Ralph J. Stephenson, P. E.
Consulting Engineer

City of Kalamazoo DPU - PAC file - disk 377

I. Date of meeting: April 11, 1995

II. Location of meeting: Kalamazoo Water Reclamation Plant offices - Kalamazoo, Michigan

III. What are the givens?

- A. Will keep the PAC system.
- B. The WAR process stays.
- C. Cannot run the PAC system without properly controlling the ash level in the secondary aeration system.
- D. The sources of ash will vary and the amounts will fluctuate.
- E. That things can change tomorrow.

IV. Why did we need the PAC system?

- A. To cope with a pharmaceutical waste problem.
- B. If the pharmaceutical problem did not exist would not need the PAC system.
- C. This was a political solution to a technical problem leading to desirable economic conditions.
- D. Who should pay for the PAC system?
  - 1. The beneficiary of the PAC system pays for the majority of the system.
- E. The PAC system is now essential to meet requirments for the NPDES permits needed for the plant operation.
  - 1. Are meeting all requirements now.
  - 2. With the present trend we are heading for phosphorus and suspended solids difficulties. We must avoid these problems.

V. Sources of ash.

- A. Alum
- B. Ash in virgin carbon
- C. Incinerator ash
- D. Influent ash
- E. Regereration process ash

VI. What is the problem?

- A. Problems we can do something about.
  - 1. Ash and phosphorus problem - root problem
    - a) Have too much ash accumulating in the secondary aeration system.
      - (1) When the secondary tank mixed liquor ash concentration exceeds 42% we start losing solids, generally ash, to the effluent.
      - (2) The tertiary filter system takes out some more of the ash and recirculates it to the secondary.
      - (3) In addition the ash keeps building in the secondary system.
    - b) Have more ash in the effluent containing phosphorus than is allowed by permit limits (npdes).
      - (1) If the accumulation of ash in the secondary mixed liquor is reduced the carry-over problem with excess phosphorus is reduced to compliance levels.
    - c) If we solve 1 we also resolve 2.
  - 2. Cost problems
    - a) Regulatory - could be fined up to $25,000 per day for each permit violation.
      - (1) Suspended solids

            (2) Phosphorus
        b) Cost of powdered activated carbon - $.35 per pound
    3. Operating and maintenance problems.
        a) If we run more carbon in the DSE overflow it results in the following problems:
            (1) Wear out plate frame press filter cloths more frequently than with a lower carbon content.
            (2) Cost of the wasted carbon.
            (3) Plug filters more frequently and faster.
            (4) Increases pump maintenance due to the greater abrasiveness of the carbon compared to the ash.
            (5) A down-the-road problem of the disposal of the ash.
    4. Sizing problem statements
        a) The PAC system is large enough.
        b) The DSE system is not large enough.
            (1) The DSE was an afterthought to the regereration problem.
            (2) How do we know the DSE is not large enough?
B. Problems we cannot do anything about (in a reasonable period of time).
    1. Controlling inflow to the plant.
C. Idea boneyard
    1. If the price of activated carbon dropped to $.05 per pound there would be no need for this meeting.
    2. What other materials could be used in place of carbon.
        a) There are no other cost-effective materials according to Kalamazoo's consultants. (J & H)
    3. Disposal costs
        a) If we wasted more carbon and ash the disposal costs would be increased by as much or more than ten times over the present costs.
            (1)
    4. Other considerations and questions.
        a) Conductivity of the materials. Is the ash charged so the polymer is not working?
        b) The system must be used with soft water. It will not work with hard water.
    5. The measure of success will be

VII. What are the solutions that have been tried?

A. Added an additional baffle to elutration tank #2
    1. Was no apparent benefit.
B. Repositioned the feed tank level probes.
    1. At first it seemed to help by making solids in feed tank more concentrated.
C. Minimized chemicals (done to reduce chemical costs)
    1. By reducing polymer the cake removal was improved (plate press). But the dispersant had been reduced too much, allowing too much ash to be removed with the carbon.
    2. An increase in dispersant did not seem to improve solids separation.
D. Changed the size of the feed and ash pumps (in 1992 or 93.)
    1. Helped the presses fill better and the pumps run in a less stressful pumping range.
E. Removed all variable frequency drive units sensitive to power fluctuations.
    1. Drives we were using were too sensitive to power fluctuations.

2. We did lose some versatility.
3. Added new drives on the return pumps.

F. Started watching elutriation tank under-flowsettling
   1. Gave a relative visual parameter.

G. Charged eductors
   1. No significant change.

H. Cut back on elutriation dilution (water)
   1. Helped increase solids to elutiation tanks and increase output some.

I. Recirculation pumps turned back on
   1. Helped remove carbon with less ash.
   2. Tried to shut the pumps off - return carbon concentration increased and settler underflowconcentration decreased.

J. Installed dropleg bypass line.
   1. Increased output
   2. Able to run two DSE units on any one WAR unit

K. WAR reactor blowdown to settler discontinued.
   1. Reduced the amount of carbon being filtered by the plate presses.
   2. Reduced the amount of heavier abrasives.

L. Tried filter cloths from different manufacturers.
   1. Found a better filter cloth.

M. Ran system with a selected crew- summer of 1994?
   1. Resulted in increased productivity(?)
   2. Limits number of people available to work in that spot.
   3. Limits number of people available for the rest of the plant.

N. Changed polymers from 582 C to 591 C - Cytech product - new product is a higher molecular product than the other. Tried about January 1994 in the secondary.
   1. Could affect the ash going to the plate presses.
   2. Significantly reduced the secondary alum required for phosphorus removal.
   3. Switched to 591 C in November ±, 1994 in the DSE.
   4. Have run bench tests on various suppliers' products, and types of polymers.

O. Changed alum suppliers.
   1. Specification both the same. Cost factor only.

VIII. Ideas at random.

A. How could we use a pilot plant scheme to help model the process.

B. Monitor condutivity of the industrial influent. Could be that this could be chemically altered to provide required conductivity.

C. Change polymers to reflect the changes in the conductivity found in the industial or municipal waste.

D. Should compare the operating performance record with the different things tried in the same time frames.

E. If we have lowered our alum feed wouldn't that explain the changed location of the phosphous?

F. Will experiment again with removing phosphorus in the primary system.

G. Did reduce the ash inventory during July, 1994 to September, 1994. Balanced the incoming ash with the ash removal. Should examine what was being done in this period.
   1. What were the operational characteristics of the plant during this period?

IX. Observations that may be significant.

A. Discussion #1

1. What is the relation of polymer type and DSE operation? Compare dates.
2. What was the significance of the selected crew operating the DSE. Compare dates.
3. January 1994 to April 1995 the alum/ash loading has decreased overall.
4. Zimpro will run, for a fee, a pilot study of the DSE system. What value would this add? Could the plant do their own pilot study?
5. Reexamine sources of ash and determine where we should concentrate.
   a) Alum - already cut back.
   b) Ash in virgin carbon - cannot change
   c) Influent ash - cannot control but can be reduced.
6. If we can't control the ash that comes in we must take the ash out somewhere along the system line.
   a) Primary settling
   b) DSE
   c) Centrifuge - to be contracted - mousehole
   d) Belt press - to be contracted - mousehole
7. Should we increase the capacity of the DSE system.
8. Of what benefit would written instructions and improved training be to operation of the DSE?
9. What other visual parameters can be used to help monitor the DSE system.
10. Must improve measurement methods.
    a) Portable low meters
    b) Other?
11. Seem to be an need for better correlation between performance and statistics.
12. What is the relation of the filter cloth problems to the overall problems. Will slowing the filtration process and reducing carbon levels solve the filter cloth problem.
13. Order more filter cloths.
14. Show graphic relation between carbon and ash levels and the various techniques that have been tried.
15. What relation is there between running levels and operation effectiveness?
16. Are pumps matched to the capacities at which they are expected to operate? What effect does a mismatch have on the carbon system.
17. Are the ash pumps the problem?

X. Definitions

A. Activated charcoal

Highly absorbent carbon obtained by heating granulated charcoal to exhaust contained gases, resulting in a highly porous form with a very large surface area. It is used primarily for purifying gases by adsorption, solvent recovery, or deodorization and as an antidote to certain poisons. Also called activated carbon.

B. Activated sludge process

A sewerage plant system in which the functions of secondary treatment (i.e. bioprecipitation and biochemical oxidation) take place on the myriad surfaces of active biological flocs (activated sludge) which are maintained in suspension and in motion throughout the sewage liquid being treated.

C. Allotropy
The existence, especially in the solid state, of two or more crystalline or molecular structural forms of an element.

D. Anionic
A negatively charged ion, especially the ion that migrates to an anode in electrolysis.

E. Ash
The grayish-white to black powdery residue left when something is burned.

F. Cationic
An ion or group of ions having a positive charge and characteristically moving toward the negative electrode in electrolysis. (Greek kation, something going down).

G. Differential
Dependent on or making use of a specific difference or distinction.

H. Dispersant
A material used to distribute (particles) evenly throughout a medium. Disperses particles

I. DRC
Dilute regenerated carbon.

J. Drop-leg
Discharge line that has flow and drops down to to a drawoff point.

K. DSE
Differential sedimentation and elutriation.

L. Educt
One substance extracted unchanged from another (distinguished from a product).

M. Elutriation
To purify, separate, or remove (ore, for example) by washing, decanting, and settling. To wash away the lighter or finer particles of (soil, for example).

N. PAC
Powder activated charcoal.

O. PACT
Powdered activated carbon treatment.

P. Phosphorus
Symbol P - A highly reactive, poisonous, nonmetallic element occurring naturally in phosphates, especially apatite, and existing in three allotropic forms, white (or sometimes yellow), red, and black.

Q. Polymer
Any of numerous natural and synthetic compounds of usually high molecular weight consisting of up to millions of repeated linked units, each a relatively light and simple molecule.

R. Regenerate
To form, construct, or create anew, especially in an improved state.

S. Sediment
Material that settles to the bottom of a liquid; lees.

T. Sidesteam
A portion of the main flow.

U. Surfactant
1. A surface-active substance.
2. A substance composed of lipoprotein that is secreted by the alveolar cells of the lung and serves to maintain the stability of pulmonary tissue by reducing the surface tension of fluids that coat the lung. [SURF(ACE)-ACT(IVE) + A(GE)NT.]

V. Thermal conditioning process
Wet air oxidation.

W. Turbidity
Having sediment or foreign particles stirred up or suspended; muddy.

X. WAR
Wet air regeneration.

XI. Supplemental pages for meeting minutes

A. Those attending:
1. Richard Beardslee
2. Duncan McDonald
3. Victor Wolff
4. Steve Helmer
5. Gary Longenecker
6. Robert Cochran
7. Dennis Youngblood
8. Dan Bogema
9. Ron Janssen
10. Ron Wilson
11. Robert DeMink
12. Bill Slack
13. Mike Wetzel

B. Discussion #2 - these are immediate action steps that all agreed to implement now!
1. Purchase 80 filter cloths
2. Change one press feed pump to a 2" pump.
3. Maintain a higher minimum sludge blanket in the spent carbon thickeners.
4. Maintain a select crew to operate the DSE system.
5. Replace one of the spent carbon thickener pump with a piston type pump.

Kalamazoo Public Services - Vandersalm Connection

I. **Date of meeting - Tuesday, April 11, 1995**

II. **Location of meeting - Water Reclamation Treatment Plant offices**

III. **Those attending:**
- A. Larry Fischer
- B. Jeff Bye
- C. Ralph J. Stephenson

IV. **Agenda**
- A. Discuss issues surrounding project.
- B. Evolve solution to project problems.

V. **Project characteristics**
- A. Problem - the ground water at the private properties is being diverted into the City's sanitary collection system. This poses two problems:
  1. Causes backups of the sanitary sewer in the area.
  2. Problem at B - Costs about $52,000 per year to treat the additional volume being diverted into the sanitary system.
  3. Problem at A - Costs about $25,000 per year to treat the additional volume being diverted into the sanitary system.
- B. Goes way back.
- C. City has identified two large sources of problem.
- D. Essentially the city system is being used as a sump for the high ground water experienced by source A and source B.
- E. A and B are not paying for the service. A and B feel that they have been doing this for so many years (±20 or more) that they are entitled to continue doing this without assessment.
- F. Sources of inflow.
  1. Building A
     - a) Surface water entering boiler building.
       - (1) Surface water often surrounds building A.
       - (2) Owner has knocked hole in basement wall of building A. Water drains through opening.
       - (3) In the basement of A the water runs by gravity feed into the City collection system and into the waste waters mains. A has an apparently legitimate connection to the city system and feels he is entitled to run the water into the City system.
     - b) It is possible that a leaking culvert at area is recycling water from pond into basements and then A and B are recycling water through the waste treatment plant.
  2. Building B
     - a) Ground water from source B is pumped deliberately into the system by B.
     - b) High ground water requires property owner to pump water out of basement to prevent flooding.
- G. Courses of action possible
  1. Building A
     - a) Construct a City-owned storm water collection system -
       - (1) Cost about $20,000
       - (2) Scope of work
         - (a) Storm water lift station
         - (b) Piping to existing storm culvert in Crosstown Parkway or directly to the public pond.
       - (3) Disadvantages
         - (a) Sets precedent of providing private dewatering system for A.
         - (b) Work would require easements and building on private property.
     - b) Buy the boiler building and plug the lead and build a city-owned storm water system.
       - (1) Scope of work

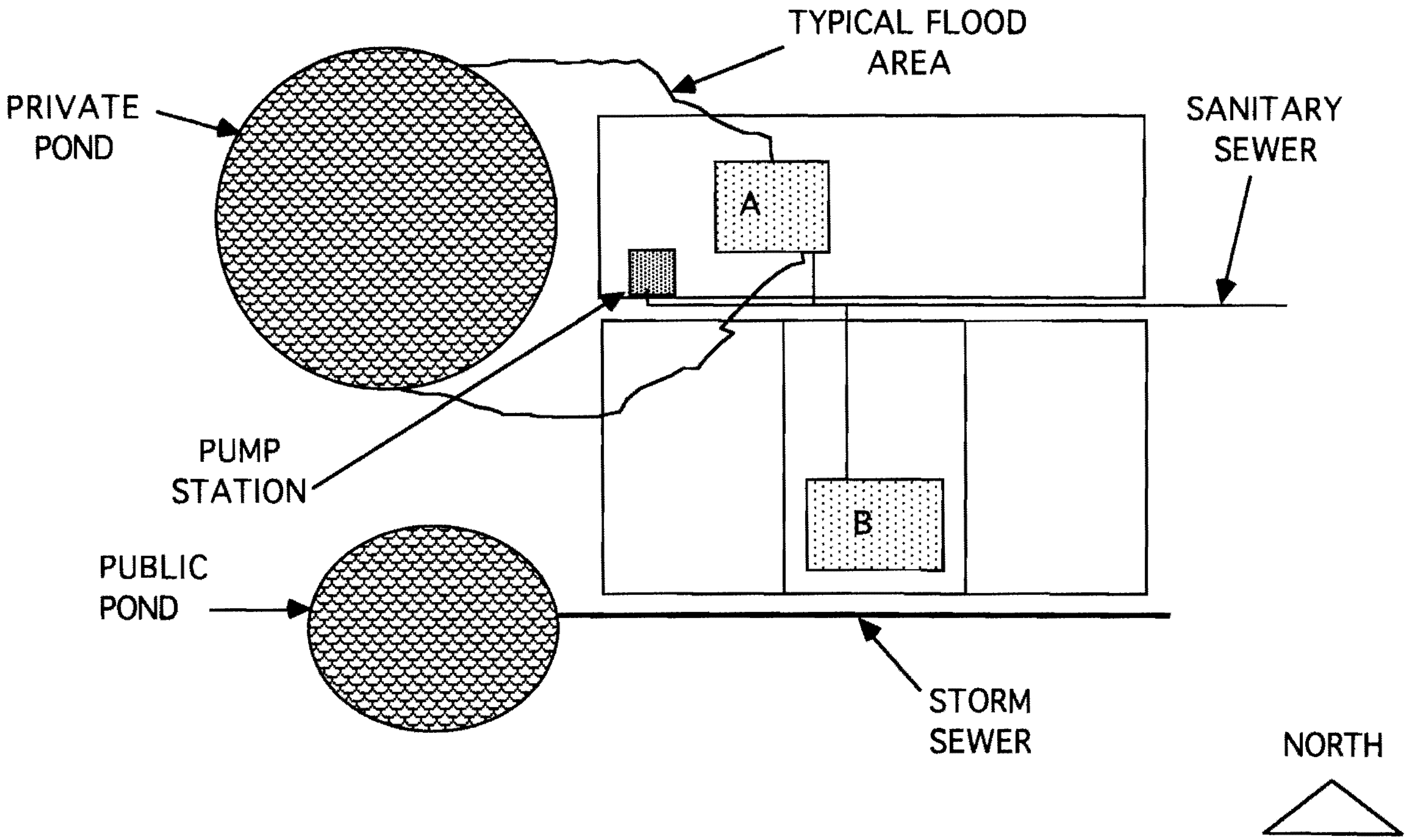
- (a) Might cost $10,000 + $20,000 = $30,000
- (b) Storm water lift station
- (c) Piping to existing storm culvert in Crosstown Parkway or directly to the public pond.

(2) Disadvantages
- (a) City would have to operate and maintain the lift station.
- (b) Will probably aggravate other property owners in the area by possibly flooding their exterior areas with backed up water.

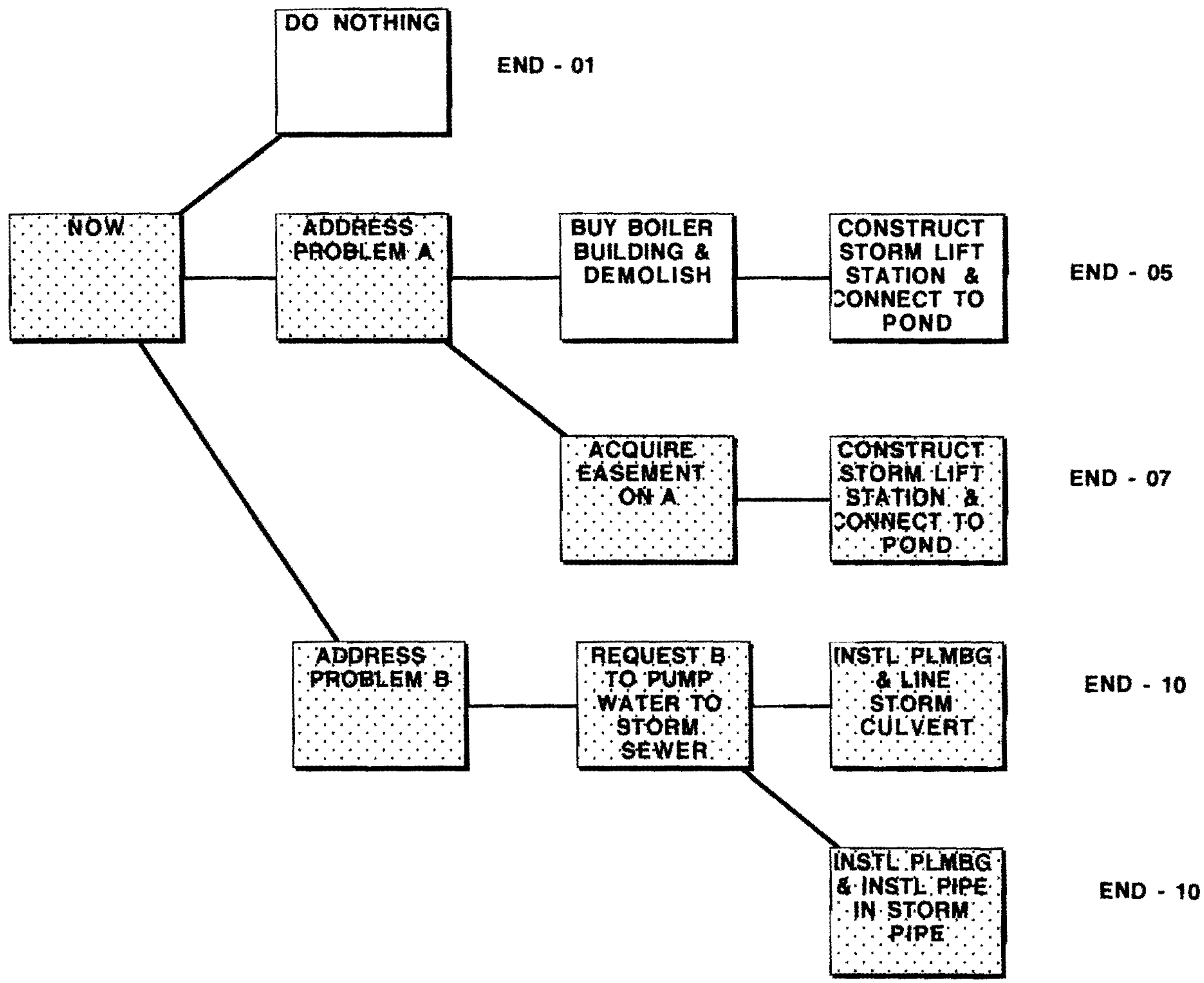
2. Building B
   - a) Request B to pump water into the storm sewer in Crosstown Parkway.
     - (1) Scope of work
       - (a) Cost about $5,000 - shared cost?
       - (b) Install tap to Crosstown Parkway.
       - (c) Modify interior plumbing.
   - b) Renovate storm sewer from public pond to Burdick
     - (1) Line storm sewer from public pond to Burdick - $250 per foot - 300 feet = $75,000
       - (a) Disadvantages
         - i) Might be recycling water from leaky culvert back to building B.
         - ii) Have cost of lining or or repairing pipe from Burdick to pond.
     - (2) Insert 2nd pipe inside existing pipe to carry water - less than $75,000.
       - (a) Disadvantages
         - i) Might be recycling water from leaky culvert back to building B.
         - ii) Have cost of lining or or repairing pipe from Burdick to pond.

VI. What does the DPS wish to do or to have done to correct the situation?

A. Stop the diversions.



VANDERSALM CONNECTION
April 11, 1995



DECISION TREE
VANDERSALM CONNECTION
April 11, 1995

THE CITY OF
Kalamazoo

DEPARTMENT OF PUBLIC UTILITIES
Water Reclamation
1415 N. Harrison
Kalamazoo, Michigan 49007-2565
(616) 337-8157
FAX (616) 337-8699

March 24, 1995

Mr. Ralph Stephenson
Consulting Engineer
323 Hiawatha Drive
Mt. Pleasant, MI 48858

Dear Ralph:

I am not certain how familiar you are with our wastewater process, so I will give you a basic overview.

We have a conventional activated sludge plant except we add powder activated carbon (PAC) to the secondary process. This allows us to remove certain constituents that would not be easily removed otherwise. So ultimately, the carbon produces an extremely high quality plant effluent. Unfortunately, there are several problems associated with PAC as well. The most difficult of these problems being ash removal, because of the high cost of PAC our system was designed to regenerate spent carbon (wasted carbon) and reintroduce it back into secondary. Our regeneration process is a Thermal Conditioning Process (wet air oxidation). The organic material attached to the carbon is literally burned off. The remaining ash is removed and the carbon sent back to the secondary aeration influent.

The ash that is attached to the regenerated carbon in addition to all the other various sources of ash, all contribute to an overall accumulation of ash in the secondary. Most of the solid in secondary are returned back to secondary. The relatively small amount of secondary solids that are wasted is the primary source of ash that can be controlled. This is also the source of carbon that is regenerated. Therefore, to control the amount of ash in the secondary we must reduce the amount in the regenerated flow.

When the regeneration process was initially started, ash was removed by gravitational separation of the regenerated carbon and ash. This was so ineffective that our secondary ash content reached 60% of the total solids in aeration. With the help of our regeneration

What would be normal w/o PAC?

process manufacturer, Zimpro, we installed an alternative means of ash separation. What was developed is called differential sedimentation and elutriation (DSE). We take a side stream portion of the regenerated flow while adding surfactant to hold the ash and carbon particles in relative suspension. The dilute regenerated carbon (DRC) is then routed to an elutriation tank where dilution water is added. The particles are separated and anionic polymer is added to settle out the carbon. Ash is then overflowed to a gravity settler where cationic polymer is added to aid in ash settling. The ash is dewatered with plate frame presses.

In June and July, 1993, we expérienced two months of effluent permit violations. Because our secondary ash concentrations had reach 53% we started to experience high secondary effluent turbidity. The effluent suspended solids were ok, but we violated on effluent phosphorus.

An emergency task force group was assembled to develop some ideas. As a result of this process a dewatering company was hired to dewater regenerated carbon and ash. Secondary mix liquor solids were reduced from 26,502 mg/l in July, to 18,293 mg/l in September. The ash solids were reduced by 638,223 lbs. Or 25%.

After the dewatering project it was decided that the DSE process should be sufficient to maintain a relatively constant ash inventory. It was determined that it would be necessary to remove 10,000 lbs/day of ash to maintain a consistent ash concentration.

The problem we are experiencing is reaching our goal of 10,000 lbs/day of ash removed and contains less than 20% volatile material. We need the ability to remove at least 10,000 lbs/day to progressively reduce the ash inventory.

Changes made:

1. Added an additional baffle to elutriation tank #2.
   A. No apparent benefit.

2. Repositioning of the feed tank level probes.
   A. At first it seemed to help, by making solids infeed tank more concentrated.

3. Minimization of chemicals.
   A. By reducing polymer the cake removal was improved (plate press). But the dispersant had been reduced too much, allowing too much ash to be removed with the carbon.

4. Changed the size of the feed and ash pumps.
   A. Helped the presses fill better and the pumps run in a less stressful pumping range.

5. Removed all variable sensitive to power units.
   - Driven we were too sensitive to power fluctuations.
   - We did lose some versatility.
   - Added new drives on the return pumps.

6. Started watching elutriation tank under flow settling.
   - This gives us a relative visual parameter.

7. Changed eductors.
   - . No significant change.

8. Cut back on elutriation dilution H_2O.
   - Helped increase solids to elutriation tanks and increase output some.

9. Recirculation pumps on.
   - Helps remove carbon with less ash.

10. Installed dropleg bypass line. ?
    - Increased output.
    - Able to run two DSE units on #1 WAR unit.

If you have any questions, please feel free to contact me at 616-337-8587.

Sincerely,

Richard Beardslee

Rich Beardslee
Operations Supervisor

RB:dw\ww_ops\beardslee\stevenson

Section No. 2
Kalamazoo MI: DSE Ash Handling

Section No. 2
Kalamzoo, MI DSE Ash Handling
Process Description

The DSE (Differential Sedimentation and Elutriation) System is a physical/chemical separation process which selectively separates suspended inert ash material from a sidestream of regenerated PAC (powdered activated carbon) slurry. The ash, which is removed by the DSE system, is disposed of while the valuable regenerated PAC is returned to the PACT^{TM} (powdered activated carbon treatment) process.

The Kalamazoo DSE system is designed to remove a minimum of 4000 pounds per day of ash from the PACT^{TM} system through each of the two DSE process trains. Each DSE process train can be run independently of the other, or the two trains can be run simultaneously, in parallel, for a combined daily ash removal of 8000 pounds.

The DSE system uses four process steps to, 1) chemically suspend the ash, 2) recover the regenerated powdered activated carbon (PAC), 3) floculate and thicken the ash and, 4) filter the thickened ash from the process flow stream.

A portion of regenerated PAC slurry is drawn from an on-line WAR (wet air regeneration) unit via a venturi eductor located at the discharge of the PCV's (pressure control valves). The regenerated PAC slurry is diluted with softened water containing dispersant conditioners.

These conditioners are used to suspend the ash material in the regenerated PAC and softened water mixture. Soft water is used to dilute the regenerated PAC to enhance the dispersant qualities of the chemical conditioners and also act as a physical medium to disperse the ash material.

Addition of sodium hexametaphosphate and sodium metasilicate dispersant conditioners alters the ionic surface charge of the ash and PAC. Enhancing the difference in surface charge between the ash and PAC particles allows sedimentation of the PAC after treatment with an anionic polymer. Following sedimentation the PAC is returned to the PACT™ process.

After the separation of the PAC from the process flow stream, the suspended ash is treated with a cationic polymer. Floculated ash solids are then thickened prior to final removal.

Final removal of ash solids is accomplished with a pressure filter system. Ash solids are dewatered to a dense filter cake with high solids concentration. Pressure filter ash cake is disposed of at an approved site. Filtrate from the dewatering process is returned to the PACT™ system.

Design of the DSE system is based on the following data:

	Minimum	Nominal
PACT™ Process Characteristics		
Mixed Liquor Suspended Ash(MLSA)(%)	45%	45-63%
Mixed Liquor Volatile Carbon (MLVC)	2500 mg/l	4300-5000 mg/l

Wet Air Regeneration Feed Slurry Characteristics

	Minimum	Nominal
Total Suspended Solids (%)	6%	6-12%
Total Suspended Ash (%)	—	45-63%

Regenerated PAC (DSE Feed) Characteristics

	Minimum	Nominal
Total Suspended Solids (%)	---	6-10%
Total Suspended Ash (%)	---	67-80%
Temperature ($^{o}F/^{o}C$)	---	200-220^{o}F/ 93-104^{o}C
Volume (gpm/lpm)	---	gpm/lpm

NOTE: The DSE system is designed to process regenerated PAC slurry which has been regenerated at the following conditions.

	Minimum	Nominal
Reactor Outlet Temperature ($^{o}F/^{o}C$)	$470^{o}F/243^{o}C$	$480^{o}F/249^{o}C$
Residual O_2 Content	1.5%	2-4%

Kalamazoo DSE Ash Handling Flow Scheme*

2.1 Dilute Regenerated Carbon (DRC) Flow to the Elutriation Flocculation Tank

A. Regenerated PAC Slurry - is collected in a drop-leg type separator downstream of the WAR PCV's. The separator functions to allow WAR process off-gases to be separated from the slurry. The separator also serves as a reservoir which provides a flooded suction to the eductor (item 4, drawing D-1003).

B. Softened Water - is used as both an elutriation medium and as a motive force to draw regenerated PAC slurry from the separator. As softened water under pressure passes through the eductor venturi throat, it creates a suction force to draw regenerated PAC slurry from the separator. The two liquid streams mix in the eductor throat and flow as a combined stream (DRC) to the elutriation flocculation tank. Softened water flow is controlled by a flow control valve (item No. 82, drawing D-1003) which is manually adjusted.

* Items and drawings enclosed by parentheses () refer to the Engineering Diagrams listed in Section 1.

Softened water is supplied by two water booster pumps, each driven by a single speed drive motor. Start/Stop pushbuttons (HS 207), unit 1 and (HS-208) unit 2 are located in the field.

In addition to supplying motive water for transportation of regenerated PAC solids, the water booster pumps also supply elutriation water to the DRC flow stream at a point just before the elutriation flocculation tank inlet. Elutriation water flow is controlled by a manually operated flow control valve (item No. 11, drawing 1003) and is monitored by flow meter (FI 105), unit 1 and (FI 114), unit 2. Total soft water flow is monitored/totalized by flow meter (FT 220), unit 1 and FT 223), unit 2. The WAR computer also records these hourly/daily flow measurements.

C. Dispersant - is injected into the soft water flow stream near the suction of the water booster pumps. The dispersant supply system consists of two hydraulically actuated, diaphragm type metering pumps, a dispersant mix tank and mixer. Dispersant flow is controlled by a manually adjusted stroke/volume control mounted on the dispersant pumps.

The dispersant mix tank is fitted with a perforated metal basket for dissolving sodium hexametaphosphate "unadjusted glass". City water is used as a mixing agent.

2.2 Elutriation Tank Flow

A. DRC - a combination of regenerated PAC, softened water and dispersant conditioners flow into the elutriation flocculation tank. DRC flow is monitored/totalized in the field by flow meter (FQI 119), unit No. 1 and (FQI 126), unit No. 2. The WAR system computer also records and displays these hourly/daily flow measurements.

B. Anionic Polymer - is injected into the DRC flow stream near the inlet of the elutriation flocculation tank. The polymer supply system consists of two, hydraulically actuated, diaphragm type, metering pumps, an anionic polymer mix tank and single speed mixer. Polymer flow is controlled by a manually adjusted stroke/volume control mounted on the anionic polymer pumps. City water is supplied to the mix tank as a polymer mixing agent, if needed.

Addition of anionic polymer to the DRC mixture, in combination with agitation supplied by the flocculation tank mixer, creates a selective flocculation of the carbon particles. The flow from the flocculation tank enters the elutriation tank where separation takes place under relatively quiescent conditions. The difference in the settling rates between the dispersed ash particles and the floculated carbon particles forms the basis for effective separation of the DRC slurry into carbon-rich and ash-rich slurry streams.

Within the clarifier-like elutriation tank, the following processes occur.

Floculated carbon particles settle rapidly to the bottom of the tank. Carbon solids are collected by a rotating plow/squeegee collector mechanism which directs the solids to a center draw off port.

Dispersed ash slurry overflows the discharge weirs at the top of the tank.

Any remaining off-gases in the DRC stream from the WAR process, are drawn from the head-space above the flocculation tank and elutriation tank by the vapor blower and are transported to the PACT^{TM} foul air system.

C. Elutriation Tank Underflow - which contains the carbon rich stream, is constantly drawn from the elutriation tank by the elutriation recycle pump. Pump speed is controlled by a field mounted adjustable frequency AC motor drive (HS-123), unit No. 1 and (HS-125), unit No. 2.

D. Elutriation Tank Recycle - is directed back to the elutriation tank inlet. The recycle of carbon solids is designed to; 1) provide additional elutriation (dilution and washing) of the carbon rich stream to disperse into solution additional ash which did not separate in the initial pass through the tank and to, 2) maintain an homogenous ash solids blanket, thus avoiding possible plugging of the tank draw-off port by heavy ash solids.

E. Carbon Return - is the carbon rich slurry which is returned to the PACT™ process. As carbon solids accumulate in the lower extremities of the elutriation tank, these solids are drawn from the tank underflow and returned to the PACT™ process. The carbon return pumps discharge to the scrubbing channel. The pump output is controlled by an adjustable frequency AC motor drive (SC-123), unit No. 1 and (SC-125), unit No. 2. Carbon return is designed to be done on an intermittent basis. Each carbon return pump has a hand-off-auto switch. In the hand position, the pump will run continuously. In the auto position, the pump will run based on interval/duration timer settings.

2.3 Ash Slurry to the Plate Settler

A. Elutriation Tank Overflow - which contains the dispersed ash solids, runs by gravity to the inlet of first of two settler flocculation tanks.

B. Cationic Polymer - is injected into the elutriation overflow stream near the inlet of the first settler flocculation tank. The cationic polymer supply system consists of one, hydraulically actuated, diaphragm type, metering pump, a cationic polymer storage/mix tank and single speed mixer. Polymer flow is controlled by a manually adjusted stroke/volume control mounted on the cationic polymer pump. City water is supplied to the mix tank as a polymer mixing agent, if needed.

2.4 Plate Settler Flow (Note: a single plate settler handles flow from both elutriation tanks)

A. The combination of elutriation tank overflow and cationic polymer enters the first settler flocculation tank where the polymer and ash-rich slurry are mixed. The mixer is a single speed, flush type and has a field start/stop station (HS-301). The mixture then runs by gravity to the second settler flocculation tank. A slow speed, variable speed floculator agitates the ash solids and polymer to enhance coagulation. The floculator speed is controlled by a field mounted adjustable frequency AC motor drive, SC-302 and has a field start/stop station. The floculated ash slurry flows by gravity to the plate settler.

B. WAR Gravity Settler Underflow - enters the plate settler in combination with the floculated ash solids. WAR gravity settler underflow (thickened WAR reactor blowdown solids) is pumped from the WAR process intermittently as a function of the reactor blowdown frequency.

Ash slurry enters the plate settler at the lower end of the inclined plates. Settling and thickening of the ash solids occurs as the more dense floculated ash particles (and reactor blowdown solids) settle at a higher rate than the upward velocity of the liquid phase.

Flow is distributed evenly via an inlet channel. The flow of ash ladden liquid is in an upward direction across the surface of the inclined plates.

4.7 Cationic Polymer System

Description: Liquid cationc polymer is pumped to the inlet of the flash mix tank of the plate settler. A single metering pump supplies cationc polymer for one or both DSE trains. (Flow from one or both elutriation tank overflow is routed to the single plate settler.) The metering pump is a variable displacement diaphragm type, equipped with manual stroke control adjustment (0-100%).

A. Cationic Polymer Metering Pumps:

Manufacturer:	Neptune Chemical Pump Co.
Model No.:	562-S-N3
Serial No.:	45815
Capacity:	0-40 gph

Maintenance:

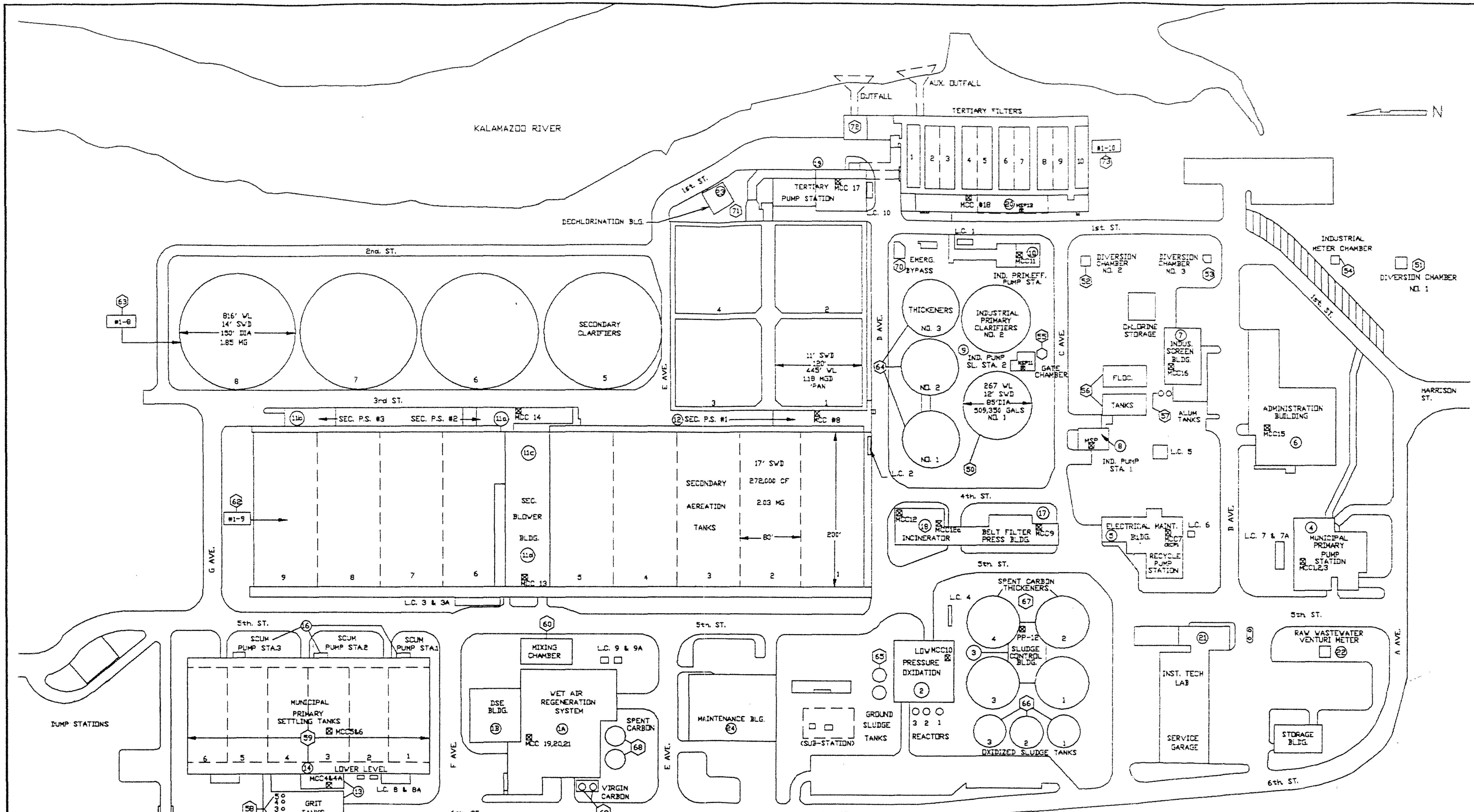
Weekly:	Check pump for hydraulic oil leakage
Monthly:	Check hydraulic oil level
6 months:	Change hydraulic oil, EP SAE 90 gear oil

B. Cationic Polymer Mixer:

Manufacturer:	Neptune Chemical Pump Co.
Model No.:	D-3.0 gear drive, 420 rpm
Serial No.:	45919
Size:	1.0 HP

Maintenance:

Yearly:	Change gear oil, EP SAE 90 gear oil



CITY OF KALAMAZOO
DEPT. OF PUBLIC UTILITIES

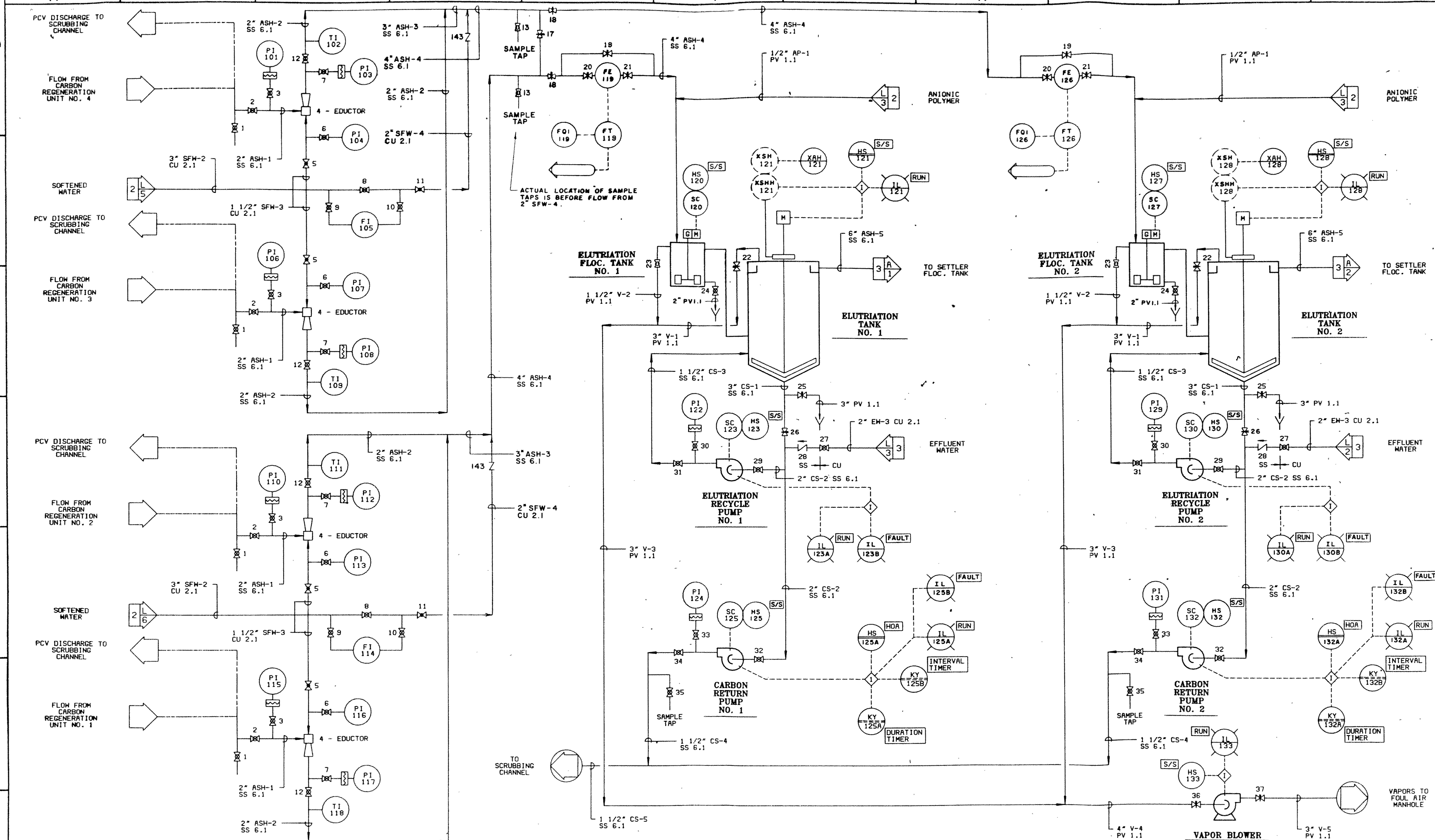
KALAMAZOO WATER RECLAMATION PLANT

KENNETH P. COLLARD - DIRECTOR

SCALE 1" = 60' JANUARY 28, 1991

PLANT\KWRPLANT.DWG REV. 10/22/92

LEGEND: ○ BUILDING NOS. ⬡ TANK AND CHAMBER NOS. ⊠ MOTOR CONTROL CENTERS



REV.	DATE	BY	DESCRIPTION	CH'KED	APPR'D

ASH HANDLING SYSTEM
FOR
KALAMAZOO, MICHIGAN

ENGINEERING FLOW DIAGRAM

DRAWN Larry J. Doephs
CHECKED N/A
APPROVED def
DATE 12-14-87 SCALE NONE
NEXT ASSEMBLY
SHEET 1 OF 3

ZIMPRO INC.
ENVIRONMENTAL ENERGY SYSTEMS
ROTHSCHILD, WISCONSIN 54474

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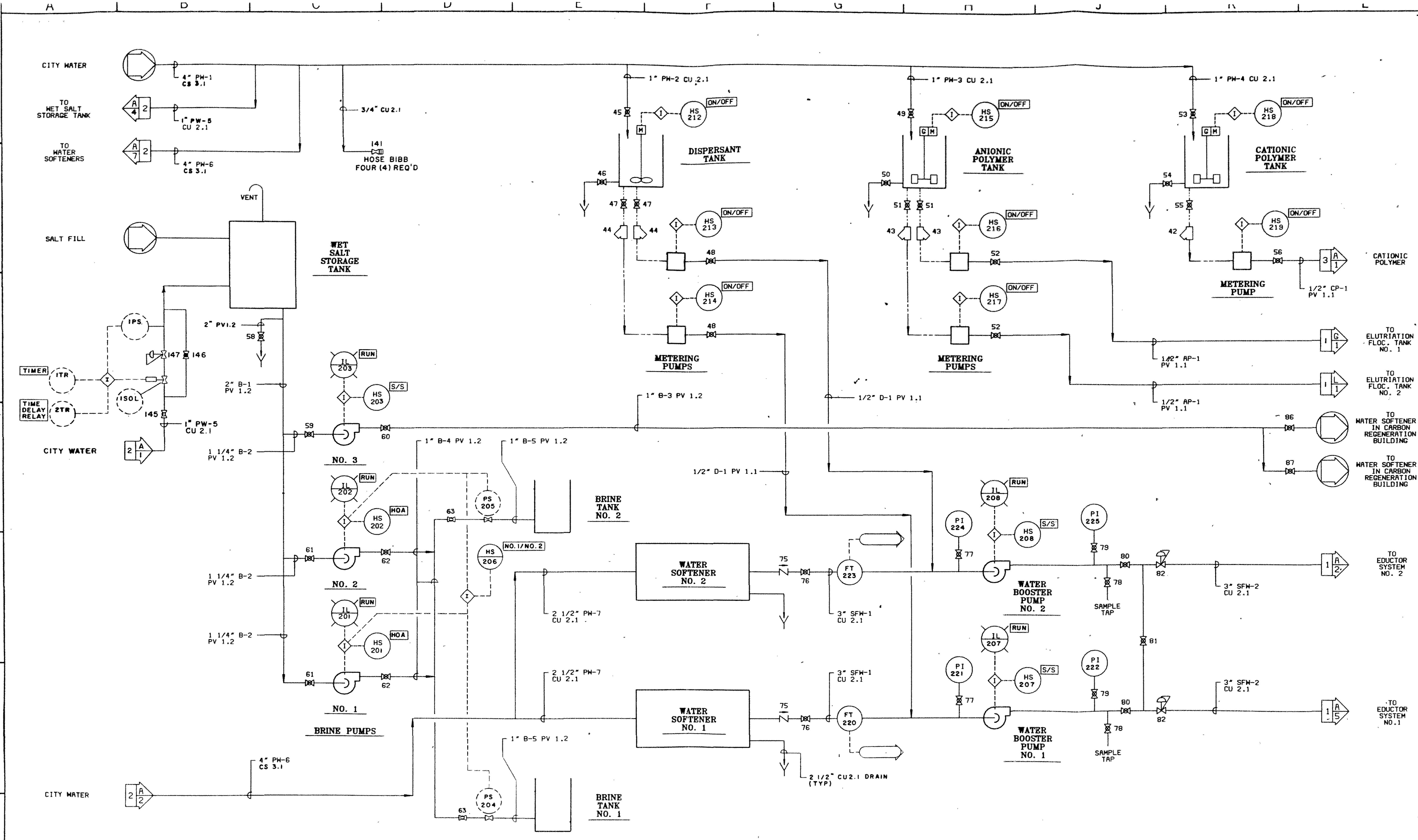

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ASH HANDLING SYSTEM
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KALAMAZOO, MICHIGAN

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APPROVED
DATE 12-14-87 SCALE NONE
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SHEET 2 OF 3

ZIMPRO INC.
ENVIRONMENTAL ENERGY SYSTEMS
ROTHSCHILD, WISCONSIN 54474

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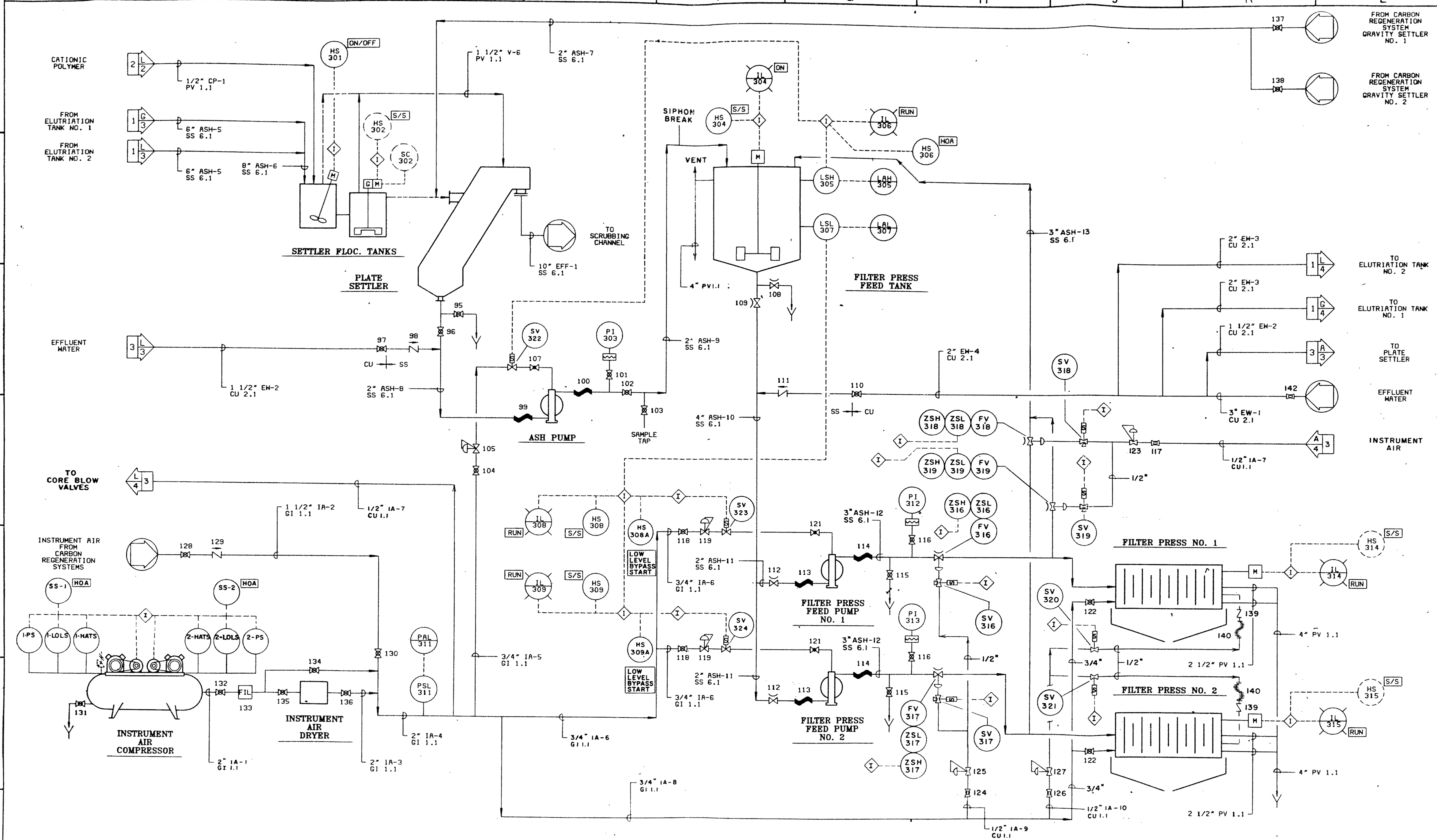

REV.	DATE	BY	DESCRIPTION	CH'KED	APPR'D

ASH HANDLING SYSTEM FOR KALAMAZOO, MICHIGAN

ENGINEERING FLOW DIAGRAM

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APPROVED [signature]
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SCALE NONE
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SHEET 3 OF 3

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