PROCEDURES FOR THE MEASUREMENT OF RADIOACTIVITY

Health-Physics Department

Davison Chemical Company
Pompton Plains, N. J.

(32)

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ALPHA COUNTING

ANALYSIS: Counting Procedure

The operations noted below are performed daily before any samples are counted.

1. Thoroughly clean the sample chamber with ethyl alcohol (C_2H_5OH).

2. To determine the background, place a blank filter paper (Whatman #41, 1-1/8 inch diameter) on the pedestal. In scintillation counters, fasten the blank in place with a plastic ring. In the proportional counter, place the blank on the middle of the pedestal. Whenever possible, allow the blank to count overnight. Record the time at which the counting was started. To determine the counts per minute, divide the total count by the count time (in minutes). This figure is recorded on the card provided.

   Example: Background (bkgd) count was 235 counts in 18-1/2 hours.

   18 x 60 = 1080 / 30 = 1110 = count time in minutes.

   235 / 1110 = .21 c/m bkgd.

   When it is impossible to count the background overnight, if may be counted in the morning. The background is then counted for 10 minutes.

   Example: Counter registered 4 counts in 15 minutes. Time in minutes was 15.

   4 / 15 = 27 c/m background.

3. The geometry is calculated after the background is counted. This is done by placing the alpha standard (496 d/m) in the chamber.

   A. In scintillation counters, the standard is counted for 640 counts and the time recorded. The standard is counted three times and the geometry is calculated from the average of the three.

B. In the proportional counter, the standard is counted for two minutes and the count recorded. This operation is repeated three times and the average count is used to calculate the geometry.

The geometry is calculated as follows: The counts per minute of the standard is divided by the known disintegrations of the standard.

Example: The counts per minute of the standard was 239. The d/m of the standard is 496.

Therefore: 239 ÷ 496 = .48 or 48% geometry.

Record this figure on the card with the background.

If the geometry drops to 35% or lower in scintillation counters or below 45% in the proportional counter, the counter should be checked by the instrument repair man.

ALPHA COUNTING

ANALYSIS: Plateaus

1. Place the alpha standard (496 d/m) in the sample chamber of the counter.
2. Find the lowest operating voltage of the counter.
3. At this voltage make three counts
   A. In scintillation counters, make three 640 counts.
   B. In the proportional counter, make three-minute counts.

   Record these figures.
4. Make three counts every 25 volts in scintillation counters and every 20 volts in the proportional counter.
5. Continue in this manner until the count becomes too fast. That is, until the scintillation counters record 640 counts in less than 1.50 minutes or the proportional counter records more than 1200 counts per three minutes.
6. Ascertain the average counts per minute by the following methods:
   A. In scintillation counters, add the three count times and divide by 3 to find the average count time. Then divide 640 by the average count time to determine average c/m.

   Example: At 950 volts the count times were 3.28, 3.50 and 2.98.

   3.28 / 3.50 / 2.98 = 9.76

   9.76 ÷ 3 = 3.25

   640 ÷ 3.25 = 197, the average counts/minute
   B. In the proportional counter, add the three counts and divide by 9 to find average counts/minute. 9 is used because there were 3 counts and each count was for 3 minutes.

   Example: At 840 volts the counts were 608, 626 and 599.

   608 / 626 / 599 = 1833

   1833 / 9 = 204, the average count/min.

7. The average counts are then plotted on graph paper against the voltage. By using French curves, a curve is drawn.

8. The operating voltage is chosen from the plateau or straight line on the graph. The operating voltage is usually 1/3 to 2/3 of the way across the plateau.

9. Plateaus should be run once every three months. If major repairs are made on the counter, or if the geometry is too low, spot checks should be made on the plateau. If the spot checks show much variance, an entire new plateau should be run.

ALPHA COUNTING

ANALYSIS: Alpha Air Dust

Procedure

1. The background and geometry should be taken daily before counting any samples. Directions for taking background and geometry appear in preparations for alpha counting.

2. The sample is placed on the pedestal and fastened with a plastic ring. Samples are counted either for 32 counts or for 15 minutes, whichever comes first. If a 32 count is reached in less than 0.05 minutes, it is advisable to recount it for a 64 count.

3. Types of Samples Counted:

   A. Uranium air dust samples – 4 to 5 hours should elapse from the time of sampling to the time of counting. This is to allow for the decay of radon gas.

   B. Thorium alpha samples - at least 24 hours should elapse between time of sampling and time of counting. This allows for the decay of thoron and other daughter products.

ALPHA COUNTING

ANALYSIS: Alpha Air Dust

Calculations

A. To determine counts per minute, divide the total count by the count time in minutes, then subtract the background of the counter. When referring to c/m, it is assumed that the background has been subtracted.

This formula is $\frac{\text{count}}{\text{time}}$ - bkgd. = c/m

Count = total count Time = time in minutes.

Example: Sample 7B counted 32 counts in 7.38 minutes.

The counter background was .12 c/m.

32 ÷ 7.38 = 4.35

4.35 - .12 = 4.23 c/m

B. To determine d/m, this formula is used:

$$d/m = \frac{c/m}{\text{geom.}}$$

Example: Sample 7B c/m = 4.23 Geom. is 48%

$$\frac{4.23}{.48} = 8.81$$

C. To determine $d/m/M^3$. Air dust samples are usually reported in this way. This formula is used:

$$d/m/M = \frac{d/m}{(.7)^* \quad (Q)^{**}}$$

*.7 is the absorption factor for the filter paper in air dust samples.

**Q is the amount of air sampled in cubic meters.

Example: Sample 7B: d/m = 8.81

Q is .6 Absorption factor is .7

$$d/m/M = \frac{8.81}{.7 \times .6} = 20.98$$

ANALYSIS: Counting Planchets

1. Before a planchet is used, it is counted for five minutes to determine the background of the planchet.

2. Planchets are always counted in the proportional counter. The planchet is placed in the middle of the pedestal. The sample is counted for 15 min. unless the count is very fast. Then the counter may be shut off at any time. (It is better to turn off the proportional counter on an even minute rather than a fraction of a minute, since calculating is easier with even minutes).

3. Planchets should be counted as soon as possible after they are dried, except for Radium at equilibrium, i.e. 40 days.

ALPHA COUNTING

ANALYSIS: Plant Effluent

Procedure

1. Sample

   A. Plate 5 ml. of the sample directly.

   B. Calculate d/m/ml in the usual way. (See Calculations)

2. Liquid Phase

   A. Place a 10 ml. aliquot of the sample in a centrifuge tube.

   B. Centrifuge for 15 minutes.

   C. Carefully plate the liquid on a stainless steel planchet 2" in diameter.

   D. Allow it to dry thoroughly and count in the proportional counter for 30 minutes.

   E. Calculate d/m/ml in the usual manner. (See Calculations)

3. Solid Phase

   A. The solid which remains in the bottom of the centrifuge tube is plated on a stainless steel planchet 2" in diameter.

   B. The centrifuge tube is rinsed with water and the rinsing is plated on the planchet.

   C. Allow the planchet to dry thoroughly and count it for 30 minutes in the proportional counter.

   D. Calculate d/m/ml in the usual manner. (See Calculations)

ANALYSIS: Alpha Activity in Murky Water

Procedure

(Clear water samples are plated directly onto stainless steel planchets. A 5 ml. aliquot is generally used.)

Method for Murky Water Samples

1. Place an aliquot of the sample (20-100 ml.) in a beaker.
2. Add an approximately equal amount (20-100 ml.) of Nitric Acid (HNO_3) to the aliquot.
3. Place the beaker on a medium heat hot plate and evaporate until about 5-10 ml. of aliquot remains.
4. Remove from the hot plate and allow the beaker to cool.
5. Add about 25 ml. of Nitric Acid (HNO_3) to the aliquot.
6. Return to the hot plate, and allow the aliquot to evaporate until about 5-10 ml. remain.
7. Repeat steps 4-6 until the aliquot is clear.
8. Plate a small amount of the aliquot on a low background stainless steel planchet by means of a dropper. Dry on a low heat hot plate. Add another small amount of aliquot and allow it to dry. Continue in this manner until all of the aliquot is plated.
9. Rinse the beaker with a small amount of water (6-25 drops) and plate the rinsing on the planchet.
10. Allow the planchet to dry thoroughly.
11. Count in a low background proportional counter for 15 minutes.

Calculations

1. To determine counts per minute, divide the total count by the count time in minutes and subtract the background of the planchet.

$$c/m = \frac{\text{total count}}{\text{count time}} - \text{bkgd.}$$

Example: 20 ml. of a sample was plated on a planchet. The background of the planchet was one count in five minutes or .20 counts per minute. The aliquot counted 7 counts in 15 minutes.

$$c/min = \frac{7}{15} - .20 = 0.27$$

2. To determine disintegrations per minute, divide the counts per minute by the geometry.

$$d/m = \frac{c/m}{\text{geom.}}$$

Example: The c/m of a sample was 0.27. The geometry of the counter was 50%.

$$d/m = \frac{0.27}{.50} = 0.54$$

3. To determine d/m/ml the d/m is divided by the sample aliquot.

$$d/m/ml = \frac{d/m}{\text{aliquot}}$$

Example: 20 ml. of a sample had a d/m of 0.54

$$d/m/ml = \frac{0.54}{20} = 0.027$$

BETA COUNTING

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BETA COUNTING

ANALYSIS: Counting Procedure

I. Background

A. The background of the beta counter is taken daily. It is always taken on the same shelf of the counting chamber on which the samples are counted.

1. The inside of the chamber and the counting shelf are thoroughly cleaned with ethyl alcohol (C_2H_5OH).
2. The shelf is placed in the second slot (or on whichever shelf the samples are to be counted.)
3. A thin aluminum absorber .001" thick is placed on the first shelf (or the shelf above the one on which the samples are to be counted). (This is done to remove the low energy RaD beta rays and the RaF alpha rays).
4. The empty shelf is then counted for fifteen minutes.
5. The total count is then divided by the count time to determine background in c/min.

$$\text{c/m bkgd} = \frac{C}{T} = \text{c/m bkgd.}$$

Example: The total count of a fifteen minute background was 125.

$$\text{c/m bkgd} = 125 \div 15 = 7.3 \text{ c/m bkgd.}$$

II. Geometry

A. The geometry is taken twice a week on the same shelf of the counting chamber on which the samples are to be counted. If another shelf is to be used, the geometry is taken on that shelf, before the sample is counted.

1. The Radium D and E source is placed on the counting shelf in the second slot of the counting chamber.
2. A thin aluminum absorber (.001" thick) is placed on the first shelf or the shelf above the one on which the samples are to be counted.
3. The source is counted for three, three minute counts.
4. The three counts are then added and the result is divided by nine and the background of the counter subtracted to determine the average c/m.

   Example: Radium D and E source counted 5300, 5282, and 5199 in three, three minute counts. The background of the counter was 7.3 c/m.

   Average c/m = 5300 / 5282 / 5199 = 15781 +- 9 = 1753.4 - 7.3 = 1746.1 c/m.

5. The d/s of the source at the time of counting is determined by use of the graph prepared for each source. This number is multiplied by 60 to determine d/m of the source. The average c/m of the source is divided by the known d/m of the source and the result is the geometry of the counter.

   Example: The source had a known d/s of 488 at the time of counting. 488 x 60 = 29280 d/m. The average c/m of the standard was 1746.1. Geo. = 1746.1 / 29280 = 6.0% geometry.

ANALYSIS: Plateaus

Procedure

1. Place the Radium D/ E standard on the second shelf of the counting chamber of the beta counter.
2. Find the lowest operating voltage of the counter.
3. Three, three minute counts are taken at this voltage.
4. Record the total count and the voltage.
5. Make three counts every twenty-five volts until the count becomes too fast. (That is, until the count is so fast that not all of the counts are registered.)
6. Ascertain the average counts per minute by adding the three counts and dividing by nine. Nine is used because there were three counts and each count was for three minutes.

   Example: At 700 volts the counts were 5200, 5169, and 5310.

   5200 / 5169 / 5310 = 15,679

   Average c/m = 15,679 ÷ 9 = 1742 c/m (average)
7. The average c/m's are then plotted on graph paper (20 x 20 sqs./in) against the voltage. By using French curves, a curve is drawn.
8. The operating voltage is chosen from the plateau or straight line on the graph. The operating voltage is 1/3 to 2/3 of the way across the plateau.
9. Plateaus should be run once every three months. If major repairs are made on the counter, or if the geometry is too low, spot checks should be made on the plateau. If the spot checks show much variance from the plateau, an entire new plateau should be run.

ANALYSIS: Beta Activity in Gumpaper

Procedure

1. The entire gumpaper sample is placed in a clean 150 ml. porcelain crucible (Reference: Cleaning porcelain crucibles)
2. The crucible is placed in the muffle furnace (800-900 ^{o}F) until the gumpaper is completely ashed (approximately 20-30 minutes).
3. The crucible is removed from the furnace and allowed to cool.
4. The sides of the crucible are scraped with a spatula to remove the ash. The ash is then transferred to a plastic planchet, 1-1/4 in. diameter.
5. The crucible is rinsed with a small amount of distilled water (10-30 m.). Two to five drops of Nitric Acid (HNO_3) is added.
6. The crucible is returned to the muffle furnace until the rinsing has evaporated.
7. The crucible is removed from the furnace and allowed to cool.
8. The residue of the rinsing is added to the sample in the planchet. (Repeat steps 5-8 until the crucible is clean)
9. Record the time and date on which the sample was counted and report it along with the results.
10. Report as d/m sample.

ANALYSIS: Beta Activity in Gumpaper

Calculations

1. To determine counts per minute (c/m): divide the total count by the count time and subtract the background of the counter.

   Example: Gumpaper 330-1 counted 1029 counts in 15 minutes.

   The background of the counter was 8/1 c/m.

   c/m = 1029 ÷ 15 = 68.6 - 8.1 = 60.5 c/m

2. To determine disintegrations per minute per sample (d/m/sample), divide the c/m by the geometry of the counter.

   Example: Gumpaper #330-1 had a c/m of 60.5. The geometry of the counter was 7.1%.

   d/m/sample = 60.5 / .071 = 852 d/m/sample.

BETA COUNTING

ANALYSIS: Beta Activity in Liquids

Procedure

1. The background of a stainless steel planchet 2" diameter cupped planchet) is determined by counting it for five minutes in the counting chamber of the beta counter on the same shelf as the sample is to be counted.
2. The planchet is placed on a transite board on a medium heat hot plate.
3. The sample is plated, a milliliter at a time on the planchet. An aliquot of 1-5 ml. is usually used.
4. When the sample is completely dried, count it for 30 minutes on the second shelf of the counting chamber of the beta counter.
5. Record the time and date on which the sample was counted and report this along with the results.
6. Report the results as d/m/ml.

ANALYSIS: Beta Activity in Liquids

Calculations

1. To determine the counts per minute (c/m): divide the total count by the time counted and subtract the background of the planchet.

$$c/m = \frac{C}{T} - \text{background} = c/m$$

Example: 3 ml. of water sample #PR 421-1 had a total count of 768 in 30 minutes. The planchet had a background of 37 counts in 5 minutes.

Bkgd. = 37 ÷ 5 = 7.4 c/m.

c/m = 768 ÷ 30 = 25.6 - 7.4 (bkgd.) = 18.2 c/m.

2. To find disintegrations per minute (d/m): divide the c/m by the geometry of the counter.

$$d/m = \frac{c/m}{geo.} = d/m$$

Example: 3 ml. of water sample #PR 421-1 had a c/m of 18.2

The geometry of the counter was 6.3%.

d/m = 18.2 ÷ .063 = 289 d/m.

3. To determine disintegrations per minute per milliliter (d/m/ml): divide the d/m by the aliquot of sample used.

$$d/m/ml = \frac{d/m}{aliquot} = d/m/ml$$

Example: 3 ml. of water sample #PR 421-1 had a d/m of 289.

d/m/ml = 289 ÷ 3 = 96.3 d/m/ml.

ANALYSIS: Beta Pleated Filters

Procedure

1. The filter is cut in half and one half is used as an aliquot. (Reference: Cleaning porcelain crucibles).

   The aliquot is placed in a 150 ml. clean porcelain crucible.

2. The crucible is placed in a muffle furnace (approximately 1000°F) until the pleated filter is ashed. (Approximately 1-1/2 hours)

3. The crucible is removed from the furnace and allowed to cool.

4. By means of a stirring rod crumble the ash to a fine powder. If a fine enough powder is not obtained, a mortar and pestle may be used to break up the ash. The ash is then placed in a plastic planchet 1-1/4 in. diameter.

5. The sample is then counted on the second shelf of the beta counting chamber for fifteen minutes. (See beta counting procedure).

6. Record the time and date on which the sample was counted and report it along with the result.

7. Report the results as beta d/m/sample.

ANALYSIS: Beta Pleated Filters

Calculations

1. To determine counts per minute (c/m): divide the total count by the count time and subtract the background of the counter.

   Example: 1/2 of pleated filter #412-1 had a total count of 562 counts in 15 minutes. The background of the counter was 8.5 c/m.

   c/m = 562 ÷ 15 = 37.5 - 8.5 c/m (bkgd.) = 29.0 c/m

2. To calculate disintegrations per minute (d/m): divide the c/m by the geometry of the counter.

   $$d/m = \frac{c/m}{geo.} = d/m$$

   Example: 1/2 of pleated filter #412-1 had a c/m of 29.0.

   The geometry of the counter was 6.4%.

   d/m = 29.0 ÷ .064 = 453.1 d/m

3. To determine beta disintegrations per minute per sample (d/m/sample): multiply the d/m by 2 since 1/2 of the entire sample was used.

   d/m/sample = d/m x 2 = d/m/sample.

   Example: 1/2 of pleated filter #412-1 had a d/m of 453.1.

   d/m/sample = 453.1 x 2 = 706.2 d/m/sample.

BETA COUNTING

ANALYSIS: Beta Activity in Solids

Procedure

1. On the analytical balance, weigh a plastic planchet 1-1/4 in. diameter. Record the weight.
2. Carefully place an aliquot of the sample (enough to cover the bottom of the planchet) into the planchet.
3. Reweigh the planchet and the sample and record the second weight.
4. Count the sample in the beta counter on the second shelf of the counting chamber for fifteen minutes.
5. Record the time and the date on which the sample was counted and report this along with the results.
6. Report the results in d/m/gram.

ANALYSIS: Beta Activity in Solids

Calculations

1. To determine counts per minute (c/m): divide the total count by the count time and subtract the background of the counter.

   Example: An aliquot of mud sample #712 counted 27198 counts in 15 minutes. The background of the counter was 8.1 c/m.

   c/m = 27198 ÷ 15 = 1813.2 - 8.1 = 1805.1 c/m

2. To determine disintegrations per minute (d/m): divide the c/m by the geometry of the counter.

   $$d/m = \frac{c/m}{geo.} = d/m$$

   Example: An aliquot of mud sample #712 had a c/m of 1805.1. The geometry of the counter was 6.2%.

   d/m = 1805.1 ÷ .062 = 29115 d/m.

3. To determine disintegrations per minute per gram (d/m/gram): Subtract the first weight of the plastic planchet from the second weight (planchet / sample) to find the weight of the sample. Divide 1 by the weight of the sample (this is the factor for converting to grams). Multiply the d/m by the factor to obtain d/m/gram.

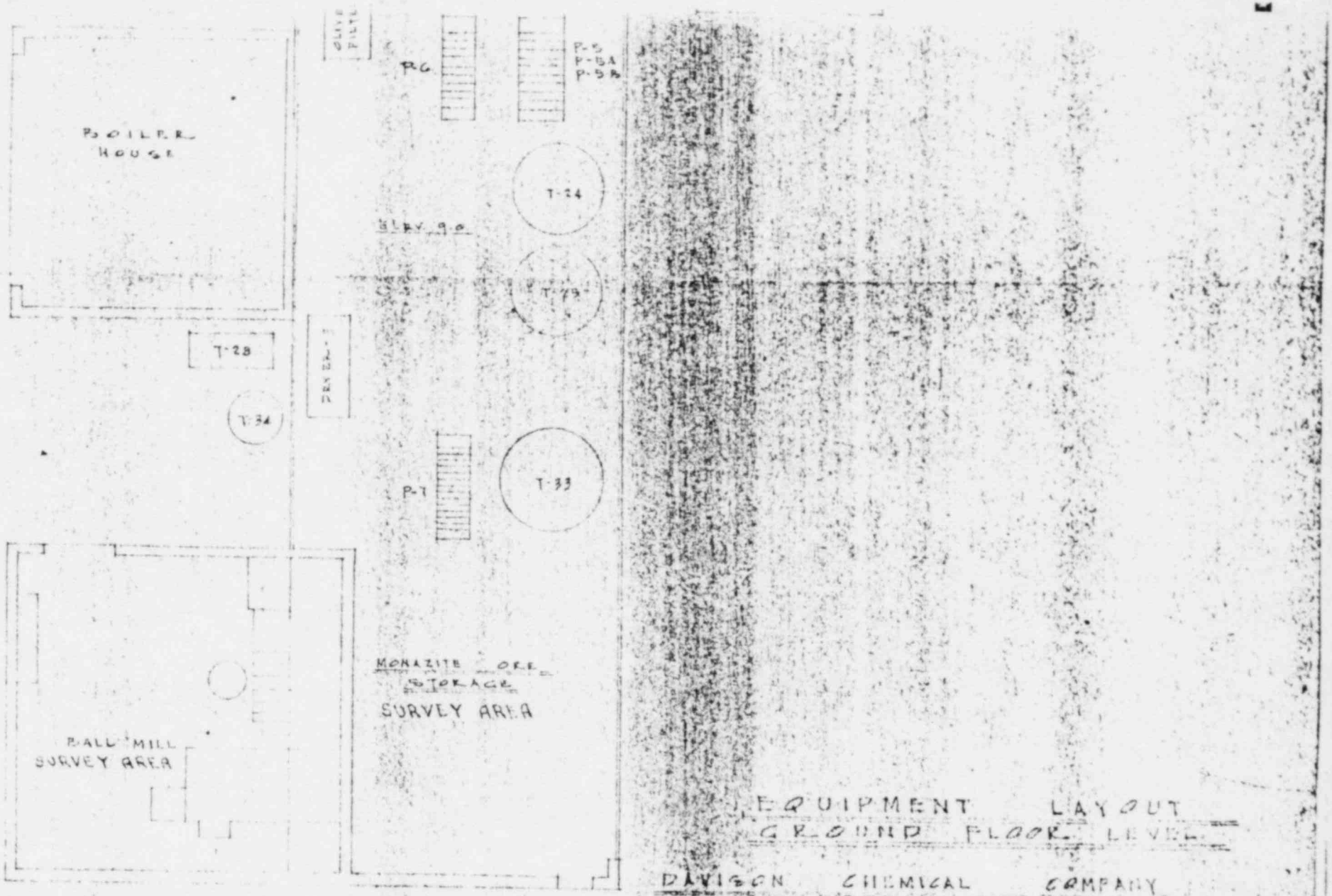
   d/m/gram = d/m x factor = d/m/gram.

   Example: The first weight of a plastic planchet was 0.3561 grams. The second weight, (sample / planchet) was 0.7678 grams. The d/m of the sample was 29115.

   0.7678g. - 0.3561g. = 0.4117g. (weight of sample)

   1 ÷ 0.4117g. = 2.43 (factor)

   d/m/gram = 29115 x 2.43 = 70749 d/m/gram.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P-6
P-5
P-5A
P-5B
T-24
ELEV. 9.0
T-23
T-28
T-34
T-33
P-7
MONAZITE ORE STORAGE
SURVEY AREA
BALL MILL SURVEY AREA
EQUIPMENT LAYOUT
GROUND FLOOR LEVEL
DAVISON CHEMICAL COMPANY
DIVISION OF W. R. GRACE & COMPANY
PEMPTON PLAINS, N.J.
SCALE 1/8" = 1'-0"
APRIL 6, 1957

Y AREAS

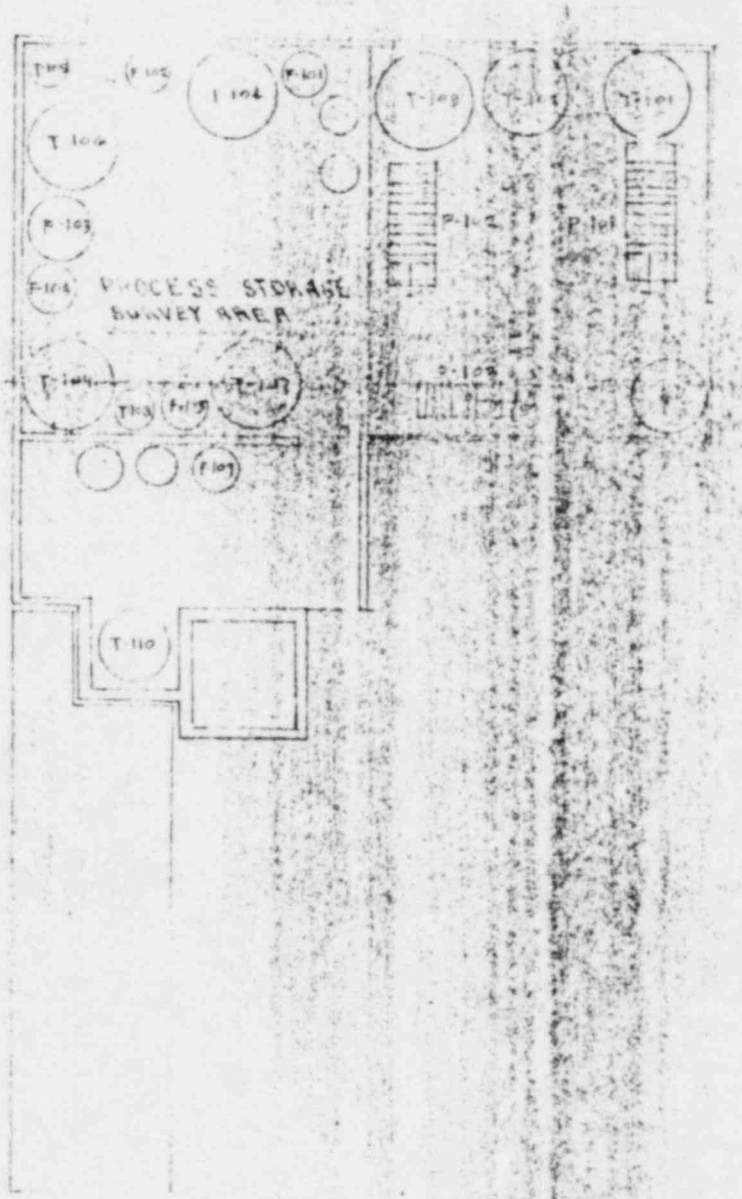
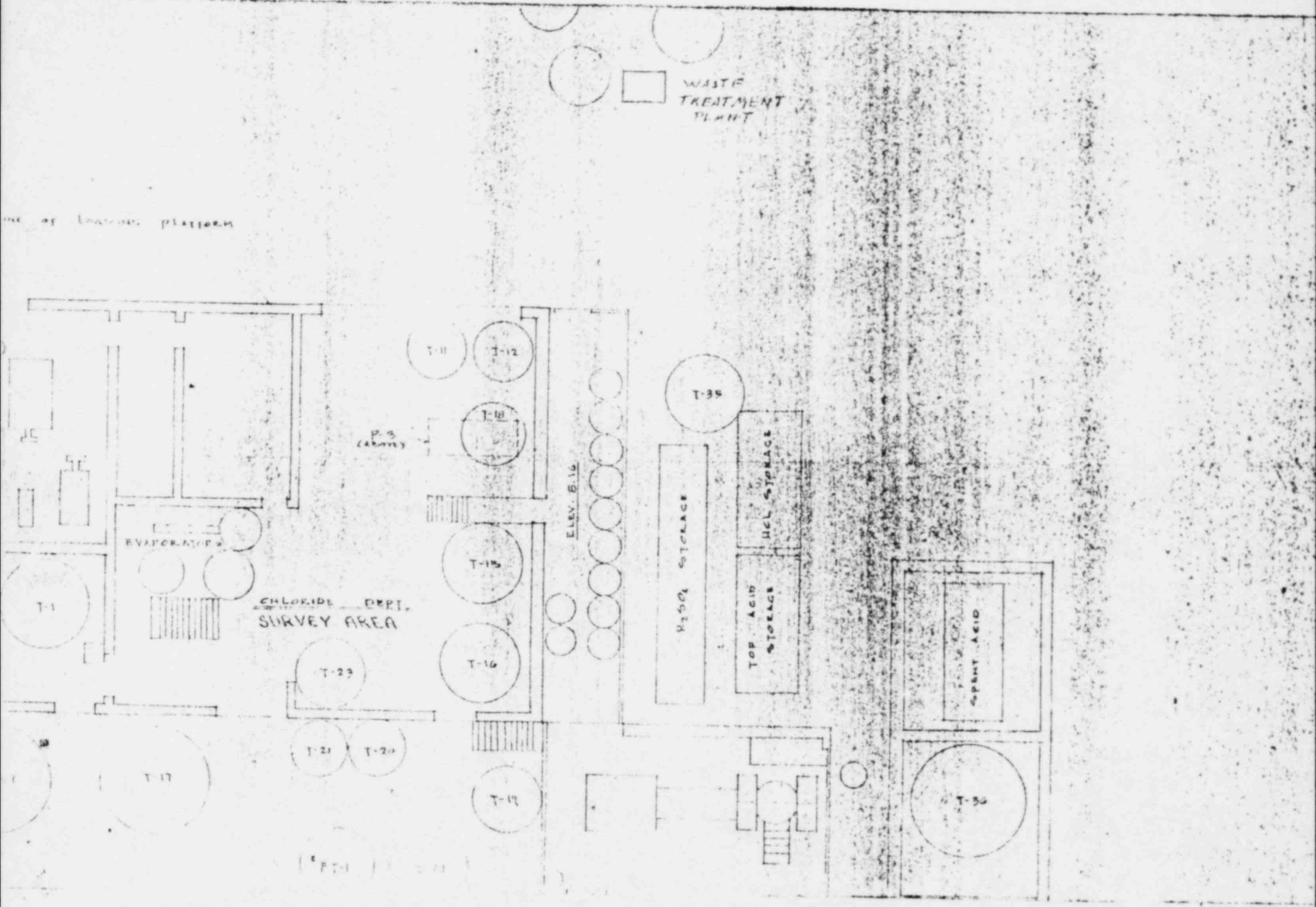


EXHIBIT # 2
RELIATION SURVEY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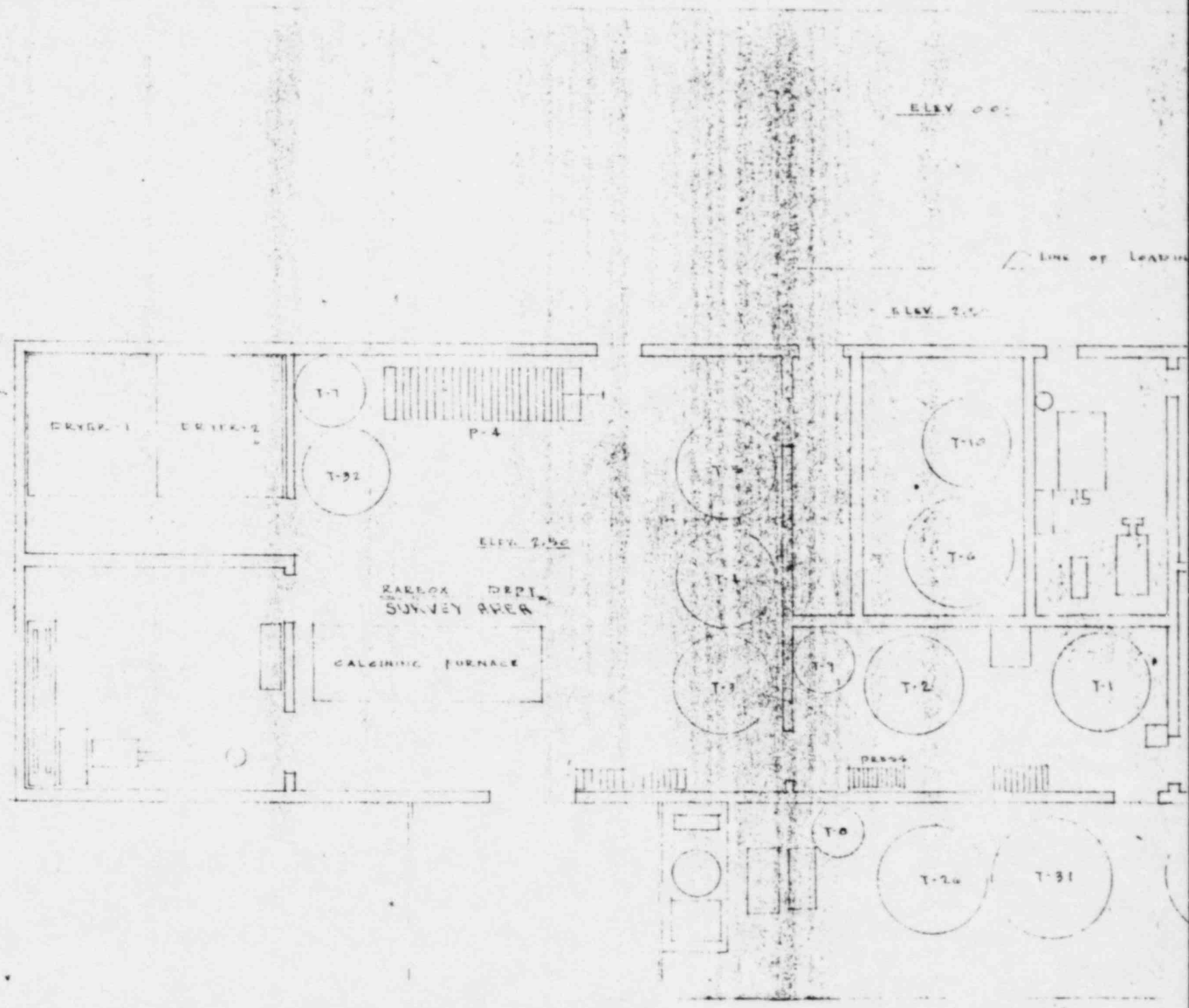
T-12
T-18
P-3
ELEV. 8.16
T-15
T-16
T-23
T-21
T-20
T-19
T-1
T-17
EVAPORATORS
CHLORIDE DEPT.
SURVEY AREA
T-35
H2SO4 STORAGE
HCL STORAGE
TOP ACID STORAGE
SPENT ACID
T-36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ELEV 2.5
DRYER-1
DRYER-2
T-7
T-32
P-4
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SURVEY AREA
CALCINING FURNACE
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T-1
T-8
T-30
T-31

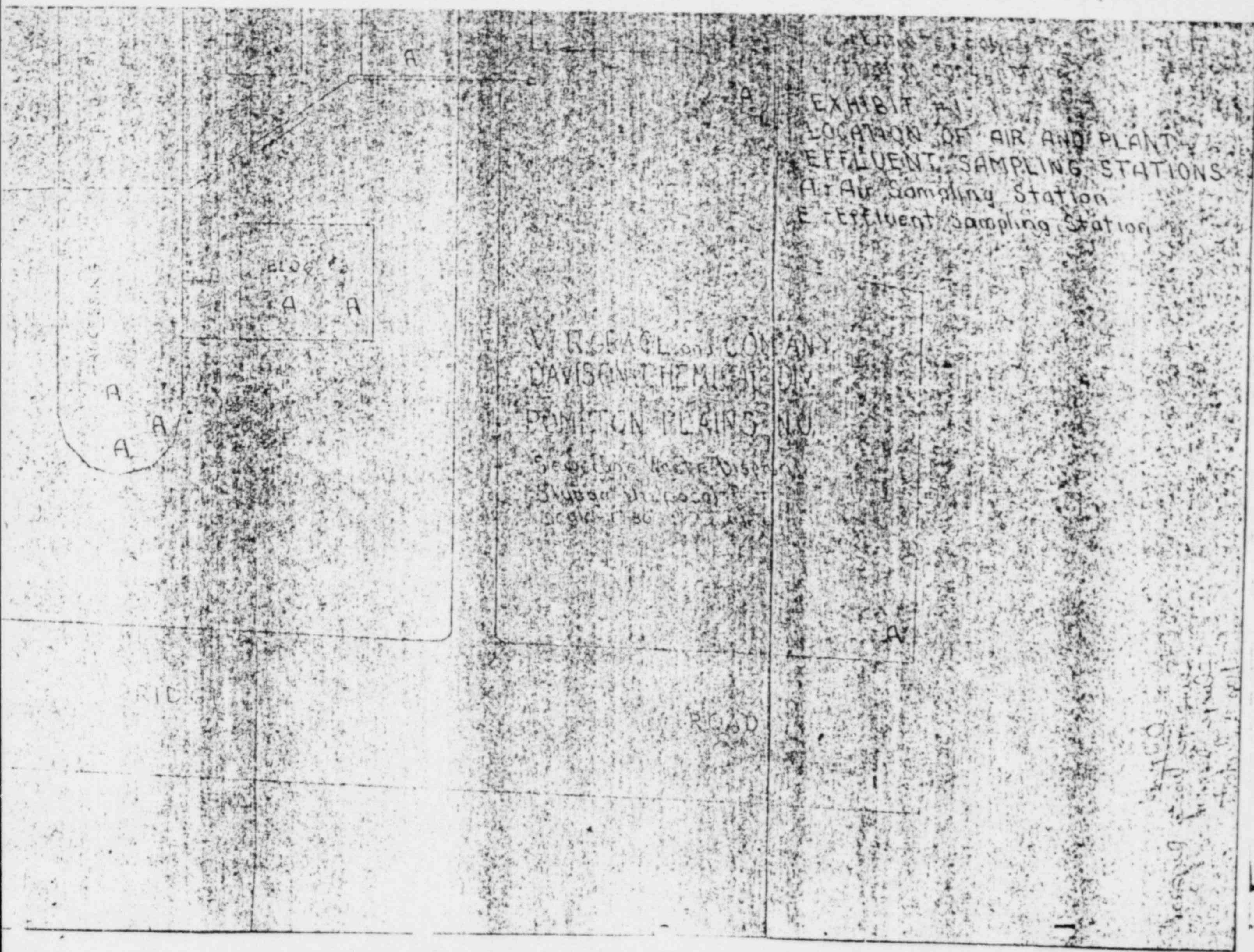
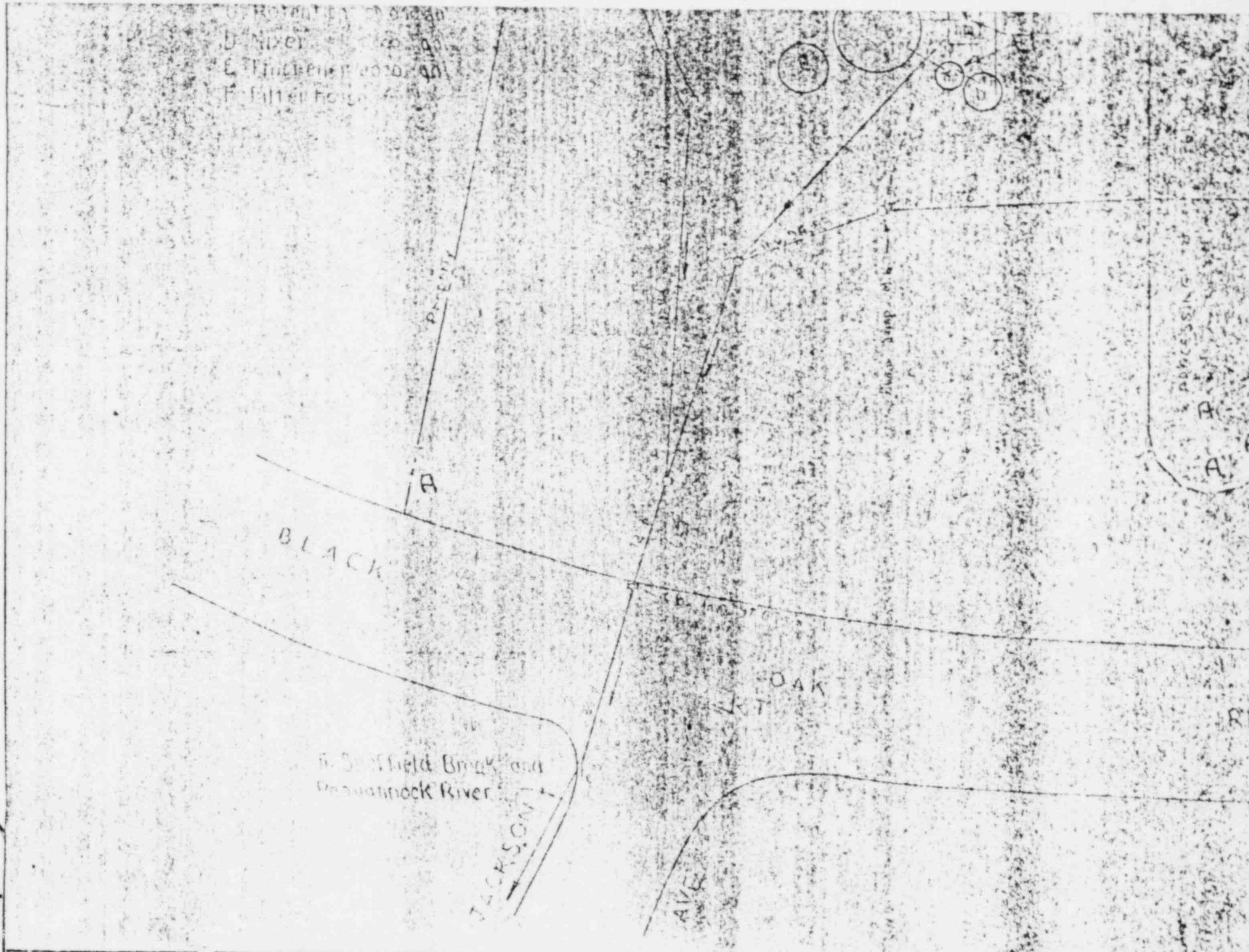


EXHIBIT
LOCATION OF AIR AND PLANT EFFLUENT SAMPLING STATIONS
A - Air Sampling Station
E - Effluent Sampling Station
W. R. GRACE and COMPANY
DAVISON CHEMICAL DIV.
POMPTON PLAINS N.J.
BLDG
A
ROAD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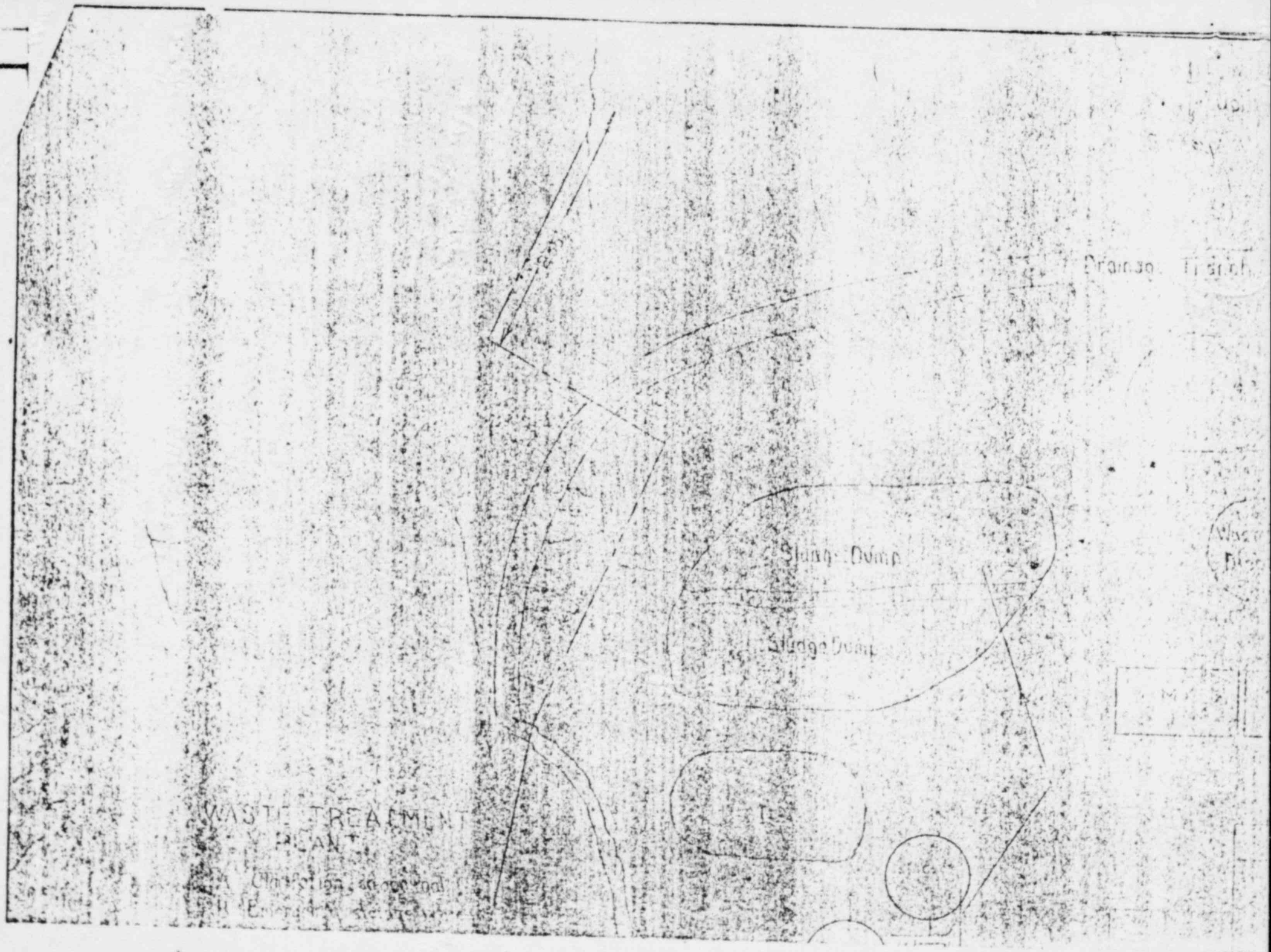
BLACK
OAK
AVE
JACKSON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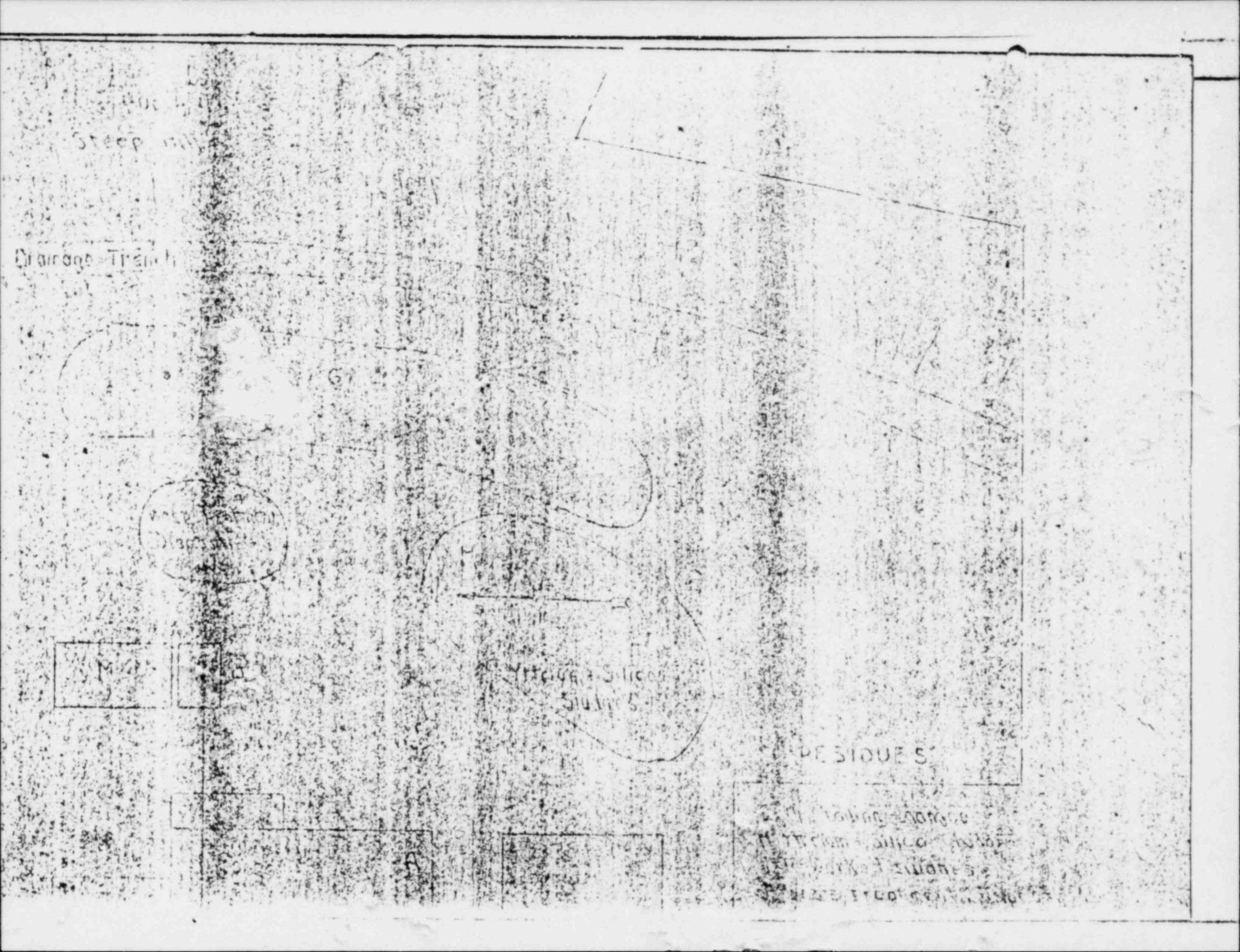
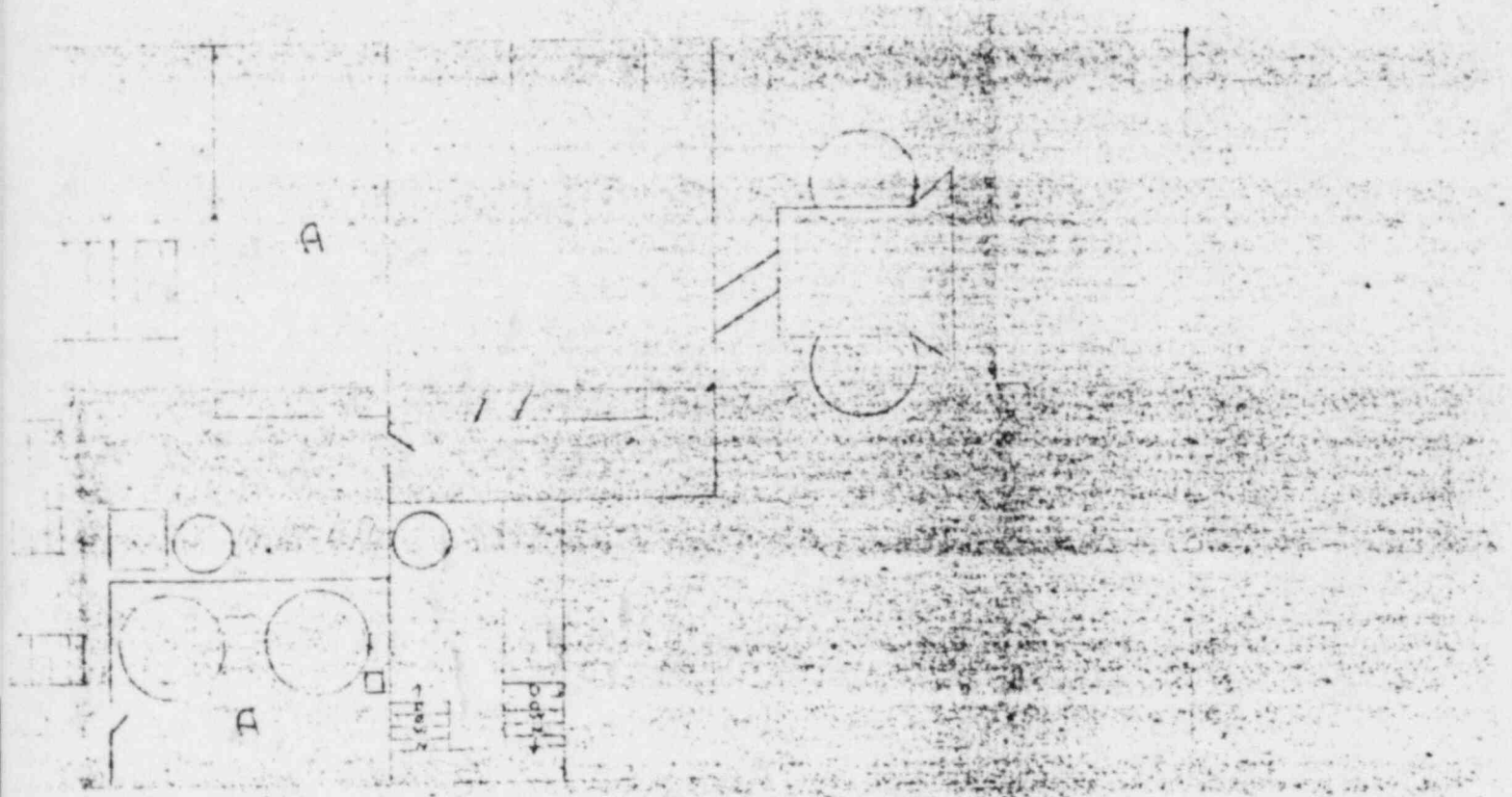
Sludge Dump
Sludge Dump
WASTE TREATMENT
PLANT

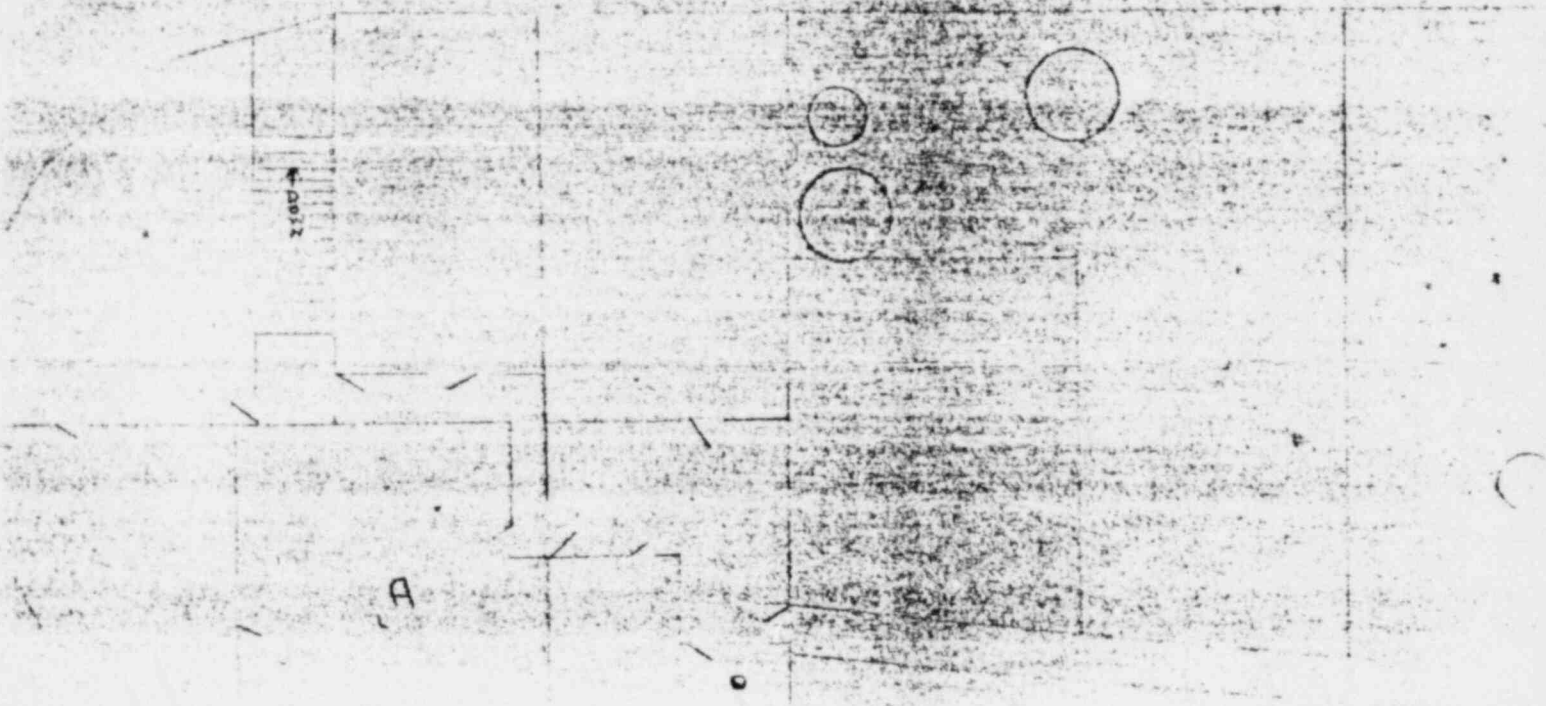




EQUIPMENT LAY OUT
SECOND FLOOR LEVEL

DAVISON CHEMICAL COMPANY
DIVISION OF W.R. GRACE & COMP.
PEMPTON PLAINS, N.J.
SCALE APPROX 1/8" = 1'-0"
JANUARY 15, 19--

FIR
ATIONS
Station


A

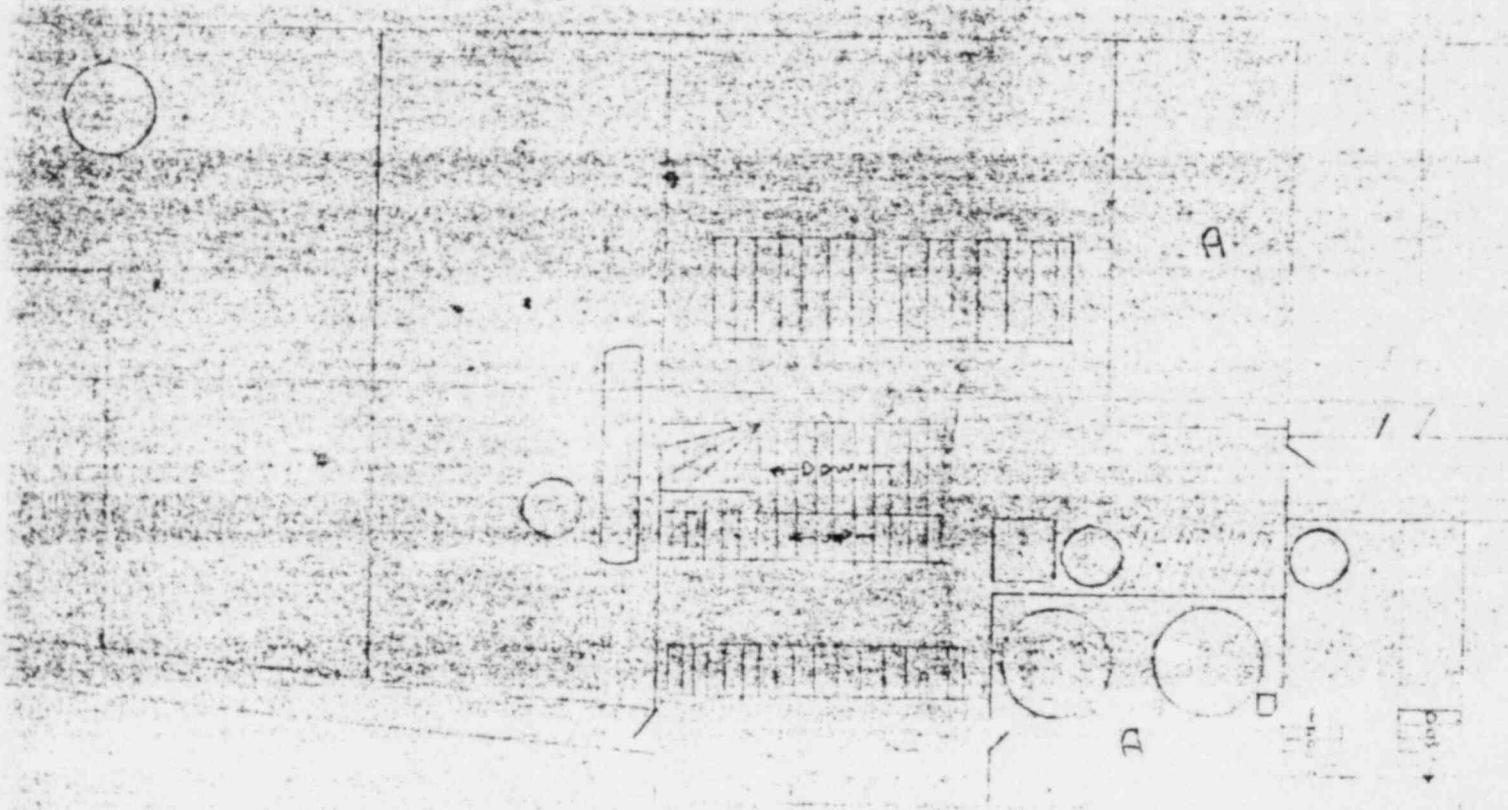


EXHIBIT #1
LOCATION OF AIR
SAMPLING STATIONS
A - Air Sampling Station