SECTION IV

EXISTING PLANT OPERATIONS

SECTION IV

EXISTING PLANT OPERATIONS

A. Plant Description

The Carl A. White Water Reclamation Plant was placed in operation in June 1978. The facility was constructed to treat acid mine water from the abandoned Ernest Mine Complex with the plant located at Creekside, Indiana County, Pennsylvania. Basically the plant is a lime neutralization, iron percipitation plant with the treated effluent discharged to McKee Run, a nearby stream, and the sludge wasted back into the abandoned mine.

The existing plant consists of a two story Control Building, strategically located in the geographical center of the treatment tanks, erected of concrete and containing an office, laboratory, electrical apparatus, mechanical equipment and two flash mixing tanks. Also included are two reinforced concrete circular aeration tanks, four reinforced concrete settling tanks, two rectangular underground reinforced concrete waste sludge wells, a waste sludge discharge point, a reinforced concrete final tank, a fiberglass domestic wastewater treatment plant and six vertical turbine type raw water pumps. The plant complex is surrounded with a cyclone type security fence and is equipped with bituminous paved access and service roadways.

The plant is located on the earths surface at a point where the coal was not mined. The raw water is received from a mine heading or passageway which is shown on existing mine maps and found via exploratory drilling at the time of plant design and construction. Sludge wasting is back into the mine at another mine heading which is shown on existing mine maps and found by the same method as the raw water heading. During the design of the treatment facilities it was anticipated that the wasted sludge would not return to the raw water pumps as quickly as it did.

Operation of the treatment plant begins with the pumping of raw mine water by any one of six raw water pumps to the second floor of the Control Building. The water is conveyed through six reinforced fiberglass pipe force mains which terminate in a distribution trough. Via a series of stop gates, flow distribution of water through the plant can be divided into either or both sides of the treatment plant. The divided flow passes through a parshall flume (one on each side of the plant) where the quantity is measured prior to being discharged into a flash mixer.

In the flash mixer lime slurry is added to neutralize the mine water and the tank contents is thoroughly mixed. A flash mixer effluent pH probe inserted in the discharge trough automatically and continuously measures the liquid pH and paces the lime slurry addition to the flash mixer tank. The pH setting desired is manually set. Provisions have been made to recirculate sludge from the final clarifiers to the flash mixing tanks.

From the flash mixer, the pre-treated (neutralized) mine water flows by gravity to an aeration tank. In the aeration tank air is furnished through submerged diffusers located at the bottom center and perimeter of the tank. The aerator mixing mechanism adds air to the tank contents as well and assures continuous and complete mixing of the liquid in the tank. Provisions have been made to recirculate sludge from the final clarifiers to the aeration tanks.

From the aeration tank flow is divided and discharged equally to two clarifiers (sometimes called settling tanks). Flow enters the clarifier at the liquid surface in the center of the tank. A clarifier center skirt prevents the liquid from moving laterally into the settling zone. The liquid must move down under the center skirt, then back up to the point of discharge. This vertical movement assists in the precipitation of the heavy particles (sludge). Discharge is via a series of radial fiberglass troughs (effluent launders) to a common discharge trough. Each clarifier is equipped with a scraper mechanism located at the tank conical shaped bottom which moves the sludge to a tank center well (hopper). The scraper drive is located on a walkway over the tank liquid surface. Wasted sludge is drawn from the hopper by the plant operator via an electrically operated plug valve with the quantity of sludge and time of withdrawal selected by the plant operator. Provisions have been made to recirculate sludge from the final clarifiers to the clarifier influent trough.

From the final clarifiers the treated water flows to a final tank, then discharges by gravity into McKee Run. Water from the final tank is used as utility water; it being pumped from the final tank via two vertical turbine pumps to a hydropneumatic tank. The hydropneumatic tank balances the utility water pressure and volume and allows periodic resting of the utility water pumps. Utility water is used primarily for lime slaking with auxilliary uses of hosing, flushing, dilution, etc. as needed.

A lime handling system consists of duplicate lime storage bins and three each: lime feeders, lime slakers, lime slurry vats and lime slurry pumps. Two lime slurry tanks located on the second floor of the control building assure a continuous supply of lime slurry for the three lime slurry feeders located adjacent to the lime slurry tanks. The lime used is pebble lime, shipped to the site in tank trucks. Loading of the lime storage bins is from the top. The bins are fitted with air pads which assist the flow of lime to the bin discharge port. The lime feeders are variable speed units with manual adjustment of feed rate. Each lime slaker is equipped with discharge rate adjustments, utility water adjustments and grit removal accessories. The lime slurry vats have mixers to keep the lime slurry in solution. The lime slurry pumps are variable speed (manually adjusted) progressing cavity type units that lift the lime slurry from the ground floor of the control building to the second floor (lime slurry tanks). The lime slurry tanks have mixers to keep the lime slurry in solution. The lime slurry feeders are variable feed rate units with the rate of feed automatically set by the pH measurement in the flash mixer effluent trough (low pH speeds up unit, high pH slows down unit).

Sludge to be recirculated, or wasted, is drawn off the clarifier center hopper by gravity to a sludge box at the clarifier perimeter. Sludge is recirculated from the sludge box at a rate desired by the treatment plant operator (sludge pump is a submersible variable speed unit) to either one, two or three points of discharge (flash mixer influent, aeration tank influent, clarifier influent). The rate of sludge recirculation is manually controlled and, in the first two points of discharge, measured with built-in instrumentation devices, while in the clarifier recirculation the rate is computed from a manual depth measurement in a three inch parshall flume.

Sludge to be wasted is drawn from the clarifier perimeter sludge box by gravity through a manually adjusted variable opening plug valve fitted with an electric operator. Operation of the plug valve may be performed manually at the valve location or remotely at the operating console in the plant office. All wasted sludge passes through a 3" parshall flume where the quantity is measured and recorded. NOTE: Instruments are located on the clarifier wasted sludge troughs so that the quantity of sludge wasted from each clarifier is measured. wasted sludge, following metering, enters a waste sludge well containing a variable speed submersible sludge pump which pumps the sludge to the point of wasted sludge entry to the abandoned mine complex. The rate of pumping is variable, being paced by the liquid level in the waste sludge box.

The existing treatment plant air used for oxidation of the neutralized mine water is obtained from two positive displacement blowers (compressors) located in a room on the second floor of the Control Building. The blower room is walled with sound buffering materials. Each blower speed is manually adjustable over a wide range of air output. Air flow to each side of the treatment plant is measured and continuously recorded.

An emergency generator has been provided which produces enough electrical power during a utility power outage to operate the entire treatment plant. The generator is located on the first floor of the Control Building and installed to automatically start upon a power failure. A return to utility electrical power is done automatically and the generator is designed to stop upon resumption of outside power.

A special room contains electrical gear, the motor starters and a major portion of the control equipment. This room is supplied with heat and air conditioning for year round temperature and subsequent humidity control. The room is adjacent to the plant office. It is readily accessable and can be monitored via a window from the office.

An electrically operated and electrically driven trolley type hoist has been provided to facilitate equipment removal, service and maintenance. Although the hoist is not utilized in any treatment process, its availability is an asset to the complete plant operation.

The existing treatment plant contains a laboratory where the basic chemical analyses needed for proper plant operation may be performed. The laboratory is fitted with cabinetry for storage, counter tops for work area, sink for clean-up, eye wash for safety and a liberal supply of glassware, plastic goods, chemicals, equipment and accessories for conducting most all tests needed for plant operations. Analyses beyond the capability of the plant laboratory must be performed at a larger and more fully equipped laboratory.

An operating console is located in the plant office. This unit is principally an electrical control center at which many plant processes can be regulated and/or controlled. Over the console is a lighted graphic of the treatment plant which contains a schematic of the plant with running lights for all major items of equipment. Below the lighted graphic is a series of recorders that permanently record on 30 day strip charts activity that is taking place in various parts of the plant such as; raw water quantity, pH, sludge recirculation quantity, wasted sludge quantity, air flow quantity, etc. Below the instrumentation section of the operating console is a sloped area containing such items as; start and stop buttons, increase and decrease speed buttons, running and malfunction lights, ammeters, elapsed time meters, etc.

The treatment plant is designed to operate continuously; 24 hours per day, 365 days per year. Three working shifts have been established. Special operating conditions are employed when there is a chance of freezing. Complete operations have been furnished by the Department of Environmental Resources under the direction and assistance of the design professional.

B. Design Operating Parameters

The existing treatment plant was designed to treat 4,500,000 gallons of acid mine drainage per day from an abandoned mine complex located at Creekside, Indiana County approximately five miles north of Indiana. The facility was designed from information received from a pilot plant that was operated in the late 60's, and from a series of mine water analyses performed in February and March 1973. At that time a typical raw mine water analysis produced the following data:

Description	Raw Mine Water	
pH	3.8	
Ferrous Iron	138	mg/l
Total Iron	304	mg/l
Free Acidity	538	mg/l
Total Acidity	657	mg/l
Alkalinity	0	mg/l
Calcium Hardness	370	mg/l
Magnesium Hardness	330	mg/l
Total Hardness	700	mg/l
Sulfates	1850	mg/l
Manganese	0.1	mg/l

The pilot plant study provided information on three principal treatment processes which were utilized in the plant design:

1. Neutralization Process

   a. Particular agent to be used for neutralization
   b. Location of introduction of neutralization agent
   c. Detention time needed for the process
   d. Mixing requirements
   e. Quantity of neutralization agent needed
   f. Effects of sludge recirculation

2. Aeration Process

   a. Quantity of air needed
   b. Detention time needed for the process
   c. Location of aeration process in the plant flow diagrams

3. Clarification Process

   a. Detention time needed for the process
   b. Description of sludge generated
   c. Effects of sludge recirculation
   d. Effects of high molecular weight polymers on sludge production
   e. Quantity of sludge to be generated

Utilizing available data from the above sources design of the treatment plant proceeded to a stage that construction was performed. Equipment design considerations were as follows:

1. Raw Water Pumps

Use three raw water pumps in each of two mine headings. One pump in each mine heading is to be used as a standby unit. Pump selection is vertical turbine type constructed of stainless steel to withstand action of raw mine water.

4,500,000 Gal/Day ÷ 1440 Min/Day = 3125 GPM
3,125 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"
Equilavent Length of Pipe = 600'
Velocity = 3.26 FPS
Friction Loss = 0.17 Ft/100 Ft.
= 0.17' x 600' ÷ 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

a. Lime Requirement

In order to obtain a desired pH of 8.25 from the acid mine drainage which had a pH of 3.5, the lime requirement was 5 pounds of lime per 1,000 gallons of mine water treated.

5 lbs/1000 Gal x 4,500,000 Gal =	22,500 lbs
22,500 lbs = 2,000 lbs/Ton =	11.25 Tons
Use 11 Tons per day	

Lime quantity was based upon 90% availability of CaO in the mixture.

b. Lime Storage

Lime storage is to be provided at the plant site for total plant operation for 1.5 weeks.

1.5 Wks x 7 Da/Wk = 10.5 Days
10.5 Days x 11 Tons/Day = 115.5 Tons

Hydrated Lime

Weight = approximately 30 lbs/Cu. Ft.
115.5 Tons x 2,000 lbs/Ton = 231,000 lbs.
231,000 lbs ÷ 30 lbs/Cu.Ft. = 7,700 Cu.Ft.

7,702 Cu. Ft. ÷ 2 Bins = 3,850 Cu.Ft./Bin
$\pi r^2 h$ = 3,850 Cu.Ft.
Select 36 Ft. high bins
r^2 = 3,850 ÷ (3.14 x 26 Ft.)
r^2 = 34.06 Sq. Ft.
r = 5.8 Ft.
Use 6.0 Ft. Radius = 12 Ft. Diameter

Bins = 12' Dia. x 36' High

Pebble Lime

Weight = approximately 60 lbs/Cu.Ft.
Use same size bin as for hydrated lime
Use same purity as hydrated lime

7,700 Cu.Ft. x 60 lbs/Cu.Ft. = 462,000 lbs.
462,000 lbs ÷ 2,000 lbs/Ton = 231 Tons
231 Tons ÷ 11 Tons/Day = 21 Days
21 Days = 3 Weeks

Use 60° hoppered bottoms for lime storage bins to facilitate lime removal. Add vibration equipment to reduce clogging.

3. Lime Feeders

Use volumetric type lime feeders, one located under each lime storage bin. Each lime feeder is sized to supply onehalf the lime requirement for the plant design rate of flow. An extra lime feeder is furnished as' a standby unit.

Lime requirement = 5 lbs/1000 Gal
3,125 GPM x 60 Min/Hr = 187,200 GPH
187,200 GPH x 5 lbs/1000 Gal = 936 lbs/hr

Hydrated Lime = 936 lbs/hr ÷ 30 lbs/Cu.Ft. =
31. 2 Cu. Ft. /Hr.
31.2 Cu.Ft./hr. ÷ 2 Feeders =
15.6 Cu.Ft./Hr.

Pebble Lime = 936 Lbs/Hr. ÷ 60 Lbs/Cu.Ft. = 15.6 Cu.Ft./Hr
15.6 Cu.Ft./Hr. ÷ 2 Feeders = 8.2 Cu.Ft./Hr.

Use variable rate of feed lime feeders with a range of 0-20 Cu. Ft./Hr.

4. Lime Slakers

Use two lime slakers, one located under each lime storage bin. Each lime slaker is designed to handle one-half the total lime requirement of the treatment plant. An extra lime slaker is furnished as a standby unit.

Lime requirement = 11 Tons/Day x 2,000 Lbs/Ton =
22,000 Lbs/Day
22,000 Lbs/Day ÷ 24 Hrs/Day =
917 Lbs/Hr.
917 Lbs/Hr ÷ 2 = 458 Lbs/Hr/Slaker

Reaction time of 10 minutes is required to make a 10% lime slurry which equals 0.93 Lbs-Lime/Gal - Water.

Water requirement = 458 LBS/Hr/Slaker ÷ 0.93 Lbs/Gal =
492 Gal/Hr
492 Gal/Hr ÷ 60 Min/Hr = 8.2 GPM

8.2 GPM x 2 Slakers = 16.4 GPM

Use lime slakers, each with capacity up to 460 Lbs/Hr Lime and water rate up to 8.2 GPM.

5. Lime Slurry Vats

Use three lime slurry vats, one for receiving lime slurry from each of the lime slakers. Detention time to be 20 minutes at a lime slurry production rate of 7.5 GPM.

20 Min. x 7.5 GPM = 150 Gallons
Allowing for freeboard use 200 gallon vats

200 Gal ÷ 7.5 Gal/Cu.Ft. = 26.67 Cu. Ft.
26.67 Cu.Ft. ÷ 1.67 Ft. (Drawdown) = 15.97 Sq.Ft.
Use 16 Sq. Ft. and square vat
√16 Ft = 4'
Vats = 4' x 4' x 2' High (Provide mixers)

6. Lime Slurry Pumps

Use one progressing cavity type lime slurry pump at each slaker. Size units to provide adequate flow velocity in piping to prevent clogging.

Pump Discharge Elevation	=	1069.0
Low Water Level in Vat	=	<u>1045.0</u>
Static Head	=	24.0

Force Main Size = 1 1/4"
Equivalent Length of Pipe = 100'
Velocity = 6.4 FPS
Friction Loss = 23.5' per 100'
100' pipe x 23.5' head loss ÷ 100' pipe = 23.5' friction head

Static Head	= 24.0'
Friction Head	= <u>23.5'</u>
TDH	= 47.5'
Use	50.0' TDH

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

7. Lime Slurry Tanks

Use two lime slurry tanks located for gravity feed to the lime slurry feeders. Capacity to be equal to two hours of lime usage from each lime slurry tank.

22,000 Lbs/Day (Lime) ÷ 0.93 Lbs/Gal (Lime)= 23,656 GPD
23,656 GPD ÷ 2 = 11,828 Gal/Unit/Day
11,828 Gal ÷ 12 Hrs = 986 Gal
Use 1,000 Gal Effective Capacity

1,000 Gal ÷ 7.5 Gal/Cu.Ft. = 133.3 Cu.Ft.
πr^2 = 133.3 Cu.Ft.
Use 6.0' Diameter
h = 133.3 Cu.Ft. ÷ r^2 (9') ÷ 3.14
h = 4.71 Ft. Use 6.0'
Tanks = 6' Dia. x 6' Ht. (Provide Mixers)

8. Lime Slurry Feeders

Use three lime slurry feeders of variable speed automatically paced by a pH instrument with two lime slurry feeders to supply the total lime slurry requirement. The third unit is furnished as a standby unit.

Lime slurry requirement = 15.0 GPM
Provide for peak flow of 2.5 times average daily
15.0 GPM x 2.5 = 37.5 GPM
37.5 GPM ÷ 2 (units) = 18.75 GPM
Use feeder with range of 0 - 20 GPM

9. Flash Mixing Tanks

Use two flash mixing tanks each sized to receive one-half of total plant flow. Detention time to be 10 minutes.

4,500,000 GPD ÷ 1440 Min/Day = 3,125 GPM
3,125 GPM x 10 Min = 31,250 Gal.
31,250 Gal ÷ 2 = 15,625 Gal/Tank

15,625 Gal ÷ 7.5 Gal/Cu.Ft. = 2,083 Cu.Ft.
Using 16' Diameter Tanks
$\pi r^2 h$ = 2,083 Cu.Ft.
h = 2,083 Cu.Ft. ÷ (3.14 x 8 Ft.^{2})
h = 10.4 Ft.
Use 10.5 Ft.

Provide 4.5 Ft. freeboard (feeding, charging, splashing)
Tanks = 16 Ft. Dia. x 15 Ft. High

Each flash mixing tank is to be equipped with a mixer sized to thoroughly mix the raw water, lime slurry and recirculated sludge. Mixing rate is to be adequate to prevent settling in the flash mixing tanks.

10. Blowers

Use two blowers (air compressors), positive displacement type each designed to furnish the total air requirement. The amount of oxygen required to treat 4,500,000 gallons of the raw mine water is 9,063 pounds.

Oxygen content of air = 20%
Weight of air @ 70° F = 0.07495 Lbs/Cu.Ft.

9,063 Lbs ÷ 0.20 = 45,315 Lbs - Air/Day
45,315 Lbs – Air ÷ 0.07495 Lbs/Cu.Ft. = 604,600 Cu.Ft./Day
604,600 Cu.Ft./Day ÷ 1440 Min/Day = 420 CFM

Diffuser submergence = 18.0 Ft.
18.0 Ft. x 0.433 Lbs/Sq.In./Ft. = 7.79 PSIG

Friction loss in 5" air main = 0.21 PSIG/100 Ft.
Equivalent length of air main = 100 Ft.

Static Head	= 7.79 PSIG
Friction Head	= 0.21 PSIG
Total Head	= 8.00 PSIG

Assume a need for 30 CFM additional air for, laboratory and miscellaneous items.

Plant air requirement =	420 CFM
Misc. air requirement =	30 CFM
Total =	450 CFM

Blower Characteristics:	450 CFM
	8.0 PSIG
	25 H.P.

11. Aeration Tanks

Use two aeration tanks each sized to receive one-half of total plant flow. Detention time to be 40 minutes.

4,500,000 GPD ÷ 1440 Min/Day = 3,125 GPM
3,125 GPM x 40 Min = 125,000 Gal
125,000 Gal ÷ 7.5 Gal/Cu.Ft. = 16,667 Cu.Ft.
16,667 Cu.Ft. ÷ 2 = 8,333 Cu.Ft./Tank

Using 24' Diameter Tanks
πr^2 h = 8,333 Cu.Ft.
h = 8,333 Cu.Ft. ÷ (3.14 x 12 Ft.^{2})
h = 18.4 Ft.
Tank Size = 24 Ft. Dia. x 18.5 Ft. high (SWD)

Fit each tank with a combination mixer-aerator. Use a 25 H.P., 1800 RPM Unit.

12. Settling Tanks (Clarifiers)

Use four upflow type settling tanks each sized to receive one-fourth of total plant flow. An upflow rate of 0.25 gallons per minute per square foot, a side water depth of 14.0 feet and a weir overflow rate not to exceed 3,000 gallons per lineal foot per day.

4,500,000 Gal/Day ÷ 1,440 Min/Day = 3,125 GPM
3,125 GPM ÷ 4 Tanks = 781 GPM/Tank

781 GPM ÷ 0.25 GPM/Sq.Ft. = 3,125 Sq.Ft.
πr^2 = 3,125 Sq.Ft.
r^2 = 3,125 Sq.Ft. ÷ 3.14
r^2 = 995 Sq.Ft.
r = 31.5 Ft.
Use 33 Ft radius = 66 Ft. Dia.

Radial launders = 25 Ft. Long
25 Ft. x 8/Tank = 200 Ft./Tank
200 Ft. x 2 Sides = 400 LF - Weir/Tank

400 LF/Tank x 4 Tanks = 1600 L.F.
4,500,000 GPD ÷ 1600 L.F. = 2,812 GPD/L.F.

$\pi r^2 h$= Volume
3.14 x 33 Ft^2 x 14 Ft. = 47,872 Cu.Ft.

781 GPM ÷ 7.5 Gal/Cu. Ft. = 104 Cu.Ft./Min.
47,872 Cu.Ft. ÷ 104 Cu.Ft./Min = 460 Min
460 Min ÷ 60 min/Hr = 7.7 Hrs.

Each settling tank is to be equipped with a rotating scraper mechanism arranged to move the settled material to the center of the settling tank. Speed of scraper is to be 2.76 revolutions per hour.

13. Final Tank

Use one final tank to collect settling tank discharge liquid before plant discharges to the receiving stream. The final tank is to be used for:

a. Holding well from which utility water is obtained
b. Tank for post aeration to insure effluent D.O. concentration

No specific design criteria relating to the treatment plant processes is required.

14. Sludge Disposal Pumps

Use two submersible type variable speed sludge disposal pumps to pump the waste sludge back into the abandoned mine. Two waste sludge wells for installation of pumps and pump control sensing devices to be provided.

Pump Discharge Elevation	= 1060.0
Low Liquid Level in Sludge Well	= <u>1035.5</u>
Static Head	= 24.5'

Force Main Size = 6"
Equivalent Length of Pipe = 1600 Ft.
Velocity 4.55 FPS
Friction Loss = 2.2 Ft/100 Ft. = 35.2 Ft.

Static Head	= 24.0'
Friction Head	= <u>35.2'</u>
TDH	= 59.2'
Use	65' TDH

Pump Characteristics: 400 GPM
65' TDH
1800 RPM
20 H.P.

15. Sludge Recirculation Pumps

Use four sludge recirculation pumps, one for each settling tank. Each unit is to be designed to pump sludge over a range of 0 - 50% of liquid flow to the settling tank. Pumps are submersible type with variable speed adjustment performed manually by the plant operator.

4,500,000 Gal/Day ÷ 1440 Min/Day = 3,125 GPM
3,125 GPM ÷ 4 Tanks = 781 GPM/Tank
781 GPM x 0.50 = 390 GPM
Use 400 GPM Each Pump
Pump Range = 0 - 400 GPM

Pump Discharge Elevation	= 1061.75'
Liquid Sludge Level	= 1022.00'
Static Head	39.75'

Force Main Size = 6"
Equivalent Length of Pipe = 75'
Velocity = 4.55 FPS
Friction Loss = 2.2 Ft/100' x 75' = 1.65

Static Head	= 39.75'
Friction Head	= 1.65'
TDH	= 41.40'
Use	43' TDH

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

16. Utility Water Pumps

Use two vertical turbine type utility water pumps located in the Final Tank to furnish a supply of water for lime slaking, hosing, cleaning, flushing, diluting, etc.

Slaker water requirement	= 16.4 GPM
Miscellaneous requirement	= 3.6 GPM
Total	= 20 GPM

Hydropneumatic Tank Total Capacity	= 2,000 Gal
Effective Capacity	= 1,000 Gal

Assume pumping rate at 10 times usage rate
20 GPM x 10 = 200 GPM

1000 Gal. Cap. ÷ 200 GPM	= 5 minutes running time
1000 Gal. Cap. ÷ 20 GPM	= 50 minutes down time

Design pump to pressurize tank to 100 psig
100 psig ÷ 0.433 Psi/Ft = 230.9 Ft. Head

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

17. Sump Pumps

A duplex sump pump arrangement is used to discharge all building floor drains, equipment overflows, etc. to the treatment plant influent. Pumps are vertical extended shaft submersible impeller type with motors mounted on the sump pit cover plate.

Pump Discharge Elevation	= 1058.5
Low Liquid Level	= 1030.0
Static Head	28.5'

Force Main Size = 4"
Equivalent Length of Pipe = 40 Ft.
Velocity = 3.8 FPS
Friction Loss = 2.6 Ft/100 Ft. = 1.04 Ft.

Static Head	= 28.5'
Friction Head	= 1.0'
TDH	= 29.5'
Use	= 30' TDH

Peak flows to Sump:

Slakers	= 16 GPM
Lime Slurry	= 30 GPM
Hosing	=100 GPM
Total	146 GPM
Use	150 GPM

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

18. Hydropneumatic Tank

One steel hydropenumatic (water-air) pressure tank is used as a source of pressurized utility water throughout the plant. Tank is sized for 2,000 gallons with an effective capacity of 1,000 gallons.

Normal water usage	= 20 GPM
1,000 Gal ÷ 20 GPM	= 50 minutes
Peak water usage	= 40 GPM
1,000 Gal ÷ 40 GPM	= 25 minutes

19. Emergency Generator

Located indoors is one 565 Kw emergency electrical generator designed with capacity to operate entire treatment plant. Fuel is No. 2 diesel oil stored on the site in a 1,000 gallon underground steel storage tank.

Major Equipment Power Requirement

Raw Water Pumps (4 units)		100 kw
Flash Mixers (2 units)		20 kw
Aerators (2 units)		50 kw
Blower (1 unit)		25 kw
Sludge Recirculation Pumps (4 units)		60 kw
Sludge Disposal Pumps (2 units)		40 kw
Misc. Small Motors		25 kw
Building Heat		165 kw
Lighting		35 kw
Other		39 kw
	Total	559 kw
	Use	565 kw

C. Raw Water Characteristics

The raw water considered here is the water pumped from the underground abandoned coal mine to be treated in the existing treatment plant. The chemical characteristics of the raw water has changed from the time considerations were being given to constructing a treatment plant to the present. Much speculation has been given regarding the causes of water quality changes. Recently changes have occurred due to the recirculation of wasted sludge in the abandoned mine.

1. Raw Water Physical Analysis

Visually the raw water is clear and free of any suspended or settleable matter. In recent times, due to sludge recirculation in the mine, the water has changed from a clear to a reddish brown color. Depending upon the quantity and time of sludge wasting, the color varies in intensity; becoming darker as more frequent and larger quantities of sludge are wasted.

Physical settling of the raw water provides a mere trace of settleable matter except at times when the sludge is being recirculated in the mine. At these latter times settable solids have gone as high as 850 milliters per liter.

Time has an effect on the settling characteristics of the raw mine water. In combination with a chemical change in the water, staining (reddish brown) of stream bottom, tanks, pipes, etc. has occurred. The longer the time period, the more stain (or darker the stain). Stains, if left for an extended period of time, develop into a film which continues to thicken with time unless physically removed.

2. Raw Water Biological Analysis

The raw mine water is toxic to most aquatic life and therefore will not support water borne organisms. In all the analyses that have been performed there has not been any evidence of biological or marine life. Consequently we have concluded that there is no significant biological activity in the raw mine water.

3. Raw Water Chemical Analysis

The raw water (typically called "acid mine drainage" or AMD) encountered at this treatment facility is produced by a chemical reaction between pyrite, oxygen and water. This yield the three principal chemical elements that are characteristic of AMD:

a. Ferrous Iron
b. Acid
c. Sulfate Ions

AMD produced in this manner has a low pH (usually between 2.0 and 4.5) and promotes the dissolving of other heavy metals such as zinc, manganese, aluminum and magnesium into the water. Water with such high acidity and metal content is toxic to most aquatic life and corrosive to nearly all man-made structures.

An analysis of the raw water influent of the existing treatment plant would typically yield the following values:*

Parameter	Result	Plus or Minus
pH	3.65	0.68
Acidity	667 mg/l	357 mg/l
Alkalinity	0	--
Sulfates	1212 mg/l	450 mg/l
Ferrous Iron	197 mg/l	237 mg/l
Total Iron	200 mg/l	121 mg/l

* Based upon data of 24 analyses 6/26/78 to 4/25/79

A thorough examination of raw water analyses and an evaluation of trends in raw water quality indicate that periods of regularly increasing and decreasing chemical values occurred during the time period of testing. This characteristic, the large standard deviations of parameter values and the rising and lowering of the mine pool level indicate that changes in the AMD is an on-going event. Future changes in the raw water quality and quantity due to a drop or rise in the mine pool level are possible. eg. More or less oxygen and water drainage into the mine will affect the AMD characteristics.

The recirculation of sludge within the abandoned mine complex, which is attributed to the short-circulating effect between the waste sludge well and raw water well, greatly affects the quality of the raw water. The ferric iron content increases drastically, the acidity decreases considerably and the pH rises significantly. Because of these factors, we have attempted to provide herein only analyses that were performed on samples of raw water collected during times of minimal recirculation (exception on 5/30/79). The following table provides the results of several raw water analyses.

Please note the slight effect of in-mine recirculation on 2/22/79, 3/7/79, 6/13/79 and 7/17/79. Also the great effect of in-mine recirculation on 5/30/79.

ERNEST MINE COMPLEX
RAW WATER ANALYSES
Samples Taken at the Treatment Plant Influent

Parameter	(Design)*	8/22/79	2/22/79	3/5/79	AM 3/7/79	PM 3/7/79	5/30/79	6/13/79	7/6/79	7/16/79	7/17/79	7/18/79	7/19/79	7/20/79
pH	3.80	3.85	4.45	3.92	3.20	4.55	6.60	4.10	3.10	3.60	4.70	3.20	3.20	3.42
Ferrous Iron	138	60		118										
Total Iron	304	111	512	246	318		3990	259	146	263	318	134	134	151
Hot Acidity		340					546	445	828					
Free Acidity	538						502	512	869	854	555	717	746	
Cold Acidity		443	965											
Total Acidity	657			992			1322	0	0	0	0	0	0	
Total Alkalinity	0	-340	0	0										
Net Alkalinity		-340	-965											
Calcium Hardness	370													
Magnesium Hardness	330													
Total Hardness	700						1300							
Sulfates	1850	1100	2600	1990			1200	1850	1300	1350	1175	1300	1250	1250
Manganese	0.1	4.1	13.6	8.15	7.0		951	10.3	6.4					
Turbidity	16													
Setteable Solids		0.1												
Suspended Solids		14	827		236	1244			41					
Dissolved Solids		1704	2930		2482	2260			1952					
Total Solids		1718	3757		2718	3504			1993					
Chlorides		15.2												
Aluminum		20.2												

* NOT BY L.R.K. LABORATORY

D. Sludge Characteristics

Sludge generated at the existing treatment facility has undergone several analyses and evaluations. During the period of plant operations, the sludge characteristics have varied considerably. Methods of sludge control, concentration, recirculation and wasting have been numerous and varied producing expected and unexpected results. We have summarized the most important sludge situations and considerations in this portion of the report.

1. Sludge Physical Analysis

The following discussion describes both visual and settleable characteristics of the sludge at the treatment plant. Sludges developed for "pilot plant" operations are not presented in this section.

It was expected that the sludge would be thick (approximately 6% solids) with high specific gravity and viscosity (1.5 or greater). For some unknown reasons, these conditions were never attained. A gypsum problem was also anticipated, which never developed.

a. Color

The sludge is an opague reddish brown color. The color varies slightly with changes in thickness, becoming more reddish as the sludge thins and more brown as the sludge thickens. The sludge stains almost everything it touches; hence, the channels, tanks, pipes, etc. are taking the color of the sludge.

b. Clarifier Sludge Level

Shortly after start-up of the treatment plant it was discovered that it was difficult to hold the sludge blanket level in the clarifiers. The sludge would rise and overflow the clarifier effluent launders if a significant quantity of sludge was not drawn from the clarifier. In order to maintain the sludge in the clarifiers several methods of plant operation were performed; none contributed significantly to thickening and/or densifying the sludge. Methods included:

- i. Raised pH
- ii. Lowered pH
- iii. Raised D.O. Level
- iv. Lowered D.O. Level
- v. Recirculated sludge
  - (a) To Flash Mixer
  - (b) To Aeration Tank
  - (c) To Clarifier

vi. Reduced Raw Water Quantity
vii. Changed Scrapers to Intermittent Operation
viii. Changed Sludge Withdrawal to Intermittent Operation

During periods of plant operation of full capacity (4.5 MGD) the sludge required to be wasted to maintain a sludge blanket level at an elevation to not overflow the effluent launder is approximately 80,000 gallons per day per clarifier. Generally this sludge would test at 1% solids. Most of the time the clarifier supernatant had evidence of suspended colloidal matter distributed evenly throughout. This material overflowed the clarifier, mixed with the plant effluent and was ultimately discharged to the receiving stream. This suspended matter was so heavy at times that the top of the sludge blanket was not visible from the clarifier bridge. Sight penetration was depleated at a depth of about three feet. The addition of polymers had an appreciable effect on the sludge quality and clarifier supernatant. Time of sludge containment affected the volume of sludge (the longer it was held the more compact it became).

On July 6, 1979 a physical measurement was made of the sludge level in two of the clarifiers in order to evaluate the effect of time on the volume of sludge produced. Clarifier Number One had been used for storage of waste sludge from both sides of the plant for a period of eight days when the samples were collected. Clarifier Number Four contained sludge produced under "normal" treatment.

i. Clarifier Number One

Location of Sample	% Solids by Weight in Sludge
Top of Sludge Blanket	0.7
4 Ft. Below Surface	1.3
8 Ft. Below Surface	1.5
12 Ft. Below Surface	2.1
16 Ft. Below Surface	2.2

ii. Clarifier Number Four

Location of Sample	% Solids by Weight in Sludge
Top of Sludge Blanket	0.2
8 Ft. Below Surface	0.3
16 Ft. Below Surface	0.6

Again on July 17, 1979 another physical measurement was conducted of the sludge on the number two side of the plant. Sludge was being recirculated in the plant and some recirculation was evident in the raw water being pumped from the mine.

The following results were obtained:

Aerator No. 2 effluent	0.4% Solids by Weight.
Clarifier No. 4 Surface	0.4% Solids by Weight
Clarifier No. 4 Middle	0.7% Solids by Weight
Clarifier No. 4 Bottom	0.8% Solids by Weight
Waste Sludge (No. 2 Side)	0.9% Solids by Weight

On the basis of the above investigations it is concluded that the sludge from the treatment plant can be compacted about two-thirds of its volume by allowing it to remain in the clarifiers for an extended period of time. Conversely, a short period of time and/or recirculation of sludge within the treatment plant prevents the sludge from compacting to a significant increase in density or percent solids.

c. Setteability Features

Samples of sludge collected and set up in the plant laboratory for settleability analysis coincided with the observations made on the sludge blanket in the clarifiers. Volumetrically the sludge would typically settle to approximately 985 ml in a 1000 ml cylinder over a period of one hour and approximately 960 ml in a 1000 ml cylinder over a period of two hours.

An analysis was performed in the L. Robert Kimball and Associates Laboratory on March 12, 1979 on treatment plant waste sludge under different pH conditions. A sample was secured which had a pH of 7.95. From this sample five samples were prepared to an adjusted pH by adding caustic soda or lime (laboratory grade) in separate 500 ml cylinders. Each 15 minutes a reading of the sludge volume was made with the following results:

	No. 1	No. 2	No. 3	No. 4	No. 5
Actual pH	7.50	8.00	8.50	9.00	9.50
Actual ml	498	495	497	500	499
Time(Min.)	Vol. %Sol.	Vol. %Sol.	Vol. %Sol.	Vol. %Sol.	Vol. %Sol
0	498(100.0)	495(100.0)	497(100.0)	500(100.0)	499(100.0)
15	498(100.0)	495(100.0)	496(99.8)	499(99.8)	499(100.0)
30	495(99.4)	494(99.8)	496(99.8)	498(99.6)	498(99.4)
45	493(99.0)	492(99.4)	493(99.6)	497(99.4)	496(99.0)
60	491(98.6)	490(99.0)	490(98.6)	495(99.0)	494(98.8)
75	489(98.2)	487(98.4)	488(98.2)	493(98.6)	493(98.8)
90	487(97.8)	485(98.0)	485(97.6)	943(98.6)	492(98.6)
105	483(97.0)	485(98.0)	484(97.4)	492(98.4)	490(98.2)
120	482(96.8)	480(97.0)	481(96.8)	490(98.0)	488(97.8)
180	474(95.2)	471(95.2)	473(95.2)	483(96.6)	482(96.6)
240	467(93.8)	463(93.6)	464(93.4)	477(95.4)	475(95.2)

The results were plotted on a graph with % sludge by volume vs. time. A copy of this graph is inserted herein. (See Figure IV-1) It can be observed that the pH has very little effect on settleability during the first hour of quiescent conditions. However, after one hour, the pH seems to have a significant effect on the sludge settleability; the lower the pH the better the settleability. After three hours the settleability favored a pH of 8.5. Since the clarifier detention time is about 7 hours (excluding sludge volume) it appears the ideal pH for settleability is 8.50.

It should also be noted that the rate of settling of the sludge continued at an equal rate from one-half to four hours. This rate probably would have continued for another two hours before drastically slowing down.

Flocculation is very light and easily upset. During settling the material stratifies (coagulates in layers with clear liquid between) at first with compaction after a time interval. Mixing of settled material with supernatant can be accomplished easily with a resultant settling volume of solids decrease. The floc is delicate and breaks up readily.

d. Handleability

The sludge is easily handled. Experience has indicated that the material can be readily pumped by the use of centrifugal pumps. There has been no blockage of pipelines and no significant build-up of materials on the pipe internal walls. There is some evidence of minor abrasion.

Open channels and flumes have carried the sludge adequately. The material is very fluid (at about 1% solids) and moves by gravity in conduits and channels. It also seeks its own level in tanks and chambers. In slow moving areas it deposits residue; however, this is removed by increasing flow velocities or by hosing with water.

The material is not coarse but is slimy to the touch. It will cling to surfaces in fine layers but is easily removed by hosing if it has not dried. A discoloration of surfaces occurs when the sludge makes contact. The sludge dries slowly under atomspheric conditions (two days in the open sun at 90°F to dry a sample in a garbage can lid about 6." diameter by 1/8" thick). Dried sludge will return to a fluid condition upon mixing with a liquid.

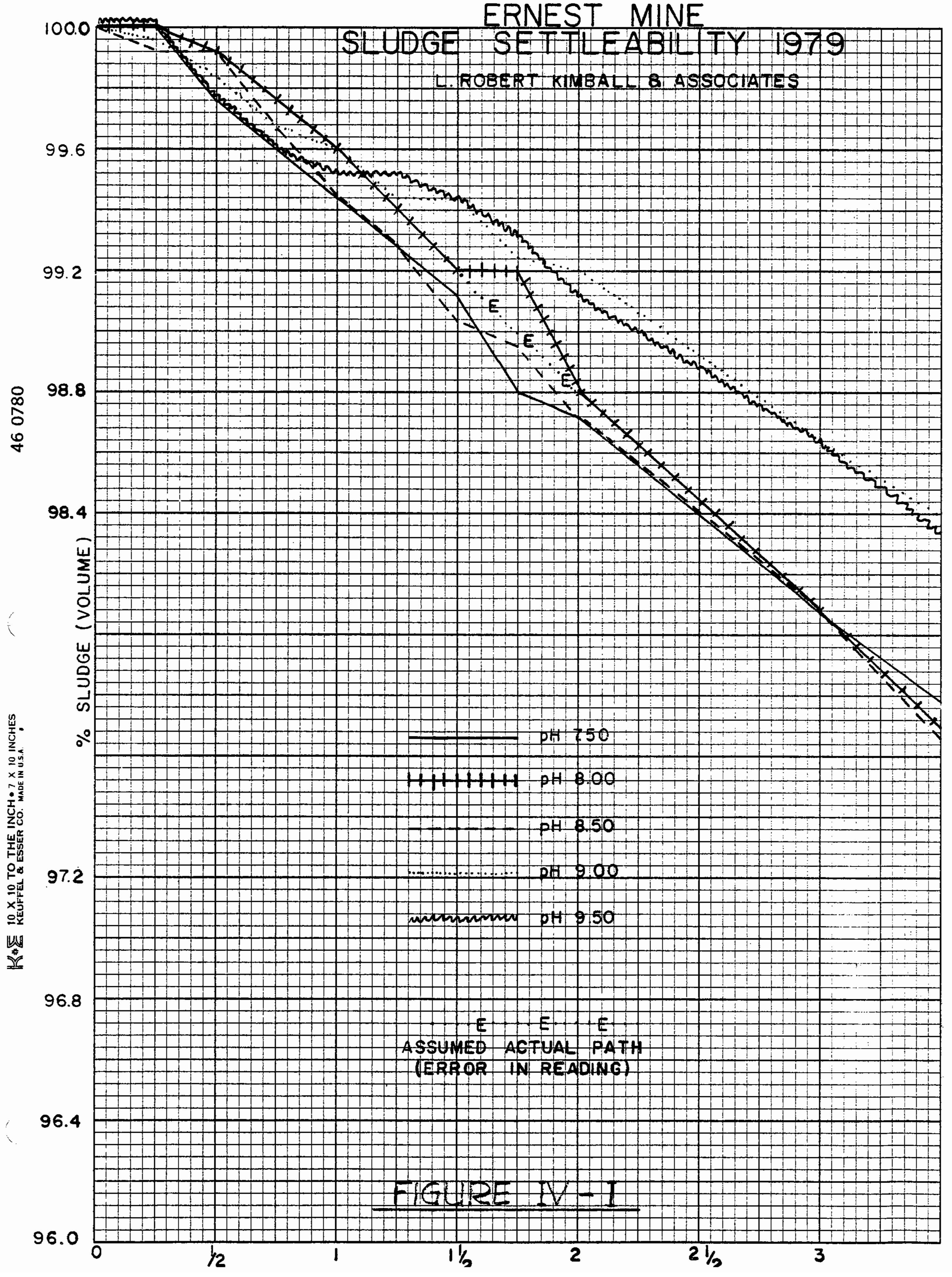

ERNEST MINE
SLUDGE SETTLEABILITY 1979
L. ROBERT KIMBALL & ASSOCIATES
% SLUDGE (VOLUME)
100.0
99.6
99.2
98.8
98.4
97.2
96.8
96.4
96.0
0
1/2
1
1 1/2
2
2 1/2
3
E
E
E
pH 7.50
pH 8.00
pH 8.50
pH 9.00
pH 9.50
E E E
ASSUMED ACTUAL PATH
(ERROR IN READING)
46 0780
10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

FIGURE IV-I

2. Sludge Chemical Analysis

A limited amount of testing was performed on the existing treatment plant sludge. The following page contains the results of the most recent heavy metals sludge analysis.

The sludge generated normally ranges in solids content from 0.5% to about 1.5%. A consistent solids content has not been maintained due to the variations in treatment plant operations.

There are insignificant amounts of silver, selenium, molybdenium and mercury. In fact, the quantity of these elements in the sludge is almost beyond detectability without extremely sophisticated testing equipment. The lead, manganese, cadmium and arsenic concentrations are also low. There is a significant amount of chromium, copper and aluminum. The nickel content is considerable and, as expected, the iron concentration is high.

E. <u>Experimental Pilot Operations</u>

During operation of the existing treatment plant and prior to the final design of any sludge dewatering facilities it is recommended that a continuing evaluation of sludge generation be conducted. Results of any such pilot operations would be applied to the design of sludge dewatering equipment.

Experimental pilot operations include but are not limited to:

a. Revising plant operations
b. Laboratory studies of sludge characteristics
c. Addition of flocculants
d. Continuing analyses of raw water & sludges

By continuing this work until the design is completed it is expected that new techniques of thickening sludge will be realized which then will become a part of the anticipated plant addition.

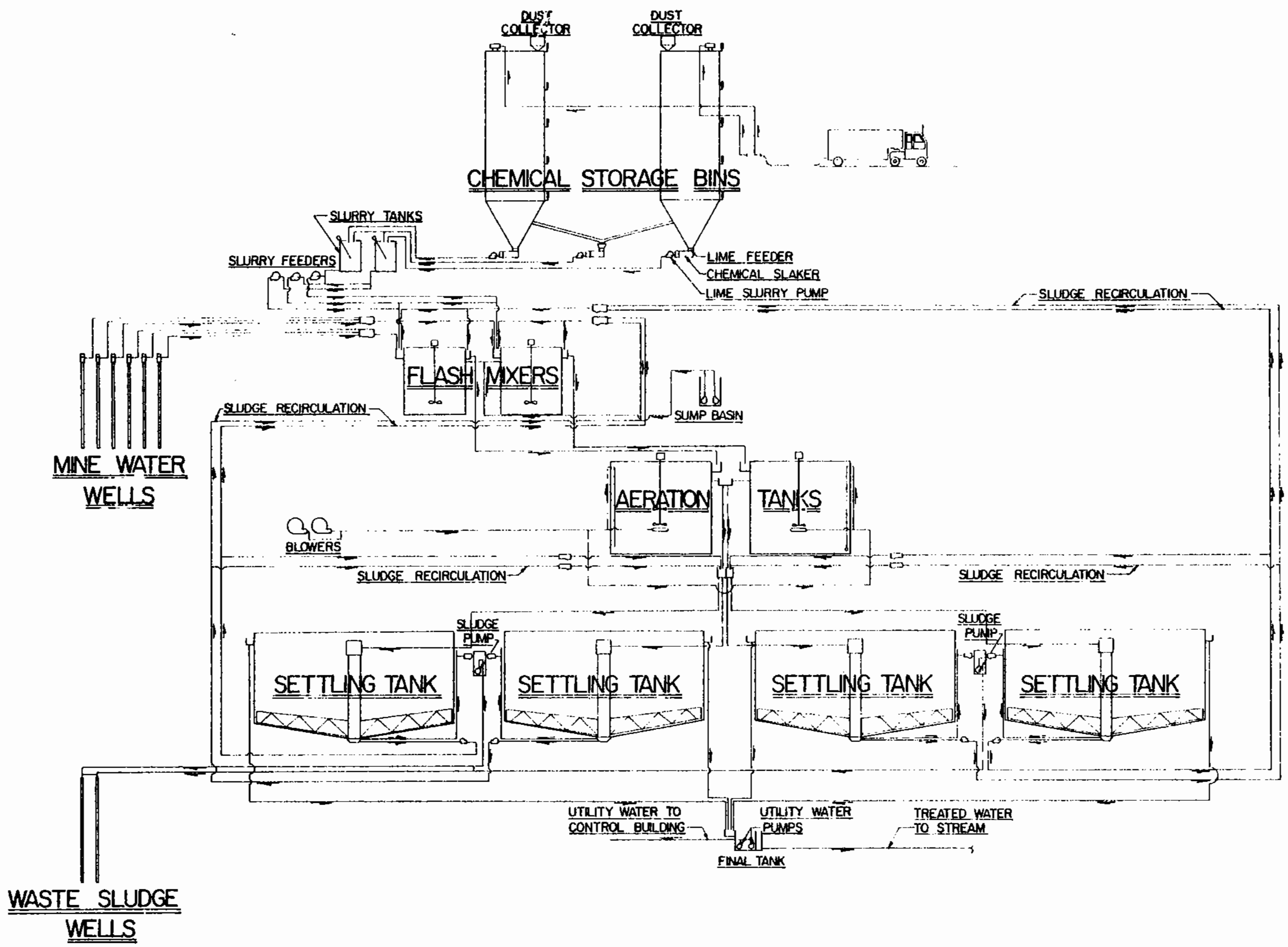
FIGURE IV - II

CARL A. WHITE
WATER RECLAMATION PLANT

ERNEST MINE COMPLEX

Analyses of sludge yields the following: for every 1 Kg of dry solids, following quantities are contained

Silver	less than 1 mg
Selenium	less than 1 mg
Nickel	172 mg
Molybdeniun	less than 1 mg
Mercury	less than 1 mg
Lead	4 mg
Chromium	33 mg
Copper	56 mg
Cadmium	1.8 mg
Arsenic	3 mg
Iron	242.8 g
Manganese	7.1 g
Aluminum	83.0 g



Process Flow Diagram of the Ernest Mine Drainage Treatment Plant

FIGURE IV - III