metallic values wherein sludge containing not less than about twenty pounds of solids is recycled for each pound of solids precipitated from the acid water.

It is another object of this invention to provide a method for treating AMD containing metallic values, for example, ferrous and ferric iron and compounds of aluminum, silicon, magnesium and the like which compounds can be sulfates and/or chlorides wherein a high calcium lime-water slurry and recycled sludge mix is caused to contact the AMD in the presence of air to neutralize the acidity of the AMD, to oxidize a substantial portion, if not all, of the metallic values therein and to precipitate the metallic values as insoluble solids which settle-out to form a densified sludge containing about 15 percent to about 50 percent solids.

DESCRIPTION OF THE DRAWING

The drawing is a block diagram showing the method of the invention.

SUMMARY OF THE INVENTION

Broadly, the method of the invention is directed to treating acid water containing metallic values with an alkali-water slurry and recycled sludge mix, with or without the presence of air, to neutralize the acidity of the water and to precipitate a substantial portion, if not all, of the metallic values as solids. The solids settle-out to form a sludge containing 15 to 50 percent solids.

DESCRIPTION OF THE PREFERRED EMBODIMENT

I have found that acid water, for example, AMD from coal mines and diluted waste pickle liquor from steel plants, containing metallic values, for example ferrous and ferric iron, compounds of aluminum, silicon, calcium, magnesium and zinc which compounds can be sulfates and/or chlorides, can be treated with a mix containing an alkali-water slurry and recycled sludge formed in the method. The alkali can be high calcium lime, dolomitic lime, and sodium hydroxide. This mix thus formed neutralizes the acidity of the water, and precipitates a substantial portion, if not all, of the metallic values therein as solids, which solids settle-out to form a sludge containing 15 to 50 percent solids.

I have found that if the iron in the acid water is substantially all in the ferrous state, air must be provided during the neutralization-oxidation step to oxidize the iron. The metallic values are also precipitated. It is not necessary to provide air during the neutralization-oxidation step if the iron values in the acid water are substantially all in the ferric state. In the latter case, neutralization of the acidity of the water will cause precipitation of the metallic values therein.

The method of the invention is diagrammatically shown in the drawing. An alkali, for example, high calcium lime, magnesia, dolomitic lime and sodium hydroxide and the like, is mixed with water to form a slurry. I prefer to use high calcium lime as the alkali. By high calcium lime, I mean lime which is the product of the calcination of high calcium limestone. High calcium limestone is a general term for stone containing calcium carbonate and little (about 2 to 4 percent) magnesium carbonate. The high calcium lime-water slurry, which for practical considerations can be 1 to 10 percent high calcium lime, flows to a first reactor. A portion of the sludge settled in the final step of the method, is passed to the first reactor. I have found that it is necessary to recycle a sludge containing not less than about 20 pounds of solids for each pound of solids precipitated from the acid water. It is preferred to recycle a sludge containing about 20 pounds to about thirty pounds of solids for each pound of solids precipitated. The high calcium lime-water slurry and recycled sludge are mixed for a time, at least 1 second, to achieve the results of the invention. The chemical reactions which occur between the high calcium lime-water slurry and recycled sludge in the first reactor are very rapid. Very little is known or understood concerning these reactions, however, the results of the invention are not achieved unless the contact between the high calcium lime-water slurry and recycled sludge is achieved. Of course, it must be understood that the retention time in the first reactor can be indeterminably long but economic considerations, for example, size and cost of the first reactor, dictate that the time be of relatively short duration. I prefer to mix the high calcium lime-water slurry and recycled sludge for not less than 1 second and not longer than 20 minutes.

The high calcium lime-water slurry and recycled sludge mix flows to a second reactor. The acid water also flows into the second reactor. The high calcium lime-water slurry and recycled sludge mix react (in a neutralization-oxidation step) with the acid water in the presence of air, which is bubbled through the reacting mixes. The acidity of the water is neutralized, that is, the pH value is modified to not less than 7.0. The oxygen in the air oxidizes substantially all the ferrous iron to insoluble hydrated ferric oxide. The compounds of aluminum, calcium, magnesium, silicon and zinc are precipitated as insoluble hydroxides and sulfates. The time in the second reactor can be as little as 5 minutes and as long as necessary to obtain substantially complete oxidation and precipitation of metallic values as insoluble solids. I prefer to use a time of about 5 minutes to about 20 minutes. The acidity of the water is neutralized, that is, the water has a pH of not less than 7.0 and may be as much as 9.0. I prefer to produce a pH of about 7.0 to 8.0 in the water in the second reactor to obtain optimum results.

The high calcium lime-water slurry-recycled sludge-acid water mixture flows to a separating means, for example, a thickener or a settling pond or the like. The precipitated solids settle-out to form a sludge containing about 15 percent to about 50 percent solids. As noted previously, a portion of the sludge is recycled to the first reactor. The remaining sludge is disposed of as a waste product. The clarified neutralized water can be recycled in the system or can be disposed of in environmental surface water.

While I have shown the use of air to oxidize ferrous iron values in the acid water, it must be understood that if substantially all the iron values are in the ferric state, it is not necessary to use air to oxidize the iron values therein. The metallic values will precipitate as solids when the acidity of the water is neutralized.

If the iron values in the acid water are in the ferric state a sludge containing about 15 percent to about 20 percent solids is obtained whereas if the iron values are in the ferrous state, a sludge containing up to about 50 percent solids is obtained. Acid water containing both ferrous and ferric iron values can be treated to obtain a sludge containing between about 15 percent to about 50 percent solids dependent upon the amount of ferrous iron values therein.

Whenever percentages are specified in the specification and claims such percentages are on a weight basis unless otherwise noted.

In a specific example of the invention, AMD having a pH of 2.8–3.1 and having the following composition (in parts per million): was treated for a period of about eight hours according to the method of the invention. A throughput of 100 milliliters per minute was maintained in the apparatus. About 10 grams of hydrated lime (made from high calcium lime) was mixed with a liter of distilled water to make a lime slurry. An average of about 55 milliliters per minute of recycled sludge containing about 15 percent solids were mixed with the lime slurry. The retention time was varied from 0.1 to 20 minutes in the first reactor. The mixture flowed to the neutralization-oxidation step or second reactor. The retention time of the AMD and mixture in the second reactor was varied between 10–20 minutes. The pH of the solution was within the range of about 7.1 to 8.0. The AMD and mixture flowed to a thickener. About 1,000 ppm. of solids were precipitated from the AMD. Settled sludge separated from the treated water contained about 50 percent solids. Sludge in excess of that required for recycle was drained from the bottom of the thickener and was discarded. The clarified neutralized water from the thickener had a pH within the range of 7.1–8.0 and was substantially free of dissolved iron.

Fe^{+2}	Fe^{T}	Al_20_3	CaO	MgO	SO_4
225 to 350	300 to 350	200	250	50	2100

In another specific example of the invention, AMD having a pH of 2.8 to 2.9 and having the following composition (in parts per million):

Fe^{+2}	60 to 120
Fe^T	200 to 320
Al_2O_3	170 to 330
CaO	230 to 270
MgO	10 to 120
Mn	7 to 9
SiO_2	40 to 70
SO_4	1900 to 2200

was treated for 1 week according to the method of the invention. A throughput of 3 gallons per minute was maintained in the apparatus. From about 0.1–1.0 pound of high calcium lime was mixed with 9–10 pounds of water to make the high calcium lime slurry. About 1.5 gallons per minute of recycled sludge containing about 6.5 percent solids were mixed with the lime slurry in a retention time of about 20 minutes in the first reactor. The mixture was pumped to the neutralization-oxidation step or second reactor. The retention time of the AMD and mixture in the second reactor was 10–12 minutes. The pH of the solution was within the range of 7.0–7.8. The AMD and mixture flowed to a thickener. About 1,054 ppm of sludge was precipitated from the AMD. The settled sludge separated from the water contained 15 percent solids. Sludge, in excess of that required for recycle, was drained from the bottom of the thickener and was discarded. The clarified neutralized water that overflowed from the thickener had a pH of 7.0 to 7.8 and had the following dissolved solids composition (in parts per million):

Fe^T	Al_2O_3	CaO	MgO	Mn	SiO_2	SO_4
<1	2 to 8	850 to 1040	50 to 170	up to 8	up to 10	1880 to 2440

In another specific example of the invention, AMD having a pH of 3.0–3.2 and having the following average chemical composition (in parts per million):

Fe^{+2}	Fe^T	Al_2O_3	SiO_2	Mn	CaO	MgO	SO_4
140	150	80	40	5	170	10	1400

was treated for a period of about 1 week according to the method of the invention. A throughput of 800–1,000 gallons per minute was flowed through the apparatus. Settled sludge separated from the treated water contained 30–40 percent solids when practicing the preferred method of maintaining the recycle solids at 20 to 30 pounds for each pound of solids precipitated from the AMD, using a mixing or reaction time of 0.1–10 minutes in the first reactor and a reaction-oxidation time of about 10 minutes in the second reactor. The reaction pH in the second reactor was within the range of 7.0–8.0. About 450 ppm of solids were precipitated from the AMD and sludge in excess of that required for recycle was drained from the bottom of the thickener and was discarded. The clarified neutralized water from the thickener was substantially free of dissolved iron.

In another specific example of the invention applied to a metal-bearing waste from a steel plant, a diluted acid waste having a pH of 1.3–2.4 and having the following composition (in parts per million):

Fe^{+2}	Fe^T	Zn	SO_4
257 to 1022	402 to 1130	3 to 120	790 to 5300

was treated according to a preferred method of the invention. A throughput of 2–4 gallons per minute was treated in the apparatus. Settled sludge separated from the treated water contained as much as 45 percent solids when practicing the preferred treatment method. From 700 ppm to 7,000 ppm of solids were precipitated from the waste, and the clarified neutralized water from the thickener had a pH of 7.5 to 8.0, was substantially free of dissolved iron and contained 0.6–7.0 ppm Zn.

I claim:

1. In a method for treating acid water containing metallic values to neutralize the acidity thereof and to oxidize and precipitate a substantial portion of the metallic values as solids and to produce a densified sludge thereof, the method comprising:

a. forming a slurry of water and at least one alkali taken from the group consisting of high calcium lime, magnesia, dolomitic lime and sodium hydroxide,

b. mixing the slurry of step (a) with a portion of the densified sludge produced in step (d) in a first reactor for a time to obtain a uniform mix consisting essentially of said slurry and said densified sludge portion,

c. thereafter mixing the mix of step (b) and acid water in a second reactor to cause the mix and acid water to react in the presence of air to neutralize the acidity of the acid water and to oxidize and precipitate a substantial portion of the metallic values therein as solids and forming a mixture thereof,

d. passing the mixture of step (c) to a separating means wherein the precipitated solids settleout to form a densified sludge containing about 15 percent to about 50 percent solids thereby obtaining clarified neutralized water, and e. drawing the clarified neutralized water from the separating means and passing a portion of the densified sludge to waste.

2. In a method for treating acid water containing metallic values in the form of ferrous and ferric iron and compounds taken from the group consisting of aluminum, calcium, magnesium, silicon and zinc, said compounds being sulfates and/or chlorides, wherein the acidity of the water is neutralized and substantially all the ferrous and ferric iron values and a substantial portion of the other metallic values are precipitated as solids, which solids settle-out to produce a densified sludge containing about 15 percent to about 50 percent solids, the method comprising:

a. mixing water and at least one alkali taken from the group consisting of high calcium lime, magnesia, dolomitic lime and sodium hydroxide to make a slurry, b. passing the slurry of step (a) to a first reactor,

c. recycling a portion of densified sludge formed in step (f) to the first reactor,

d. mixing the slurry of step (a) and the portion of densified sludge of step (c) for a time to obtain a uniform mix consisting essentially of said slurry and said densified sludge portion,

e. thereafter mixing the mix of step (d) with the acid water in a second reactor in the presence of air for a time to neutralize the acidity of the water and to oxidize the ferrous iron values and precipitate substantially all the iron values and a substantial portion of the metallic values as solids,

f. passing the mixture of step (e) to a separating means wherein the precipitated solids settle-out to form a densified sludge containing about 15 percent to about 50 percent solids thereby obtaining clarified neutralized water, and

g. drawing off the clarified neutralized water as an overflow from the separating means, and passing a portion of the densified sludge to waste.

3. The method of claim **2** in which the alkali of step (a) is high calcium lime.

4. The method of claim **2** in which said portion of the sludge of step (c) contains at least about 20 pounds of solids per pound of solids precipitated in the second reactor.

5. The method of claim **2** in which the time of mixing of step (d) is not less than 1 second.

6. The method of claim **2** in which the time of mixing in step (e) is about 5 minutes to about 20 minutes.

7. The method of claim **2** in which the acid water is neutralized to a pH of about 7.0 and to about 9.0 with a preferred range of about 7.0 to about 8.0 in step (e).

8. The method of claim **2** wherein the acid water is waste acid pickle liquor from a steel plant.

9. In a method for treating acid water containing iron values in the form of ferric iron and compounds taken from the group consisting of aluminum, calcium, magnesium, silicon and zinc, the compounds being sulfates and/or chlorides, wherein the acidity of the water is neutralized and substantially all of the ferric iron values and a substantial portion of the other metallic values are precipitated as solids, which solids settle-out to produce a densified sludge containing at least about 15 percent solids, the method comprising:

a. mixing water and at least one alkali taken from the group consisting of high calcium lime, magnesia, dolomitic lime and sodium hydroxide to form a slurry thereof,

b. passing the slurry of step (a) to a first reactor,

c. recycling a portion of the densified sludge formed in step (f) to the first reactor,

d. mixing the slurry of step (a) and the portion of the densified sludge of step (c) for a time to obtain a uniform mix consisting essentially of said slurry and said densified sludge portion, e. thereafter mixing the mix of step (d) with the acid water in a second reactor to neutralize the acidity of the water and to precipitate the metallic values as solids,

f. passing the materials of step (e) to a separating means wherein the precipitated solids settle-out to form a densified sludge containing at least about 15 percent solids and clarified neutralized water, and

g. drawing off the clarified neutralized water as an overflow from the separating means and passing a portion of the densified sludge to waste.

10. In a method for treating acid water containing metallic values in the form of ferrous and ferric iron and compounds taken from the group consisting of aluminum, calcium, magnesium, silicon, and zinc, said compounds being sulfates and/or chlorides, wherein the acidity of the water is neutralized and substantially all the ferrous and ferric iron values and a substantial portion of the other metallic values are precipitated as solids, which solids settle-out to produce a densified sludge containing about 15 percent to about 50 percent solids, the method comprising:

a. mixing high calcium lime and water to form a slurry of about 1 percent to about 10 percent high calcium lime,

b. passing the slurry to a first reactor,

c. passing a portion of sludge formed in step (f) to the first reactor, said portion containing about 20 pounds to about 30 pounds of solids for each pound of metallic values precipitated in step (e), d. mixing the slurry of step (a) and the portion of sludge of step (c) for a time between about one second and about 20 minutes to form a mix consisting essentially of said slurry and said sludge portion, e. thereafter mixing the mix of step (d) with the acid water in a second reactor for about 5 minutes to about 20 minutes in the presence of air to neutralize the acidity of the water to a pH of about 7.0 to about 9.0, with a preferred range of about 7.0 to about 8.0, and to oxidize substantially all the ferrous iron and to precipitate substantially all the iron values and a substantial portion of the other metallic values as solids,

f. passing the mixture of step (e) to a thickener wherein the precipitated solids settle-out to form a sludge containing about 15 percent to about 50 percent solids and to obtain clarified neutralized water, and

g. drawing off the clarified neutralized water as an overflow from the thickener and passing sludge to waste.

11. In a method for treating acid water containing metallic values in the form of ferric iron and compounds taken from the group consisting of aluminum, calcium, magnesium, silicon, and zinc, said compounds being sulfates and/or chlorides, wherein the acidity of the water is neutralized and substantially all the ferric iron values and a substantial portion of the other metallic values are precipitated as solids, which solids settle-out to produce a densified sludge containing at least about 15 percent solids, the method comprising:

a. mixing high calcium lime and water to form a slurry of about 1 percent to about 10 percent high calcium lime,

b. passing the slurry to a first reactor,

c. passing a portion of sludge formed in step (f) to the first reactor, said portion containing about 20 pounds to about 30 pounds of solids for each pound of metallic values precipitated in step (e),

d. mixing the slurry of step (a) and the portion of sludge of step (c) for a time between about one second and about 20 minutes to form a mix consisting essentially of said slurry and said sludge portion,

e. thereafter mixing the mix of step (d) with the acid water in a second reactor for about 5 minutes to about 20 minutes to neutralize the acidity of water to a pH of about 7.0 to about 9.0 with a preferred range of about 7.0 to about 8.0, and to precipitate substantially all the iron values and a substantial portion of the other metallic values as solids,

f. passing the mixture of step (e) to a thickener wherein the precipitated solids settle-out to form a sludge containing at least about 15 percent solids and to obtain clarified neutralized water, and

g. drawing off the clarified neutralized water as an overflow from the thickener and passing sludge to waste.

12. In a method for treating acid water containing metallic values in the form of ferrous iron and compounds taken from the group consisting of aluminum, calcium, magnesium, silicon and zinc, said compounds being sulfates and/or chlorides, wherein the acidity of the water is neutralized and substantially all the ferrous iron values and a substantial portion of the other metallic values are precipitated as solids, which solids settle-out to produce a densified sludge containing about 50 percent solids, the method comprising:

a. mixing water and at least one alkali taken from the group consisting of high calcium lime, magnesia, dolomitic lime, and sodium hydroxide to form a slurry thereof,
b. passing the slurry of step (a) to a first reactor,
c. recycling a portion of the densified sludge formed in step (f) to the first reactor,
d. mixing the slurry of step (a) and the portion of the densified sludge of step (c) for a time to obtain a uniform mix consisting essentially of said slurry and said densified sludge portion,
(e) thereafter mixing the mix of step (d) with the acid water in a second reactor to neutralize the acidity of the water and to precipitate the metallic values as solids,
f. passing the materials of step (e) to a separating means wherein the precipitated solids settle-out to form a densified sludge containing about 50 percent solids and clarified neutralized water, and
g. drawing off the clarified neutralized water as an overflow from the separating means and passing a portion of the densified sludge to waste.

13. In a method for treating acid water containing metallic values in the form of ferrous iron and compounds taken from the group consisting of aluminum, calcium, magnesium, silicon and zinc, which compounds are sulfates and/or chlorides wherein the acidity of the water is neutralized and substantially all the ferrous iron and a substantial portion of the other metallic values are precipitated as solids, which solids settle-out to form a densified sludge containing about 50 percent solids, the method comprising:

a. mixing high calcium lime and water to form a slurry of about 1 percent to about 10 percent high calcium lime,
b. passing the slurry to a first reactor,
c. passing a portion of densified sludge formed in step (f) to the first reactor, the portion of densified sludge containing about 20 pounds to about 30 pounds of solids for each pound of metallic values precipitated in step (e),
d. mixing the slurry of step (a) and the portion of densified sludge of step (c) for about one second to about 20 minutes to obtain a uniform mix consisting essentially of said slurry and said densified sludge portion,
e. thereafter mixing the mix of step (d) with the acid water in a second reactor for about 5 minutes to about 20 minutes to neutralize the acidity of the acid water to a pH of about 7.0 to about 9.0 with a preferred range of about 7.0 to about 8.0 and to precipitate substantially all the ferrous iron values and a substantial portion of the metallic values as solids,
f. passing the mixture of step (e) to a thickener wherein the precipitated solids settle-out to form a densified sludge containing about 50 percent solids and to obtain clarified neutralized water, and
g. drawing off the clarified neutralized water as an overflow from the thickener and passing a portion of the densified sludge to waste.

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Dedication

3,738,932.—*Paul D. Kostenbader*, Bethlehem, Pa. METHOD FOR TREATING ACID WATER CONTAINING METALLIC VALUES. Patent dated June 12, 1973. Dedication filed June 1, 1976, by the assignee, *Bethlehem Steel Corporation.*

Hereby dedicates to the Public the entire remaining term of said patent.

[*Official Gazette January 11, 1977.*]