APPENDIX B

PLANT DESIGN SUMMARY

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A. GENERAL

Appendix B is a summary of design information, of the acid mine drainage treatment plant at the Ernest Mine Complex, Creekside, Indiana County, Pennsylvania.

The Ernest Mine Complex was mined by the Rochester and Pittsburgh Coal Company during the early part of the twentieth century. Some mining continued until the late 1940's however the major operation was over by this time.

The mine is discharging approximately 4.5 million gallons of water per day. The water is extremely low in pH and contains a high concentration of iron.

The Acid Mine Drainage Treatment Plant is designed to provide pollution abatement measures which will subsequently perform an environmental impact service for the area.

Plant design is for 4.5 MGD raw acid mine water, with hydraulic design capabilities of 50% recirculation. The basic design consideration is neutralization with lime, aeration and settling out of the settleable solids by clarification.

Raw water is pumped from an abandoned mine heading under the plant site, processed through the plant and utimately discharged to McKee Run. Waste sludge is discharged back into the mine.

B. WATER QUALITY

	RAW WATER*	FINAL EFFLUENT
pH	3.80	8.7
Ferrous Iron	138mg/L	0 mg/l
Total Iron	304mg/L	3 mg/l
Free Acidity	538mg/L ($CaCO_3$)	0 mg/l
Total Acidity	657mg/L (" ")	0 mg/l
Alkalinity	0mg/L (" ")	20 mg/l
Calcium Hardness	370mg/L (" ")	700 mg/l
Magnesium Hardness	330mg/L (" ")	350 mg/l

Total Hardness	700mg/L	("	") 1050mg/l
Sulfates	1850mg/L	("	") 1800 mg/l
Manganese	0.1mg/L	("	") 0.1 mg/l

*Typical analysis over the period 2/9/73 - 3/16/73

C. SUMMARY OF PILOT STUDY

1. Neutralization Phase

a. Neutralizing agent to be added to flash mixer prior to aeration. Recommended reagent is $Ca(OH)_2$ in slurry form.
b. Required detention time is ten (10) minutes.
c. Mixing to be accomplished by a flash mixer. Agitation to be set to insure complete mixing without physical destruction of floc.
d. $Ca(OH)_2$ requirement to effect required effluent criteria is fourteen (14) tons per day (based on 100% purity). Sludge recirculation is expected to reduce this rate slightly.
e. Sludge recirculation will possibly decrease $Ca(OH)_2$ requirement and show some increase in per cent solids content and rate of settling of the sludge.

2. Aeration Phase

a. Significant levels of ferrous iron require an aeration rate of 420cfm

b. The high pH of the aeration phase will result in rapid oxidation of ferrous iron. Estimated aeration detention time is 8.5 minutes. In conditions of oxygen saturation (50°F) this time is reduced to an estimated 2.0 minutes.
c. Aeration phase should be subsequent to neutralization.

3. Clarification

a. At clarification design pH the sludge settles to a primary equilibrium (15% volume) in approximately thirty (30) minutes. At this non-recirculating condition, final solids content is six (6) per cent by weight. Sludge recirculation capability of 0-50% is expected to increase the solids contents to 10-15% by weight.
b. The effect to date, of various high molecular weight polymers shows that little benefit is realized in increased settling rates or increased solids content.

c. Based on current raw water quality, the amount of sludge per day (4.5mgd) is estimated at 36,000 lbs. (on a dry basis).
d. Optimum sludge recirculation benefit appears when the solids content of the neutralization reactor is held at three (3) per cent.
e. Required detention time in the clarification phase is estimated at seven (7) hours.

D. INSTRUMENTATION

The following list of instruments have been provided:

MEASURING MEDIA	PRIMARY DEVICE	RECEIVER DATA
Raw Water #1	9" Parshall Flume	Totalize, Indicate, Record
Raw Water #2	9" Parshall Flume	Totalize, Indicate, Record
Sludge Recirculation #1	6" Parshall Flume	Totalize, Indicate, Record
Sludge Recirculation #2	6" Parshall Flume	Totalize, Indicate, Record
Sludge Recirculation #3	3" Parshall Flume	None
Sludge Recirculation #4	3" Parshall Flume	None
Sludge Recirculation #5	3" Parshall Flume	None
Sludge Recirculation #6	3" Parshall Flume	None
Sludge Waste #1	3" Parshall Flume	Totalize, Indicate, Record
Sludge Waste #2	3" Parshall Flume	Totalize, Indicate, Record
Sludge Waste #3	3" Parshall Flume	Totalize, Indicate, Record
Sludge Waste #4	3" Parshall Flume	Totalize, Indicate, Record
Air Flow #1	Orifice Plate	Totalize, Indicate, Record
Air Flow #2	Orifice Plate	Totalize, Indicate, Record
Electricity Used	Watthour Meter	Totalize, Indicate
Mine Water Level	Bubbler System	Indicate
pH #1	Probe	Indicate, Record
pH #2	Probe	Indicate, Record

NOTE: pH instruments are designed to automatically pace the lime slurry feed rate

E. FAILSAFE FEATURES

1. Emergency Generator

The emergency generator is designed to provide enough electricity to operate the entire plant should the outside (public utility) power source fail. There is a time dalay in start-up to compensate for momentary power failure and a time delay in shutdown to compensate for momentary power restoration. The generator should be exercised weekly.

2. Alarms

Certain malfunctions in the plant are detected electrically and a telephone dialing system is actuated if the dialer is on. When the plant is manned, the dialer should be turned off. The following list of malfunctions are connected to the dialer:

a. Mine Water High Level
b. Sludge Well No. 1 High Level (Sludge Disposal)
c. Sludge Well No. 2 High Level "
d. Flash Mixer No. 1 Low pH (6.5)
e. Flash Mixer No. 1 High pH (8.5)
f. Flash Mixer No. 2 Low pH (6.5)
g. Flash Mixer No. 2 High pH (8.5)
h. Raw Water Flume #1 No Flow
i. Raw Water Flume #2 No Flow
j. Waste Sludge No. 1 No Flow
k. Waste Sludge No. 2 No Flow
l. Waste Sludge No. 3 No Flow
m. Waste Sludge No. 4 No Flow
n. Air Flow No. 1 No Flow
o. Air Flow No. 2 No Flow
p. Lime Storage Bin No. 1 Low Level
q. Lime Storage Bin No. 2 Low Level
r. Sludge Recirculation Flume #1 No Flow
s. Sludge Recirculation Flume #2 No Flow
t. Lime Slurry Vat No. 1 Low Level
u. Lime Slurry Vat No. 2 Low Level
v. Lime Slurry Vat No. 3 Low Level
w. No Power
x. Settling Tank No. 1 Torque (High)
y. Settling Tank No. 2 Torque (High)
z. Settling Tank No. 3 Torque (High)
aa Settling Tank No. 4 Torque (High)
bb High Sump Level
cc Hydropneumatic Tank Pressure (Low)
dd Lime Slurry Tank No. 1 Low Level
ee Lime Slurry Tank No. 2 Low Level

F. EQUIPMENT DESIGN CONSIDERATIONS

1. Raw Water Pumps

Use three pumps in each of two mine headings. One pump in each heading to be used as a spare. Selection is vertical turbine type.

Q = 3120 GPM ÷ 4 pumps = 780 GPM/Pump
Pump Discharge Elevation = 1061.75
Low Water Level in Mine = 1022.00
Static Head = 39.75
Force Main Size = 10"
Velocity = 3.26fps (C=100)
Friction Loss = 0.17' per 100'
Equivalent length of pipe = 600'
600' x 0.17' ÷ 100' = 1.00'
Static Head = 39.75
Friction Head = 1.00
TDH = 40.75 Use 45' TDH

Pump Characteristics: 780 GPM
45' TDH
1800 RPM
25 H.P.

2. Lime Requirement and Storage

In order to obtain a pH of 8.25 desired from AMD which had a pH of 3.5 the lime requirement was 5 pounds per 1,000 gallons or approximately 11 tons per day (lime quantity based upon 90% available CaO).

Lime storage to be provided for one and one-half (1-1/2) weeks.

1.5 weeks x 7 days/week = 10.5 days
10.5 days x 11 tons-lime/day = 115.5 tons
Hydrated Lime weighs approximately 30 lbs./Cu. Ft.
115.5 tons x 2,000 lbs/ton - 231,000 pounds
231,000 pounds ÷ 30 pounds/Cu. Ft. = 7,700 Cu. Ft. Reg'd.
7,700 Cu. Ft. ÷ 2 storage bins = 3,850 Cu. Ft./Bin
3,850 Cu. Ft. ÷ 34 Ft. = 113.24 Sq. Ft.
$\pi r^2 = 113.24$ or $r^2 = 113.24 \div 3.14 = 36$ r=6
Use 2 storage bins: 12'-0" Dia. x 36' High (Each)
Use 60° hoppered bottom
If pebble lime is used (60 lbs/Cu.Ft.) at 90% purity storage is available for 3 weeks plant operation. 7,700 Cu. Ft. x 60 lbs/ Cu. Ft. = 462,000 lbs (231 tons)
231 tons ÷ 11 Tons/Day = 21 days

3. Lime Feeders

A volumetric type lime feeder to be located under each lime storage bin. Each sized to supply one-half the lime requirement for the Q rate of flow. An extra feeder is furnished as a standby unit.

Lime requirement = 5 lbs. per l,000 gallons
3,120 gpm x 60 min/hr = 187,200 Gal/Hr.
187,200 gal/hr x 5 lbs/1,000 gal = 936 lbs/hr
936 lbs. ÷ 30 lbs/Cu. Ft. = 31.2 Cu. Ft./Hr.
31.2 Cu. Ft./Hr. ÷ 2 Feeders = 15.6 Cu. Ft./ Each

4. Lime Slakers

Two lime slakers, one located under each lime storage bin are sized to handle the total lime requirement. Lime requirement is 11 tons/ day = 22,000 pounds/day =917 lbs/hr. 917 lbs/hr ÷ 2 = 458 lbs/hr each slaker. Use reaction time of 10 minutes to make slurry from lime. Slurry solution expected will be approximately 10% or 0.93 lb/gal.

Water requirement: 458 lbs/hr/ slaker ÷ 0.93lbs/gal= 492 GPH/slaker
492 GPH ÷ 60 Min/Hr = 8.2 GPM/slaker
Total water required = 16.4 GPM

An extra slaker is furnished as a standby unit.

5. Lime Slurry Pumps

Provide one progressing cavity type at each slaker.

Static Head	=35'
Friction Head	=15'
TDH	=50'

Pump Characteristics:	30	GPM
	50'	TDH
	1800	RPM
	2	H.P.

6. Lime Slurry Tanks, Vats and Feeders

Capacity of Lime Slurry Tanks designed to equal two hours supply of slurry in each slurry tank.

22,000 lbs/day ÷ 0.93 lbs/gal = 22,500 GPD
22,500 GPD ÷ 12 hrs = 1876 gal; Use 2,000 gal (Maximum)
Each tank to have 1,000 gal effective capacity

Capacity of Lime Slurry vats to equal detention time of 20 minutes at lime slurry useage of 7.5 GPM per unit. 20 min x 7.5 GPM = 150 gal. Allowing for freeboard; Use 200 gal each. Lime slurry feeders rated at 0 to 18.75 GPM to provide for peak flows of 2.5 times estimated average daily of 7.5 GPM.

7. Flash Mixing Tanks

Two flash mixing tanks are provided. Each tank is sized for 10 minutes detention split between the two tanks at a flow of Q (4.5 MGD)

3,125 GPM x 10 min ÷ 7.5gal/Cu. Ft. = 4,167 Cu. Ft.
4,167 Cu. Ft. ÷ 2 tanks = 2083 Cu. Ft. per tank
Use 16' diameter tanks.

$\pi r^2 h = 2083$
$h = 2083 \div (3.1416 \times 8^2)$
h= 10.4' Use 10.5'

Provide 4.5' freeboard to allow for feeding, charging and splash.

Each mixing tank to be equipped with one flash mixer sized to thoroughly mix the raw AMD with the recirculated sludge and the added lime slurry. Mixing to occur at such a rate as to prevent settling in the mixing tank.

8. Blowers

9,063 lbs. of oxygen is required to satisfy the COD requirements of the conditioned AMD at a rate of 4.5 MGD of AMD. Assuming oxygen content of air at 20%: 9,063 lbs ÷ 0.20 = 45,315 lbs-air/day

At 70°F air weighs 0.07495 lbs/Cu. Ft.
45,315 lbs ÷ 0.07495 lbs/Cu. Ft. = 604,600 CF/day
604,600 CFD ÷ 1440 min/day = 420 CFM
Depth of submergence of aerators is 18.0' 18.0 ft-water x
0.433 psi/ft = 7.79 psig

Friction losses in lines assumed at 0.21 psig.

Static Head	= 7.79
Friction Head	= 0.21
T.D.H.	= 8.0 psig

Assume 30 CFM required for laboratory and miscellaneous items

Provide two blowers each rated at:	450	CFM
	8.0	psig
	25	H.P.

9. Aeration Tanks

Two aeration tanks are provided sized to adequately aerate flows of 4.5 MGD of conditioned AMD. Each tank is sized for 40 minutes detention at Q flow.

3.125 GPM x 40 min ÷ 7.5 gal/CF = 16,667 Cu. Ft.

16,667 Cu. Ft. ÷ 2 tanks = 8,333 Cu. Ft./tank

Use 24'-0" diameter tanks

$\pi r^2 h$ = 8,333 Cu. Ft.

h = 8,333 Cu. Ft. ÷ (3.1416 x 12 x 12)=18.4 Ft.

Tanks are placed outside to reduce dangers of over humidification of interiors and the prevention of larger building design and the installation of extra ventilation and dehumidification equipment.

Each aeration tank to be equipped with one 25 H.P., 1800 RPM aerator plus perimeter diffusers and center sparge ring.

10. Settling Tanks

Four upflow type settling tanks (clarifiers) are provided based upon an upflow rate of 0.25 gal/min/sq. ft. at design flow of 4.5 MGD. A minimum side-water-depth of 14'-0" is required to acquire proper coagulation and upflow filter blanket to keep the flow within the tank for proper clarification.

3,125 GPM ÷ 4 tanks = 781 GPM/Tank

781 GPM ÷ 0.25 GPM/Sq. Ft. = 3,125 Sq. Ft./Tank

πr^2 = 3,125

r^2 = 3,125 ÷ 3.1416

r^2 = 995

r^2 = 31.5

Use diameter of 66'-0" to fit standard manufacturers clarification equipment of this type of installation.

Overflow weir rate to be kept to less than 3,000 GPD/LF to prevent an overflow of suspended material from the clarifier. Use 8 radial launders each 25'-0" long with overflow occuring along each side:

25' x 8 x 2 = 400 L.F. weir per tank
4.5 MGD ÷ 4 tanks = 1.125 MGD/tank
1,125,000 GPD ÷ 400 L.F. = 2812 GPD/L.F.

Each clarifier is equipped with a rotating scraping mechanism arranged to transfer the settled material (sludge) along the sloped bottom (1 in 12) of the clarifier to a central sludge well. Mechanism is rated at 2.76 revolutions per hour.

Detention time in each clarifier at Q rate of flow with all four clarifiers in operation is 7.2 hours.

11. Final Tank

One final tank follows the clarifiers and is located just ahead of the plant effluent to McKee Run. The final tank accomplishes the following:

a. Provides a wet well from which to draw required process make-up water for operating the plant.
b. Provides a point from which grab samples of final water may be taken.
c. Provides a potential aeration facility to assure concentrations of D.O. in the effluent of not less than 5 mg/l.

12. Sludge Disposal Pumps

Two sludge disposal pumps are provided to pump the settled sludge from the clarifiers back into the abandoned underground coal mine. Sludge is drawn from each clarifier via a pipeline, the quantity being controlled by an electrically operated two-way plug valve, into a sludge holding well. The sludge is continuously measured as it enters the sludge well so that at all times it is known the amount of sludge withdrawn from each clarifier. The sludge draw-off quantity is controlled by a valve position selector switch on the operating console.

Two sludge wells are provided (one for each two clarifiers) and equipped with liquid level controls which automatically senses and programs the sludge disposal pumps. Pumps are equipped with variable speed drive units which are operated automatically at 400 GPM at high speed.

Pump Characteristics:	400	GPM
	65'	TDH
	20	HP
	1800	RPM
	Submersible	

Force main size is 6" diameter
Two extra pumps are provided for standby units.

13. Sludge Recirculation Pumps

One sludge recirculation pump is provided for each settling tank. A recirculation rate of from 0% to 50% is anticipated; therefore pumps are rated at

3125 GPM ÷ 2 = 1562.5 GPM total
1562.5 GPM ÷ 4 = 390 GPM each
Use 400 GPM

The operator may adjust the recirculation rate of the sludge from each clarifier from 400 GPM to 0 GPM.

Pump Characteristics:	400	GPM
	43'	TDH
	15	H.P.
	1800	RPM

Two extra pumps are provided for standby units.

14. Utility Water Pumps

Two utility water pumps are furnished and located in the Final Tank. The purpose of these pumps is to supply flushing water, slaker water and clean-up water throughout the treatment plant. One utility water pump is to be used as a standby unit.

Hosing pressures of 60 psig and flushing pressures of 85 psig are desired. For flushing, 200 gallons per minute has been selected.

Pump Characteristics	200	GPM
	230'	TDH
	20	H.P.
	3600	RPM

15. Sump Pumps

One duplex type sump pump has been included to handle all floor drains.

Pump Characteristics:	150	GPM Each
	30'	TDH
	5	H.P. Each
	1200	RPM

16. Hydro-pneumatic Tank

One Hydro-pneumatic tank is furnished to hold an ample supply of utility water. Tank is steel construction with effective capacity of 1,000 gallons (this will supply 25 minutes worth of water required by the slakers or 12 minutes supply for peak demand on the system).

17. Emergency Generator

Description	Size	Kilowatts
4 Raw Water Pumps	25 HP	100
2 Flash Mixer Mixers	10 HP	20
2 Aeration Tank Aerators	25 HP	50
1 Blower	25 HP	25
1 Conveyor	1 HP	1
2 Lime Slurry Tank Mixers	2 HP	4
2 Slakers	2 HP	4
4 Clarifier Drives	1-1/2 HP	6
4 Sludge Recirculation Pumps	15 HP	60
2 Sludge Disposal Pumps	20 HP	40
1 Utility Water Pump	20 HP	5
1 Sump Pump	5 HP	5
2 Lime Slurry Pumps	2 HP	2
1 Potable Water Pump	1 HP	1
1 Air Compressor	1 HP	1
Misc. Small Motors	25 HP	25
Building Heat		165
Building Lights & Outlets		35
		564

Use 565 KW Unit

18. Maintenance Features

The plant is layed out and designed to provide access to all mechanized equipment for servicing, repair and replacement. Access ways are available around each machine and working space is provided adjacent to the equipment.

Each piece of equipment is provided with lifting lugs and lifting bolts are provided overhead within the building structure. Piping fittings are provided for ease of removal and replacement of piping.

A complete set of maintenance tools, lubricating equipment and instruction manuals are to be provided so that a major portion of the maintenance may be performed at the job site.

Service sinks and clean-up areas are provided for each floor to maintain cleanliness and sanitary conditions. Building is constructed of materials that will permit hosing down the floors and walls without damage to the construction. Care will be required in hosing due to location of machinery.

Access to the building is made convenient through the use of paved service roads and parking areas.

The building is made of materials that require a minimum of maintenance. Building shall be painted so that cleanliness may be secured and maintained. Minor site work will be required to keep the grounds in a neat appearance.