GULFPORT FERTILIZER
GULFPORT, MS
HARRISON COUNTY
Site Assessment Reports
1995 – March 1999

SITE CHARACTERIZATION REPORT

PROPOSED LEASED PARCEL (7.9-ACRES)
FORMER GULFPORT FERTILIZER PLANT SITE
33RD STREET
GULFPORT, MISSISSIPPI

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PREPARED
FOR
THE HANCOCK BANK
COMMERCIAL LOAN DEPARTMENT
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1.0 Executive Summary

The subject property is an approximate 33.06-acre parcel of land located on 33rd Street approximately 1 block west of its intersection with State Highway 49 in Gulfport, Mississippi. The Gulfport Fertilizer Company, which closed for business in circa 1960, was formerly located on the subject property. The fertilizer company reportedly manufactured sulfuric acid and superphosphate fertilizer. Improvements to the land once consisted of concrete buildings, surfaced roads and railroad spurs, but the improvements have been largely destroyed.

A portion (approximately 7.9 acres) of this parcel along the eastern perimeter is to be partitioned or subdivided for the purpose of leasing the property to a potential purchaser and is the subject of this Site Characterization Report. The owner of the property through foreclosure, Hancock Bank of Gulfport, Mississippi (The Bank), will retain surface ownership. It is the intent of the Bank to address the minor contamination on the 7.9 acre parcel so as to allow the Bank to lease the 7.9 acre parcel immediately. A work plan for characterizing the remaining portion of the 33.06 acres will be submitted to the Mississippi Department of Environmental quality (MDEQ) for review and approved in accordance with a reasonable schedule to be determined at a later time. A site characterization report and corrective action plan will be submitted to the MDEQ upon completion of the work proposed in the approved work plan.

A subsurface investigation was conducted by Covington and Associates (Covington) for a potential purchaser/lessee in May and June of 1998. The investigation focused on an area approximately 720 feet (ft) by 720 ft, in the northern half of the 33.06-acre parcel. Exploratory soil pits and two 4-inch diameter monitoring wells were installed during this investigation. The results of soil samples collected by Covington at the site indicated that elevated levels of lead (ranging up to 11,000 milligrams per kilogram (mg/kg)) and arsenic (ranging up to 1,310 mg/kg) contamination exists in the subsurface soils. Contamination at low levels was shown to exist in the groundwater, as well. The Bank has been furnished a copy of a map indicating sample locations and laboratory results only. The actual analytical laboratory report(s), findings, and sampling protocols have not been received, but have been requested, as of the date of this report. The sample results furnished have been reproduced on Figures 3 and 5, herein for informational purposes.

On September 30 and October 1, 1998, Butler Services of Mississippi, Inc. (Butler) performed soil and groundwater sampling using "Geoprobe's" direct push probes and Screen Point 15 groundwater sampler. The primary purpose of this subsurface investigation was to characterize the 7.9 area parcel to be leased by The Bank. The results of the soil samples collected within the 7.9 area parcel indicated lead and arsenic levels in subsurface soils ranging from less than 0.1 mg/kg to 306 mg/kg and from less than 0.1 mg/kg to 10.2 mg/kg, respectively with the exception of two distinct areas. One of the areas is located adjacent to the former railroad spur, approximately 800 feet south of the northeast corner of the subject property. The second area with subsurface soils that contained elevated levels of arsenic only is located 400 feet south and 300 feet west of the northeast corner of the subject property. Additional soil sampling was conducted in the isolated area adjacent to the former railroad spur on October 21, 1998. The sample results from this additional sampling indicate that lead contamination exceeding 400 mg/kg and arsenic contamination exceeding 15 mg/kg are confined to an area approximately 10 ft by 10 ft. Lead and Arsenic levels in the groundwater samples collected along the eastern property boundary and western perimeter of the 7.9 acre parcel were all less than the laboratory detection limits of 0.005 milligrams per liter (mg/l) with the exception of samples collected in an area near the former railroad spur. The samples in this isolated area correlates with the elevated levels found in the soil in this same area. Soil and groundwater sample results are shown on Figures 4 and 6.

2.0 Introduction

The subject property is an approximate 33.06-acre parcel of land located on 33rd Street approximately 1 block west of its intersection with State Highway 49 in Gulfport, Mississippi. The Gulfport Fertilizer plant, which closed for business in circa 1960, was formerly located on the subject property. The plant reportedly manufactured sulfuric acid and superphosphate fertilizer. Improvements to the land once consisted of concrete buildings, surfaced roads and railroad spurs, but the improvements have been largely destroyed.

A portion (approximately 7.9 acres) of this parcel along the eastern perimeter is to be partitioned or subdivided for the purpose of leasing the property to a potential purchaser/lessee and is the subject of this Site Characterization Report (see Figure No. 2). The owner of the property through foreclosure, Hancock Bank of Gulfport, Mississippi (The Bank), will retain surface ownership. It is the intent of the Bank to address the minor contamination on the 7.9 acre parcel so as to allow the Bank to lease the 7.9 acre parcel immediately. A work plan for characterizing the remaining portion of the 33.06 acres will be submitted to the Mississippi Department of Environmental quality (MDEQ) for review and approved in accordance with a reasonable schedule to be determined at a later time. A site characterization report and corrective action plan will be submitted to the MDEQ upon completion of the work proposed in the approved work plan.

2.1 Property Background

The subject property is an approximate 33.06-acre parcel of land located on 33rd Street approximately 1 block west of its intersection with State Highway 49 in Gulfport, Harrison County, and Mississippi. The Immediate adjacent properties include vacant land and a low to middle income residential subdivision on the North side; the Illinois Central Railroad and yard on the East and Northeast side; commercial facilities including moving and storage and freight transport companies, and a Coca Cola Bottling facility on the East side; vacant lands on the west side and CAE Plastic Inc., and vacant lands on the South side.

A 1929 Harrison Country Tax Assessors Map, the "Gulfport, North" Topographic Quadrangle Map and the series of aerial photography examined by others, beginning in 1940 to 1990, confirms the adjacent lands past use and subsequent events to its present day status. According to a 1940 aerial photograph, the facility that bounds the subject site on the South side appears to have been the site of the first Gulfport Airport hangar facilities. The immediate adjacent lands were vacant. Subsequent photography examined, beginning in the year 1956, indicates light industrial use of the properties east of the railroad or approximately 200 to 300 feet east of the subject property. The plastic production facility on the south side of the subject property is also visible in the 1956 photography.

It appears that the subject property was an active commercial site from approximately 1904 to sometime between about 1972 and 1978 (+/-68 years). The first recorded indication of industrial use of the property found is a Warranty Deed dated July 6, 1903 from J.T. Jones to the Gulfport Cotton Oil, Fertilizer & Manufacturing Co., and which covered file subject (Deed Book 56@ Page 404). The instrument stated that "The grantee must complete the oil mill plant by January 1, 1904." On September 21, 1908, Gulfport Cotton Oil Fertilizer & Manufacturing Co., conveyed the same to the Exporters Cotton Oil Company (Deed Book 88 @ Page 248). A site sketch and survey was included with this recorded instrument. The site sketch shows six dummy rail lines from the Illinois Central Railroad, what appears to be a sulfuric acid manufacturing configuration and a phosphate fertilizer production facility, several oil tanks and other facilities used in connection with raw cotton bulk product handling.

The exact period that the cotton oil and product facility operated from 1904 to 1920 was not determined from the records. However, the existence of a "refinery shed" is noted in the conveyance records. The conveyance records show that for a period of about two years beginning in 1920, the cotton product facility was used as "The Continental Tire & Rubber Co.", manufacturers of automobile tires & tubes. A Sanborn Insurance Map dated 1921 further corroborates the land records with a sketch indicating the production configuration at that time. The land records, a 1929 Sanborn map and aerial photography dated after 1922 reviewed indicate the cessation of and the dismantling of the tire and rubber manufacturing facility. The site was not used for this purpose again.

Both a 1940 aerial photograph and a 1950 Sanborn Fire Insurance Map indicate the presence of a cotton ginning facility in the Southeast comer of the property. There was no evidence of this facility in subsequent Sanborn and aerial photography examined.

As previously noted above, records indicate that at least the upper half of the subject tract was being used in connection with the production of sulfuric acid and superphosphate. The land records also show that The Gulfport Cotton Oil, Fertilizer & Manufacturing Co. used this site from approximately 1904 until Exporters Cotton Oil Company look over the operations in 1908. In 1914, the Exporters Cotton Oil lost the property through foreclosure. It is believed that from 1914 to approximately 1920, Gulfport Fertilizer Company operated the production facilities for Mell R. Wilkinson, The Lowery National Bank of Atlanta, or both. A 1921 Sanborn Fire Insurance Map indicates that Gulfport Fertilizer Company was operating the facility at that time. By the year 1925, Gulfport Fertilizer Co. was the sole owner and operator of the facilities. The Gulfport Fertilizer Company continuously used the site for sulfuric acid and superphosphalte production until sometime in the 1950's. Sanborn Fire Insurance maps from 1929 and 1950 indicate that the fertilizer manufacturing facilities were in full operation. In 1960 the Gulfport Fertilizer Co. relinquished ownership of the subject lands unto H & F Engineering Co., Inc., which lost the property through foreclosure to Deposit Guaranty National Bank, within two years. On June 10, 1995 Mr. R. W Hyde, III, son of R.W. Hyde, Jr., who was the owner of H&F Engineering Co., stated that his father was in the sewerage and drainage business and that he was never in the fertilizer business. There was no evidence that the site was used for any commercial purpose from approximately 1960, when H & F Engineering Co. owned the property for about two years, and during the period when Deposit Guaranty National Bank owned the property for about two years. In the year 1966, the Deposit Guaranty National Bank sold the subject lands to Ernest Yeager & Sons, Inc. Mr. Leroy Yeager, who was secretary treasurer of Ernest Yeager & Sons, Inc., in 1966, stated on June 9, 1995 that Ernest Yeager and Sons, Inc. acquired the property for investment purposes only and that they were never involved with any process activity at the site. A Sanborn Map from 1967 indicates that the site was inactive at that time. In 1972 Ernest Yeager & Sons, Inc., granted a 15-year lease, which covered approximately 4.00 acres to Best Concrete Products, Inc., for the purpose of manufacturing concrete block and masonry. A 1975 aerial photograph of the site indicated that the site was being used probably as a block and masonry business, however, the small objects in the photograph were not recognizable. On or about the year 1982 the Hancock Bank secured the property through foreclosure proceedings. Since the year 1982 the property has not been occupied or operated for industrial or commercial purposes. Both the 1982 and 1990 aerial photographs examined indicated that the site was vacant except for a few remaining structures.

Other than the plant site described above, it appears that the remainder of the property was previously used for residential and office purposes.

2.2 Previous Investigation

Covington and Associates Corporation (Covington) conducted a Preliminary Subsurface Investigation of the subject property (33.06-acre parcel) in May and June 1998, on behalf of a potential purchaser/lessee. Exploratory soil pits and two 4-inch diameter monitoring wells were installed during this investigation. The results of soil samples collected by Covington at the site indicated that elevated levels of lead (ranging up to 11,000 mg/kg) and arsenic (ranging up to 1,310 mg/kg) contamination exists in the subsurface soils. Contamination at low levels was shown to exist in the groundwater, as well. The samples were collected from an area approximately 720' X 720' , in the northern half of the property. Areas excluded from the northern section sampling included a parcel measuring approximately 908' X 180' along the northern perimeter, and a 720' X 180' parcel along the eastern perimeter.

3.0 Investigative Activities

On September 30, and October 1, and October 21, 1998, Butler Services of Mississippi, Inc. (Butler) performed soil and groundwater sampling in connection with the 7.9 acre parcel to be subdivided and leased by the bank. The project was overseen and performed by Butler's Senior Project Manager, William D. Bates, P.E. Singley Construction Company provided equipment to advance the borings and collect groundwater samples. Micro-Methods, Ocean Springs, Mississippi, conducted laboratory analytical work.

Soil samples were collected on a 100-foot grid north and south of the proposed radial conveyor line to be installed on the 7.9-acre parcel. These samples were collected for the purpose of determining if the subsurface soils have been impacted in this area. The soil sampling locations are identified in Figure No. 4 and the results of the sample analysis listed in Table 1.

Groundwater samples were collected in the borings along the eastern and western perimeter of the 7.9-acre parcel. These samples were collected for the purpose of determining if groundwater had been impacted beneath the property in this area. The groundwater sampling locations are identified in Figure No. 6 and the sample results listed in Table 2.

3.1 Property Soil and Vadose Zone Characteristic

Fifty-six (56) soil borings were advanced to a depth of four (4) feet below ground surface (bgs) and a total of 112 soil samples collected at the site on September 30 and October 1, 1998. Forty-six of the borings were located within the 7.9-acre parcel to be leased and are listed in Table 1. Soil samples were collected at depths of two and four feet in each boring. Groundwater was encountered at approximately four feet bgs. There were no unusual conditions or complications encountered during the drilling operations.

A track-mounted direct-push Geoprobe 5400 unit supplied by Singley Construction Company Inc. (SCC) of Columbia, Mississippi was used to advance the borings. The soil borings were advanced using Geoprobe's Macro-core soil sampler (a 48-inch log x 2-inch diameter soil sampler capable of recovering a sample that measures up to 1300 ml in volume in the form of a 45-inch x 1.5-inch core). Soil samples were collected at two and four feet bgs using new clear PVC sample collection liners (46-inch long x 1.75-inch diameter). After samples had been collected from the soil cores, the remaining soil was returned to the borehole. The boring was then sealed to the ground surface with Bentonite.

All soil samples were delivered in a chilled preserved condition, under chain-of –custody documentation to Micro-Methods, Inc. in Ocean Springs, Mississippi for analysis. Micro-Methods is an EPA contract, and Mississippi State certified environmental laboratory.

3.2 Property Groundwater/Acquifer Characteristics

Of the twenty-five groundwater samples collected, eighteen were from borings located along the eastern property boundary and western perimeter of the 7.9-acre parcel. The remaining samples were collected from borings along the western and southern property boundary of the subject property.

Geoprobe's Screen Point 15 Groundwater sampler (which consists of a 1.5-inch OD x 52-inch sheath with expendable point driven to required depth, then pulled back approximately 44 inches to expose a stainless steel 1–inch x 41-inch.004 slot size screen) was used to collect groundwater samples. The groundwater was then pumped using a peristaltic pump through new 3/8-inch x ¼-inch ID polyethylene tubing directed to the bottom of the screen. Prior to collecting the samples, the groundwater was pumped until a clear flow of water was achieved – generally no more than 1 to 2 quarts.

All groundwater samples were delivered in a chilled preserved condition, under chain-of –custody documentation to Micro-Methods, Inc. in Ocean Springs, Mississippi for analysis. Micro-Methods is an EPA contract, and Mississippi State certified environmental laboratory.

4.0 **Property Physical Characteristics**

Topographically, the site is astride one of the many coastwise, east/west, parallel trending buried beach ridges. Elevations at the site vary from slightly above, + 25 feet mean sea level near the center of the site to at or just below + 25 feet mean sea level near the Northern limit of the property.

4.1 Surface Water

The nearest major body of water is the Mississippi Sound located about 1.75 miles to the south. Surface drainage off-site appears to be sufficient and is generally to the north into a low wetlands area. There is some drainage to the southwest where additional wetlands are suspected. Drainage from the northern wetlands is northwest via several drainage ditches into Turkey Creek. The drainage Southward is via a collection ditch that eventually discharges into the western extremities of Brickyard Bayou.

4.2 Regional and Property Geology

The general geology of the site is similar to that of the region, all part of the northern Gulf Coast margin. The stratigraphic column consists primarily of a wedge of Mesozoic and Cenozoic sediments derived from continental interior drainage. Sediment supply in most of the area exceeded the subsidence rate, resulting in the seaward progradation of the Gulf continental margin (Knox, 1994).

Geologically, the side is located within a series of East/West, coastwise trending beach ridges. Specifically, the site is astride a buried beach ridge which comprise a part of the Gulfport ridge complex, As a result, there is variation of soil types due to drainage and modified hydrologic patterns. Soils at the site consist primarily of Harleston sandy loam, which is well drained, exhibits moderate permeability, and slow runoff. Along the Northern limits of the property, Plummer loamy sand is found. This is a soil, poorly drained with very slow run off. Along the West property line, Atmore silty loams are identified which are also, poorly drained and exhibit slow runoff.

5.0 Nature and Extent of Contamination

Site specific background levels for Lead and Arsenic in the soil and groundwater have not yet been established for the subject property. These background levels will be developed in the work plan in accordance with Environmental Protection Agency (EPA) guidelines (EPA/540/S-96/500 and EPA/530/SW-89/026).

5.1 Soils and Vadose Zone

The soil samples were submitted for analysis for lead (Pb) and arsenic (As) by EPA Method SW 846, 6010A-ICP. The results of the laboratory analyses are included in Appendix B and are listed in Table 1. Total lead in the soil samples ranged in concentrations from 0.2 milligrams per kilogram (mg/kg) to 306 mg/kg at a depth of two feet below ground surface (bgs) and from <0.1 mg/kg to 22.8 mg/kg at four feet bgs with the exception of an isolated area adjacent to the former railroad spur (Sample No. 31S51). The lead concentrations in the subsurface soils in this isolated area located approximately 800 ft south of the northeast corner of the subject property ranged from 539 mg/kg at two feet bgs to 1241 mg/kg at four feet bgs.

Arsenic concentrations in the soils ranged from <0.1 mg/kg to 10.2 mg/kg at a depth of two feet bgs and from <0.1 mg/kg to 6.7 mg/kg at a depth of four feet bgs with the exception of two distinct areas within the 7.9-acre parcel. One of the areas coincides with the isolated area adjacent to the former railroad spur (Sample No. 31S51) that contained elevated levels of lead concentrations. Arsenic concentrations in the subsurface soils in this area were 57.6 mg/kg at two feet bgs and 74.5 at four feet bgs. The second area with elevated levels of arsenic, encompasses an area approximately 150 feet by 300 feet and is located approximately 400 feet south and 300 feet west of the northeast corner of the subject property. In this second area arsenic concentrations range from 106 mg/kg at two feet bgs to 23.4 mg/kg at four feet bgs.

Additional soil sampling was conducted in the isolated area located adjacent to the railroad spur on October 21, 1998. The sample results from this additional sampling indicate that lead contamination exceeding 400 mg/kg and arsenic contamination exceeding 15 mg/kg in this area are confined to an area approximately 10 ft by 10 ft to a depth of approximately four feet bgs.

5.2 Groundwater

The groundwater samples collected on September 30 and October 1, 1998 were submitted for analysis of lead (Pb) and arsenic (As) concentrations by EPA Method 200.7-ICP. The results of the laboratory analyses are included in Appendix B and are listed in Table 2. It should be noted that nitric acid, a preservative, was added to the Groundwater samples collected on September 30, 1998 (sample identifications beginning with the number "30"). And it was determined after consultation with the laboratory that due to the amount of sediment in the groundwater samples that the results would not be valid due to leaching. Hence, the September 30th borings locations were re-established on October 21, 1998 and groundwater samples collected using the Geoprobe groundwater sampler. The October 21st results are shown on the figures and in the tables herein. The original sample results are contained in the Appendix to this report.

Lead and Arsenic levels in the groundwater samples collected along the eastern property boundary and western perimeter of the 7.9 acre parcel were all less than the laboratory detection limits of 0.005 milligrams per liter (mg/l) with the exception of samples in an area near the former railroad spur. The samples in this isolated area correlates with the elevated levels found in the soil in this same area.

6.0 Summary and Conclusions

The results of soil and groundwater samples indicate that lead contamination exceeding 400 mg/kg and arsenic contamination exceeding 15 mg/kg in the soils are confined to an isolated area on the 7.9-acre parcel. This area is approximately 800 ft south of the northeast corner of the subject property and adjacent to a former railroad spur (See Sample No. 31S51 location). The horizontal extent of the contamination in this area appears to be approximately 10 ft by 10 ft. It is proposed that the soil and vadose zone in this isolated area be excavated to a depth of 4 ft. The excavated materials will be disposed of in an approved manner.

It is proposed that an area (approximately 7.9-acres) along the eastern perimeter the subject property be partitioned or subdivided for the purpose of leasing the property to a potential purchaser/lessee. The owner of the property through foreclosure, Hancock Bank of Gulfport, Mississippi, will retain surface ownership. The Bank would like to proceed immediately to lease the 7.9 acres based upon the site characterization work completed to date.

A work plan for characterizing the remaining portion of the 33.06 acres will be submitted to the Mississippi Department of Environmental quality (MDEQ) for review and approved in accordance with a reasonable schedule to be determined at a later time. Upon completion of the work proposed in the approved work plan, a site characterization report and corrective action plan will be submitted to the MDEQ.

TABLES

TABLE 1

LEASED PARCEL (7.9 Acres)
SOIL SAMPLING ANALYTICAL RESULTS

Sept. 30, Oct .1 & Oct. 21, 1998
FORMER GULFPORT FERTILIZER PLANT
33RD STREET
GULFPORT, MISSISSIPPI
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Sample Number	Sample Location	Sample Depth 2ft		Sample Depth 4ft		REMARKS
		Arsenic As (mg/kg)	Lead Pb (mg/kg)	Arsenic As (mg/kg)	Lead Pb (mg/kg)	
30N31	300 ft North of Radial Conveyor Line	2.0	11.8	0.1	0.2	Adjacent to rail spur
30N32	300 ft North of Radial Conveyor Line	6.6	170	0.3	5.2	
30N33	300 ft North of Radial Conveyor Line	0.6	2.7	0.5	5.1	
30N34	300 ft North of Radial Conveyor Line	0.9	28.3	<0.1	3.9	
30N35	300 ft North of Radial Conveyor Line	0.6	2.4	2.5	0.6	
30N21	200 ft North of Radial Conveyor Line	0.6	3.2	1.3	4.8	Adjacent to rail spur
30N22	200 ft North of Radial Conveyor Line	0.6	15.0	3.6	6.0	
30N23	200 ft North of Radial Conveyor Line	0.7	3.2	0.4	0.2	
30N24	200 ft North of Radial Conveyor Line	0.8	0.8	2.5	22.8	
30N25	200 ft North of Radial Conveyor Line	1.2	2.2	1.4	1.1	
30N11	100 ft North of Radial Conveyor Line	0.1	0.2	2.7	6.5	Adjacent to rail spur
30N12	100 ft North of Radial Conveyor Line	1.1	8.4	0.8	5.9	
30N13	100 ft North of Radial Conveyor Line	2.0	3.0	1.0	3.2	
30N14	100 ft North of Radial Conveyor Line	1.3	3.8	1.0	2.5	
30N15	100 ft North of Radial Conveyor Line	1.8	3.3	1.5	2.6	
30RC1	Radial Conveyor Line	0.8	6.1	0.6	2.8	Adjacent to rail spur
30RC2	Radial Conveyor Line	0.6	4.9	0.6	6.4	
30RC3	Radial Conveyor Line	3.4	30.7	0.9	5.6	
30RC4	Radial Conveyor Line	3.1	7.2	3.7	15.8	
30RC5	Radial Conveyor Line	26.8	20.3	1.8	4.2	
31S11	100 ft South of Radial Conveyor Line	2.4	8.3	0.4	5.2	Adjacent to rail spur
31S12	100 ft South of Radial Conveyor Line	0.2	7.0	2.6	8.3	
31S13	100 ft South of Radial Conveyor Line	10.2	4.9	2.6	4.1	
31S14	100 ft South of Radial Conveyor Line	106	4.9	6.7	1.8	
31S15	100 ft South of Radial Conveyor Line	42.7	17.0	23.4	3.6	
31S21	200 ft South of Radial Conveyor Line	3.8	12.8	2.3	6.7	Adjacent to rail spur
31S22	200 ft South of Radial Conveyor Line	<0.1	6.2	0.1	4.8	
31S23	200 ft South of Radial Conveyor Line	2.2	3.6	0.8	2.9	

TABLE 1
LEASED PARCEL (7.9 Acres)
SOIL SAMPLING ANALYTICAL RESULTS
Sept. 30, Oct.1 & Oct. 21, 1998
FORMER GULFPORT FERTILIZER PLANT
33^{RD} STREET
GULFPORT, MISSISSIPPI
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Sample Number	Sample Location	Sample Depth 2ft		Sample Depth 4ft		REMARKS
		Arsenic As (mg/kg)	Lead Pb (mg/kg)	Arsenic As (mg/kg)	Lead Pb (mg/kg)	
31S24	200 ft South of Radial Conveyor Line	35.7	306	4.8	0.8	
31S25	200 ft South of Radial Conveyor Line	21.2	21.3	1.3	2.9	
31S31	300 ft South of Radial Conveyor Line	1.9	3.0	0.2	3.0	Adjacent to rail spur
31S32	300 ft South of Radial Conveyor Line	0.5	3.4	0.8	4.8	
31S33	300 ft South of Radial Conveyor Line	8.6	55.1	1.4	1.8	
31S34	300 ft South of Radial Conveyor Line	0.6	1.6	0.5	3.5	
31S35	300 ft South of Radial Conveyor Line	19.0	5.3	1.7	1.2	
31S41	400 ft South of Radial Conveyor Line	1.9	3.5	0.4	0.6	Adjacent to rail spur
31S42	400 ft South of Radial Conveyor Line	2.4	5.8	0.9	1.9	
31S43	400 ft South of Radial Conveyor Line	<0.1	4.5	0.9	6.1	
31S51	500 ft South of Radial Conveyor Line	57.6	70.5	74.5	1241	Adjacent to rail spur
21S51	500 ft South of Radial Conveyor Line	-	-	1.2	27.5	
31S52	500 ft South of Radial Conveyor Line	0.7	3.2	0.2	2.4	
31S53	500 ft South of Radial Conveyor Line	1.4	0.5	0.4	0.4	
31S61	600 ft South of Radial Conveyor Line	10.4	539	0.4	4.0	Adjacent to rail spur
21S61	600 ft South of Radial Conveyor Line	-	-	1.5	2.6	
31S62	600 ft South of Radial Conveyor Line	0.5	6.5	0.9	2.5	
31S63	600 ft South of Radial Conveyor Line	1.5	3.2	0.8	0.4	

See Appendix for actual laboratory analysis sheets.

Method References:
(1) Arsenic (As), SW 846, 6010A – ICP
(2) Lead (Pb), SW846, 6010A - ICP

NA	:	Not Analyzed.
ND	:	Not detected at a value greater than reporting limit.
<	:	less than
(mg/kg)	:	milligrams per kilogram (ppm)
ppm	:	parts per million

TABLE 2
LEASED PARCEL (7.9 Acres)
GROUNDWATER SAMPLING ANALYTICAL RESULTS

Sept. 30, Oct. 1 & Oct. 21, 1998
FORMER GULFPORT FERTILIZER PLANT
33^{RD} STREET
GULFPORT, MISSISSIPPI

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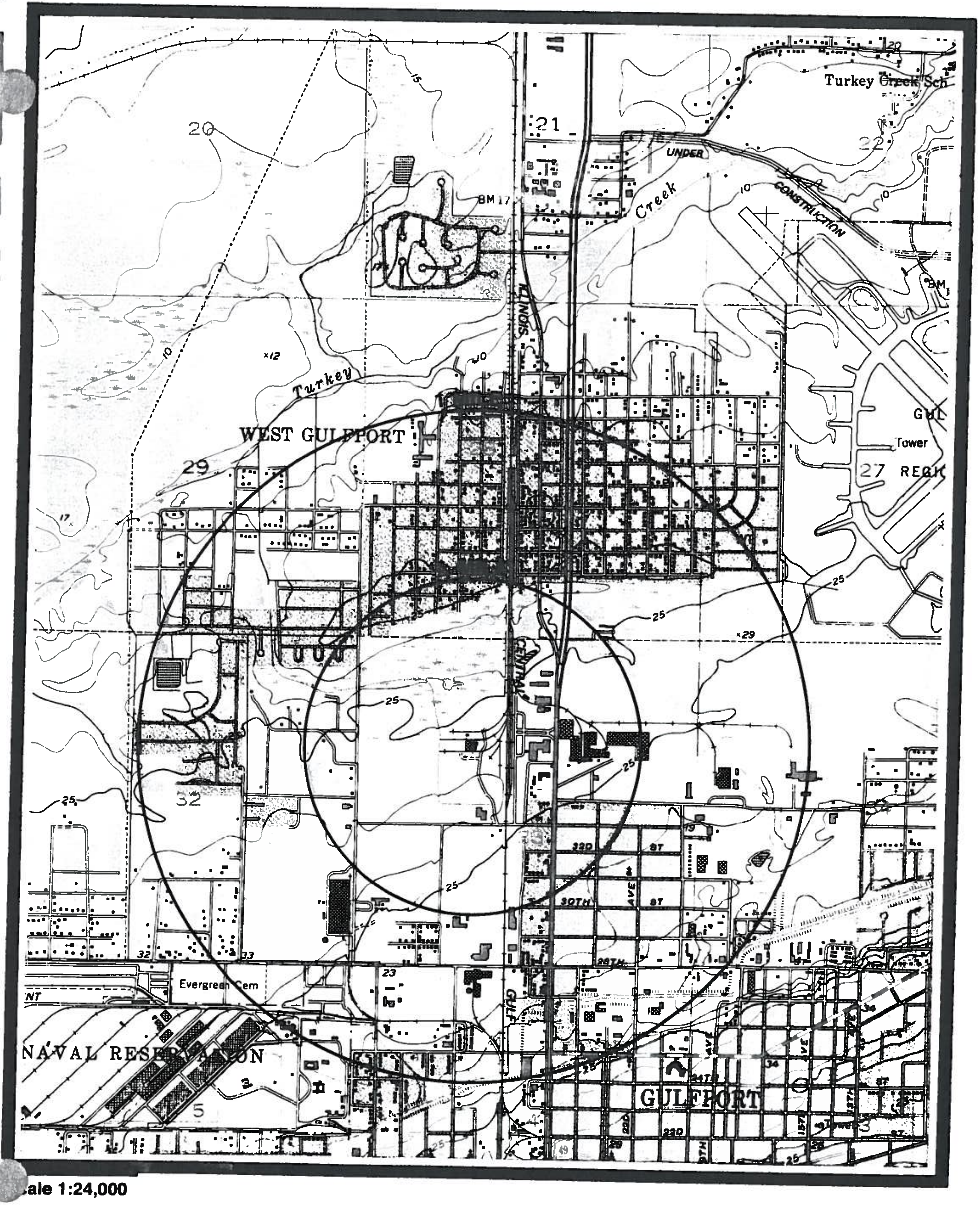
Sample Number	Sample Location	Sample Parameters		REMARKS
		Arsenic As (µg/l)	Lead Pb (µg/l)	
30N31	300 ft North of Radial Conveyor Line	<5	<5	Geoprobe Groundwater sample, Adjacent to rail spur
31N34	300 ft North of Radial Conveyor Line	<5	<5	Geoprobe Groundwater sample
31N21	200 ft North of Radial Conveyor Line	<5	<5	Geoprobe Groundwater sample, Adjacent to rail spur
31N24	200 ft North of Radial Conveyor Line	<5	<5	Geoprobe Groundwater sample
31N12	100 ft North of Radial Conveyor Line	<5	<5	Geoprobe Groundwater sample
31N14	100 ft North of Radial Conveyor Line	<5	<5	Geoprobe Groundwater sample
31RC1	Radial Conveyor Line	<5	<5	Geoprobe Groundwater sample, Adjacent to rail spur
31RC4	Radial Conveyor Line	<5	<5	Geoprobe Groundwater sample
31S11	100 ft North of Radial Conveyor Line	<5	<5	Geoprobe Groundwater sample, Adjacent to rail spur
31S14	100 ft North of Radial Conveyor Line	<5	<5	Geoprobe Groundwater sample
31S21	200 ft North of Radial Conveyor Line	<5	<5	Geoprobe Groundwater sample, Adjacent to rail spur
31S24	200 ft North of Radial Conveyor Line	<5	<5	Geoprobe Groundwater sample
31S31	300 ft North of Radial Conveyor Line	<5	<5	Geoprobe Groundwater sample, Adjacent to rail spur
31S34	300 ft North of Radial Conveyor Line	<5	<5	Geoprobe Groundwater sample
31S41	400 ft North of Radial Conveyor Line	<5	<5	Geoprobe Groundwater sample, Adjacent to rail spur
31S51	500 ft North of Radial Conveyor Line	78.9	7.31	Geoprobe Groundwater sample, Adjacent to rail spur
21S51	500 ft North of Radial Conveyor Line	13	<5	Geoprobe Groundwater sample, 20 ft west of 31S51
31561	600 ft North of Radial Conveyor Line	<5	<5	Geoprobe Groundwater sample, Adjacent to rail spur

See Appendix for actual laboratory analysis sheets.

Method References:
(1) Arsenic (As), EPA 200.7-ICP
(2) Lead (Pb), EPA 200.7-ICP

NA	:	Not Analyzed.
ND	:	Not detected at a value greater than reporting limit.
<	:	Less than
(µg/l)	:	micrograms per liter (ppb).
ppb	:	Parts per billion

FIGURES



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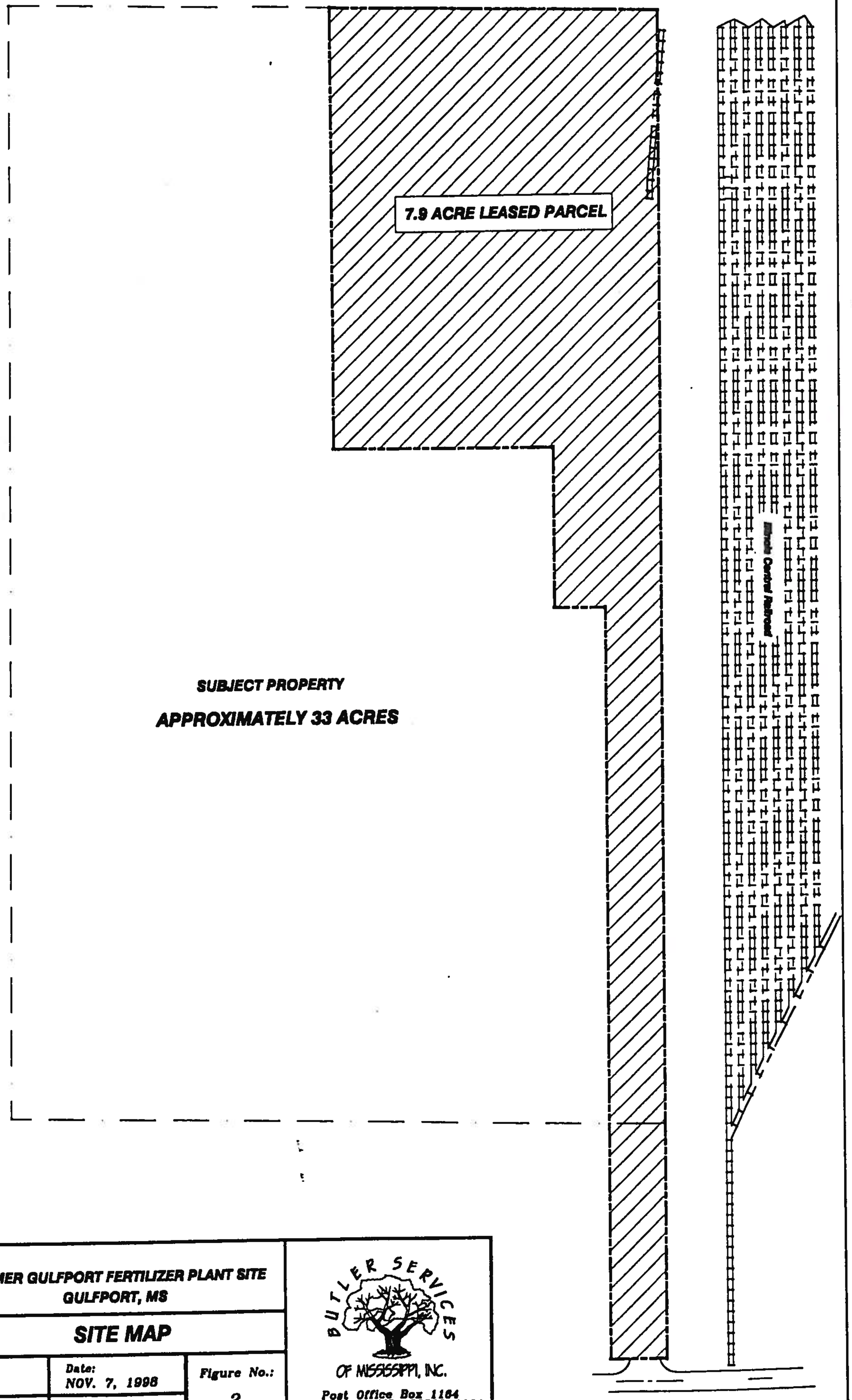

FORMER GULFPORT FERTILIZER PLANT SITE
GULFPORT, MS

SITE MAP

Scale: NTS	Date: NOV. 7, 1998	Figure No.: 2 Sheet 1 of 1
Drawn By: AFE	Approved By:	

BUTLER SERVICES OF MISSISSIPPI, INC.
Post Office Box 1164
Pascagoula, MS 39568-1164
(228) 769-6983

APPENDIX A
AERIAL PHOTOGRAPH

APPENDIX B

LABORATORY ANALYTICAL RESULTS

MICRO-METHODS
LABORATORY, INC.

ANALYTICAL SERVICE COMPANY

October 15, 1998

Butler Services
P. O. Box 1164
Pascagoula, MS 39567

ATTN: Louis Fortenberry

REPORT OF ANALYSES

The results of the analyses of the samples received date and description as shown, lab file #176-BS-10-98, are as attached.

If we can be of further assistance, please contact the office.

Sincerely,

Thomas J. Wilson, Sr.

TJW/dd

encl.

6500 Sunplex Drive • Ocean Springs, MS 39564 (228) 875-6420 • FAX (228) 875-6423

TO: Butler Services

FROM: Micro-Methods, Inc.
Lab File #176-BS-10-98

GULFPORT FERTILIZER COMPANY
9/30/98
SOIL SAMPLES

SAMPLE DESCRIPTION	MM#	ARSENIC mg/kg	LEAD mg/kg
30RC1-2	67327	0.8	6.1
30RC1-4	67328	0.6	2.8
30RC2-2	67329	0.6	4.9
30RC2-4	67330	0.6	6.4
30RC3-2	67331	3.4	30.7
30RC3-4	67332	0.9	5.6
30RC4-2	67333	3.1	7.2
30RC4-4	67334	3.7	15.8
30RC5-2	67335	26.8	20.3
30RC5-4	67336	1.8	4.2
30N11-2	67337	0.1	0.2
30N11-4	67338	2.7	6.5
30N12-2	67339	1.1	8.4
30N12-4	67340	0.8	5.9
30N13-2	67341	2.0	3.0
30N13-4	67342	1.0	3.2
30N14-2	67343	1.3	3.8
30N14-4	67344	1.0	2.5

METHODOLOGY
SW 846, 6010A - ICP

TO: Butler Services

FROM: Micro-Methods, Inc.
Lab File #176-BS-10-98

GULFPORT FERTILIZER COMPANY
9/30/98
SOIL SAMPLES

SAMPLE DESCRIPTION	MM#	ARSENIC mg/kg	LEAD mg/kg
30N15-2	67345	1.8	3.3
30N15-4	67346	1.5	2.6
30N21-2	67347	0.6	3.2
30N21-4	67348	1.3	4.8
30N22-2	67349	0.6	15.0
30N22-4	67350	3.6	6.0
30N23-2	67351	0.7	3.2
30N23-4	67352	0.4	0.2
30N24-2	67353	0.8	0.8
30N24-4	67354	2.5	22.8
30N25-2	67355	1.2	2.2
30N25-4	67356	1.4	1.1
30N31-2	67357	2.0	11.8
30N31-4	67358	0.1	0.2
30N32-2	67359	6.6	170
30N32-4	67360	0.3	5.2
30N33-2	67361	0.6	2.7
30N33-4	67362	0.5	5.1
30N34-2	67363	0.9	28.3

METHODOLOGY
SW 846, 6010A - ICP

TO: Butler Services

FROM: Micro-Methods, Inc.
Lab File #176-BS-10-98

GULFPORT FERTILIZER COMPANY
9/30/98
SOIL SAMPLES

SAMPLE DESCRIPTION	MM#	ARSENIC mg/kg	LEAD mg/kg
30N34-4	67364	<0.1	3.9
30N35-2	67365	0.6	2.4
30N35-4	67366	2.5	0.6

METHODOLOGY
SW 846, 6010A - ICP

TO: Butler Services

FROM: Micro-Methods, Inc.
Lab File #176-BS-10-98

GULFPORT FERTILIZER COMPANY
9/30/98
WATER SAMPLES

SAMPLE DESCRIPTION	MM#	ARSENIC µg/l	LEAD µg/l
30RC1	67367	<5	14.5
30RC4	67368	<5	9.3
30N11	67369	<5	22.5
30N14	67370	<5	63.3
30N21	67371	<5	41.4
30N24	67372	<5	21.5
30N31	67373	<5	6.1
30N34	67374	<5	36.6

METHODOLOGY
EPA 200.7-ICP

MICRO-METHODS, INC.
6500 SUNPLEX DRIVE
OCEAN SPRINGS, MS 39564

QA/QC METALS

TO: Butler Services

LAB FILE # 176-BS-10-98

	ARSENIC			LEAD		
MM#	Spiked with 50 µg conc. found	Calculated Conc. spl + 50	% REC.	Spiked with 50 µg conc. found	Calculated Conc. spl + 50	% REC.
67330	40.9	54.1	75.6	66	92	71.7
67337	30.9	51	60	70	77.6	90.2
67344	42.2	58.2	72.5	72	65.4	110
67351	42.1	53	79.4	52	66	78.8
67358	38.5	51	75.5	76	90.3	84.2
67365	44.3	52.8	83.9	48	63.6	75.5

Page 1 5

Butler Services of Mississippi, Inc.

Post Office Box 1164 • Pascagoula, Mississippi
Telephone (601) 769-6983

Analysis Request and Chain of Custody Record

Sample submitted by: LOUIS W. FORTENBERRY

Client/Project Name: GULFPORT FERTILIZER COMPANY

Company	Address	Contact	Project Location	Project No.
BUTLER SERVICES	PASCAGOULA, MS	L.W. FORTENBERRY Phone (228) 769-6983	33RD STREET GULFPORT, MS	300998

Field Sample No./ Identification	Date and Time	Grab	Comp	Sample Container (Size/Mat'l)	Sample Type (Liquid, Soil Sludge, Etc.)	Preservative	ANALYSIS REQUESTED TEST	ANALYSIS REQUESTED METHOD	REMARKS
30RC1-2	9/30/98 10:00			9oz W/M Glass	SOIL	–	Lead, Arsenic		Geoprobe
30RC1-4	9/30/98 10:02			"	"	–	" "		"
30RC2-2	9/30/98 10:10			"	"	–	" "		"
30RC2-4	9/30/98 10:12			"	"	–	" "		"
30RC3-2	9/30/98 10:18			"	"	–	" "		"
30RC3-4	9/30/98 10:20			"	"	–	" "		"
30RC4-2	9/30/98 10:35			"	"	–	" "		"
30RC4-4	9/30/98 10:38			"	"	–	" "		"
30RC5-2	9/30/98 11:02			"	"	–	" "		"
30RC5-4	9/30/98 11:08			"	"	–	" "		"

Samplers: (Signature)

Affiliation: BUTLER SERVICES

Relinquished by: (Signature) L.W. FORTENBERRY	Date: 10/1/98 Time: 1100 am	Received by: (Signature)	Date: Time:	Intact
Relinquished by: (Signature)	Date: Time:	Received by: (Signature)	Date: Time:	Intact
Relinquished by: (Signature)	Date: Time:	Received by: (Signature)	Date: Time:	Intact
		Received for laboratory: (Signature) C.K. Hughes	Date: 10/1/98 Time: 1100	Laboratory No.
		Data Results to: report completed		10/16/98

W. Doolith

SAMPLER REMARKS:

Seal #

Page 2 of 5

Butler Services of Mississippi, Inc.

Post Office Box 1164 • Pascagoula, Mississippi
Telephone (601) 769-6983

Analysis Request and Chain of Custody Record

Sample submitted by: Louis W. Fortenberry

Client/Project Name: Gulfport Fertilizer Company

Company	Address	Contact / Phone	Project Location	Project No.
Butler Services	Pascagoula, MS	Contact L.W. Fortenberry Phone (228) 769-6583	33rd Street, Gulfport, MS	306998

Field Sample No./Identification	Date and Time	Grab	Comp	Sample Container (Size/Mat'l)	Sample Type (Liquid, Soil Sludge, Etc.)	Preservative	ANALYSIS REQUESTED TEST	METHOD	REMARKS
30N11-2	9/30/98 1:15			4oz w/m glass	Soil	—	Lead, Arsenic		Geoprobe
30N11-4	9/30/98 1:17			"	"	—	" "		"
30N12-2	9/30/98 1:32			"	"	—	" "		"
30N12-4	9/30/98 1:34			"	"	—	" "		"
30N13-2	9/30/98 1:49			"	"	—	" "		"
30N13-4	9/30/98 1:52			"	"	—	" "		"
30N14-2	9/30/98 2:08			"	"	—	" "		"
30N14-4	9/30/98 2:10			"	"	—	" "		"
30N15-2	9/30/98 2:25			"	"	—	" "		"
30N15-4	9/30/98 2:28				"	—	" "		"

Samplers: (Signature)	Relinquished by: (Signature) L.W. Fortenberry	Date: 10/1/98 Time: 1000am	Received by: (Signature)	Date: Time:	Intact
Butler Services Affiliation	Relinquished by: (Signature)	Date: Time:	Received by: (Signature)	Date: Time:	Intact
	Relinquished by: (Signature)	Date: Time:	Received by: (Signature)	Date: Time:	Intact
SAMPLER REMARKS:			Received for laboratory: (Signature)	Date: Time:	Laboratory No.
Seal #			Data Results to:		

report completed 10/16/98
10-16 [illegible]

Page 3 of 5

Butler Services of Mississippi, Inc.

Post Office Box 1164 • Pascagoula, Mississippi
Telephone (601) 769-6983

Analysis Request and Chain of Custody Record

Sample submitted by: LEWIS W. FONTENBERRY

Client/Project Name: GULFPORT FERTILIZER COMPANY

ompany UTLER SERVICES	Address PASCAGOULA, MS	Contact L W FONTENBERRY Phone (228)769-6585	Project Location 33RD STREET, GULFPORT, MS	Project No. 300958

Field Sample No./ Identification	Date and Time	Grab	Comp	Sample Container (Size/Mat'l)	Sample Type (Liquid, Soil Sludge, Etc.)	Preservative	ANALYSIS REQUESTED		REMARKS
							TEST	METHOD	
ON21-2	9/30/98 2:38			8oz w/m Glass	SOIL	—	Lead, Arsenic		GeoProbe
ON21-4	9/30/98 2:40			"	"	—	" "		"
ON22-2	9/30/98 2:55			"	"	—	" "		"
ON22-4	9/30/98 2:55			"	"	-	" "		"
ON23-2	9/30/98 3:05			"	"	—	" "		"
ON23-4	9/30/98 3:08			"	"	—	" "		"
ON24-2	9/30/98 3:18			"	"	—	" "		"
ON24-4	9/30/98 3:20			"	"	—	" "		"
ON25-2	9/30/98 3:35			"	"	—	" "		"
ON25-4	9/30/98 3:37			"	"	—	" "		"

Samplers: (Signature)	Relinquished by: L W FONTENBERRY (Signature)	Date: 10/1/98 Time: 10:00am	Received by: (Signature)	Date: Time:	Intact
BUTLER SERVICES Affiliation	Relinquished by: (Signature)	Date: Time:	Received by: (Signature)	Date: Time:	Intact
	Relinquished by: (Signature)	Date: Time:	Received by: (Signature)	Date: Time:	Intact
MPLER REMARKS:			Received for laboratory: (Signature)	Date: Time:	Laboratory No.
eal #			Data Results to:		

report completed 10/16/98
D. Doolittle

Page 4 5

Butler Services of Mississippi, Inc.

Analysis Request and Chain of Custody Record

Post Office Box 1164 • Pascagoula, Mississippi
Telephone (601) 769-6983

Sample submitted by: Louis W. Fortenberry

Client/Project Name: Gulfport Fertilizer Company

Company Butler Services	Address Pascagoula, MS	Contact L W Fortenberry Phone (228) 769-6583	Project Location 33rd Street, Gulfport, MS	Project No. 500998

Field Sample No./ Identification	Date and Time	Grab	Comp	Sample Container (Size/Mat'l)	Sample Type (Liquid, Soil Sludge, Etc.)	Preservative	ANALYSIS REQUESTED TEST	METHOD	REMARKS
30N31-2	9/30/98 3:50			9oz w/m glass	Soil	—	Lead, Arsenic		Geo Probe
30N31-4	9/30/98 3:52			"	"	—	" "		"
30N32-2	9/30/98 4:05			"	"	—	" "		"
30N32-4	9/30/98 4:07			"	"	—	" "		"
30N33-2	9/30/98 4:17			"	"	—	" "		"
30N33-4	9/30/98 4:19			"	"	—	" "		"
30N34-2	9/30/98 4:30			"	"	—	" "		"
30N34-4	9/30/98 4:32			"	"	—	" "		"
30N35-2	9/30/98 4:46			"	"	—	" "		"
30N35-4	9/30/98 4:48			"	"	—	" "		"

Samplers: (Signature) W D Bates	Relinquished by: (Signature) L W Fortenberry	Date: 10/1/98 Time: 11:00 am	Received by: (Signature)	Date: Time:	Intact	
Butler Services Affiliation	Relinquished by: (Signature)	Date: Time:	Received by: (Signature)	Date: Time:	Intact	
	Relinquished by: (Signature)	Date: Time:	Received by: (Signature)	Date: Time:	Intact	
SAMPLER REMARKS:			Received for laboratory: (Signature)	Date: Time:	Laboratory No.	
Seal #			Data Results to:			

Report Completed
10/16/98 W. Woodle

Page 5 of 5

Butler Services of Mississippi, Inc.

Post Office Box 1164 • Pascagoula, Mississippi
Telephone (601) 769-6983

Analysis Request and Chain of Custody Record

Sample submitted by: LOUIS W. FORTENBERRY

Client/Project Name: GULFPORT FERTILIZER COMPANY

Company: BUTLER SERVICES

Address: PASCAGOULA, MS

Contact: L W FORTENBERRY

Phone: (228) 769-6983

Project Location: 33rd STREET, GULFPORT, MS

Project No.: 300998

Field Sample No./ Identification	Date and Time	Grab	Comp	Sample Container (Size/Mat'l)	Sample Type (Liquid, Soil Sludge, Etc.)	Preservative	ANALYSIS REQUESTED TEST	ANALYSIS REQUESTED METHOD	REMARKS
30RC1	9/30/98 10:08			Plastic	water	HNO3	Lead, Arsenic		GeoProbe 4½'-5'
30RC4	9/30/98 10:42			"	"	"	" "		" "
30N11	9/30/98 1:19			"	"	"	" "		" "
30N14	9/30/98 2:15			"	"	"	" "		" "
30N21	9/30/98 2:45			"	"	"	" "		" "
30N24	9/30/98 3:25			"	"	"	" "		" "
30N31	9/30/98 3:55			"	"	"	" "		" "
30N34	9/30/98 4:36			"	"	"	" "		" "

Samplers: (Signature)

BUTLER SERVICES
Affiliation

Relinquished by: (Signature) L.W. FORTENBERRY
Date: 10/01/98
Time: 11 [illegible]

Received by: (Signature)
Date:
Time:
Intact

Relinquished by: (Signature)
Date:
Time:

Received by: (Signature)
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Intact

Relinquished by: (Signature)
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Time:
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SAMPLER REMARKS:

Received for laboratory: (Signature)
Date:
Time:

Laboratory No.

Seal #

Data Results to:

MICRO-METHODS
LABORATORY, INC.

ANALYTICAL SERVICE COMPANY

October 15, 1998

Butler Services
P. O. Box 1164
Pascagoula, MS 39567

ATTN: Louis Fortenberry

REPORT OF ANALYSES

The results of the analyses of the samples received date and description as shown, lab file #177-BS-10-98, are as attached.

If we can be of further assistance, please contact the office.

Sincerely,

Thomas J Wilson

Thomas J. Wilson, Sr.

TJW/dd

encl.

TO: Buller Services

FROM: Micro-Methods, Inc.
Lab File #177-BS-10-98

GULFPORT FERTILIZER COMPANY
10/1/98
SOIL SAMPLES

SAMPLE DESCRIPTION	MM#	ARSENIC mg/kg	LEAD mg/kg
31S11-2	67532	2.4	8.3
31S11-4	67533	0.4	5.2
31S12-2	67534	0.2	7.0
31S12-4	67535	2.6	8.3
31S13-2	67536	10.2	4.9
31S13-4	67537	2.6	4.1
31S14-2	67538	106	4.9
31S14-4	67539	6.7	1.8
31S15-2	67540	42.7	17.0
31S15-4	67541	23.4	3.6
31S21-2	67542	3.8	12.8
31S21-4	67543	2.3	6.7
31S22-2	67544	<0.1	6.2
31S22-4	67545	0.1	4.8
31S23-2	67546	2.2	3.6
31S23-4	67547	0.8	2.9
31S24-2	67548	35.7	306
31S24-4	67549	4.8	0.8
31S25-2	67550	21.2	21.3

METHODOLOGY
SW 846, 6010A - ICP

TO: Butler Services

FROM: Micro-Methods, Inc.
Lab File #177-BS-10-98

GULFPORT FERTILIZER COMPANY
10/1/98
SOIL SAMPLES

SAMPLE DESCRIPTION	MM#	ARSENIC mg/kg	LEAD mg/kg
31S25-4	67551	1.3	2.9
31S31-2	67552	1.9	3.0
31S31-4	67553	0.2	3.0
31S32-2	67554	0.5	3.4
31S32-4	67555	0.8	4.8
31S33-2	67556	8.6	55.1
31S33-4	67558	1.4	1.8
31S34-2	67559	0.6	1.6
31S34-4	67560	0.5	3.5
31S35-2	67561	19.0	5.3
31S35-4	67562	1.7	1.2
31S41-2	67563	1.9	3.5
31S41-4	67564	0.4	0.6
31S42-2	67565	2.4	5.8
31S42-4	67566	0.9	1.9
31S43-2	67567	<0.1	4.5
31S43-4	67568	0.9	6.1

METHODOLOGY
SW 846, 6010A - ICP

TO: Butler Services

FROM: Micro-Methods, Inc.
Lab File #177-BS-10-98

GULFPORT FERTILIZER COMPANY
10/1/98
SOIL SAMPLES

SAMPLE DESCRIPTION	MM#	ARSENIC mg/kg	LEAD mg/kg
31S51-2	67569	57.6	70.5
31S51-4	67570	74.5	1241
31S52-2	67571	0.7	3.2
31S52-4	67572	0.2	2.4
31S53-2	67573	1.4	0.5
31S53-4	67574	0.4	0.4
31S61-2	67575	10.4	539
31S61-4	67576	0.4	4.0
31S62-2	67577	0.5	6.5
31S62-2 DUPLICATE	67578	1.9	2.3
31S62-4	67579	0.9	2.5
31S63-2	67580	1.5	3.2
31S63-4	67581	0.8	0.4
31N36-2	67591	1.5	4.8
31N36-4	67592	0.3	5.1
31N37-2	67593	4.5	12.9
31N38-4	67594	1.8	2.8

METHODOLOGY
SW 846, 6010A - ICP

TO: Butler Services

FROM: Micro-Methods, Inc.
Lab File #177-BS-10-98

GULFPORT FERTILIZER COMPANY
10/1/98
SOIL SAMPLES

SAMPLE DESCRIPTION	MM#	ARSENIC mg/kg	LEAD mg/kg
31N39-2	67595	1.6	7.3
31N26-2	67597	0.7	1.5
31N26-4	67598	<0.1	2.1
31N27-2	67599	4.6	3.8
31N27-4	67600	0.9	8.0
31N28-2	67601	1.1	5.3
31N28-4	67602	0.2	0.1
31N29-2	67603	1.2	6.5
31N29-4	67604	20.2	16.5
31N19-2	67605	9.5	42.3
31N19-4	67606	66.5	14.0
31S39-2	67607	7.1	6.2
31S39-4	67608	1.4	1.7
31S79-2	67609	1.8	43.9
31S79-4	67610	1.1	1.6
31N39	67611	<0.1	2.3
31N37-4	67649	0.1	2.1
31N38-2	67650	0.5	5.4

METHODOLOGY
SW 846, 6010A - ICP

TO: Butler Services

FROM: Micro-Methods, Inc.
Lab File #177-BS-10-98

GULFPORT FERTILIZER COMPANY
10/1/98
WATER SAMPLES

SAMPLE DESCRIPTION	MM#	ARSENIC µg/l	LEAD µg/l
31S11	67582	<5	<5
31S14	67583	<5	<5
31S21	67584	<5	<5
31S24	67585	<5	<5
31S31	67586	<5	<5
31S34	67587	<5	<5
31S41	67588	<5	<5
31S51	67589	78.9	7.31
31S61	67590	<5	<5
31N39-4	67596	<5	5.35
31S39	67612	18.8	<5
31S79	67613	<5	<5
31S149	67614	<5	<5
31S146	67615	<5	<5
31S143	67616	<5	<5

METHODOLOGY
EPA 200.7-ICP

MICRO-METHODS, INC.
6500 SUNPLEX DRIVE
OCEAN SPRINGS, MS 39564

QA/QC METALS

TO: Butler Services

LAB FILE # 177-BS-10-98

	ARSENIC			LEAD		
MM#	**Spiked with 50 µg conc. found**	**Calculated Conc. spl + 50**	**% REC.**	**Spiked with 50 µg conc. found**	**Calculated Conc. spl + 50**	**% REC.**
67538	572	590.5	96.9	85	90.6	93.8
67545	31.7	50.6	62.6	68	76.8	88.4
67552	46	63.4	72.5	68	70.6	96.3
67559	37.1	52.8	70.2	71	59.6	119
67566	35.1	55	63.8	56	62.2	90
67573	44.2	55.8	79.2	51	52.9	96.4
67580	25	54.8	45.6	44	65.2	67.5
67602	46.4	51	90.9	49	78.6	62.3
67609	39.7	60.4	65.7	451	339.7	132.7

Butler Services of Mississippi, Inc.

Post Office Box 1164 • Pascagoula, Mississippi
Telephone (601) 769-6983

Analysis Request and Chain of Custody Record

Sample submitted by: L.W. FORTENBERRY

Client/Project Name: GULFPORT FERTILIZER PLANT

Company BUTLER SERVICES	Address PASCAGOULA, MS	Contact L.W FORTENBERRY Phone (228) 769-6983	Project Location 33RD STREET, GULFPORT, MS	Project No. 300998

Field Sample No./ Identification	Date and Time	Grab	Comp	Sample Container (Size/Mat'l)	Sample Type (Liquid, Soil Sludge, Etc.)	Preservative	ANALYSIS REQUESTED TEST	METHOD	REMARKS
31S11-2	10/01/98 7:15A			4oz w/m glass	SOIL	–	Lead, Arsenic		
31S11-4	10/01/98 7:17A			"	"	–	" "		
31S12-2	10/01/98 7:32A			"	"	–	" "		
31S12-4	10/01/98 7:34A			"	"	–	" "		
31S13-2	10/01/98 7:42A			"	"	–	" "		
31S13-4	10/01/98 7:44A			"	"	–	" "		
31S14-2	10/01/98 7:54A			"	"	–	" "		
31S14-4	10/01/98 7:56A			"	"	–	" "		report completed
31S15-2	10/01/98 8:12A			"	"	–	" "		10/15/98
31S15-4	10/01/98 8:14A			"	"	–	" "		W. Woolleth

Samplers: (Signature) ALD Baker	Relinquished by: L.W FORTENBERRY (Signature) Louis Fortenberry	Date: 11/2/98 Time: 1130 Am	Received by: (Signature)	Date: Time:	Intact
BUTLER SERVICES Affiliation	Relinquished by: (Signature)	Date: Time:	Received by: (Signature)	Date: Time:	Intact
	Relinquished by: (Signature)	Date: Time:	Received by: (Signature)	Date: Time:	Intact
SAMPLER REMARKS:			Received for laboratory: (Signature)	Date: 10/2/98 Time: 1130	Laboratory No.
Seal #			Data Results to:		

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Butler Services of Mississippi, Inc.

Post Office Box 1164 • Pascagoula, Mississippi
Telephone (601) 769-6983

Analysis Request and Chain of Custody Record

Sample submitted by: L.W. FORTENBERRY

Client/Project Name: GULFPORT FERTILIZER PLANT

Company BUTLER SERVICES	Address PASCAGOULA, MS	Contact L.W. FORTENBERRY Phone: (228) 769-6983	Project Location 33 RD STREET, GULFPORT, MS	Project No. 300998

Field Sample No./ Identification	Date and Time	Grab	Comp	Sample Container (Size/Mat'l)	Sample Type (Liquid, Soil Sludge, Etc.)	Preservative	ANALYSIS REQUESTED TEST	ANALYSIS REQUESTED METHOD	REMARKS
31521-2	10/01/98 8:24			16 OZ W/M GLASS	SOIL	—	Lead, Arsenic		
31521-4	10/01/98 8:26			16 OZ W/M GLASS	"	—	" "		
31522-2	10/01/98 8:38			16 OZ W/M GLASS	"	—	" "		
31522-4	10/01/98 8:40			16 OZ W/M GLASS	"	—	" "		
31523-2	10/01/98 8:50			4 OZ W/M GLASS	"	—	" "		
31523-4	10/01/98 8:52			"	"	—	" "		
31524-2	10/01/98 9:00			"	"	—	" "		report completed
31524-4	10/01/98 9:02			"	"	—	" "		11/15/98
31525-2	10/01/98 9:18			"	"	—	" "		?. Doolittle
31525-4	10/01/98 9:21			"	"	—	" "		

Samplers: (Signature) W.D. Butler	Relinquished by: (Signature) L.W. FORTENBERRY Louis Fortenberry	Date: 11/2/98 Time: 1130 Am	Received by: (Signature)	Date: Time:	Intact
BUTLER SERVICES Affiliation	Relinquished by: (Signature)	Date: Time:	Received by: (Signature)	Date: Time:	Intact
	Relinquished by: (Signature)	Date: Time:	Received by: (Signature)	Date: Time:	Intact
SAMPLER REMARKS:			Received for laboratory: (Signature) K. Daigle	Date: 11/2/98 Time: 11:30	Laboratory No.
Seal #			Data Results to:		

Butler Services of Mississippi, Inc.

Post Office Box 1164 • Pascagoula, Mississippi
Telephone (601) 769-6983

Analysis Request and Chain of Custody Record

Sample submitted by: LW FORTENBERRY

Client/Project Name: GULFPORT FERTILIZER PLANT

Company	Address	Contact	Project Location	Project No.
BUTLER SERVICES	PASCAGOULA, MS	LW FORTENBERRY Phone: (228) 769-6983	33RD STREET, GULFPORT, MS	300998

Field Sample No./ Identification	Date and Time	Grab	Comp	Sample Container (Size/Mat'l)	Sample Type (Liquid, Soil Sludge, Etc.)	Preservative	ANALYSIS REQUESTED TEST	METHOD	REMARKS
31S31-2	10/01/98 9:32A			16oz w/m glass	SOIL	—	Lead, Arsenic		
31S31-4	10/01/98 9:34A			"	"	—	" "		
31S32-2	10/01/98 9:50A			"	"	—	" "		
31S32-4	10/01/98 9:52A			"	"	—	" "		
31S33-2	10/01/98 10:00A			"	"	—	" "		
31S33-2 DUP	10/01/98 10:02A			250ml HDPE	"	—	" "		DUPLICATE
31S33-4	10/01/98 10:04A			16 oz w/m glass	"	—	" "		rept completed 10/15/98 D. Woolwth
31S34-2	10/01/98 10:14A			4oz w/m glass	"	—	" "		
31S34-4	10/01/98 10:16A			"	"	—	" "		
31S35-2	10/01/98	10:28A		"	"	=	" "		
31S35-4	10/01/98	10:27A		"	"		" "		

Samplers: (Signature)	Relinquished by: (Signature) LW FORTENBERRY Lewis Fortenberry	Date: 11/2/98 Time: 1130 Am	Received by: (Signature)	Date: Time:	Intact
BUTLER SERVICES Affiliation	Relinquished by: (Signature)	Date: Time:	Received by: (Signature)	Date: Time:	Intact
	Relinquished by: (Signature)	Date: Time:	Received by: (Signature)	Date: Time:	Intact
SAMPLER REMARKS:			Received for laboratory: (Signature) C.K. Dugler	Date: 10/2/98 Time: 11:30	Laboratory No.
Seal #			Data Results to:		

Butler Services of Mississippi, Inc.

Post Office Box 1164 • Pascagoula, Mississippi
Telephone (601) 769-6983

Analysis Request and Chain of Custody Record

Sample submitted by: L.W. FORTENBERRY

Client/Project Name: GULFPORT FERTILIZER PLANT

Company: BUTLER SERVICES

Address: PASCAGOULA, MS

Contact: L.W. FORTENBERRY

Phone: (228) 769-6983

Project Location: 33RD STREET, GULFPORT, MS

Project No.: 300998

Field Sample No./ Identification	Date and Time	Grab	Comp	Sample Container (Size/Mat'l)	Sample Type (Liquid, Soil Sludge, Etc.)	Preservative	ANALYSIS REQUESTED TEST	ANALYSIS REQUESTED METHOD	REMARKS
31541-2	10/01/98 10:36			16OZ W/M GLASS	SOIL	—	LEAD, ARSENIC		
31541-4	10/01/98 10:38			"	"	—	" "		
31542-2	10/01/98 10:50			250 ML HDPE	"	—	" "		
31542-4	10/01/98 10:52			"	"	—	" "		
31543-2	10/01/98 11:00			"	"	—	" "		
31543-4	10/01/98 11:02			"	"	—	" "		
									rept completed
									10/15/98
									D. [illegible]

Samplers: (Signature)

BUTLER SERVICES
Affiliation

Relinquished by: (Signature) L.W. FORTENBERRY Louis Fortenberry	Date: 11/2/98 Time: 1130 Am	Received by: (Signature)	Date: Time:	Intact
Relinquished by: (Signature)	Date: Time:	Received by: (Signature)	Date: Time:	Intact
Relinquished by: (Signature)	Date: Time:	Received by: (Signature)	Date: Time:	Intact
		Received for laboratory: (Signature) C. K. [illegible]	Date: 10/2/98 Time: 1130	Laboratory No.
		Data Results to:		

SAMPLER REMARKS:

Seal #

Butler Services of Mississippi, Inc.

Post Office Box 1164 • Pascagoula, Mississippi
Telephone (601) 769-6983

Analysis Request and Chain of Custody Record

Sample submitted by: L. W. FORTENBERRY

Client/Project Name: GULFPORT FERTILIZER PLANT

Company	Address	Contact	Project Location	Project No.
BUTLER SERVICES	PASCAGOULA, MS	L.W. FORTENBERRY Phone: (228) 769-6983	33RD STREET, GULFPORT, MS	300998

Field Sample No./ Identification	Date and Time	Grab	Comp	Sample Container (Size/Mat'l)	Sample Type (Liquid, Soil Sludge, Etc.)	Preservative	ANALYSIS REQUESTED TEST	ANALYSIS REQUESTED METHOD	REMARKS
31551-2	10/01/98 11:12			16 OZ W/M GLASS	SOIL	—	LEAD, ARSENIC *		
31551-4	10/01/98 11:14			"	"	—	" " *		Refusal or conc. ±4'
31552-2	10/01/98 11:36			"	"	—	" "		
31552-4	10/01/98 11:32			"	"	—	" "		
31553-2	10/01/98 11:40			"	"	—	" "		
31553-4	10/01/98 11:44			"	"	—	" "		
									report completed
									10/15/98
									D. Doolittle

Samplers: (Signature)	Relinquished by: (Signature) L. W. FORTENBERRY Laurus Fortenberry	Date: 11/2/98 Time: 1130 Am	Received by: (Signature)	Date: Time:	Intact
BUTLER SERVICES Affiliation	Relinquished by: (Signature)	Date: Time:	Received by: (Signature)	Date: Time:	Intact
	Relinquished by: (Signature)	Date: Time:	Received by: (Signature)	Date: Time:	Intact

SAMPLER REMARKS: * sample producing gas bubbles - use caution

Received for laboratory: (Signature) C. K. Dugler

Date: 10/2/98
Time: 1130

Laboratory No.

Data Results to:

Seal #

Page 5 of 16

Butler Services of Mississippi, Inc.

Post Office Box 1164 • Pascagoula, Mississippi
Telephone (601) 769-6983

Analysis Request and Chain of Custody Record

Sample submitted by: L. W. FORTENBERRY

Client/Project Name: GULFPORT FERTILIZER PLANT

Company	Address	Contact	Project Location	Project No.
BUTLER SERVICES	PASCAGOULA, MS	L. W. FORTENBERRY Phone: (228) 769-6983	33RD STREET, GULFPORT, MS	300998

Field Sample No./ Identification	Date and Time	Grab	Comp	Sample Container (Size/Mat'l)	Sample Type (Liquid, Soil Sludge, Etc.)	Preservative	ANALYSIS REQUESTED TEST	ANALYSIS REQUESTED METHOD	REMARKS
31N36-2	10/01/98 1:46p			250ml HDPE	SOIL	–	Lead, Arsenic		
31N36-4	10/01/98 1:48p			″	″	–	″ ″		
31N37-2	10/01/98 1:56p			″	″	–	″ ″		
31N38-4	10/01/98 1:58p			″	″	–	″ ″		
31N39-2	10/01/98 2:05p			″	″	–	″ ″		
31N39-4	10/01/98 2:07p			″	″	–	″ ″		
31N26-2	10/01/98 2:22p			″	″	–	″ ″		report complete
31N26-4	10/01/98 2:24p			″	″	–	″ ″		10/25/98
31N27-2	10/01/98 2:32p			″	″	–	″ ″		D. Woolcutt
31N27-4	10/01/98 2:36p			″	″	–	″ ″		

Samplers: (Signature) BUTLER SERVICES Affiliation	Relinquished by: (Signature) L.W. FORTENBERRY Louis Fortenberry	Date: 11/2/98 Time: 11:30 Am	Received by: (Signature)	Date: Time:	Intact
	Relinquished by: (Signature)	Date: Time:	Received by: (Signature)	Date: Time:	Intact
	Relinquished by: (Signature)	Date: Time:	Received by: (Signature)	Date: Time:	Intact
SAMPLER REMARKS:			Received for laboratory: (Signature) C. K. Hughes	Date: 10/2/98 Time: 11:30	Laboratory No.
Seal #			Data Results to:		

Butler Services of Mississippi, Inc.

Analysis Request and Chain of Custody Record

Post Office Box 1164 • Pascagoula, Mississippi
Telephone (601) 769-6983

Sample submitted by: L.W. FORTENBERRY

Client/Project Name: GULFPORT FERTILIZER PLANT

Company BUTLER SERVICES	Address PASCAGOULA, MS	Contact L.W. FORTENBERRY Phone: (228) 769-6983	Project Location 33RD STREET, GULFPORT, MS	Project No. 300998

Field Sample No./ Identification	Date and Time	Grab	Comp	Sample Container (Size/Mat'l)	Sample Type (Liquid, Soil Sludge, Etc.)	Preservative	ANALYSIS REQUESTED TEST	METHOD	REMARKS
31N28-2	10/01/98 2:47p			250 ML HDPE	SOIL	–	Lead, Arsenic		
31N28-4	10/01/98 2:46p			"	"	–	" "		
31N29-2	10/01/98 2:56p			"	"	–	" "		
31N29-4	10/01/98 2:58p			"	"	–	" "		
31N19-2	10/01/98 3:12p			"	"	–	" "		
31N19-4	10/01/98 3:14p			"	"	–	" "		
31S39-2	10/01/98 3:24p			"	"	–	" "		
31S39-4	10/01/98 3:26p			"	"	–	" "		report complete
31S79-2	10/01/98 4:15p			"	"	–	" "		10/15/98
31S79-4	10/01/98 4:18p			"	"	–	" "		D. Doolittle

Samplers: (Signature) BUTLER SERVICES Affiliation	Relinquished by: L.W. FORTENBERRY (Signature) James Fortenberry	Date: 11/2/98 Time: 1130 Am	Received by: (Signature)	Date: Time:	Intact
	Relinquished by: (Signature)	Date: Time:	Received by: (Signature)	Date: Time:	Intact
	Relinquished by: (Signature)	Date: Time:	Received by: (Signature)	Date: Time:	Intact
SAMPLER REMARKS:			Received for laboratory: (Signature) C.K. Hughes	Date: 10/2/98 Time: 1130	Laboratory No.
Seal #			Data Results to:		

Page 1 of 0

Butler Services of Mississippi, Inc.

Post Office Box 1164 • Pascagoula, Mississippi
Telephone (601) 769-6983

Analysis Request and Chain of Custody Record

Sample submitted by: L.W. FORTENBERRY

Client/Project Name: GULFPORT FERTILIZER PLANT

Company	Address	Contact	Project Location	Project No.
BUTLER SERVICES	PASCAGOULA, MS	L.W. FORTENBERRY Phone: (228) 769-6983	33RD STREET, GULFPORT, MS	300998

Field Sample No./ Identification	Date and Time	Grab	Comp	Sample Container (Size/Mat'l)	Sample Type (Liquid, Soil Sludge, Etc.)	Preservative	ANALYSIS REQUESTED TEST	ANALYSIS REQUESTED METHOD	REMARKS
31N39	10/01/98 2:12p			250mL HDPE	WATER	—	Lead, Arsenic		
31S39	10/01/98 3:42p			"	"	—	" "		
31S79	10/01/98 4:25p			"	"	—	" "		
31S149	10/01/98 4:32			"	"	—	" "		
31S146	10/01/98 4:42			"	"	—	" "		
31S143	10/01/98 4:56			"	"	—	" "		report complete
FIELD BLANK	10/01/98 —			"	"	—	" "		10/15/98 to W. Cobb
31N37-4	10/01/98			"	SOIL				not listed on
31N38-2	10/01/98			"	SOIL				COC CKD

Samplers: (Signature)	Relinquished by: (Signature) L.W. FORTENBERRY Louis Fortenberry	Date: 11/2/98 Time: 1130 Am	Received by: (Signature)	Date: Time:	Intact	
BUTLER SERVICES Affiliation	Relinquished by: (Signature)	Date: Time:	Received by: (Signature)	Date: Time:	Intact	
	Relinquished by: (Signature)	Date: Time:	Received by: (Signature)	Date: Time:	Intact	
SAMPLER REMARKS:			Received for laboratory: (Signature) C.K. Ingler	Date: 10/2/98 Time: 1130	Laboratory No.	
Seal #			Data Results to:			

MICRO-METHODS
LABORATORY, INC.

ANALYTICAL SERVICE COMPANY

October 23, 1998

Butler Services
P. O. Box 1164
Pascagoula, MS 39567

ATTN: Louis Fortenberry

REPORT OF ANALYSES

The results of the analyses of the samples received date and description as shown, lab file #288-BS-10-98, are as attached.

If we can be of further assistance, please contact the office.

Sincerely,

Thomas J. Wilson, Sr.

TJW/dd

encl.

TO: Butler Services

FROM: Micro-Methods, Inc.
Lab File #288-BS-10-98

GULFPORT FERTILIZER COMPANY
10/21/98
WATER SAMPLES

SAMPLE DESCRIPTION	MM#	ARSENIC µg/l	LEAD µg/l
RC1	68217	<5	<5
RC 4	68218	<5	<5
N 12	68219	<5	<5
N 14	68220	<5	<5
N 21	68221	<5	<5
N 24	68222	<5	<5
N 31	68223	<5	<5
N 34	68224	<5	<5
S 39	68225	16.7	8
S 51	68226	13	<5

METHODOLOGY
EPA 206.2-Furnace - Arsenic
EPA 239.2-Furnace - Lead

TO: Butler Services

FROM: Micro-Methods, Inc.
Lab File #288-BS-10-98

GULFPORT FERTILIZER COMPANY
10/21/98
SOIL SAMPLES

SAMPLE DESCRIPTION	MM#	ARSENIC mg/kg	LEAD mg/kg
S 51	68227	1.2	27.5
S 61	68228	1.5	2.6

METHODOLOGY
SW 846, 7060A-Furnace - Arsenic
SW 846, 7421-Furnace - Lead

BUTLER SERVICES

CHAIN OF CUSTODY RECORD

PROJ. NO Gulfport [illegible]	PROJECT NAME GFCo 98309					NO. OF CON-TAINERS								REMARKS
SAMPLERS: (Signature)														
STA. NO	DATE	TIME	COMP	GRAB	STATION LOCATION									
RC1	10/21	10am		X		1								
RC4	10/21	1015 am		X		1								Pb
N12	10/21	1030am		X		1								+ on all
N14	10/21	1045am		X		1								water As Samples
N21	10/21	1130am		X		1								
N24	10/21	1150am		X		1								
N31	10/21	1220pm		X		1								
N34	10/21	1245 pm		X		1								
S39	10/21	120pm		X		1								
S51	10/21	140pm		X		1								+
S51	10/21	210pm		X		[illegible]								Soil report completed
S61	10/21	230pm		X		1								Soil 10/23/98
														M. McCulloch

(S) South

Relinquished by: (Signature)	Date/Time 10/21/98 330pm	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Relinquished by: (Signature)	Date/Time	Received for Laboratory by: (Signature)	Date/Time 10/21/98 1530	Remarks:	

Covington & Associates Corporation

FILE COPY

RECEIVED
MAR 22 1999
DEQ-OPC

REPORT

PRIVILEGED AND CONFIDENTIAL

THIS REPORT HAS BEEN PREPARED UNDER CONTRACT WITH MR. ANDY ALFONSO OF HANCOCK BANK. ANY REUSE OR RELIANCE ON THIS REPORT WITHOUT THE EXPRESSED WRITTEN CONSENT OF COVINGTON AND ASSOCIATES CORPORATION IS PROHIBITED. USE OF THIS REPORT, ITS INFORMATION AND ITS CONCLUSIONS BY ANYONE OTHER THAN HANCOCK BANK IS WITHOUT LIABILITY TO COVINGTON AND ASSOCIATES CORPORATION.

Project # 06-175

PHASE II ENVIRONMENTAL SITE ASSESSMENT

CASE STUDY:
Former Gulfport Fertilizer Production Facility Gulfport, Mississippi

Prepared for
Mr. Andy Alfonso
Hancock Bank

March 2, 1999

Prepared by:
COVINGTON AND ASSOCIATES CORPORATION
Delivery Address: 112 Davis Avenue
Mailing Address: P. O. Box 177
Pass Christian, Mississippi 39571
(601) 452-4999
FAX: (601) 452-0117

Covington & Associates Corporation

March 2, 1999

Mr. Andy J. Alfonso, Jr.
Hancock Bank
P.O. Box 4019
Gulfport, Mississippi 39502

Re: **EXECUTIVE SUMMARY, Phase II Environmental Site Assessment**
Former Gulfport Fertilizer Company
Gulfport, Mississippi
Project #6175

Dear Mr. Alfonso:

Commencing on May 11, 1998, Covington & Associates Corporation (CAC) performed a limited Phase II Environmental Site Assessment (ESA) of the referenced facility. The Phase II ESA was conducted to evaluate the subject property for potential impacts to the soil and shallow groundwater that could have occurred as the result of previous superphosphate fertilizer and sulfuric acid production.

Site investigation activities and results of laboratory analyses of soil and groundwater samples indicated that elevated concentrations of arsenic and lead were detected in the soil, and elevated concentrations of lead were detected in the groundwater.

Corporate Office: P.O. Box 177 • 112 Davis Avenue • Pass Christian, Mississippi 39571 • Office: 228-452-4999 • FAX: 228-452-0117
Regional Office: Resource Consultants, Inc. • P.O. Box 1848 • Brentwood, Tennessee 37024-1848

Based on the elevated concentrations of arsenic and lead in the soil samples and the elevated concentrations of lead in the groundwater sample from MW-1, it is recommended that a meeting be arranged with the MDEQ prior to conducting additional testing in order to discuss site closure options and to minimize additional sampling costs.

The following REPORT represents the findings of the assessment in full. We appreciate this opportunity to be of continued professional service to Hancock Bank.

Respectfully submitted,

COVINGTON AND ASSOCIATES CORPORATION

Rimmer Covington, CPL/ESA
Principal

Alane C. Young, P.G.
Senior Consultant

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LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

On May 11, 1998 Covington and Associates Corporation (CAC) commenced a limited Phase II Environmental Site Assessment (ESA) of the former Gulfport Fertilizer Production Facility located in Gulfport, Mississippi. The Phase II ESA was conducted for Mr. Gary Yelvington, a potential purchaser of the property. The investigation sought to determine if contaminants had adversely impacted the soil and shallow groundwater on site due to previous site activities when a super phosphate fertilizer production facility operated on the property over an extended period (circa 1904 until circa 1960). Mr. Yelvington approved the Phase II ESA scope of work, which consisted of the excavation of nine trenches and the advancement of three Geoprobe borings.

Analytical results of the limited Phase II ESA indicated the presence of elevated concentrations of arsenic and lead in the near surface soils and elevated concentrations of chromium and lead in the groundwater. Therefore, by letter of May 29, 1998 to Mr. Andy Alfonso, Jr., of Hancock Bank (property owner), CAC proposed additional testing to determine the extent of the arsenic and lead contamination in the near surface soil and to install groundwater monitoring wells for additional groundwater sample collection and analysis.

The locations of all soil borings, monitoring wells and trenches conducted during the May and June, 1998 investigations are depicted on Figure 1, which is included in Appendix A.

This report outlines the methods employed during the field investigations and presents the results of the soil and groundwater laboratory analyses of the selected samples.

Three borings were advanced at the site on May 11 1998, by Great Lakes Geotechnical Services, Inc., of New Orleans, Louisiana, for the purpose of groundwater sample collection. Nine exploratory trenches were excavated on May 11, 1998 to collect soil samples, to visually inspect for evidence of dumping, and for subsurface strata delineation.

Additional exploratory trenching was conducted in an area where underground petroleum storage tank(s) were reported to have existed (immediately north of the "Brick Remains" as depicted on Figure 1). Exploratory trenching was also conducted in the southeastern portion of the property, where a tire and rubber manufacturing facility and a cottonseed oil refinery had previously been located (as described in CAC's Phase I Environmental Site Assessment dated June 12, 1995). No evidence of subsurface contamination was observed in the additional areas of exploratory trenching and therefore no soil samples were collected from those locations.

Soil and groundwater samples were shipped to the Resource Analytical Solutions (RAS) Laboratory in Brentwood, Tennessee for chemical analysis. The soil samples were analyzed for water soluble fluoride, distilled ammonia, and for the eight Resource Conservation and Recovery Act (RCRA) metals, because the presence of these constituents could indicate the presence of superphosphate fertilizer. In addition, two of the soil samples were randomly selected for analysis of Hazardous Substance List Volatiles (HSLV) and the Hazardous Substance List Semivolatiles (HSLS), and two soil samples were randomly selected for analysis of pesticides and polychlorinated biphenyls (PCBs). Groundwater samples were analyzed for sulfate, nitrogen-ammonia, fluoride, pH and for the eight RCRA metals, since these parameters could be indicative of superphosphate fertilizer production. In addition, one groundwater sample was randomly selected for analysis of Hazardous Substance List Volatiles (HSLV) and the Hazardous Substance List Semivolatiles (HSLS), and one groundwater sample was randomly selected for analysis of polynuclear aromatic hydrocarbons (PAHs) and PCBs. Results of the soil and groundwater laboratory analyses are summarized in Table 1 (page 15) and Table 2 (page 16), respectively.

During the second phase of testing, two groundwater monitoring wells were installed by Walker Hill Environmental, Inc. on June 2, 1998. Seventy-one soil samples were collected on June 3, 1998, using a post-hole digger and a rubber-tired backhoe. The wells were developed on June 2, 1998, and groundwater samples were collected from the monitoring wells on June 10, 1998. The soil and groundwater samples were shipped to the RAS Laboratory for chemical analysis. The soil samples were analyzed for arsenic and lead, and the groundwater samples were analyzed for chromium, lead and sulfate. Results of the soil and groundwater laboratory analyses are summarized in Table 3 (page 17) and Table 4 (page 19), respectively.

2.0 REVIEW OF SITE CHARACTERISTICS

2.1 Site Location & Setting

The subject property is located in the east half of the northwest quarter of Section 33, Township 7 South, Range 11 West, Harrison County (Gulfport), Mississippi. The subject property encompasses 33.06 acres, more or less, but this investigation focused on the northern portion of the property where superphosphate fertilizer and sulfuric acid were produced by Gulfport Fertilizer Company from circa 1904 until circa 1960.

2.2. Natural Features

2.2.1 Topographic Features

Physiographically, the site is astride one of the many coastwise, east/west, parallel trending buried beach ridges. Elevations at the site vary from slightly above +25 feet mean sea level near the center of the site to at or just below +25 feet mean sea level near the northern limit of the property.

Surface drainage off-site is sufficient and is generally to the north into a low wetlands area. There is some drainage to the southwest. Drainage from the northern wetlands is northwest via several drainage ditches into Turkey Creek; the drainage southward is via a collection ditch and eventually into the western extremities of Brickyard Bayou.

2.2.2 Geologic Features

Geologically, the site is located with a series of east-west trending beach ridges. Specifically, the site is astride a buried beach ridge that is part of the Gulfport ridge complex. As a result, there is variation of soil types due to drainage and modified hydrologic patterns. Soils at the site consist primarily of Harleston sandy loam which is well drained, exhibits moderate permeability, and slow runoff. Along the northern limits of the property, Plummer loamy sand is found. This is a hydric soil, poorly drained with very slow run-off. Along the west property line, Atmore silty loams are identified which are also hydric, poorly drained and exhibit slow runoff. In addition, there is a zone, located southwest of the previous location of the phosphate rock processing building, which appears to be wetlands.

Subsurface soils encountered during trenching and boring operations conducted on May 11, June 2 and June 3, 1998 consisted of one to three feet of fill (which included bricks, brick fragments, concrete, and coal), underlain by silty fine sand with varying amounts of clay. A white well-sorted fine to medium sand was encountered at a depth of ten to twelve feet below ground surface (BGS).

3.0 FIELD INVESTIGATION ACTIVITIES

3.1 General

The purpose of this investigation was to determine if contaminants had adversely impacted the soil and shallow groundwater on site due to previous site activities when a super phosphate fertilizer production facility operated on the referenced property over an extended period.

3.2 Field Investigation and Sampling Methodology

3.2.1 May 1998 Investigation

On May 11, 1998, three soil borings and nine exploratory trenches were conducted on site. Boring and trenching locations are shown on Figure 1 (Appendix A)

The three borings (B-1 through B-3) were advanced at selected locations across the site to collect groundwater samples for chemical analysis. The borings were drilled using a 1-1/2 inch core barrel that was hydraulically pushed into the ground by use of a Terraprobe mobile coring unit. The closed piston borings were terminated at 12.0 feet BGS. A registered professional geologist determined soil boring depths based on subsurface conditions at each boring location.

Groundwater samples were collected from each of the three borings by use of a Terraprobe 2-foot stainless steel slotted screen sampler, lowered into the borings at the 10.0 to 12.0-foot interval, where formation permeability was sufficient to provide an adequate volume of groundwater for sample collection. The sampler was purged until the water cleared. After recovery, groundwater samples were collected by use of a peristaltic pump and a small-diameter bailer. The groundwater samples were transferred into properly labeled, laboratory-prepared containers, placed on ice, and shipped to RAS Laboratories following strict chain of custody (COC) protocol.

Nine exploratory trenches were excavated by use of a rubber-tired backhoe to collect soil samples for chemical analysis, to visually inspect for evidence of dumping, and for subsurface strata delineation. The depths of the trenches were determined based on the thickness of the fill encountered. Fill thickness ranged from approximately 1.0 feet to 3.0 feet. The trenches were terminated at approximately 3.0 feet BGS. Groundwater was encountered at depths of approximately 3.0 feet BGS in the exploratory trenches.

Soil samples were collected from the exploratory trenches by a registered professional geologist. The soil samples were field-screened for the presence of total volatile organic compounds (VOCs) using an HNU photoionization detector (Datalogger 101) calibrated to a benzene reference, and headspace screening techniques. No concentrations of total VOCs were detected in the soil samples. One soil sample from each of the nine exploratory trenches was retained for chemical analysis. The soil samples were properly labeled, placed on ice, and shipped to RAS Laboratories following strict COC protocol.

Additional exploratory trenching was conducted in an area where underground petroleum storage tanks (USTs) were reported to have existed. No USTs were discovered; however, a remnant of what appeared to be a product line was discovered in the trench. There was no visual evidence of hydrocarbon-stained soil and no unusual odors were detected.

In general, subsurface soils encountered at the site during subsurface boring and trenching operations conducted on May 11, 1998 consisted of up to three feet of fill underlain by silty fine sand with varying amounts of clay. Bricks, brick fragments, coal, and concrete were included in the fill material. White, well-sorted fine to medium-grained sand was encountered at a depth of 10.0 to 12.0 feet BGS in the soil borings.

3.2.2 June 1998 Investigation

On June 2, 1998 two groundwater monitoring wells were installed at the subject site. Walker Hill Environmental, Inc. of Columbia, Mississippi was subcontracted for drilling services including soil borings and monitoring well installations. Each soil boring location was probed with a posthole digger to a minimum depth of two feet BGS prior to drilling with the drilling unit in order to ensure that no shallow subsurface utilities were encountered. The drilling subcontractor used a B-57 hydraulically-driven, truck-mounted drilling unit with a 10 5/8 -inch outside diameter (O.D.) by 8.75-inch inside diameter (I.D.) continuous flight hollow-stem auger system to perform the soil borings. All augers, drill stems, rods, tools and associated equipment was steam-cleaned and wire-brushed before being brought on site, and steam cleaned on site between boreholes.

Groundwater was encountered at depths of approximately 5.0 feet BGS during drilling operations. Two groundwater monitoring wells were installed, constructed of 4-inch schedule 40 PVC with 0.010-inch factory slotted screen openings and threaded flush joints. PVC plugs were threaded onto the bottom of each well screen to prevent the intrusion of filter material, and threaded locking caps were placed on the well pipe openings at the surface.

Monitoring well MW-1 was installed at a depth of 11.5 feet BGS, with the screen set from 11.5 feet to 1.5 foot BGS. The 3.3-inch annular space between the monitoring well and the borehole wall was backfilled with clean 20/40 sand to a depth of 1 feet BGS. A 0.8-foot thick seal of bentonite pellets was immediately placed above the filter pack in the monitoring well and packed into place. The remainder of the annular space in the well was grouted to land surface with a grout mixture composed of 95% portland cement and 5% bentonite by weight.

Monitoring well MW-2 was installed at depths of 12 feet BGS, with a 10-foot section of screen from 12 feet to 2 feet BGS. The 3.3-inch annular space between the monitoring well and the borehole walls was backfilled with a clean 20/40 sand to a depth of 1.0 feet BGS. A one-foot thick seal of bentonite pellets was immediately placed above the filter pack in the monitoring well and packed into place. The remainder of the annular space in the well was grouted to land surface with a grout mixture composed of 95% portland cement and 5% bentonite by weight. Monitor well construction details are provided in Appendix B.

Walker Hill Environmental, Inc. developed the monitoring wells on June 3, 1998. Development was achieved by use of a bladder pump until the discharged water was observed to be clear.

On June 3, 1998, seventy-one shallow (1 feet to 3 feet below ground surface) soil samples were collected by use of a post-hole digger and by use of a rubber tired backhoe. The soil samples were properly labeled, placed on ice, and shipped to RAS Laboratories following strict COC protocol.

3.2.3 Groundwater Sampling Methodology

The two monitoring wells were sampled on June 10, 1998. Prior to sampling, groundwater levels were measured and recorded. Depth to groundwater ranged from 4.4 feet BGS (MW-1) to 4.9 feet BGS (MW-2), so the groundwater intersected the screened interval of all the monitoring wells. A peristaltic pump was used to purge each monitoring well by removing a volume of water equal to five well volumes (MW-1) and a volume of water equal to 4.3 well volumes (MW-2). Well sampling field data sheets are enclosed in Appendix C.

After purging, groundwater samples were collected from monitoring wells MW-1 and

MW-2 by use of a peristaltic pump on June 10, 1998. The samples were obtained directly from the pump discharge into laboratory-prepared containers for analysis of chromium, lead and sulfates. The containers were properly labeled, placed on ice, and shipped to RAS Laboratory following strict COC protocol. Results of the chemical analyses are discussed in Section 6.0 and are illustrated in Figure 1 of Appendix A. The laboratory reports are enclosed as Appendix C.

4.0 QA/QC PROCEDURES

4.1 Field Sampling Procedures

The sampling equipment was decontaminated prior to the commencement of drilling activities, between each sample, and before each boring. Prior to sample collection, all sampling equipment was decontaminated by washing with laboratory grade detergent (liquinox) and tap water, by rinsing several times with distilled water, by then rinsing with a solvent (iso-propanol), and by then allowing the sampling equipment to air dry. During sample collection, sampling personnel wore clean, disposable latex gloves to transfer the sample to the appropriate, pre-labeled sample container. A new pair of gloves was used at each sampling point. Soil samples were immediately placed into appropriate containers. The groundwater samples were immediately placed into laboratory prepared containers. All samples collected were then transferred to a cooler with ice to maintain 4°C (when required). The container labels contained all of the necessary information regarding the sample, as prescribed in SW-846, Test Methods for Evaluating Solid Waste, Physical/Chemical Test Methods, 3rd Edition (USEPA 1986). Collection of a sample initiated the Chain of Custody process. The completed chain of custody forms included information regarding the sample type, sampling location, date and time of collection, type of container, preservative, and the name of the person who collected the sample. The samples were immediately shipped to RAS Laboratory for chemical analysis. Chain of Custody forms for all collected samples are included in Appendix C.

4.2 Laboratory Procedures

Only approved EPA analytical procedures were employed for sample analysis. Analytical methods and corresponding quality assurance objectives were achieved using SW-846, Test Methods for Evaluating Solid Waste, Third Edition. Methods 9038 (Sulfate); 9040B (pH in groundwater); 350.3 (Nitrogen-Ammonia); 350.2 (Distilled Ammonia); 340.2 (Fluoride); 7471and 7470A (Mercury); 6010 (arsenic, barium, cadmium, chromium, lead, selenium, and silver); 8081 (pesticides and PCBs); 8260 (HSLV); and 8270 (HSLS and PAH).

RAS Laboratory quality control checks include, but are not limited to the following: calibration procedures and frequency; data evaluation and documentation: preventative maintenance on instrumentation; procedures for assessing data precision, accuracy and completeness; and data reduction, validation, and reporting.

A summarization of the analytical data is presented in Table 1, Table 2, Table 3 and Table 4.

5.0 ANALYTICAL RESULTS

Laboratory analytical results of the soil and groundwater samples are included in Appendix C. A summarization of the analytical data is presented below in Table 1.Table 2, Table 3 and Table 4.

Table 1
Summary of Analytical Data
Soil Samples Collected May 11, 1998
Former Gulfport Fertilizer Production Facility
Gulfport, Mississippi
Project #06-175

Sample I.D.	Sample Depth and Date	Fluoride (mg/kg)	Ammonia (mg/kg)	RCRA metals mg/kg (detected analytes only)	
T-1	2' (5/11/98)	26	16	**Arsenic: 1.2** Barium: 91 Chromium: 2 Lead: 20	HSLV/HSLS Not Detected
T-2	2.5' (5/11/98)	10	Not Detected	Barium: 5 Chromium: 3 Lead: 1	
T-3	1.6' (5/11/98)	78	10	**Arsenic: 1.5** Barium: 10 Chromium: 5 Lead: 2	
T-4	2.5' (5/11/98)	Not Detected	Not Detected	**Arsenic: 20.9** Barium: 286 Chromium: 1 Lead: 207 Silver: 0.8	
T-5	3' (5/11/98)	Not Detected	Not Detected	**Arsenic: 108** Barium: 20 Chromium: 2 Lead: 135 Silver: 0.6	Pesticides/PCBs Not Detected
T-6	1.5' (5/11/98)	Not Detected	52	**Arsenic: 17.9** Barium: 15 Chromium: 1 Lead: 172	HSLV/HSLS Not Detected
T-7	1' (5/11/98)	44	16	**Arsenic: 14.6** Barium: 111 Chromium: 22 Lead: 50	
T-8	2.5' (5/11/98)	5	18	Barium: 3 Chromium: 1 Lead: 1	
T-9	1' (5/11/98)	12	150	**Arsenic: 87** Barium: 21 Cadmium: 0.8 Chromium: 6 **Lead: 927** Silver: 11.7	Pesticides/PCBs Not Detected

HSLVs - Hazardous Substance List Volatiles; HSLSs - Hazardous Substance List Semivolatiles PCBs – Polychlorinated biphenyls
Bold lettering indicates concentrations exceeding MDEQ regulatory levels of 400 mg/kg (Lead) and 0.426 mg/kg (Arsenic)

Table 2
Summary of Analytical Data
Groundwater Samples Collected May 11, 1998
Abandoned Gulfport Fertilizer Production Facility
Gulfport, Mississippi
Project #06-175

Sample I.D.	Sulfate (mg/L)	Nitrogen-Ammonia (mg/L)	Fluoride (mg/L)	pH (S.U.)	RCRA metals (mg/L)		
B-1	37	0.17	0.12	6.1	Arsenic (0.026) Barium (0.03) Cadmium (0.0007) Chromium (0.011) Lead (0.004 mg/L)	PAHs ND	Pesticides/ PCBs ND
B-2	*398*	2.06	0.96	3.6	Arsenic (0.029) Barium (0.05) Cadmium (0.0015) Chromium (0.065) **Lead (0.016 mg/L)** Selenium (0.007)	HSLV Benzene (0.002 mg/L) EthylBenzene (0.002 mg/L) Toluene (0.007 mg/L) Total Xylenes (0.008 mg/L)	HSLS ND
B-3	*257*	1.06	ND	1.8	Arsenic (0.031) Barium (0.05) Chromium (0.107) **Lead (0.031 mg/L)** Selenium (0.013)		

ND= Not Detected
HSLV - Hazardous Substance List Volatiles
HSLS - Hazardous Substance List Semivolatiles
PAH – Polynuclear Aromatic Hydrocarbons

Bold lettering indicates concentrations exceeding MDEQ regulatory levels of 0.015 mg/L (Lead) and 0.05 mg/L (Arsenic)

Italicized lettering indicates concentrations exceeding Secondary Drinking Water Standards of 250 mg/L for Sulfate. Secondary drinking water standards are unenforceable federal guidelines regarding the taste, odor, color and certain other non-aesthetic effects of drinking water. Federal law does not require water systems to comply with them.

Table 3
Summary of Analytical Data
Soil Samples Collected June 3, 1998
Former Gulfport Fertilizer Production Facility
Gulfport, Mississippi
Project #06-175

Sample I.D.	Sample Depth And Date	Arsenic (mg/kg)	Lead (mg/kg)
North End Background	2' (6/3/98)	**14.6**	295
South End Background	2.5' (6/3/98)	**1.3**	**8**
Test Pit 4	2.5'-3.5'(6/3/98)	**52.8**	**1680**
T-4 50' N	1'- 2' (6/3/98)	**240**	**2810**
T-4 100' N	1'- 2' (6/3/98)	**16**	13
T-4 50' E	1'- 2' (6/3/98)	**30.4**	**2580**
T-4 100' E	1'- 2' (6/3/98)	**132**	**6260**
T-4 50' S	1'- 2' (6/3/98)	**56.2**	**11000**
T-4 100' S	1'- 2' (6/3/98)	**22.5**	**722**
T-4 50' W	1'- 2' (6/3/98)	**274**	**784**
T-4 100' W	1'- 2' (6/3/98)	**28.4**	**3500**
Test Pit 5	3'- 5' (6/3/98)	**309**	**5170**
T-5 50' N	1'- 2' (6/3/98)	**1310**	**4070**
T-5 100' N	1'- 2' (6/3/98)	**19.9**	389
T-5 50' E	1'- 2' (6/3/98)	**18.6**	74
T-5 100' E	1'- 2' (6/3/98)	**87.3**	**1150**
T-5 50' S	1'- 2' (6/3/98)	**326**	**4980**
T-5 100' S	1'- 2' (6/3/98)	**58**	**546**
T-5 50' W	1'- 2' (6/3/98)	**21.3**	**3270**
T-5 100' W	1'- 2' (6/3/98)	**46.6**	**631**
Test Pit 6	2'- 3' (6/3/98)	**14.8**	127
T-6 50' N	1'- 2' (6/3/98)	**60.3**	147
T-6 100' N	1'- 2' (6/3/98)	**147**	**665**
T-6 50' E	1'- 2' (6/3/98)	**5.6**	48
T-6 100' E	1'- 2' (6/3/98)	**5.3**	33
T-6 50' S	1'- 2' (6/3/98)	**69.7**	68
T-6 100' S	1'- 2' (6/3/98)	**18.1**	89
T-6 50' W	1'- 2' (6/3/98)	**206**	**613**
T-6 100' W	1'- 2' (6/3/98)	**83.7**	62

Bold lettering indicates concentrations exceeding MDEQ regulatory levels of 400 mg/kg (Lead) and 0.426 mg/kg (Arsenic)

Table 3 (continued)

Sample I.D.	Sample Depth And Date	Arsenic (mg/kg)	Lead (mg/kg)
Test Pit 7	2'- 3' (6/3/98)	**49.5**	**1640**
T-7 50' N	1'- 2' (6/3/98)	**27.1**	185
T-7 100' N	1'- 2' (6/3/98)	**63.3**	**2960**
T-7 50' E	1'- 2' (6/3/98)	**14.1**	66
T-7 100' E	1'- 2' (6/3/98)	**198**	**1470**
T-7 50' S	1'- 2' (6/3/98)	**6.6**	38
T-7 100' S	1'- 2' (6/3/98)	**10.6**	69
T-7 50' W	1'- 2' (6/3/98)	**77.7**	**474**
T-7 100' W	1'- 2' (6/3/98)	**32.5**	371
Test Pit 9	2' – 3' (6/3/98)	**104**	**1890**
T-9 50' N	1'- 2'(6/3/98)	**15.4**	101
T-9 100' N	1'- 2'(6/3/98)	**3.2**	11
T-9 50'E	1'- 2'(6/3/98)	**58.1**	**925**
T-9 100'E	1'- 2'(6/3/98)	**23.7**	387
T-9 50' S	1'- 2'(6/3/98)	**20.0**	**424**
T-9 100' S	1'- 2' (6/3/98)	**15.5**	105
T-9 50' W	1'- 2'(6/3/98)	**10.8**	130
T-9 100' W	1'- 2'(6/3/98)	**172**	**2880**
P-1	1'- 2' (6/3/98)	**4.2**	10
P-2	1'- 2' (6/3/98)	**10.5**	54
P-3	1'- 2' (6/3/98)	**11.3**	143
P-4	1'- 2' (6/3/98)	**11.6**	59
P-5	1'- 2' (6/3/98)	**6.2**	49
P-6	1'- 2' (6/3/98)	**1.4**	6
P-7	1'- 2' (6/3/98)	**2.7**	8
P-8	1'- 2' (6/3/98)	**7.7**	7
P-9	1'- 2' (6/3/98)	**10.3**	5
P-10	1'- 2' (6/3/98)	**1.8**	7
P-11	1'- 2' (6/3/98)	**26.4**	10
P-12	1'- 2' (6/3/98)	**24.6**	296
P-13	1'- 2' (6/3/98)	**2.3**	59
P-14	1'- 2' (6/3/98)	**10.4**	47
P-15	1'- 2' (6/3/98)	**121**	111
P-16	1'- 2' (6/3/98)	**3.8**	15
P-17	1'- 2' (6/3/98)	**1.6**	7
P-18	1'- 2' (6/3/98)	**6.4**	40
P-19	1'- 2' (6/3/98)	**0.8**	6
P-20	1'- 2' (6/3/98)	**3.4**	13
P-21	1'- 2' (6/3/98)	**55.9**	**495**
P-22	1'- 2' (6/3/98)	**2.9**	27
P-23	1'- 2' (6/3/98)	**8.4**	37
P-24	1'- 2' (6/3/98)	**84.0**	**714**

Bold lettering indicates concentrations exceeding MDEQ regulatory levels of 400 mg/kg (Lead) and 0.426 mg/kg (Arsenic)

Table 4
Summary of Analytical Data
Groundwater Samples Collected June 10, 1998
Abandoned Gulfport Fertilizer Production Facility
Gulfport, Mississippi
Project #06-175

Sample I.D.	Field pH	Sulfate	Chromium (mg/L)	Lead (mg/L)
MW-1	3.48 – 3.65	*561*	0.014	**1.94**
MW-2	5.42 – 5.46	*600*	ND	0.002

ND= Not Detected
Bold lettering indicates concentrations exceeding MDEQ regulatory levels of 0.015 mg/L (Lead) and 0.05 mg/L (Arsenic)
Italicized lettering indicates concentrations exceeding Secondary Drinking Water Standards of 250 mg/L for Sulfate. Secondary drinking water standards are unenforceable federal guidelines regarding the taste, odor, color and certain other non-aesthetic effects of drinking water. Federal law does not require water systems to comply with them.

6.0 CONCLUSIONS AND RECOMMENDATIONS

This report constitutes the findings and conclusions of the Phase II environmental site investigation completed on the former Gulfport Fertilizer Company property, Gulfport, Mississippi. This Phase II ESA was commenced on May 11, 1998 by CAC to determine if contaminants had adversely impacted the soil and shallow groundwater on site due to previous superphospate and sulfuric acid production on the property.

Based on the elevated concentrations of arsenic and lead in the soil samples and the elevated concentrations of lead in the groundwater sample from MW-1, a Phase III Environmental Site Assessment (consisting of additional soil and groundwater sampling) will likely be required to delineate the degree and extent of metals contamination on site. However, it is recommended that a meeting be arranged with the MDEQ prior to conducting additional testing in order to discuss site closure options and to minimize additional sampling costs. It is also be recommended that a higher clean-up level for arsenic be proposed, based on the high concentrations of arsenic which are believed to be naturally occurring on site, due to the concentration of arsenic found in the background soil samples taken at the north and south end of the property.

7.0 LIMITATION OF LIABILITY

Th first phase of this investigation was authorized by Mr. Gary Yelvington and the second phase of the investigation was authorized by Mr. Andy Alfonso of Hancock Bank. This report has been prepared solely for the use by Mr. Andy Alfonso (the Client) and may not be used by other parties for purposes of satisfying the requirements of an environmental site assessment or other purposes without first obtaining the expressed written consent of Covington And Associates Corporation and partner Resource Consultants, Inc/Dames and Moore. (the Consultant). The Consultant shall bear no liability for any unauthorized used of the information contained in this report. Regulatory action levels reviewed for this report include current RCRA corrective action levels, Mississippi Department of Environmental Quality regulatory action levels, Safe Drinking Water Act Standards and National Primary Drinking Water Standards. In the event that new information not contained in this report is obtained relating to environmental or hazardous waste issues at the site or nearby, such information shall be brought to the consultant's attention promptly and we may, upon evaluation, modify the conclusions stated in this report. The evaluations, analyses and recommendations contained in this report represent the consultant's professional opinions and judgments based on the current, generally accepted engineering, geologic and technical practices for the nature and scope of this site inspection authorized by the client. The consultant has not conducted a geophysical survey to confirm or refute the potential presence of any subsurface structures. This investigation is based on conditions observed on May 11, June 2 and June 3, 1998, and on the laboratory analytical results of soil and groundwater results collected on those dates, as well as records review as described herein or the selections of any information deemed appropriate by the consultant's representatives at the time of the site inspection whether stated in previous or subsequent sections of this report or not. The findings of this investigation are based on existing conditions at the site and surrounding areas at the time of our inspection. Work described in this report was limited in its scope and coverage due to conditions imposed by the client. Limited visual observations and conclusions were possible to only those areas reasonably accessible. Access was not available to conduct interviews with the previous property owners/tenants and maintenance personnel. It was not always possible to obtain specific information on the normal practices of property owners and/or their tenants with regard to solid waste disposal, on-site use, generation, storage and/or disposal of chemicals or oil and hazardous materials, and any privately obtained environmental monitoring data for the property, except where provided to the consultant by the client. Additionally, the consultant has relied on information provided by various officials and other parties as referenced herein. Although believed to be accurate, the consultant has not attempted to independently verify the accuracy or completeness of information provided by officials and other parties, which was received or reviewed during the course of completing these services. The findings presented in the report were based solely upon the services described in Covington & Associates Corporation's Phase II ESA scopes of work dated March 30, 1998 and May 29, 1998, and not on tasks or procedures beyond the scope of the described services. No other warranty, expressed or implied, is made. The information contained in this investigation is not intended to be all-inclusive or to identify all potential concerns associated with the site investigation. It should be noted that any investigation cannot determine that a site is completely free of chemicals or toxic substances. Therefore, this investigation cannot certify that the site is "absolutely clean." This investigation is made to provide information to the client concerning conditions at the site. This report was prepared exclusively for the use of the client.

APPENDIX "A"

Figures

APPENDIX "B"

Monitoring Well Construction Reports

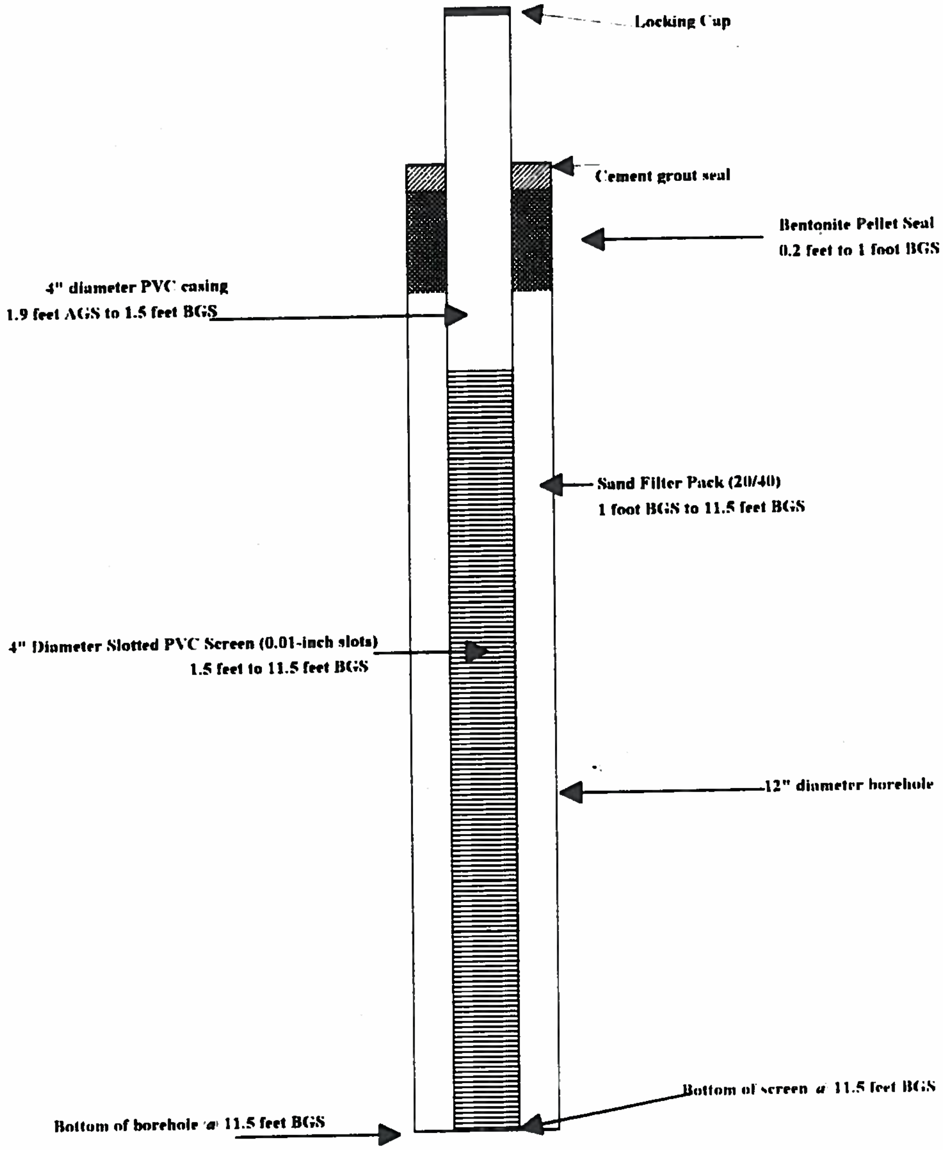
Well Construction Diagram
Former Gulfport Fertilizer Company
Gulfport, Mississippi

Logged by: ACY
Start Date: 6/2/98
Completion Date: 6/2/98
Location: Former Gulfport Fertilizer Co. Site

Rig Type: H.S.A. B-57
Boring Type: 10.6-inch hollow stem auger
Hammer Wt/Drop: N/A

Surface Elevation: N/A
Casing Elevation: N/A
Refusal Depth: N/A

WELL CONSTRUCTION



Not To Scale

WELL CONSTRUCTION DIAGRAM
Former Gulfport Fertilizer Company

CAC PROJECT NO. 6175

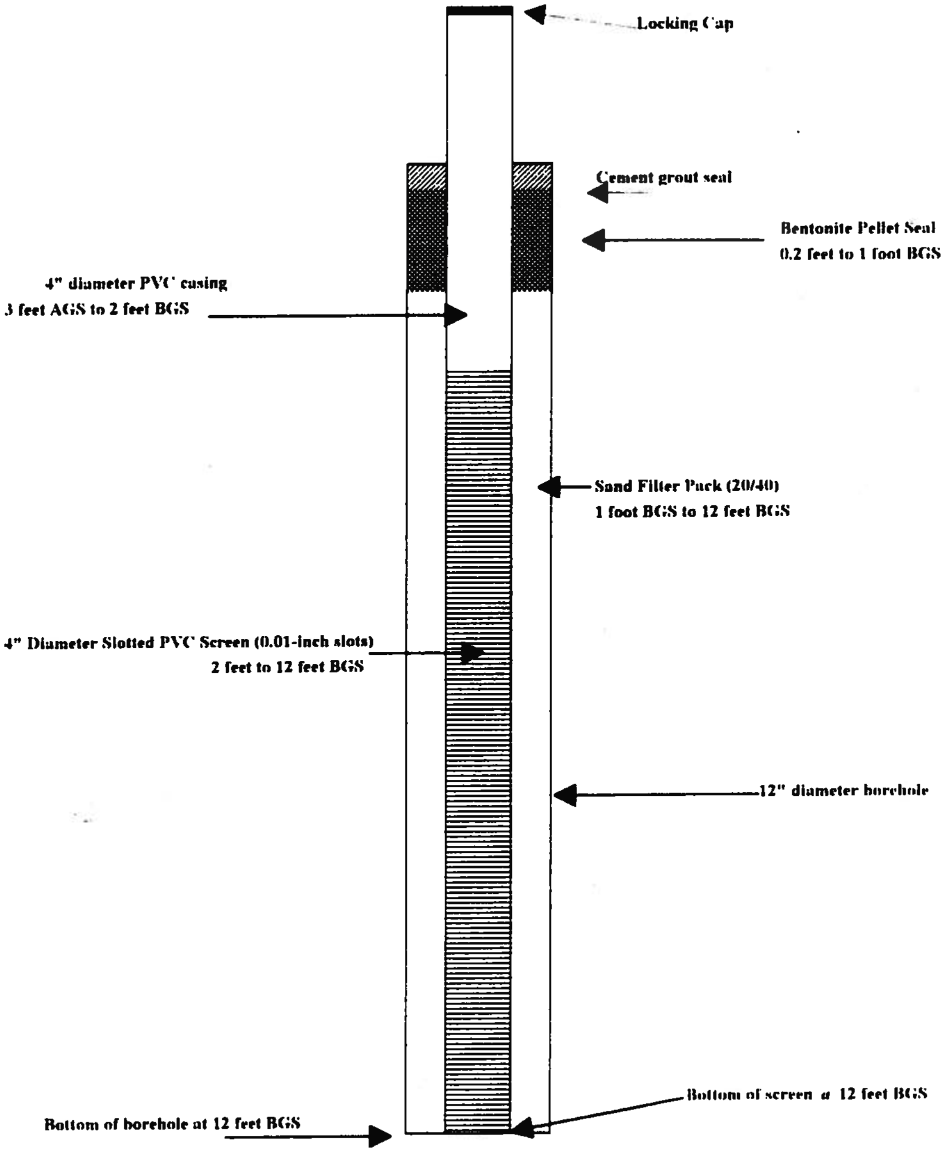
Well MW-1

Sheet 1 of 1
Figure 1

Well Construction Diagram
Former Gulfport Fertilizer Company
Gulfport, Mississippi

Logged by: ACY	**Rig Type:** H.S.A. B-57	**Surface Elevation:** N/A
Start Date: 6/2/98	**Boring Type:** 10.6-inch hollow stem auger	**Casing Elevation:** N/A
Completion Date: 6/2/98	**Hammer Wt/Drop:** N/A	**Refusal Depth:** N/A
Location: Former Gulfport Fertilizer Co. Site		

WELL CONSTRUCTION



Not To Scale

	WELL CONSTRUCTION DIAGRAM **Former Gulfport Fertilizer Company** **CAC PROJECT NO. 6175**	**Well MW-2** Sheet 1 of 1 Figure 1

APPENDIX "C"

Laboratory Report Sheets

Resource Analytical Solutions™
Environmental Laboratory Services
7121 CROSSROADS Blvd BRENTWOOD, TN 37027 • TEL (615) 373-5040 • 1(800) 272 2573 • Fax (615) 370-1026 • P O Box 1848 BRENTWOOD TN 37024-1848 • EMERGENCY Pgr (615) 726

ANALYTICAL REPORT

28-MAY-1998

Mr. Rimmer Covington
Covington & Associates
112 Davis Avenue
Pass Christian, MS 39571

Sample Description: Groundwater Grab
Client ID: B-1
Site/Plant :
Date Collected: 11-MAY-98 16:20
Date Received: 13-MAY-98 14:54
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7247-1

Parameter	Method	Units	RDL	Result	Analyzed	Analyst
Sulfate	9038	mg/l	1.	37.	18-MAY-98	CSG
Nitrogen-Ammonia	350.3	mg/l	0.10	0.17	15-MAY-98	KLC
Fluoride	340.2	mg/l	0.10	0.12	14-MAY-98	KLC
pH	9040B	pH		6.1	15-MAY-98	JPH
Mercury - Total	7470A	mg/l	0.0002	ND	18-MAY-98	JPH
Arsenic - Total	6010	mg/l	0.005	0.026	18-MAY-98	CSG
Barium - Total	6010	mg/l	0.01	0.03	18-MAY-98	CSG
Cadmium - Total	6010	mg/l	0.0005	0.0007	18-MAY-98	CSG
Chromium - Total	6010	mg/l	0.002	0.011	18-MAY-98	CSG
Lead - Total	6010	mg/l	0.002	0.004	18-MAY-98	CSG
Selenium - Total	6010	mg/l	0.005	ND	18-MAY-98	CSG
Silver - Total	6010	mg/l	0.001	ND	18-MAY-98	CSG
Polyaromatic Hydrocarbons						
Anthracene	8270	mg/l	0.001	ND	15-MAY-98	EDD
Acenaphthene	8270	mg/l	0.001	ND	15-MAY-98	EDD
Acenaphthylene	8270	mg/l	0.001	ND	15-MAY-98	EDD
Benzo(a)anthracene	8270	mg/l	0.001	ND	15-MAY-98	EDD
Benzo(a)pyrene	8270	mg/l	0.001	ND	15-MAY-98	EDD
Benzo(b)fluoranthene	8270	mg/l	0.001	ND	15-MAY-98	EDD
Benzo(ghi)perylene	8270	mg/l	0.001	ND	15-MAY-98	EDD
Benzo(k)fluoranthene	8270	mg/l	0.001	ND	15-MAY-98	EDD
Chrysene	8270	mg/l	0.001	ND	15-MAY-98	EDD
Dibenz(a,h)Anthracene	8270	mg/l	0.001	ND	15-MAY-98	EDD
Fluoranthene	8270	mg/l	0.001	ND	15-MAY-98	EDD
Fluorene	8270	mg/l	0.001	ND	15-MAY-98	EDD
Indeno(1,2,3-cd)pyrene	8270	mg/l	0.001	ND	15-MAY-98	EDD
Naphthalene	8270	mg/l	0.001	ND	15-MAY-98	EDD
Phenanthrene	8270	mg/l	0.001	ND	15-MAY-98	EDD
Pyrene	8270	mg/l	0.001	ND	15-MAY-98	EDD
Pesticides/PCBs						
Aldrin	8081	mg/l	0.00005	ND	26-MAY-98	WGM
alpha-BHC	8081	mg/l	0.00005	ND	26-MAY-98	WGM
beta-BHC	8081	mg/l	0.00005	ND	26-MAY-98	WGM
delta-BHC	8081	mg/l	0.00005	ND	26-MAY-98	WGM

ND-Not Detected
RDL-Reported Detection Limit

Peter Ciarleglio
Peter Ciarleglio, M.S., Q.A. Officer

[illegible]47-1 (PESTICIDES) - This test was requested out of the extraction holding time.

Resource Analytical Solutions™
Environmental Laboratory Services

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ANALYTICAL REPORT

28-MAY-1998

r. Rimmer Covington
ovington & Associates
12 Davis Avenue
ass Christian, MS 39571

Sample Description: Groundwater Grab
Client ID: B-1
Site/Plant :
Date Collected: 11-MAY-98 16:20
Date Received: 13-MAY-98 14:54
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7247-1

arameter	Method	Units	RDL	Result	Analyzed	Analyst
gamma-BHC (Lindane)	8081	mg/l	0.00005	ND	26-MAY-98	WGM
Chlordane	8081	mg/l	0.00005	ND	26-MAY-98	WGM
4,4'-DDD	8081	mg/l	0.0001	ND	26-MAY-98	WGM
4,4'-DDE	8081	mg/l	0.0001	ND	26-MAY-98	WGM
4,4'-DDT	8081	mg/l	0.0001	ND	26-MAY-98	WGM
Dieldrin	8081	mg/l	0.0001	ND	26-MAY-98	WGM
Endosulfan I	8081	mg/l	0.00005	ND	26-MAY-98	WGM
Endosulfan II	8081	mg/l	0.0001	ND	26-MAY-98	WGM
Endosulfan Sulfate	8081	mg/l	0.0001	ND	26-MAY-98	WGM
Endrin	8081	mg/l	0.0001	ND	26-MAY-98	WGM
Endrin Aldehyde	8081	mg/l	0.0001	ND	26-MAY-98	WGM
Heptachlor	8081	mg/l	0.00005	ND	26-MAY-98	WGM
Heptachlor Epoxide	8081	mg/l	0.00005	ND	26-MAY-98	WGM
Methoxychlor	8081	mg/l	0.0001	ND	26-MAY-98	WGM
Toxaphene	8081	mg/l	0.0005	ND	26-MAY-98	WGM
PCB 1016	8081	mg/l	0.0005	ND	26-MAY-98	WGM
PCB 1221	8081	mg/l	0.0005	ND	26-MAY-98	WGM
PCB 1232	8081	mg/l	0.0005	ND	26-MAY-98	WGM
PCB 1242	8081	mg/l	0.0005	ND	26-MAY-98	WGM
PCB 1248	8081	mg/l	0.0005	ND	26-MAY-98	WGM
PCB 1254	8081	mg/l	0.0005	ND	26-MAY-98	WGM
PCB 1260	8081	mg/l	0.0005	ND	26-MAY-98	WGM

Not Detected
-Reported Detection Limit

Pete Ciarleglio
Peter Ciarleglio, M.S., Q.A. Officer

47-1 (PESTICIDES) - This test was requested out of the extraction holding time.

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ANALYTICAL REPORT

27-MAY-1998

r. Rimmer Covington
ovington & Associates
12 Davis Avenue
ass Christian, MS 39571

Sample Description: Groundwater Grab
Client ID: B-2
Site/Plant :
Date Collected: 11-MAY-98 16:20
Date Received: 13-MAY-98 14:54
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7247-12

arameter	Method	Units	RDL	Result	Analyzed	Analyst
Sulfate	9038	mg/l	1.	398.	18-MAY-98	CSG
Nitrogen-Ammonia	350.3	mg/l	0.10	2.06	15-MAY-98	KLC
Fluoride	340.2	mg/l	0.10	0.96	14-MAY-98	KLC
pH	9040B	pH		3.6	15-MAY-98	JPH
Mercury - Total	7470A	mg/l	0.0002	ND	18-MAY-98	JPH
rsenic - Total	6010	mg/l	0.005	0.029	18-MAY-98	CSG
arium - Total	6010	mg/l	0.01	0.05	18-MAY-98	CSG
Cadmium - Total	6010	mg/l	0.0005	0.0015	18-MAY-98	CSG
Chromium - Total	6010	mg/l	0.002	0.065	18-MAY-98	CSG
Lead - Total	6010	mg/l	0.002	0.016	18-MAY-98	CSG
Selenium - Total	6010	mg/l	0.005	0.007	18-MAY-98	CSG
Silver - Total	6010	mg/l	0.001	ND	18-MAY-98	CSG
L Volatiles						
Acetone	8260	mg/l	0.01	ND	19-MAY-98	KFS
Benzene	8260	mg/l	0.001	0.002	19-MAY-98	KFS
Bromodichloromethane	8260	mg/l	0.001	ND	19-MAY-98	KFS
Bromoform	8260	mg/l	0.001	ND	19-MAY-98	KFS
arbon Disulfide	8260	mg/l	0.001	ND	19-MAY-98	KFS
arbon Tetrachloride	8260	mg/l	0.001	ND	19-MAY-98	KFS
hlorobenzene	8260	mg/l	0.001	ND	19-MAY-98	KFS
2-Chloroethylvinyl ether	8260	mg/l	0.001	ND	19-MAY-98	KFS
hloroethane	8260	mg/l	0.001	ND	19-MAY-98	KFS
hloroform	8260	mg/l	0.001	ND	19-MAY-98	KFS
ibromochloromethane	8260	mg/l	0.001	ND	19-MAY-98	KFS
,1-Dichloroethane	8260	mg/l	0.001	ND	19-MAY-98	KFS
,1-Dichloroethene	8260	mg/l	0.001	ND	19-MAY-98	KFS
,2- Dichloroethane	8260	mg/l	0.001	ND	19-MAY-98	KFS
,2-Dichloropropane	8260	mg/l	0.001	ND	19-MAY-98	KFS
is-1,2-Dichloroethene	8260	mg/l	0.001	ND	19-MAY-98	KFS
rans-1,2-Dichloroethene	8260	mg/l	0.001	ND	19-MAY-98	KFS
is-1,3-Dichloropropene	8260	mg/l	0.001	ND	19-MAY-98	KFS
rans-1,3-Dichloropropene	8260	mg/l	0.001	ND	19-MAY-98	KFS
thylbenzene	8260	mg/l	0.001	0.002	19-MAY-98	KFS
-Hexanone	8260	mg/l	0.001	ND	19-MAY-98	KFS
ethyl Bromide	8260	mg/l	0.001	ND	19-MAY-98	KFS

Not Detected
-Reported Detection Limit

Pete Ciarleglio
Peter Ciarleglio, M.S., Q.A. Officer

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ANALYTICAL REPORT

r. Rimmer Covington
ovington & Associates
12 Davis Avenue
ass Christian, MS 39571

27-MAY-1998

Sample Description: Groundwater Grab
Client ID: B-2
Site/Plant :
Date Collected: 11-MAY-98 16:20
Date Received: 13-MAY-98 14:54
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7247-12

rameter	Method	Units	RDL	Result	Analyzed	Analyst
Methyl Chloride	8260	mg/l	0.001	ND	19-MAY-98	KFS
Methylene Chloride	8260	mg/l	0.001	ND	19-MAY-98	KFS
Methyl Ethyl Ketone	8260	mg/l	0.001	ND	19-MAY-98	KFS
Methyl Isobutyl Ketone	8260	mg/l	0.001	ND	19-MAY-98	KFS
Styrene	8260	mg/l	0.001	ND	19-MAY-98	KFS
1,1,2,2-Tetrachloroethane	8260	mg/l	0.001	ND	19-MAY-98	KFS
etrachloroethene	8260	mg/l	0.001	ND	19-MAY-98	KFS
oluene	8260	mg/l	0.001	0.007	19-MAY-98	KFS
,1,1-Trichloroethane	8260	mg/l	0.001	ND	19-MAY-98	KFS
,1,2-Trichloroethane	8260	mg/l	0.001	ND	19-MAY-98	KFS
richlorethene	8260	mg/l	0.001	ND	19-MAY-98	KFS
inyl Acetate	8260	mg/l	0.001	ND	19-MAY-98	KFS
inyl Chloride	8260	mg/l	0.001	ND	19-MAY-98	KFS
ylene (total)	8260	mg/l	0.001	0.008	19-MAY-98	KFS
Semi-Volatiles						
nthracene	8270	mg/l	0.0010	ND	19-MAY-98	EDD
cenaphthene	8270	mg/l	0.0010	ND	19-MAY-98	EDD
cenaphthylene	8270	mg/l	0.0010	ND	19-MAY-98	EDD
nzidine	8270	mg/l	0.0010	ND	19-MAY-98	EDD
nzo(a)anthracene	8270	mg/l	0.0010	ND	19-MAY-98	EDD
nzo(a)pyrene	8270	mg/l	0.0010	ND	19-MAY-98	EDD
nzo(b)fluoranthene	8270	mg/l	0.0010	ND	19-MAY-98	EDD
nzo(ghi)perylene	8270	mg/l	0.0010	ND	19-MAY-98	EDD
nzo(k)fluoranthene	8270	mg/l	0.0010	ND	19-MAY-98	EDD
nzoic Acid	8270	mg/l	0.0010	ND	19-MAY-98	EDD
nzyl alcohol	8270	mg/l	0.0010	ND	19-MAY-98	EDD
s(2-chloroethoxy)methane	8270	mg/l	0.0010	ND	19-MAY-98	EDD
s(2-chloroethyl)ether	8270	mg/l	0.0010	ND	19-MAY-98	EDD
s(2-chloroisopropyl)ether	8270	mg/l	0.0010	ND	19-MAY-98	EDD
(2-ethylhexyl)phthalate	8270	mg/l	0.0010	ND	19-MAY-98	EDD
yl benzyl phthalate	8270	mg/l	0.0010	ND	19-MAY-98	EDD
romophenyl phenyl ether	8270	mg/l	0.0010	ND	19-MAY-98	EDD
hloroaniline	8270	mg/l	0.0010	ND	19-MAY-98	EDD
hloronaphthalene	8270	mg/l	0.0010	ND	19-MAY-98	EDD
hlorophenyl phenyl ether	8270	mg/l	0.0010	ND	19-MAY-98	EDD
ysene	8270	mg/l	0.0010	ND	19-MAY-98	EDD
resol	8270	mg/l	0.0010	ND	19-MAY-98	EDD
esol	8270	mg/l	0.0010	ND	19-MAY-98	EDD
lorophenol	8270	mg/l	0.0010	ND	19-MAY-98	EDD
loro-3-Methylphenol	8270	mg/l	0.0010	ND	19-MAY-98	EDD

Detected
ported Detection Limit

Pete Ciarleglio
Peter Ciarleglio, M.S., Q.A. Officer

Resource Analytical Solutions™
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ANALYTICAL REPORT

27-MAY-1998

Ir. Rimmer Covington
:ovington & Associates
12 Davis Avenue
'ass Christian, MS 39571

Sample Description: Groundwater Grab
Client ID: B-2
Site/Plant :
Date Collected: 11-MAY-98 16:20
Date Received: 13-MAY-98 14:54
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7247-12

arameter	Method	Units	RDL	Result	Analyzed	Analyst
Dibenz(a,h)Anthracene	8270	mg/l	0.0010	ND	19-MAY-98	EDD
Dibenzofuran	8270	mg/l	0.0010	ND	19-MAY-98	EDD
1,2-Dichlorobenzene	8270	mg/l	0.0010	ND	19-MAY-98	EDD
1,3-Dichlorobenzene	8270	mg/l	0.0010	ND	19-MAY-98	EDD
1,4-Dichlorobenzene	8270	mg/l	0.0010	ND	19-MAY-98	EDD
2,4-Dichlorophenol	8270	mg/l	0.0010	ND	19-MAY-98	EDD
3,3-Dichlorobenzidine	8270	mg/l	0.0010	ND	19-MAY-98	EDD
Diethyl phthalate	8270	mg/l	0.0010	ND	19-MAY-98	EDD
Dimethyl phthalate	8270	mg/l	0.0010	ND	19-MAY-98	EDD
Di-n-butyl phthalate	8270	mg/l	0.0010	ND	19-MAY-98	EDD
2,4-Dimethylphenol	8270	mg/l	0.0010	ND	19-MAY-98	EDD
2,4-Dinitrophenol	8270	mg/l	0.0010	ND	19-MAY-98	EDD
2,4-Dinitrotoluene	8270	mg/l	0.0010	ND	19-MAY-98	EDD
2,6-Dinitrotoluene	8270	mg/l	0.0010	ND	19-MAY-98	EDD
4,6-Dinitro-o-Cresol	8270	mg/l	0.0010	ND	19-MAY-98	EDD
Di-n-octyl phthalate	8270	mg/l	0.0010	ND	19-MAY-98	EDD
1,2-Diphenyl-Hydrazine	8270	mg/l	0.0010	ND	19-MAY-98	EDD
Fluoranthene	8270	mg/l	0.0010	ND	19-MAY-98	EDD
Fluorene	8270	mg/l	0.0010	ND	19-MAY-98	EDD
Hexachlorobenzene	8270	mg/l	0.0010	ND	19-MAY-98	EDD
Hexachlorobutadiene	8270	mg/l	0.0010	ND	19-MAY-98	EDD
Hexachlorocyclopentadiene	8270	mg/l	0.0010	ND	19-MAY-98	EDD
Hexachloroethane	8270	mg/l	0.0010	ND	19-MAY-98	EDD
Indeno(1,2,3-cd)pyrene	8270	mg/l	0.0010	ND	19-MAY-98	EDD
Isophorone	8270	mg/l	0.0010	ND	19-MAY-98	EDD
2-Methylnaphthalene	8270	mg/l	0.0010	ND	19-MAY-98	EDD
Naphthalene	8270	mg/l	0.0010	ND	19-MAY-98	EDD
2-Nitroaniline	8270	mg/l	0.0010	ND	19-MAY-98	EDD
3-Nitroaniline	8270	mg/l	0.0010	ND	19-MAY-98	EDD
4-Nitroaniline	8270	mg/l	0.0010	ND	19-MAY-98	EDD
2-Nitrophenol	8270	mg/l	0.0010	ND	19-MAY-98	EDD
4-Nitrophenol	8270	mg/l	0.0010	ND	19-MAY-98	EDD
Nitrobenzene	8270	mg/l	0.0010	ND	19-MAY-98	EDD
N-Nitrosodimethylamine	8270	mg/l	0.0010	ND	19-MAY-98	EDD
N-Nitrosodipropylamine	8270	mg/l	0.0010	ND	19-MAY-98	EDD
N-Nitrosodiphenylamine	8270	mg/l	0.0010	ND	19-MAY-98	EDD
Pentachlorophenol	8270	mg/l	0.0010	ND	19-MAY-98	EDD
Phenanthrene	8270	mg/l	0.0010	ND	19-MAY-98	EDD
Phenol	8270	mg/l	0.0010	ND	19-MAY-98	EDD
Pyrene	8270	mg/l	0.0010	ND	19-MAY-98	EDD
1,2,4-Trichlorobenzene	8270	mg/l	0.0010	ND	19-MAY-98	EDD

-Not Detected
-Reported Detection Limit

Pete Ciarleglio
Peter Ciarleglio, M.S., Q.A. Officer

Resource Analytical Solutions™
Environmental Laboratory Services

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ANALYTICAL REPORT

. Rimmer Covington
vington & Associates
2 Davis Avenue
ss Christian, MS 39571

27-MAY-1998

Sample Description: Groundwater Grab
Client ID: B-2
Site/Plant :
Date Collected: 11-MAY-98 16:20
Date Received: 13-MAY-98 14:54
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7247-12

ameter	Method	Units	RDL	Result	Analyzed	Analyst
,4,5-Trichlorophenol	8270	mg/l	0.0010	ND	19-MAY-98	EDD
,4,6-Trichlorophenol	8270	mg/l	0.0010	ND	19-MAY-98	EDD

t Detected
eported Detection Limit

Pete Ciarleglio
Peter Ciarleglio, M.S., Q.A. Officer

Resource Analytical Solutions™
Environmental Laboratory Services

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ANALYTICAL REPORT

27-MAY-1998

Ir. Rimmer Covington
ovington & Associates
12 Davis Avenue
ass Christian, MS 39571

Sample Description: Groundwater Grab
Client ID: B-3
Site/Plant :
Date Collected: 11-MAY-98 17:50
Date Received: 13-MAY-98 14:54
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7247-2

arameter	Method	Units	RDL	Result	Analyzed	Analyst
Sulfate	9038	mg/l	1.	257.	18-MAY-98	CSG
Nitrogen-Ammonia	350.3	mg/l	0.10	1.06	15-MAY-98	KLC
Fluoride	340.2	mg/l	0.10	ND	14-MAY-98	KLC
pH	9040B	pH		1.8	15-MAY-98	JPH
Mercury - Total	7470A	mg/l	0.0002	ND	18-MAY-98	JPH
rsenic - Total	6010	mg/l	0.005	0.031	18-MAY-98	CSG
arium - Total	6010	mg/l	0.01	0.05	18-MAY-98	CSG
Cadmium - Total	6010	mg/l	0.0005	ND	18-MAY-98	CSG
Chromium - Total	6010	mg/l	0.002	0.107	18-MAY-98	CSG
Lead - Total	6010	mg/l	0.002	0.031	18-MAY-98	CSG
Selenium - Total	6010	mg/l	0.005	0.013	18-MAY-98	CSG
Silver - Total	6010	mg/l	0.001	ND	18-MAY-98	CSG

-Not Detected
-Reported Detection Limit

Pete Ciarleglio
Peter Ciarleglio, M.S., Q.A. Officer

Resource Analytical Solutions™
Environmental Laboratory Services

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ANALYTICAL REPORT

27-MAY-1998

Rimmer Covington
ington & Associates
Davis Avenue
s Christian, MS 39571

Sample Description:	Soil Grab
Client ID:	T-1/2'
Site/Plant :	
Date Collected:	11-MAY-98 11:30
Date Received:	13-MAY-98 14:54
RAS Account No.:	8164.00
RAS Project No.:	8164.00
RAS Sample No.:	L7247-3

ameter	Method	Units	RDL	Result	Analyzed	Analyst
luoride- Water Soluble	340.2	mg/kg	1.	26.	21-MAY-98	TKD
mmonia, Distilled	350.2	mg/kg	10	16.	18-MAY-98	KLC
ercury - Total	7471A	mg/kg	0.1	ND	18-MAY-98	JPH
senic - Total	6010	mg/kg	0.5	1.2	18-MAY-98	CSG
rium - Total	6010	mg/kg	1.	91.	18-MAY-98	CSG
dmium - Total	6010	mg/kg	0.3	ND	18-MAY-98	CSG
romium - Total	6010	mg/kg	1.	2.	18-MAY-98	CSG
ead - Total	6010	mg/kg	1.	20	18-MAY-98	CSG
lenium - Total	6010	mg/kg	1.	ND	18-MAY-98	CSG
lver - Total	6010	mg/kg	0.5	ND	18-MAY-98	CSG
Volatiles						
etone	8260	mg/kg	0.25	ND	20-MAY-98	KFS
nzene	8260	mg/kg	0.025	ND	20-MAY-98	KFS
omoform	8260	mg/kg	0.025	ND	20-MAY-98	KFS
rbon Disulfide	8260	mg/kg	0.025	ND	20-MAY-98	KFS
rbon Tetrachloride	8260	mg/kg	0.025	ND	20-MAY-98	KFS
lorobenzene	8260	mg/kg	0.025	ND	20-MAY-98	KFS
bromochloromethane	8260	mg/kg	0.025	ND	20-MAY-98	KFS
loroethane	8260	mg/kg	0.025	ND	20-MAY-98	KFS
Chloroethylvinyl ether	8260	mg/kg	0.025	ND	20-MAY-98	KFS
loroform	8260	mg/kg	0.025	ND	20-MAY-98	KFS
omodichloromethane	8260	mg/kg	0.025	ND	20-MAY-98	KFS
1-Dichloroethane	8260	mg/kg	0.025	ND	20-MAY-98	KFS
2- Dichloroethane	8260	mg/kg	0.025	ND	20-MAY-98	KFS
1-Dichloroethene	8260	mg/kg	0.025	ND	20-MAY-98	KFS
2-Dichloropropane	8260	mg/kg	0.025	ND	20-MAY-98	KFS
s-1,3-Dichloropropene	8260	mg/kg	0.025	ND	20-MAY-98	KFS
ans-1,3-Dichloropropene	8260	mg/kg	0.025	ND	20-MAY-98	KFS
hylbenzene	8260	mg/kg	0.025	ND	20-MAY-98	KFS
thyl Bromide	8260	mg/kg	0.025	ND	20-MAY-98	KFS
thyl Chloride	8260	mg/kg	0.025	ND	20-MAY-98	KFS
thyl Ethyl Ketone	8260	mg/kg	0.025	ND	20-MAY-98	KFS
thyl Isobutyl Ketone	8260	mg/kg	0.025	ND	20-MAY-98	KFS
Hexanone	8260	mg/kg	0.025	ND	20-MAY-98	KFS
thylene Chloride	8260	mg/kg	0.025	ND	20-MAY-98	KFS
yrene	8260	mg/kg	0.025	ND	20-MAY-98	KFS
1,2,2-Tetrachloroethane	8260	mg/kg	0.025	ND	20-MAY-98	KFS

ot Detected
Reported Detection Limit

Pete Ciarleglio
Peter Ciarleglio, M.S., Q.A. Officer

ANALYTICAL REPORT

27-MAY-1998

Mr. Rimmer Covington
Covington & Associates
112 Davis Avenue
Pass Christian, MS 39571

Sample Description: Soil Grab
Client ID: T-1/2'
Site/Plant :
Date Collected: 11-MAY-98 11:30
Date Received: 13-MAY-98 14:54
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7247-3

Parameter	Method	Units	RDL	Result	Analyzed	Analyst
Tetrachloroethene	8260	mg/kg	0.025	ND	20-MAY-98	KFS
Toluene	8260	mg/kg	0.025	ND	20-MAY-98	KFS
cis-1,2-Dichloroethene	8260	mg/kg	0.025	ND	20-MAY-98	KFS
trans-1,2-Dichloroethene	8260	mg/kg	0.025	ND	20-MAY-98	KFS
1,1,1-Trichloroethane	8260	mg/kg	0.025	ND	20-MAY-98	KFS
1,1,2-Trichloroethane	8260	mg/kg	0.025	ND	20-MAY-98	KFS
Trichlorethene	8260	mg/kg	0.025	ND	20-MAY-98	KFS
Vinyl Acetate	8260	mg/kg	0.025	ND	20-MAY-98	KFS
Vinyl Chloride	8260	mg/kg	0.025	ND	20-MAY-98	KFS
Xylene (total)	8260	mg/kg	0.025	ND	20-MAY-98	KFS
Semi-Volatiles						
Anthracene	8270	mg/kg	0.10	ND	22-MAY-98	EDD
Acenaphthene	8270	mg/kg	0.10	ND	22-MAY-98	EDD
Acenaphthylene	8270	mg/kg	0.10	ND	22-MAY-98	EDD
Benzidine	8270	mg/kg	0.10	ND	22-MAY-98	EDD
Benzo(a)anthracene	8270	mg/kg	0.10	ND	22-MAY-98	EDD
Benzo(a)pyrene	8270	mg/kg	0.10	ND	22-MAY-98	EDD
Benzo(b)fluoranthene	8270	mg/kg	0.10	ND	22-MAY-98	EDD
Benzo(ghi)perylene	8270	mg/kg	0.10	ND	22-MAY-98	EDD
Benzo(k)fluoranthene	8270	mg/kg	0.10	ND	22-MAY-98	EDD
Benzoic Acid	8270	mg/kg	0.10	ND	22-MAY-98	EDD
Benzyl alcohol	8270	mg/kg	0.10	ND	22-MAY-98	EDD
Bis(2-chloroethoxy)methane	8270	mg/kg	0.10	ND	22-MAY-98	EDD
Bis(2-chloroisopropyl)ether	8270	mg/kg	0.10	ND	22-MAY-98	EDD
Bis(2-chloroethyl)ether	8270	mg/kg	0.10	ND	22-MAY-98	EDD
Bis(2-ethylhexyl)phthalate	8270	mg/kg	0.10	ND	22-MAY-98	EDD
Butyl benzyl phthalate	8270	mg/kg	0.10	ND	22-MAY-98	EDD
4-Bromophenyl phenyl ether	8270	mg/kg	0.10	ND	22-MAY-98	EDD
4-Chloroaniline	8270	mg/kg	0.10	ND	22-MAY-98	EDD
2-Chloronaphthalene	8270	mg/kg	0.10	ND	22-MAY-98	EDD
4-Chlorophenyl phenyl ether	8270	mg/kg	0.10	ND	22-MAY-98	EDD
Chrysene	8270	mg/kg	0.10	ND	22-MAY-98	EDD
o-Cresol	8270	mg/kg	0.10	ND	22-MAY-98	EDD
p-Cresol	8270	mg/kg	0.10	ND	22-MAY-98	EDD
2-Chlorophenol	8270	mg/kg	0.10	ND	22-MAY-98	EDD
4-Chloro-3-Methylphenol	8270	mg/kg	0.10	ND	22-MAY-98	EDD
Dibenz(a,h)Anthracene	8270	mg/kg	0.10	ND	22-MAY-98	EDD
Dibenzofuran	8270	mg/kg	0.10	ND	22-MAY-98	EDD
1,2-Dichlorobenzene	8270	mg/kg	0.10	ND	22-MAY-98	EDD
1,3-Dichlorobenzene	8270	mg/kg	0.10	ND	22-MAY-98	EDD

)-Not Detected
)L-Reported Detection Limit

Peter Ciarleglio
Peter Ciarleglio, M.S., Q.A. Officer

Resource Analytical Solutions™
Environmental Laboratory Services
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ANALYTICAL REPORT

27-MAY 1998

Rimmer Covington
ington & Associates
Davis Avenue
s Christian, MS 39571

Sample Description: Soil Grab
Client ID: T-1/2'
Site/Plant :
Date Collected: 11-MAY-98 11:30
Date Received: 13-MAY-98 14:54
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7247-3

ameter	Method	Units	RDL	Result	Analyzed	Analyst
,4-Dichlorobenzene	8270	mg/kg	0.10	ND	22-MAY-98	EDD
,4-Dichlorophenol	8270	mg/kg	0.10	ND	22-MAY-98	EDD
,3-Dichlorobenzidine	8270	mg/kg	0.10	ND	22-MAY-98	EDD
iethyl phthalate	8270	mg/kg	0.10	ND	22-MAY-98	EDD
imethyl phthalate	8270	mg/kg	0.10	ND	22-MAY-98	EDD
i-n-butyl phthalate	8270	mg/kg	0.10	ND	22-MAY-98	EDD
,4-Dimethylphenol	8270	mg/kg	0.10	ND	22-MAY-98	EDD
,4-Dinitrophenol	8270	mg/kg	0.10	ND	22-MAY-98	EDD
,4-Dinitrotoluene	8270	mg/kg	0.10	ND	22-MAY-98	EDD
,6-Dinitrotoluene	8270	mg/kg	0.10	ND	22-MAY-98	EDD
,6-Dinitro-o-Cresol	8270	mg/kg	0.10	ND	22-MAY-98	EDD
i-n-octyl phthalate	8270	mg/kg	0.10	ND	22-MAY-98	EDD
,2-Diphenyl-Hydrazine	8270	mg/kg	0.10	ND	22-MAY-98	EDD
luoranthene	8270	mg/kg	0.10	ND	22-MAY-98	EDD
luorene	8270	mg/kg	0.10	ND	22-MAY-98	EDD
exachlorobenzene	8270	mg/kg	0.10	ND	22-MAY-98	EDD
exachlorobutadiene	8270	mg/kg	0.10	ND	22-MAY-98	EDD
exachlorocyclopentadiene	8270	mg/kg	0.10	ND	22-MAY-98	EDD
exachloroethane	8270	mg/kg	0.10	ND	22-MAY-98	EDD
ndeno(1,2,3-cd)pyrene	8270	mg/kg	0.10	ND	22-MAY-98	EDD
sophorone	8270	mg/kg	0.10	ND	22-MAY-98	EDD
-Methylnaphthalene	8270	mg/kg	0.10	ND	22-MAY-98	EDD
aphthalene	8270	mg/kg	0.10	ND	22-MAY-98	EDD
-Nitroaniline	8270	mg/kg	0.10	ND	22-MAY-98	EDD
-Nitroaniline	8270	mg/kg	0.10	ND	22-MAY-98	EDD
-Nitroaniline	8270	mg/kg	0.10	ND	22-MAY-98	EDD
-Nitrophenol	8270	mg/kg	0.10	ND	22-MAY-98	EDD
-Nitrophenol	8270	mg/kg	0.10	ND	22-MAY-98	EDD
itrobenzene	8270	mg/kg	0.10	ND	22-MAY-98	EDD
-Nitrosodipropylamine	8270	mg/kg	0.10	ND	22-MAY-98	EDD
-Nitrosodiphenylamine	8270	mg/kg	0.10	ND	22-MAY-98	EDD
entachlorophenol	8270	mg/kg	0.10	ND	22-MAY-98	EDD
henanthrene	8270	mg/kg	0.10	ND	22-MAY-98	EDD
henol	8270	mg/kg	0.10	ND	22-MAY-98	EDD
yrene	8270	mg/kg	0.10	ND	22-MAY-98	EDD
,2,4-Trichlorobenzene	8270	mg/kg	0.10	ND	22-MAY-98	EDD
,4,5-Trichlorophenol	8270	mg/kg	0.10	ND	22-MAY-98	EDD
,4,6-Trichlorophenol	8270	mg/kg	0.10	ND	22-MAY-98	EDD

Not Detected
-Reported Detection Limit

Peter Ciarleglio
Peter Ciarleglio, M.S., Q.A. Officer

Resource Analytical Solutions™
Environmental Laboratory Services

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ANALYTICAL REPORT

27-MAY-1998

Mr. Rimmer Covington
Covington & Associates
112 Davis Avenue
Pass Christian, MS 39571

Sample Description: Soil Grab
Client ID: T-2/2.5'
Site/Plant :
Date Collected: 11-MAY-98 11:35
Date Received: 13-MAY-98 14:54
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7247-4

Parameter	Method	Units	RDL	Result	Analyzed	Analyst
Fluoride- Water Soluble	340.2	mg/kg	1.	10	21-MAY-98	TKD
Ammonia, Distilled	350.2	mg/kg	10	ND	18-MAY-98	KLC
Mercury - Total	7471A	mg/kg	0.1	ND	18-MAY-98	JPH
Arsenic - Total	6010	mg/kg	0.5	ND	18-MAY-98	CSG
Barium - Total	6010	mg/kg	1.	5.	18-MAY-98	CSG
Cadmium - Total	6010	mg/kg	0.3	ND	18-MAY-98	CSG
Chromium - Total	6010	mg/kg	1.	3.	18-MAY-98	CSG
Lead - Total	6010	mg/kg	1.	1.	18-MAY-98	CSG
Selenium - Total	6010	mg/kg	1.	ND	18-MAY-98	CSG
Silver - Total	6010	mg/kg	0.5	ND	18-MAY-98	CSG

-Not Detected
L-Reported Detection Limit

Peter Ciarleglio
Peter Ciarleglio, M.S., Q.A. Officer

Resource Analytical Solutions™
Environmental Laboratory Services

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ANALYTICAL REPORT

27-MAY-1998

Mr. Rimmer Covington
Covington & Associates
112 Davis Avenue
Pass Christian, MS 39571

Sample Description: Soil Grab
Client ID: T-3/1.6'
Site/Plant :
Date Collected: 11-MAY-98 11:50
Date Received: 13-MAY-98 14:54
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7247-5

Parameter	Method	Units	RDL	Result	Analyzed	Analyst
Fluoride- Water Soluble	340.2	mg/kg	1.	78.	21-MAY-98	TKD
Ammonia, Distilled	350.2	mg/kg	10	10	18-MAY-98	KLC
Mercury - Total	7471A	mg/kg	0.1	ND	18-MAY-98	JPH
Arsenic - Total	6010	mg/kg	0.5	1.5	18-MAY-98	CSG
Barium - Total	6010	mg/kg	1.	10	18-MAY-98	CSG
Cadmium - Total	6010	mg/kg	0.3	ND	18-MAY-98	CSG
Chromium - Total	6010	mg/kg	1.	5.	18-MAY-98	CSG
Lead - Total	6010	mg/kg	1.	2.	18-MAY-98	CSG
Selenium - Total	6010	mg/kg	1.	ND	18-MAY-98	CSG
Silver - Total	6010	mg/kg	0.5	ND	18-MAY-98	CSG

ND-Not Detected
RDL-Reported Detection Limit

Peter Ciarleglio
Peter Ciarleglio, M.S., Q.A. Officer

Resource Analytical Solutions™
Environmental Laboratory Services

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ANALYTICAL REPORT

27-MAY-1998

Mr. Rimmer Covington
Covington & Associates
112 Davis Avenue
Pass Christian, MS 39571

Sample Description: Soil Grab
Client ID: T-4/2.5'
Site/Plant :
Date Collected: 11-MAY-98 12:15
Date Received: 13-MAY-98 14:54
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7247-6

Parameter	Method	Units	RDL	Result	Analyzed	Analyst
Fluoride- Water Soluble	340.2	mg/kg	1.	ND	21-MAY-98	TKD
Ammonia, Distilled	350.2	mg/kg	10	ND	18-MAY-98	KLC
Mercury - Total	7471A	mg/kg	0.1	ND	18-MAY-98	JPH
Arsenic - Total	6010	mg/kg	0.5	20.9	18-MAY-98	CSG
Barium - Total	6010	mg/kg	1.	286.	18-MAY-98	CSG
Cadmium - Total	6010	mg/kg	0.3	ND	18-MAY-98	CSG
Chromium - Total	6010	mg/kg	1.	1.	18-MAY-98	CSG
Lead - Total	6010	mg/kg	1.	207.	18-MAY-98	CSG
Selenium - Total	6010	mg/kg	1.	ND	18-MAY-98	CSG
Silver - Total	6010	mg/kg	0.5	0.8	18-MAY-98	CSG

ND-Not Detected
RDL-Reported Detection Limit

Pete Ciarleglio
Peter Ciarleglio, M.S., Q.A. Officer

Resource Analytical Solutions™
Environmental Laboratory Services

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ANALYTICAL REPORT

27-MAY-1998

Mr. Rimmer Covington
Covington & Associates
112 Davis Avenue
Pass Christian, MS 39571

Sample Description: Soil Grab
Client ID: T-5/3'
Site/Plant :
Date Collected: 11-MAY-98 13:00
Date Received: 13-MAY-98 14:54
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7247-7

arameter	Method	Units	RDL	Result	Analyzed	Analyst
Fluoride- Water Soluble	340.2	mg/kg	1.	ND	21-MAY-98	TKD
Ammonia, Distilled	350.2	mg/kg	10	ND	18-MAY-98	KLC
Mercury - Total	7471A	mg/kg	0.1	ND	18-MAY-98	JPH
Arsenic - Total	6010	mg/kg	0.5	108.	18-MAY-98	CSG
Barium - Total	6010	mg/kg	1.	20	18-MAY-98	CSG
Cadmium - Total	6010	mg/kg	0.3	ND	18-MAY-98	CSG
Chromium - Total	6010	mg/kg	1.	2.	18-MAY-98	CSG
Lead - Total	6010	mg/kg	1.	135.	18-MAY-98	CSG
Selenium - Total	6010	mg/kg	1.	ND	18-MAY-98	CSG
Silver - Total	6010	mg/kg	0.5	0.6	18-MAY-98	CSG
esticides/PCBs						
Aldrin	8081	mg/kg	0.0017	ND	22-MAY-98	WGM
alpha-BHC	8081	mg/kg	0.0017	ND	22-MAY-98	WGM
beta-BHC	8081	mg/kg	0.0017	ND	22-MAY-98	WGM
gamma-BHC (Lindane)	8081	mg/kg	0.0017	ND	22-MAY-98	WGM
delta-BHC	8081	mg/kg	0.0017	ND	22-MAY-98	WGM
Chlordane	8081	mg/kg	0.0017	ND	22-MAY-98	WGM
4,4'-DDD	8081	mg/kg	0.0033	ND	22-MAY-98	WGM
4,4'-DDE	8081	mg/kg	0.0033	ND	22-MAY-98	WGM
4,4'-DDT	8081	mg/kg	0.0033	ND	22-MAY-98	WGM
Dieldrin	8081	mg/kg	0.0033	ND	22-MAY-98	WGM
Endosulfan I	8081	mg/kg	0.0017	ND	22-MAY-98	WGM
Endosulfan II	8081	mg/kg	0.0033	ND	22-MAY-98	WGM
Endosulfan Sulfate	8081	mg/kg	0.0033	ND	22-MAY-98	WGM
Endrin	8081	mg/kg	0.0033	ND	22-MAY-98	WGM
Endrin Aldehyde	8081	mg/kg	0.0033	ND	22-MAY-98	WGM
Heptachlor	8081	mg/kg	0.0017	ND	22-MAY-98	WGM
Heptachlor Epoxide	8081	mg/kg	0.0017	ND	22-MAY-98	WGM
Methoxychlor	8081	mg/kg	0.0033	ND	22-MAY-98	WGM
Toxaphene	8081	mg/kg	0.020	ND	22-MAY-98	WGM
PCB 1016	8081	mg/kg	0.020	ND	22-MAY-98	WGM
PCB 1221	8081	mg/kg	0.020	ND	22-MAY-98	WGM
PCB 1232	8081	mg/kg	0.020	ND	22-MAY-98	WGM
PCB 1242	8081	mg/kg	0.020	ND	22-MAY-98	WGM
PCB 1248	8081	mg/kg	0.020	ND	22-MAY-98	WGM
PCB 1254	8081	mg/kg	0.020	ND	22-MAY-98	WGM
PCB 1260	8081	mg/kg	0.020	ND	22-MAY-98	WGM

Not Detected
-Reported Detection Limit

Peter Carleglio
Peter Ciarleglio, M.S., Q.A. Officer

Resource Analytical Solutions™
Environmental Laboratory Services

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ANALYTICAL REPORT

28-MAY-1998

Mr. Rimmer Covington
Covington & Associates
112 Davis Avenue
Pass Christian, MS 39571

Sample Description: Soil Grab
Client ID: T-6/1.5'
Site/Plant :
Date Collected: 11-MAY-98 13:15
Date Received: 13-MAY-98 14:54
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7247-8

Parameter	Method	Units	RDL	Result	Analyzed	Analyst
Fluoride- Water Soluble	340.2	mg/kg	1.	ND	21-MAY-98	TKD
Ammonia, Distilled	350.2	mg/kg	10	52.	18-MAY-98	KLC
Mercury - Total	7471A	mg/kg	0.1	ND	18-MAY-98	JPH
Arsenic - Total	6010	mg/kg	0.5	17.9	18-MAY-98	CSG
Barium - Total	6010	mg/kg	1.	15.	18-MAY-98	CSG
Cadmium - Total	6010	mg/kg	0.3	ND	18-MAY-98	CSG
Chromium - Total	6010	mg/kg	1.	1.	18-MAY-98	CSG
Lead - Total	6010	mg/kg	1.	172.	18-MAY-98	CSG
Selenium - Total	6010	mg/kg	1.	ND	18-MAY-98	CSG
Silver - Total	6010	mg/kg	0.5	ND	18-MAY-98	CSG
HSL Volatiles						
Acetone	8260	mg/kg	0.25	ND	19-MAY-98	KFS
Benzene	8260	mg/kg	0.025	ND	19-MAY-98	KFS
Bromoform	8260	mg/kg	0.025	ND	19-MAY-98	KFS
Carbon Disulfide	8260	mg/kg	0.025	ND	19-MAY-98	KFS
Carbon Tetrachloride	8260	mg/kg	0.025	ND	19-MAY-98	KFS
Chlorobenzene	8260	mg/kg	0.025	ND	19-MAY-98	KFS
Dibromochloromethane	8260	mg/kg	0.025	ND	19-MAY-98	KFS
Chloroethane	8260	mg/kg	0.025	ND	19-MAY-98	KFS
2-Chloroethylvinyl ether	8260	mg/kg	0.025	ND	19-MAY-98	KFS
Chloroform	8260	mg/kg	0.025	ND	19-MAY-98	KFS
Bromodichloromethane	8260	mg/kg	0.025	ND	19-MAY-98	KFS
1,1-Dichloroethane	8260	mg/kg	0.025	ND	19-MAY-98	KFS
1,2- Dichloroethane	8260	mg/kg	0.025	ND	19-MAY-98	KFS
1,1-Dichloroethene	8260	mg/kg	0.025	ND	19-MAY-98	KFS
1,2-Dichloropropane	8260	mg/kg	0.025	ND	19-MAY-98	KFS
cis-1,3-Dichloropropene	8260	mg/kg	0.025	ND	19-MAY-98	KFS
trans-1,3-Dichloropropene	8260	mg/kg	0.025	ND	19-MAY-98	KFS
Ethylbenzene	8260	mg/kg	0.025	ND	19-MAY-98	KFS
Methyl Bromide	8260	mg/kg	0.025	ND	19-MAY-98	KFS
Methyl Chloride	8260	mg/kg	0.025	ND	19-MAY-98	KFS
Methyl Ethyl Ketone	8260	mg/kg	0.025	ND	19-MAY-98	KFS
Methyl Isobutyl Ketone	8260	mg/kg	0.025	ND	19-MAY-98	KFS
2-Hexanone	8260	mg/kg	0.025	ND	19-MAY-98	KFS
Methylene Chloride	8260	mg/kg	0.025	ND	19-MAY-98	KFS
Styrene	8260	mg/kg	0.025	ND	19-MAY-98	KFS
1,1,2,2-Tetrachloroethane	8260	mg/kg	0.025	ND	19-MAY-98	KFS

ND-Not Detected
RDL-Reported Detection Limit

Pete Ciarleglio
Peter Ciarleglio, M.S., Q.A. Officer

ANALYTICAL REPORT

Mr. Rimmer Covington
Covington & Associates
112 Davis Avenue
Pass Christian, MS 39571

28-MAY-1998

Sample Description: Soil Grab
Client ID: T-6/1.5'
Site/Plant :
Date Collected: 11-MAY-98 13:15
Date Received: 13-MAY-98 14:54
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7247-8

Parameter	Method	Units	RDL	Result	Analyzed	Analyst
Tetrachloroethene	8260	mg/kg	0.025	ND	19-MAY-98	KFS
Toluene	8260	mg/kg	0.025	ND	19-MAY-98	KFS
cis-1,2-Dichloroethene	8260	mg/kg	0.025	ND	19-MAY-98	KFS
trans-1,2-Dichloroethene	8260	mg/kg	0.025	ND	19-MAY-98	KFS
1,1,1-Trichloroethane	8260	mg/kg	0.025	ND	19-MAY-98	KFS
1,1,2-Trichloroethane	8260	mg/kg	0.025	ND	19-MAY-98	KFS
Trichlorethene	8260	mg/kg	0.025	ND	19-MAY-98	KFS
Vinyl Acetate	8260	mg/kg	0.025	ND	19-MAY-98	KFS
Vinyl Chloride	8260	mg/kg	0.025	ND	19-MAY-98	KFS
Xylene (total)	8260	mg/kg	0.025	ND	19-MAY-98	KFS
L Semi-Volatiles						
Anthracene	8270	mg/kg	0.10	ND	27-MAY-98	EDD
Acenaphthene	8270	mg/kg	0.10	ND	27-MAY-98	EDD
Acenaphthylene	8270	mg/kg	0.10	ND	27-MAY-98	EDD
Benzidine	8270	mg/kg	0.10	ND	27-MAY-98	EDD
Benzo(a)anthracene	8270	mg/kg	0.10	ND	27-MAY-98	EDD
Benzo(a)pyrene	8270	mg/kg	0.10	ND	27-MAY-98	EDD
Benzo(b)fluoranthene	8270	mg/kg	0.10	ND	27-MAY-98	EDD
Benzo(ghi)perylene	8270	mg/kg	0.10	ND	27-MAY-98	EDD
Benzo(k)fluoranthene	8270	mg/kg	0.10	ND	27-MAY-98	EDD
Benzoic Acid	8270	mg/kg	0.10	ND	27-MAY-98	EDD
Benzyl alcohol	8270	mg/kg	0.10	ND	27-MAY-98	EDD
Bis(2-chloroethoxy)methane	8270	mg/kg	0.10	ND	27-MAY-98	EDD
Bis(2-chloroisopropyl)ether	8270	mg/kg	0.10	ND	27-MAY-98	EDD
Bis(2-chloroethyl)ether	8270	mg/kg	0.10	ND	27-MAY-98	EDD
Bis(2-ethylhexyl)phthalate	8270	mg/kg	0.10	ND	27-MAY-98	EDD
Butyl benzyl phthalate	8270	mg/kg	0.10	ND	27-MAY-98	EDD
4-Bromophenyl phenyl ether	8270	mg/kg	0.10	ND	27-MAY-98	EDD
4-Chloroaniline	8270	mg/kg	0.10	ND	27-MAY-98	EDD
2-Chloronaphthalene	8270	mg/kg	0.10	ND	27-MAY-98	EDD
4-Chlorophenyl phenyl ether	8270	mg/kg	0.10	ND	27-MAY-98	EDD
Chrysene	8270	mg/kg	0.10	ND	27-MAY-98	EDD
o-Cresol	8270	mg/kg	0.10	ND	27-MAY-98	EDD
p-Cresol	8270	mg/kg	0.10	ND	27-MAY-98	EDD
2-Chlorophenol	8270	mg/kg	0.10	ND	27-MAY-98	EDD
4-Chloro-3-Methylphenol	8270	mg/kg	0.10	ND	27-MAY-98	EDD
Dibenz(a,h)Anthracene	8270	mg/kg	0.10	ND	27-MAY-98	EDD
Dibenzofuran	8270	mg/kg	0.10	ND	27-MAY-98	EDD
1,2-Dichlorobenzene	8270	mg/kg	0.10	ND	27-MAY-98	EDD
1,3-Dichlorobenzene	8270	mg/kg	0.10	ND	27-MAY-98	EDD

-Not Detected
L-Reported Detection Limit

Pete Ciarleglio
Peter Ciarleglio, M.S., Q.A. Officer

Resource Analytical Solutions™
Environmental Laboratory Services

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ANALYTICAL REPORT

28-MAY-1998

Mr. Rimmer Covington
Covington & Associates
112 Davis Avenue
Pass Christian, MS 39571

Sample Description: Soil Grab
Client ID: T-6/1.5'
Site/Plant :
Date Collected: 11-MAY-98 13:15
Date Received: 13-MAY-98 14:54
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7247-8

arameter	Method	Units	RDL	Result	Analyzed	Analyst
1,4-Dichlorobenzene	8270	mg/kg	0.10	ND	27-MAY-98	EDD
2,4-Dichlorophenol	8270	mg/kg	0.10	ND	27-MAY-98	EDD
3,3-Dichlorobenzidine	8270	mg/kg	0.10	ND	27-MAY-98	EDD
Diethyl phthalate	8270	mg/kg	0.10	ND	27-MAY-98	EDD
Dimethyl phthalate	8270	mg/kg	0.10	ND	27-MAY-98	EDD
Di-n-butyl phthalate	8270	mg/kg	0.10	ND	27-MAY-98	EDD
2,4-Dimethylphenol	8270	mg/kg	0.10	ND	27-MAY-98	EDD
2,4-Dinitrophenol	8270	mg/kg	0.10	ND	27-MAY-98	EDD
2,4-Dinitrotoluene	8270	mg/kg	0.10	ND	27-MAY-98	EDD
2,6-Dinitrotoluene	8270	mg/kg	0.10	ND	27-MAY-98	EDD
[illegible],6-Dinitro-o-Cresol	8270	mg/kg	0.10	ND	27-MAY-98	EDD
Di-n-octyl phthalate	8270	mg/kg	0.10	ND	27-MAY-98	EDD
1,2-Diphenyl-Hydrazine	8270	mg/kg	0.10	ND	27-MAY-98	EDD
Fluoranthene	8270	mg/kg	0.10	ND	27-MAY-98	EDD
Fluorene	8270	mg/kg	0.10	ND	27-MAY-98	EDD
Hexachlorobenzene	8270	mg/kg	0.10	ND	27-MAY-98	EDD
Hexachlorobutadiene	8270	mg/kg	0.10	ND	27-MAY-98	EDD
Hexachlorocyclopentadiene	8270	mg/kg	0.10	ND	27-MAY-98	EDD
Hexachloroethane	8270	mg/kg	0.10	ND	27-MAY-98	EDD
Indeno(1,2,3-cd)pyrene	8270	mg/kg	0.10	ND	27-MAY-98	EDD
Isophorone	8270	mg/kg	0.10	ND	27-MAY-98	EDD
2-Methylnaphthalene	8270	mg/kg	0.10	ND	27-MAY-98	EDD
Naphthalene	8270	mg/kg	0.10	ND	27-MAY-98	EDD
2-Nitroaniline	8270	mg/kg	0.10	ND	27-MAY-98	EDD
3-Nitroaniline	8270	mg/kg	0.10	ND	27-MAY-98	EDD
4-Nitroaniline	8270	mg/kg	0.10	ND	27-MAY-98	EDD
2-Nitrophenol	8270	mg/kg	0.10	ND	27-MAY-98	EDD
4-Nitrophenol	8270	mg/kg	0.10	ND	27-MAY-98	EDD
Nitrobenzene	8270	mg/kg	0.10	ND	27-MAY-98	EDD
N-Nitrosodipropylamine	8270	mg/kg	0.10	ND	27-MAY-98	EDD
N-Nitrosodiphenylamine	8270	mg/kg	0.10	ND	27-MAY-98	EDD
Pentachlorophenol	8270	mg/kg	0.10	ND	27-MAY-98	EDD
Phenanthrene	8270	mg/kg	0.10	ND	27-MAY-98	EDD
Phenol	8270	mg/kg	0.10	ND	27-MAY-98	EDD
Pyrene	8270	mg/kg	0.10	ND	27-MAY-98	EDD
1,2,4-Trichlorobenzene	8270	mg/kg	0.10	ND	27-MAY-98	EDD
2,4,5-Trichlorophenol	8270	mg/kg	0.10	ND	27-MAY-98	EDD
2,4,6-Trichlorophenol	8270	mg/kg	0.10	ND	27-MAY-98	EDD

D-Not Detected
DL-Reported Detection Limit

Pete Ciarleglio
Peter Ciarleglio, M.S., Q.A. Officer

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ANALYTICAL REPORT

27-MAY-1998

r. Rimmer Covington
ovington & Associates
12 Davis Avenue
ass Christian, MS 39571

Sample Description: Soil Grab
Client ID: T-7/1'
Site/Plant :
Date Collected: 11-MAY-98 13:20
Date Received: 13-MAY-98 14:54
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7247-9

arameter	Method	Units	RDL	Result	Analyzed	Analyst
Fluoride- Water Soluble	340.2	mg/kg	1.	44.	21-MAY-98	TKD
Ammonia, Distilled	350.2	mg/kg	10	16.	18-MAY-98	KLC
Mercury - Total	7471A	mg/kg	0.1	ND	18-MAY-98	JPH
Arsenic - Total	6010	mg/kg	0.5	14.6	18-MAY-98	CSG
Barium - Total	6010	mg/kg	1.	111.	18-MAY-98	CSG
Cadmium - Total	6010	mg/kg	0.3	ND	18-MAY-98	CSG
Chromium - Total	6010	mg/kg	1.	22.	18-MAY-98	CSG
Lead - Total	6010	mg/kg	1.	50	18-MAY-98	CSG
Selenium - Total	6010	mg/kg	1.	ND	18-MAY-98	CSG
Silver - Total	6010	mg/kg	0.5	ND	18-MAY-98	CSG

D-Not Detected
DL-Reported Detection Limit

Pete Ciarleglio
Peter Ciarleglio, M.S., Q.A. Officer

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ANALYTICAL REPORT

Mr. Rimmer Covington
Covington & Associates
112 Davis Avenue
Pass Christian, MS 39571

27-MAY-1998

Sample Description: Soil Grab
Client ID: T-8/2.5'
Site/Plant :
Date Collected: 11-MAY-98 13:35
Date Received: 13-MAY-98 14:54
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7247-10

Parameter	Method	Units	RDL	Result	Analyzed	Analyst
Fluoride- Water Soluble	340.2	mg/kg	1.	5.	21-MAY-98	TKD
Ammonia, Distilled	350.2	mg/kg	10	18.	18-MAY-98	KLC
Mercury - Total	7471A	mg/kg	0.1	ND	18-MAY-98	JPH
Arsenic - Total	6010	mg/kg	0.5	ND	18-MAY-98	CSG
Barium - Total	6010	mg/kg	1.	3.	18-MAY-98	CSG
Cadmium - Total	6010	mg/kg	0.3	ND	18-MAY-98	CSG
Chromium - Total	6010	mg/kg	1.	1.	18-MAY-98	CSG
Lead - Total	6010	mg/kg	1.	1.	18-MAY-98	CSG
Selenium - Total	6010	mg/kg	1.	ND	18-MAY-98	CSG
Silver - Total	6010	mg/kg	0.5	ND	18-MAY-98	CSG

-Not Detected
L-Reported Detection Limit

Peter Ciarleglio, M.S., Q.A. Officer

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ANALYTICAL REPORT

27-MAY-1998

. Rimmer Covington
ovington & Associates
12 Davis Avenue
ass Christian, MS 39571

Sample Description: Soil Grab
Client ID: T-9/1'
Site/Plant :
Date Collected: 11-MAY-98 13:50
Date Received: 13-MAY-98 14:54
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7247-11

rameter	Method	Units	RDL	Result	Analyzed	Analyst
Fluoride- Water Soluble	340.2	mg/kg	1.	12.	21-MAY-98	TKD
Ammonia, Distilled	350.2	mg/kg	10	150	18-MAY-98	KLC
Mercury - Total	7471A	mg/kg	0.1	ND	18-MAY-98	JPH
Arsenic - Total	6010	mg/kg	0.5	87.0	18-MAY-98	CSG
Barium - Total	6010	mg/kg	1.	21.	18-MAY-98	CSG
Cadmium - Total	6010	mg/kg	0.3	0.8	18-MAY-98	CSG
Chromium - Total	6010	mg/kg	1.	6.	18-MAY-98	CSG
ead - Total	6010	mg/kg	1.	927.	18-MAY-98	CSG
elenium - Total	6010	mg/kg	1.	ND	18-MAY-98	CSG
Silver - Total	6010	mg/kg	0.5	11.7	18-MAY-98	CSG
sticides/PCBs						
ldrin	8081	mg/kg	0.0017	ND	22-MAY-98	WGM
lpha-BHC	8081	mg/kg	0.0017	ND	22-MAY-98	WGM
eta-BHC	8081	mg/kg	0.0017	ND	22-MAY-98	WGM
amma-BHC (Lindane)	8081	mg/kg	0.0017	ND	22-MAY-98	WGM
elta-BHC	8081	mg/kg	0.0017	ND	22-MAY-98	WGM
hlordane	8081	mg/kg	0.0017	ND	22-MAY-98	WGM
,4'-DDD	8081	mg/kg	0.0033	ND	22-MAY-98	WGM
,4'-DDE	8081	mg/kg	0.0033	ND	22-MAY-98	WGM
,4'-DDT	8081	mg/kg	0.0033	ND	22-MAY-98	WGM
ieldrin	8081	mg/kg	0.0033	ND	22-MAY-98	WGM
ndosulfan I	8081	mg/kg	0.0017	ND	22-MAY-98	WGM
ndosulfan II	8081	mg/kg	0.0033	ND	22-MAY-98	WGM
ndosulfan Sulfate	8081	mg/kg	0.0033	ND	22-MAY-98	WGM
ndrin	8081	mg/kg	0.0033	ND	22-MAY-98	WGM
ndrin Aldehyde	8081	mg/kg	0.0033	ND	22-MAY-98	WGM
eptachlor	8081	mg/kg	0.0017	ND	22-MAY-98	WGM
eptachlor Epoxide	8081	mg/kg	0.0017	ND	22-MAY-98	WGM
ethoxychlor	8081	mg/kg	0.0033	ND	22-MAY-98	WGM
oxaphene	8081	mg/kg	0.020	ND	22-MAY-98	WGM
CB 1016	8081	mg/kg	0.020	ND	22-MAY-98	WGM
CB 1221	8081	mg/kg	0.020	ND	22-MAY-98	WGM
CB 1232	8081	mg/kg	0.020	ND	22-MAY-98	WGM
CB 1242	8081	mg/kg	0.020	ND	22-MAY-98	WGM
CB 1248	8081	mg/kg	0.020	ND	22-MAY-98	WGM
CB 1254	8081	mg/kg	0.020	ND	22-MAY-98	WGM
CB 1260	8081	mg/kg	0.020	ND	22-MAY-98	WGM

Not Detected
-Reported Detection Limit

Pete Ciarleglio
Peter Ciarleglio, M.S., Q.A. Officer

RAS Project Number, Title and Site CAC 06-175 Gulfport Fertilizer, Gulfport MS
Contact/Address Alane Young CAC
Desired Turnaround Date Standard

Resource Analytical Solutions™
Environmental Laboratory Services

MAIL:
P.O. Box 1848
Brentwood, TN 37024-1848
Phone: (615) 373-5040

Delivery:
7121 CrossRoads Blvd.
Brentwood, TN 37027
Lab Fax: (615) 370-1026

Lab Use Only RAS Log No.	SAMPLE DESCRIPTION Include all Information for completely identifying each sample. Also include physical descriptions: water, soil, groundwater, etc.	Date and Time Collected		Sample Type GRAB	Sample Type COMP	Number and Type of Containers	Field Pres.	Field pH	ANALYSIS REQUIRED Special Comments/Instuctions, etc.	LAB USE ONLY (Upon Reciept) Preservative	pH	Chlorine	Head Space
SEE CVDS —	T-1 2' soil	5/11/98	11:30	✓		2 4-oz.	no		Fluorides, ~~[illegible]~~				
—	T-2 2.5' Soil	5/11/98	11:35	✓		2 4-oz.			~~Phosphates~~, [illegible]				
—	T-3 1.6' Soil	5/11/98	11:50	✓		2 4-oz.			Ammonia Nitrogen,				
—	T-4 1.5' Soil	5/11/98	12:15	✓		2 4oz.			8 RCRA metals				
—	T-5 3' Soil	5/11/98	13:00	✓		2 4-oz.			for all				
—	T-6 1.5' Soil	5/11/98	13:15	✓		2 4-oz. 1 2oz.			HSLV, HSLS + above				
—	T-7 1' Soil	5/11/98	13:20	✓		2 4-oz.			Fluorides				
—	T-8 2.5' Soil	5/11/98	13:35	✓		2 4-oz.			Ammonia Nitrogen				
—	T-9 1' Soil	5/11/98	13:50	✓		2 4oz.			8 RCRA metals				
LG	B-1 10-12' GW	5/11/98	16:20	✓		1-32oz 3-32oz. 1 32oz plastic	H2SO4 none HNO3		Fluorides, 8 RCRA metals, Ammonia Nitrogen				
L7247.12	B-2 10'-12' GW	5/11/98		✓		2 VOAs 2 32oz 3 32oz 1 32oz plastic	HCl none H2SO4 HNO3		Fluorides, 8 RCRA metals, Ammonia Nitrogen, HSLV, HSLS,				
LG	B-3 10'-12' GW	5/11/98		✓		1 32oz 1 32 oz 1 32oz plastic	none H2SO4 HNO3		Fluorides, 8 RCRA metals, Ammonia Nitrogen				

SIGNATURE REQUIRED OF ALL PERSONS HANDLING SAMPLES

Sample Collected By:
Received By:
Received By:
Logged In RAS Lab By:
Sample Returned By:
Received By:

SAMPLE TRANSPORT: METHOD AND CONDITION

Air [illegible]

Temperature Upon

Distribution: Goldenrod retained by Client/Project Manager all others accompany sample shipment to Laboratory

(615) 726 702

N-1998

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Environmental Laboratory Services

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ANALYTICAL REPORT

11-JUN-199

Mr. Rimmer Covington
Covington & Associates
112 Davis Avenue
Pass Christian, MS 39571

Sample Description: Soil Composite
Client ID: NORTH END BACKGROUND
Site/Plant : #6175
Date Collected: 03-JUN-98 16:30
Date Received: 05-JUN-98 15:01
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7439-1

Parameter	Method	Units	RDL	Result	Analyzed	Analyst
Arsenic - Total	7060	mg/kg	0.5	14.6	10-JUN-98	CSG
Lead - Total	7420	mg/kg	5.	295.	10-JUN-98	CSG

ND-Not Detected
RDL-Reported Detection Limit

Peter Ciarleglio
Peter Ciarleglio, M.S., Q.A. Officer

Resource Analytical Solutions™
Environmental Laboratory Services

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ANALYTICAL REPORT

11-JUN-1998

r. Rimmer Covington
ovington & Associates
12 Davis Avenue
ass Christian, MS 39571

Sample Description:	Soil Composite
Client ID:	SOUTH END BACKGROUND
Site/Plant :	#6175
Date Collected:	03-JUN-98 16:30
Date Received:	05-JUN-98 15:01
RAS Account No.:	8164.00
RAS Project No.:	8164.00
RAS Sample No.:	L7439-2

arameter	Method	Units	RDL	Result	Analyzed	Analyst
Arsenic - Total	7060	mg/kg	0.5	1.3	10-JUN-98	CSG
Lead - Total	7420	mg/kg	5.	8.	10-JUN-98	CSG

-Not Detected
-Reported Detection Limit

Peter Ciarleglio
Peter Ciarleglio, M.S., Q.A. Officer

Resource Analytical Solutions™
Environmental Laboratory Services

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ANALYTICAL REPORT

Mr. Rimmer Covington
Covington & Associates
112 Davis Avenue
Pass Christian, MS 39571

15-JUN-1998

Sample Description: Soil Composite
Client ID: PIT 4/2.5-3.5'
Site/Plant : #6175
Date Collected: 03-JUN-98 12:10
Date Received: 11-JUN-98 15:43
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7480-1

Parameter	Method	Units	RDL	Result	Analyzed	Analyst
Arsenic - Total	6010	mg/kg	0.5	52.8	13-JUN-98	CSG
Lead - Total	6010	mg/kg	1.	1680	13-JUN-98	CSG

Not Detected
-Reported Detection Limit

Pete Ciarleglio
Peter Ciarleglio, M.S., Q.A. Officer

Resource Analytical Solutions™
Environmental Laboratory Services

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ANALYTICAL REPORT

15-JUN-1998

Mr. Rimmer Covington
Covington & Associates
112 Davis Avenue
Pass Christian, MS 39571

Sample Description: Soil Composite
Client ID: T-4 4/100E
Site/Plant : #6175
Date Collected: 03-JUN-98 12:20
Date Received: 11-JUN-98 15:43
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7480-2

Parameter	Method	Units	RDL	Result	Analyzed	Analyst
Arsenic - Total	6010	mg/kg	0.5	132.	13-JUN-98	CSG
Lead - Total	6010	mg/kg	1.	6260	13-JUN-98	CSG

ND-Not Detected
RDL-Reported Detection Limit

Peter Ciarleglio
Peter Ciarleglio, M.S., Q.A. Officer

Resource Analytical Solutions™
Environmental Laboratory Services

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ANALYTICAL REPORT

15-JUN-1998

Mr. Rimmer Covington
Covington & Associates
112 Davis Avenue
Pass Christian, MS 39571

Sample Description: Soil Composite
Client ID: PIT 4/50N/1-2'
Site/Plant : #6175
Date Collected: 03-JUN-98 12:30
Date Received: 11-JUN-98 15:43
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7480-3

Parameter	Method	Units	RDL	Result	Analyzed	Analyst
Arsenic - Total	6010	mg/kg	0.5	240	13-JUN-98	CSG
Lead - Total	6010	mg/kg	1.	2810	13-JUN-98	CSG

ND-Not Detected
RDL-Reported Detection Limit

Peter Ciarleglio
Peter Ciarleglio, M.S., Q.A. Officer

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ANALYTICAL REPORT

15-JUN 1998

Mr. Rimmer Covington
Covington & Associates
112 Davis Avenue
Pass Christian, MS 39571

Sample Description: Soil Composite
Client ID: PIT 4/100N/1-2'
Site/Plant : #6175
Date Collected: 03-JUN-98 12:40
Date Received: 11-JUN-98 15:43
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7480-4

Parameter	Method	Units	RDL	Result	Analyzed	Analyst
Arsenic - Total	6010	mg/kg	0.5	16.	13-JUN-98	CSG
Lead - Total	6010	mg/kg	1.	13.	13-JUN-98	CSG

ND-Not Detected
RDL-Reported Detection Limit

Peter Ciarleglio
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ANALYTICAL REPORT

15-JUN-1998

1998

r. Rimmer Covington
ovington & Associates
l2 Davis Avenue
ass Christian, MS 39571

Sample Description:	Soil Composite
Client ID:	PIT 4/50E/1-2'
Site/Plant :	#6175
Date Collected:	03-JUN-98 12:50
Date Received:	11-JUN-98 15:43
RAS Account No.:	8164.00
RAS Project No.:	8164.00
RAS Sample No.:	L7480-5

arameter	Method	Units	RDL	Result	Analyzed	Analyst
Arsenic - Total	6010	mg/kg	0.5	30.4	13-JUN-98	CSG
Lead - Total	6010	mg/kg	1.	2580	13-JUN-98	CSG

ND-Not Detected
RDL-Reported Detection Limit

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ANALYTICAL REPORT

15-JUN-1998

Mr. Rimmer Covington
Covington & Associates
112 Davis Avenue
Pass Christian, MS 39571

Sample Description: Soil Composite
Client ID: PIT 4/50S/1-2'
Site/Plant : #6175
Date Collected: 03-JUN-98 13:00
Date Received: 11-JUN-98 15:43
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7480-6

Parameter	Method	Units	RDL	Result	nalyst
Arsenic - Total	6010	mg/kg	0.5	56.2	CSG
Lead - Total	6010	mg/kg	1.	11000	CSG

ND-Not Detected
RDL-Reported Detection Limit

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ANALYTICAL REPORT

15-JUN-1998

Mr. Rimmer Covington
Covington & Associates
112 Davis Avenue
Pass Christian, MS 39571

Sample Description: Soil Composite
Client ID: PIT 4/100S/1-2'
Site/Plant : #6175
Date Collected: 03-JUN-98 13:10
Date Received: 11-JUN-98 15:43
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7480-7

Parameter	Method	Units	RDL	Result	Analyzed	Analyst
Arsenic - Total	6010	mg/kg	0.5	22.5	13-JUN-98	CSG
Lead - Total	6010	mg/kg	1.	722.	13-JUN-98	CSG

ND-Not Detected
RDL-Reported Detection Limit

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ANALYTICAL REPORT

Mr. Rimmer Covington
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112 Davis Avenue
Pass Christian, MS 39571

15-JUN-199

Sample Description: Soil Composite
Client ID: PIT 4/50W/1-2'
Site/Plant : #6175
Date Collected: 03-JUN-98 13:20
Date Received: 11-JUN-98 15:43
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7480-8

Parameter	Method	Units	RDL	Result	Analyzed	Analyst
Arsenic - Total	6010	mg/kg	0.5	274.	13-JUN-98	CSG
Lead - Total	6010	mg/kg	1.	784.	13-JUN-98	CSG

ND-Not Detected
RDL-Reported Detection Limit

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Mr. Rimmer Covington
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Pass Christian, MS 39571

Sample Description: Soil Composite
Client ID: PIT 4/100W/1-2'
Site/Plant : #6175
Date Collected: 03-JUN-98 13:30
Date Received: 11-JUN-98 15:43
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7480-9

Parameter	Method	Units	RDL	Result	Analyzed	Analyst
Arsenic - Total	6010	mg/kg	0.5	28.4	13-JUN-98	CSG
Lead - Total	6010	mg/kg	1.	3500	13-JUN-98	CSG

ND-Not Detected
RDL-Reported Detection Limit

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ANALYTICAL REPORT

15-JUN-1998

Mr. Rimmer Covington
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Pass Christian, MS 39571

Sample Description: Soil Composite
Client ID: PIT 5/3-5'
Site/Plant : #6175
Date Collected: 03-JUN-98 13:40
Date Received: 11-JUN-98 15:43
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7480-10

Parameter	Method	Units	RDL	Result	Analyzed	Analyst
Arsenic - Total	6010	mg/kg	0.5	309.	13-JUN-98	CSG
Lead - Total	6010	mg/kg	1.	5170	13-JUN-98	CSG

ND-Not Detected
RDL-Reported Detection Limit

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ANALYTICAL REPORT

15-JUN-1998

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ass Christian, MS 39571

Sample Description: Soil Composite
Client ID: PIT 5/50N/1-2'
Site/Plant : #6175
Date Collected: 03-JUN-98 13:50
Date Received: 11-JUN-98 15:43
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7480-11

arameter	Method	Units	RDL	Result	Analyzed	Analyst
Arsenic - Total	6010	mg/kg	0.5	1310	13-JUN-98	CSG
Lead - Total	6010	mg/kg	1.	4070	13-JUN-98	CSG

-Not Detected
L-Reported Detection Limit

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Sample Description:	Soil Composite
Client ID:	PIT 5/100N/1-2'
Site/Plant :	#6175
Date Collected:	03-JUN-98 14:00
Date Received:	11-JUN-98 15:43
RAS Account No.:	8164.00
RAS Project No.:	8164.00
RAS Sample No.:	L7480-12

Parameter	Method	Units	RDL	Result	Analyzed	Analyst
Arsenic - Total	6010	mg/kg	0.5	19.9	13-JUN-98	CSG
Lead - Total	6010	mg/kg	1.	389.	13-JUN-98	CSG

ND-Not Detected
RDL-Reported Detection Limit

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Sample Description: Soil Composite
Client ID: PIT 5/50E/1-2'
Site/Plant : #6175
Date Collected: 03-JUN-98 14:10
Date Received: 11-JUN-98 15:43
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7480-13

arameter	Method	Units	RDL	Result	Analyzed	Analyst
Arsenic - Total	6010	mg/kg	0.5	18.6	13-JUN-98	CSG
Lead - Total	6010	mg/kg	1.	74.	13-JUN-98	CSG

D-Not Detected
DL-Reported Detection Limit

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Mr. Rimmer Covington
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Sample Description:	Soil Composite
Client ID:	PIT 5/100E/1-2'
Site/Plant :	#6175
Date Collected:	03-JUN-98 14:20
Date Received:	11-JUN-98 15:43
RAS Account No.:	8164.00
RAS Project No.:	8164.00
RAS Sample No.:	L7480-14

Parameter	Method	Units	RDL	Result	Analyzed	Analyst
Arsenic - Total	6010	mg/kg	0.5	87.3	13-JUN-98	CSG
Lead - Total	6010	mg/kg	1.	1150	13-JUN-98	CSG

ND-Not Detected
RDL-Reported Detection Limit

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ass Christian, MS 39571

Sample Description: Soil Composite
Client ID: PIT 5/100S/1-2'
Site/Plant : #6175
Date Collected: 03-JUN-98 14:40
Date Received: 11-JUN-98 15:43
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7480-16

'arameter	Method	Units	RDL	Result	Analyzed	Analyst
Arsenic - Total	6010	mg/kg	0.5	58.0	13-JUN-98	CSG
Lead - Total	6010	mg/kg	1.	546.	13-JUN-98	CSG

D-Not Detected
DL-Reported Detection Limit

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15-JUN-1998

Sample Description: Soil Composite
Client ID: PIT 5/50W/1-2'
Site/Plant : #6175
Date Collected: 03-JUN-98 14:50
Date Received: 11-JUN-98 15:43
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7480-17

ameter	Method	Units	RDL	Result	Analyzed	Analyst
rsenic - Total	6010	mg/kg	0.5	21.3	13-JUN-98	CSG
ead - Total	6010	mg/kg	1.	3270	13-JUN-98	CSG

Detected
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ass Christian, MS 39571

Sample Description: Soil Composite
Client ID: PIT 5/100W/1-2'
Site/Plant : #6175
Date Collected: 03-JUN-98 15:00
Date Received: 11-JUN-98 15:43
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7480-18

arameter	Method	Units	RDL	Result	Analyzed	Analyst
Arsenic - Total	6010	mg/kg	0.5	46.6	13-JUN-98	CSG
Lead - Total	6010	mg/kg	1.	631.	13-JUN-98	CSG

-Not Detected
L-Reported Detection Limit

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Sample Description: Soil Composite
Client ID: PIT 6/2-3'
Site/Plant : #6175
Date Collected: 03-JUN-98 15:10
Date Received: 11-JUN-98 15:43
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7480-19

arameter	Method	Units	RDL	Result	Analyzed	Analyst
Arsenic - Total	6010	mg/kg	0.5	14.8	13-JUN-98	CSG
Lead - Total	6010	mg/kg	1.	127.	13-JUN-98	CSG

D-Not Detected
DL-Reported Detection Limit

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ANALYTICAL REPORT

15-JUN-1998

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Sample Description: Soil Composite
Client ID: PIT 6/50N/1-2'
Site/Plant : #6175
Date Collected: 03-JUN-98 15:20
Date Received: 11-JUN-98 15:43
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7480-20

rameter	Method	Units	RDL	Result	Analyzed	Analyst
Arsenic - Total	6010	mg/kg	0.5	60.3	13-JUN-98	CSG
Lead - Total	6010	mg/kg	1.	147.	13-JUN-98	CSG

lot Detected
Reported Detection Limit

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ANALYTICAL REPORT

15-JUN-1998

Mr. Rimmer Covington
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Sample Description: Soil Composite
Client ID: PIT 6/100N/1-2'
Site/Plant : #6175
Date Collected: 03-JUN-98 15:30
Date Received: 11-JUN-98 15:43
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7480-21

Parameter	Method	Units	RDL	Result	Analyzed	Analyst
Arsenic - Total	6010	mg/kg	0.5	147.	13-JUN-98	CSG
Lead - Total	6010	mg/kg	1.	665.	13-JUN-98	CSG

ND-Not Detected
RDL-Reported Detection Limit

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ANALYTICAL REPORT

15-JUN-1998

Mr. Rimmer Covington
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Sample Description: Soil Composite
Client ID: PIT 6/50E/1-2'
Site/Plant : #6175
Date Collected: 03-JUN-98 15:40
Date Received: 11-JUN-98 15:43
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7480-22

Parameter	Method	Units	RDL	Result	Analyzed	Analyst
Arsenic - Total	6010	mg/kg	0.5	5.6	13-JUN-98	CSG
Lead - Total	6010	mg/kg	1.	48.	13-JUN-98	CSG

ND-Not Detected
RDL-Reported Detection Limit

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Sample Description: Soil Composite
Client ID: PIT 6/100E/1-2'
Site/Plant : #6175
Date Collected: 03-JUN-98 15:50
Date Received: 11-JUN-98 15:43
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7480-23

Parameter	Method	Units	RDL	Result	Analyzed	Analyst
Arsenic - Total	6010	mg/kg	0.5	5.3	13-JUN-98	CSG
Lead - Total	6010	mg/kg	1.	33.	13-JUN-98	CSG

ND-Not Detected
RDL-Reported Detection Limit

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Sample Description: Soil Composite
Client ID: PIT 6/50S/1-2'
Site/Plant : #6175
Date Collected: 03-JUN-98 15:00
Date Received: 11-JUN-98 15:43
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7480-24

Parameter	Method	Units	RDL	Result	Analyzed	Analyst
Arsenic - Total	6010	mg/kg	0.5	69.7	13-JUN-98	CSG
Lead - Total	6010	mg/kg	1.	68.	13-JUN-98	CSG

ND-Not Detected
RDL-Reported Detection Limit

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Sample Description: Soil Composite
Client ID: PIT 6/100S/1-2'
Site/Plant : #6175
Date Collected: 03-JUN-98 16:10
Date Received: 11-JUN-98 15:43
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7480-25

rameter	Method	Units	RDL	Result	Analyzed	Analyst
Arsenic - Total	6010	mg/kg	0.5	18.1	13-JUN-98	CSG
Lead - Total	6010	mg/kg	1.	89.	13-JUN-98	CSG

-Not Detected
L-Reported Detection Limit

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15-JUN-1998

Sample Description: Soil Composite
Client ID: PIT 6/50W/1-2'
Site/Plant : #6175
Date Collected: 03-JUN-98 16:20
Date Received: 11-JUN-98 15:43
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7480-26

·ameter	Method	Units	RDL	Result	Analyzed	Analyst
ırsenic - Total	6010	mg/kg	0.5	206.	13-JUN-98	CSG
.ead - Total	6010	mg/kg	1.	613.	13-JUN-98	CSG

ot Detected
Reported Detection Limit

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ss Christian, MS 39571

Sample Description: Soil Composite
Client ID: PIT 6/100W/1-2'
Site/Plant : #6175
Date Collected: 03-JUN-98 16:30
Date Received: 11-JUN-98 15:43
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7480-27

rameter	Method	Units	RDL	Result	Analyzed	Analyst
rsenic - Total	6010	mg/kg	0.5	83.7	13-JUN-98	CSG
ead - Total	6010	mg/kg	1.	62.	13-JUN-98	CSG

ot Detected
eported Detection Limit

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ANALYTICAL REPORT

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15-JUN-1998

Sample Description: Soil Composite
Client ID: PIT 7/2-3'
Site/Plant : #6175
Date Collected: 03-JUN-98 16:40
Date Received: 11-JUN-98 15:43
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7480-28

rameter	Method	Units	RDL	Result	Analyzed	Analyst
Arsenic - Total	6010	mg/kg	0.5	49.5	13-JUN-98	CSG
Lead - Total	6010	mg/kg	1.	1640	13-JUN-98	CSG

ot Detected
Reported Detection Limit

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ANALYTICAL REPORT

Mr. Rimmer Covington
Covington & Associates
112 Davis Avenue
Pass Christian, MS 39571

15-JUN-1998

Sample Description: Soil Composite
Client ID: PIT 7/50N/1-2'
Site/Plant : #6175
Date Collected: 03-JUN-98 16:50
Date Received: 11-JUN-98 15:43
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7480-29

Parameter	Method	Units	RDL	Result	Analyzed	Analyst
Arsenic - Total	6010	mg/kg	0.5	27.1	13-JUN-98	CSG
Lead - Total	6010	mg/kg	1.	185.	13-JUN-98	CSG

ID-Not Detected
DL-Reported Detection Limit

Pete Ciarleglio
Peter Ciarleglio, M.S., Q.A. Officer

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ANALYTICAL REPORT

15-JUN-1998

. Rimmer Covington
ovington & Associates
12 Davis Avenue
ss Christian, MS 39571

Sample Description: Soil Composite
Client ID: PIT 7/100N/1-2'
Site/Plant : #6175
Date Collected: 03-JUN-98 17:00
Date Received: 11-JUN-98 15:43
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7480-30

rameter	Method	Units	RDL	Result	Analyzed	Analyst
rsenic - Total	6010	mg/kg	0.5	63.3	13-JUN-98	CSG
ead - Total	6010	mg/kg	1.	2960	13-JUN-98	CSG

ot Detected
eported Detection Limit

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ANALYTICAL REPORT

15-JUN-1998

. Rimmer Covington
vington & Associates
2 Davis Avenue
ss Christian, MS 39571

Sample Description: Soil Composite
Client ID: PIT 7/50E/1-2'
Site/Plant : #6175
Date Collected: 03-JUN-98 17:05
Date Received: 11-JUN-98 15:43
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7480-31

rameter	Method	Units	RDL	Result	Analyzed	Analyst
Arsenic - Total	6010	mg/kg	0.5	14.1	13-JUN-98	CSG
Lead - Total	6010	mg/kg	1.	66.	13-JUN-98	CSG

-Not Detected
L-Reported Detection Limit

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ANALYTICAL REPORT

15-JUN-1998

Rimmer Covington
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Davis Avenue
s Christian, MS 39571

Sample Description:	Soil Composite
Client ID:	PIT 7/100E/1-2'
Site/Plant :	#6175
Date Collected:	03-JUN-98 17:10
Date Received:	11-JUN-98 15:43
RAS Account No.:	8164.00
RAS Project No.:	8164.00
RAS Sample No.:	L7480-32

ameter	Method	Units	RDL	Result	Analyzed	Analyst
rsenic - Total	6010	mg/kg	0.5	198.	13-JUN-98	CSG
ead - Total	6010	mg/kg	1.	1470	13-JUN-98	CSG

lot Detected
-Reported Detection Limit

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ANALYTICAL REPORT

15-JUN-1998

. Rimmer Covington
vington & Associates
2 Davis Avenue
ss Christian, MS 39571

Sample Description: Soil Composite
Client ID: PIT 7/50S/1-2′
Site/Plant : #6175
Date Collected: 03-JUN-98 17:15
Date Received: 11-JUN-98 15:43
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7480-33

ameter	Method	Units	RDL	Result	Analyzed	Analyst
rsenic - Total	6010	mg/kg	0.5	6.6	13-JUN-98	CSG
ead - Total	6010	mg/kg	1.	38.	13-JUN-98	CSG

ot Detected
-Reported Detection Limit

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ANALYTICAL REPORT

15-JUN-1998

Rimmer Covington
ngton & Associates
Davis Avenue
; Christian, MS 39571

Sample Description:	Soil Composite
Client ID:	PIT 7/100S/1-2'
Site/Plant :	#6175
Date Collected:	03-JUN-98 17:20
Date Received:	11-JUN-98 15:43
RAS Account No.:	8164.00
RAS Project No.:	8164.00
RAS Sample No.:	L7480-34

ameter	Method	Units	RDL	Result	Analyzed	Analyst
rsenic - Total	6010	mg/kg	0.5	10.6	13-JUN-98	CSG
ead - Total	6010	mg/kg	1.	69.	13-JUN-98	CSG

)-Not Detected
)L-Reported Detection Limit

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ANALYTICAL REPORT

15-JUN-1998

Mr. Rimmer Covington
Covington & Associates
112 Davis Avenue
Pass Christian, MS 39571

Sample Description: Soil Composite
Client ID: PIT 7/50W/1-2'
Site/Plant : #6175
Date Collected: 03-JUN-98 17:25
Date Received: 11-JUN-98 15:43
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7480-35

arameter	Method	Units	RDL	Result	Analyzed	Analyst
Arsenic - Total	6010	mg/kg	0.5	77.7	13-JUN-98	CSG
Lead - Total	6010	mg/kg	1.	474.	13-JUN-98	CSG

-Not Detected
L-Reported Detection Limit

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ANALYTICAL REPORT

r. Rimmer Covington
ovington & Associates
12 Davis Avenue
ass Christian, MS 39571

15-JUN-1998

Sample Description: Soil Composite
Client ID: PIT 7/100W/1-2'
Site/Plant : #6175
Date Collected: 03-JUN-98 17:30
Date Received: 11-JUN-98 15:43
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7480-36

rameter	Method	Units	RDL	Result	Analyzed	Analyst
Arsenic - Total	6010	mg/kg	0.5	32.5	13-JUN-98	CSG
Lead - Total	6010	mg/kg	1.	371.	13-JUN-98	CSG

ot Detected
Reported Detection Limit

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ANALYTICAL REPORT

r. Rimmer Covington
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12 Davis Avenue
ass Christian, MS 39571

15-JUN-1998

Sample Description: Soil Composite
Client ID: PIT 9/2-3'
Site/Plant : #6175
Date Collected: 03-JUN-98 17:35
Date Received: 11-JUN-98 15:43
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7480-37

rameter	Method	Units	RDL	Result	Analyzed	Analyst
Arsenic - Total	6010	mg/kg	0.5	104.	13-JUN-98	CSG
Lead - Total	6010	mg/kg	1.	1890	13-JUN-98	CSG

ot Detected
Reported Detection Limit

Peter Ciarleglio
Peter Ciarleglio, M.S., Q.A. Officer

ANALYTICAL REPORT

15-JUN-1998

r. Rimmer Covington
ovington & Associates
12 Davis Avenue
ass Christian, MS 39571

Sample Description: Soil Composite
Client ID: PIT 9/50N/1-2'
Site/Plant : #6175
Date Collected: 03-JUN-98 17:40
Date Received: 11-JUN-98 15:43
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7480-38

ırameter	Method	Units	RDL	Result	Analyzed	Analyst
Arsenic - Total	6010	mg/kg	0.5	15.4	13-JUN-98	CSG
Lead - Total	6010	mg/kg	1.	101.	13-JUN-98	CSG

Not Detected
-Reported Detection Limit

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ANALYTICAL REPORT

15-JUN-1998

Mr. Rimmer Covington
Covington & Associates
112 Davis Avenue
Pass Christian, MS 39571

Sample Description: Soil Composite
Client ID: PIT 9/100N/1-2'
Site/Plant : #6175
Date Collected: 03-JUN-98 17:45
Date Received: 11-JUN-98 15:43
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7480-39

Parameter	Method	Units	RDL	Result	Analyzed	Analyst
Arsenic - Total	6010	mg/kg	0.5	3.2	13-JUN-98	CSG
Lead - Total	6010	mg/kg	1.	11.	13-JUN-98	CSG

D-Not Detected
DL-Reported Detection Limit

Pete Ciarleglio
Peter Ciarleglio, M.S., Q.A. Officer

ANALYTICAL REPORT

15-JUN-1998

Mr. Rimmer Covington
Covington & Associates
112 Davis Avenue
Pass Christian, MS 39571

Sample Description: Soil Composite
Client ID: PIT 9/50E/1-2'
Site/Plant : #6175
Date Collected: 03-JUN-98 17:50
Date Received: 11-JUN-98 15:43
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7480-40

Parameter	Method	Units	RDL	Result	Analyzed	Analyst
Arsenic - Total	6010	mg/kg	0.5	58.1	13-JUN-98	CSG
Lead - Total	6010	mg/kg	1.	925.	13-JUN-98	CSG

ND-Not Detected
RDL-Reported Detection Limit

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ANALYTICAL REPORT

15-JUN-1998

Mr. Rimmer Covington
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112 Davis Avenue
Pass Christian, MS 39571

Sample Description: Soil Composite
Client ID: PIT 9/100E/1-2'
Site/Plant : #6175
Date Collected: 03-JUN-98 17:55
Date Received: 11-JUN-98 15:43
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7480-41

Parameter	Method	Units	RDL	Result	Analyzed	Analyst
Arsenic - Total	6010	mg/kg	0.5	23.7	13-JUN-98	CSG
Lead - Total	6010	mg/kg	1.	387.	13-JUN-98	CSG

ND-Not Detected
RDL-Reported Detection Limit

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ANALYTICAL REPORT

15-JUN-1998

Mr. Rimmer Covington
Covington & Associates
112 Davis Avenue
Pass Christian, MS 39571

Sample Description: Soil Composite
Client ID: PIT 9/50S/1-2'
Site/Plant : #6175
Date Collected: 03-JUN-98 18:00
Date Received: 11-JUN-98 15:43
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7480-42

Parameter	Method	Units	RDL	Result	Analyzed	Analyst
Arsenic - Total	6010	mg/kg	0.5	20.0	13-JUN-98	CSG
Lead - Total	6010	mg/kg	1.	424.	13-JUN-98	CSG

ND-Not Detected
RDL-Reported Detection Limit

Pete Ciarleglio
Peter Ciarleglio, M.S., Q.A. Officer

ANALYTICAL REPORT

15-JUN-1998

. Rimmer Covington
/ington & Associates
? Davis Avenue
;s Christian, MS 39571

Sample Description: Soil Composite
Client ID: PIT 9/100S/1-2'
Site/Plant : #6175
Date Collected: 03-JUN-98 18:05
Date Received: 11-JUN-98 15:43
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7480-43

-ameter	Method	Units	RDL	Result	Analyzed	Analyst
\rsenic - Total	6010	mg/kg	0.5	15.5	13-JUN-98	CSG
.ead - Total	6010	mg/kg	1.	105.	13-JUN-98	CSG

·Not Detected
.-Reported Detection Limit

Pete Ciarleglio
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ANALYTICAL REPORT

15-JUN-1998

Mr. Rimmer Covington
Covington & Associates
112 Davis Avenue
Pass Christian, MS 39571

Sample Description: Soil Composite
Client ID: PIT 9/50W/1-2'
Site/Plant : #6175
Date Collected: 03-JUN-98 18:10
Date Received: 11-JUN-98 15:43
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7480-44

Parameter	Method	Units	RDL	Result	Analyzed	Analyst
Arsenic - Total	6010	mg/kg	0.5	10.8	13-JUN-98	CSG
Lead - Total	6010	mg/kg	1.	130	13-JUN-98	CSG

ND-Not Detected
RDL-Reported Detection Limit

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ANALYTICAL REPORT

15-JUN-1998

. Rimmer Covington
vington & Associates
2 Davis Avenue
ss Christian, MS 39571

Sample Description: Soil Composite
Client ID: PIT 9/100W/1-2'
Site/Plant : #6175
Date Collected: 03-JUN-98 18:15
Date Received: 11-JUN-98 15:43
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7480-45

rameter	Method	Units	RDL	Result	Analyzed	Analyst
Arsenic - Total	6010	mg/kg	0.5	172.	13-JUN-98	CSG
Lead - Total	6010	mg/kg	1.	2880	13-JUN-98	CSG

-Not Detected
-Reported Detection Limit

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ANALYTICAL REPORT

15-JUN-1998

Mr. Rimmer Covington
Covington & Associates
112 Davis Avenue
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Sample Description: Soil Composite
Client ID: P-1/1-2'
Site/Plant : #6175
Date Collected: 03-JUN-98 08:00
Date Received: 05-JUN-98 14:39
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7438-1

Parameter	Method	Units	RDL	Result	Analyzed	Analyst
Arsenic - Total	6010	mg/kg	0.5	4.2	11-JUN-98	CSG
Lead - Total	6010	mg/kg	1.	10	11-JUN-98	CSG

ND-Not Detected
RDL-Reported Detection Limit

Peter Ciarleglio
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ANALYTICAL REPORT

15-JUN-1998

Mr. Rimmer Covington
Covington & Associates
112 Davis Avenue
Pass Christian, MS 39571

Sample Description: Soil Composite
Client ID: P-2/1-2'
Site/Plant : #6175
Date Collected: 03-JUN-98 08:10
Date Received: 05-JUN-98 14:39
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7438-2

Parameter	Method	Units	RDL	Result	Analyzed	Analyst
Arsenic - Total	6010	mg/kg	0.5	10.5	11-JUN-98	CSG
Lead - Total	6010	mg/kg	1.	54.	11-JUN-98	CSG

-Not Detected
L-Reported Detection Limit

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ANALYTICAL REPORT

15-JUN-1998

Mr. Rimmer Covington
Covington & Associates
112 Davis Avenue
Pass Christian, MS 39571

Sample Description: Soil Composite
Client ID: P-3/1-2'
Site/Plant : #6175
Date Collected: 03-JUN-98 08:15
Date Received: 05-JUN-98 14:39
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7438-3

Parameter	Method	Units	RDL	Result	Analyzed	Analyst
Arsenic - Total	6010	mg/kg	0.5	11.3	11-JUN-98	CSG
Lead - Total	6010	mg/kg	1.	143.	11-JUN-98	CSG

ND-Not Detected
RDL-Reported Detection Limit

Peter Ciarleglio
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ANALYTICAL REPORT

15-JUN-1998

Mr. Rimmer Covington
Covington & Associates
112 Davis Avenue
Pass Christian, MS 39571

Sample Description: Soil Composite
Client ID: P-4/1-2'
Site/Plant : #6175
Date Collected: 03-JUN-98 08:20
Date Received: 05-JUN-98 14:39
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7438-4

Parameter	Method	Units	RDL	Result	Analyzed	Analyst
Arsenic - Total	6010	mg/kg	0.5	11.6	11-JUN-98	CSG
Lead - Total	6010	mg/kg	1.	59.	11-JUN-98	CSG

ND-Not Detected
RDL-Reported Detection Limit

Peter Ciarleglio
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ANALYTICAL REPORT

15-JUN-199

Mr. Rimmer Covington
Covington & Associates
112 Davis Avenue
Pass Christian, MS 39571

Sample Description: Soil Composite
Client ID: P-5/1-2'
Site/Plant : #6175
Date Collected: 03-JUN-98 08:30
Date Received: 05-JUN-98 14:39
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7438-5

Parameter	Method	Units	RDL	Result	Analyzed	Analyst
Arsenic - Total	6010	mg/kg	0.5	6.2	11-JUN-98	CSG
Lead - Total	6010	mg/kg	1.	49.	11-JUN-98	CSG

ND-Not Detected
RDL-Reported Detection Limit

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ANALYTICAL REPORT

15-JUN-1998

Mr. Rimmer Covington
Covington & Associates
112 Davis Avenue
Pass Christian, MS 39571

Sample Description:	Soil Composite
Client ID:	P-6/1-2'
Site/Plant :	#6175
Date Collected:	03-JUN-98 08:40
Date Received:	05-JUN-98 14:39
RAS Account No.:	8164.00
RAS Project No.:	8164.00
RAS Sample No.:	L7438-6

Parameter	Method	Units	RDL	Result	Analyzed	Analyst
Arsenic - Total	6010	mg/kg	0.5	1.4	11-JUN-98	CSG
Lead - Total	6010	mg/kg	1.	6.	11-JUN-98	CSG

ND-Not Detected
RDL-Reported Detection Limit

Pete Ciarleglio
Peter Ciarleglio, M.S., Q.A. Officer

ANALYTICAL REPORT

15-JUN-1998

Mr. Rimmer Covington
Covington & Associates
112 Davis Avenue
Pass Christian, MS 39571

Sample Description: Soil Composite
Client ID: P-7/1-2'
Site/Plant : #6175
Date Collected: 03-JUN-98 08:50
Date Received: 05-JUN-98 14:39
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7438-7

Parameter	Method	Units	RDL	Result	Analyzed	Analyst
Arsenic - Total	6010	mg/kg	0.5	2.7	11-JUN-98	CSG
Lead - Total	6010	mg/kg	1.	8.	11-JUN-98	CSG

ND-Not Detected
RDL-Reported Detection Limit

Peter Ciarleglio
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ANALYTICAL REPORT

15-JUN-1998

r. Rimmer Covington
ovington & Associates
12 Davis Avenue
ass Christian, MS 39571

Sample Description: Soil Composite
Client ID: P-8/1-2'
Site/Plant : #6175
Date Collected: 03-JUN-98 12:15
Date Received: 05-JUN-98 14:39
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7438-8

arameter	Method	Units	RDL	Result	Analyzed	Analyst
Arsenic - Total	6010	mg/kg	0.5	7.7	11-JUN-98	CSG
Lead - Total	6010	mg/kg	1.	7.	11-JUN-98	CSG

D-Not Detected
DL-Reported Detection Limit

Pete Ciarleglio
Peter Ciarleglio, M.S., Q.A. Officer

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ANALYTICAL REPORT

15-JUN-1998

Mr. Rimmer Covington
Covington & Associates
112 Davis Avenue
Pass Christian, MS 39571

Sample Description: Soil Composite
Client ID: P-9/1-2'
Site/Plant : #6175
Date Collected: 03-JUN-98 09:00
Date Received: 05-JUN-98 14:39
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7438-9

Parameter	Method	Units	RDL	Result	Analyzed	Analyst
Arsenic - Total	6010	mg/kg	0.5	10.3	11-JUN-98	CSG
Lead - Total	6010	mg/kg	1.	5.	11-JUN-98	CSG

-Not Detected
L-Reported Detection Limit

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ANALYTICAL REPORT

15-JUN-1998

Mr. Rimmer Covington
Covington & Associates
112 Davis Avenue
Pass Christian, MS 39571

Sample Description:	Soil Composite
Client ID:	P-10/1-2'
Site/Plant :	#6175
Date Collected:	03-JUN-98 09:10
Date Received:	05-JUN-98 14:39
RAS Account No.:	8164.00
RAS Project No.:	8164.00
RAS Sample No.:	L7438-10

Parameter	Method	Units	RDL	Result	Analyzed	Analyst
Arsenic - Total	6010	mg/kg	0.5	1.8	11-JUN-98	CSG
Lead - Total	6010	mg/kg	1.	7.	11-JUN-98	CSG

ND-Not Detected
RDL-Reported Detection Limit

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ANALYTICAL REPORT

15-JUN-1998

Mr. Rimmer Covington
Covington & Associates
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Pass Christian, MS 39571

Sample Description: Soil Composite
Client ID: P-11/1-2'
Site/Plant : #6175
Date Collected: 03-JUN-98 09:20
Date Received: 05-JUN-98 14:39
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7438-11

Parameter	Method	Units	RDL	Result	Analyzed	Analyst
Arsenic - Total	6010	mg/kg	0.5	26.4	11-JUN-98	CSG
Lead - Total	6010	mg/kg	1.	10	11-JUN-98	CSG

-Not Detected
L-Reported Detection Limit

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ANALYTICAL REPORT

15-JUN-1998

Mr. Rimmer Covington
Covington & Associates
112 Davis Avenue
Pass Christian, MS 39571

Sample Description: Soil Composite
Client ID: P-12/1-2'
Site/Plant : #6175
Date Collected: 03-JUN-98 09:30
Date Received: 05-JUN-98 14:39
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7438-12

Parameter	Method	Units	RDL	Result	Analyzed	Analyst
Arsenic - Total	6010	mg/kg	0.5	24.6	11-JUN-98	CSG
Lead - Total	6010	mg/kg	1.	296.	11-JUN-98	CSG

ND-Not Detected
RDL-Reported Detection Limit

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ANALYTICAL REPORT

Mr. Rimmer Covington
Covington & Associates
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Pass Christian, MS 39571

15-JUN-1998

Sample Description: Soil Composite
Client ID: P-13/1-2'
Site/Plant : #6175
Date Collected: 03-JUN-98 09:40
Date Received: 05-JUN-98 14:39
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7438-13

Parameter	Method	Units	RDL	Result	Analyzed	Analyst
Arsenic - Total	6010	mg/kg	0.5	2.3	11-JUN-98	CSG
Lead - Total	6010	mg/kg	1.	59.	11-JUN-98	CSG

D-Not Detected
L-Reported Detection Limit

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ANALYTICAL REPORT

15-JUN-1998

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Sample Description: Soil Composite
Client ID: P-14/1-2'
Site/Plant : #6175
Date Collected: 03-JUN-98 09:50
Date Received: 05-JUN-98 14:39
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7438-14

Parameter	Method	Units	RDL	Result	Analyzed	Analyst
Arsenic - Total	6010	mg/kg	0.5	10.4	11-JUN-98	CSG
Lead - Total	6010	mg/kg	1.	47.	11-JUN-98	CSG

ND-Not Detected
RDL-Reported Detection Limit

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ANALYTICAL REPORT

15-JUN-1998

Mr. Rimmer Covington
Covington & Associates
112 Davis Avenue
Pass Christian, MS 39571

Sample Description: Soil Composite
Client ID: P-15/1-2'
Site/Plant : #6175
Date Collected: 03-JUN-98 10:00
Date Received: 05-JUN-98 14:39
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7438-15

arameter	Method	Units	RDL	Result	Analyzed	Analyst
Arsenic - Total	6010	mg/kg	0.5	121.	11-JUN-98	CSG
Lead - Total	6010	mg/kg	1.	111.	11-JUN-98	CSG

-Not Detected
-Reported Detection Limit

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ANALYTICAL REPORT

Mr. Rimmer Covington
Covington & Associates
112 Davis Avenue
Pass Christian, MS 39571

15-JUN-1998

Sample Description: Soil Composite
Client ID: P-16/1-2'
Site/Plant : #6175
Date Collected: 03-JUN-98 10:10
Date Received: 05-JUN-98 14:39
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7438-16

Parameter	Method	Units	RDL	Result	Analyzed	Analyst
Arsenic - Total	6010	mg/kg	0.5	3.8	11-JUN-98	CSG
Lead - Total	6010	mg/kg	1.	15.	11-JUN-98	CSG

ot Detected
Reported Detection Limit

Peter Ciarleglio
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ANALYTICAL REPORT

15-JUN-1998

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Sample Description: Soil Composite
Client ID: P-17/1-2'
Site/Plant : #6175
Date Collected: 03-JUN-98 10:20
Date Received: 05-JUN-98 14:39
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7438-17

rameter	Method	Units	RDL	Result	Analyzed	Analyst
rsenic - Total	6010	mg/kg	0.5	1.6	11-JUN-98	CSG
ead - Total	6010	mg/kg	1.	7.	11-JUN-98	CSG

-Not Detected
L-Reported Detection Limit

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ANALYTICAL REPORT

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Sample Description: Soil Composite
Client ID: P-18/1-2'
Site/Plant : #6175
Date Collected: 03-JUN-98 10:30
Date Received: 05-JUN-98 14:39
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7438-18

ameter	Method	Units	RDL	Result	Analyzed	Analyst
rsenic - Total	6010	mg/kg	0.5	6.4	11-JUN-98	CSG
ead - Total	6010	mg/kg	1.	40	11-JUN-98	CSG

lot Detected
-Reported Detection Limit

Peter Ciarleglio
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ANALYTICAL REPORT

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Sample Description: Soil Composite
Client ID: P-19/1-2'
Site/Plant : #6175
Date Collected: 03-JUN-98 10:40
Date Received: 05-JUN-98 14:39
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7438-19

ameter	Method	Units	RDL	Result	Analyzed	Analyst
rsenic - Total	6010	mg/kg	0.5	0.8	11-JUN-98	CSG
ead - Total	6010	mg/kg	1.	6.	11-JUN-98	CSG

lot Detected
·Reported Detection Limit

Peter Ciarleglio
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ANALYTICAL REPORT

15-JUN-1998

immer Covington
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avis Avenue
Christian, MS 39571

Sample Description: Soil Composite
Client ID: P-20/1-2'
Site/Plant : #6175
Date Collected: 03-JUN-98 10:50
Date Received: 05-JUN-98 14:39
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7438-20

eter	Method	Units	RDL	Result	Analyzed	Analyst
enic - Total	6010	mg/kg	0.5	3.4	11-JUN-98	CSG
d - Total	6010	mg/kg	1.	13.	11-JUN-98	CSG

Detected
orted Detection Limit

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15-JUN-1998

Sample Description: Soil Composite
Client ID: P-22/1-2'
Site/Plant : #6175
Date Collected: 03-JUN-98 11:10
Date Received: 05-JUN-98 14:39
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7438-22

meter	Method	Units	RDL	Result	Analyzed	Analyst
senic - Total	6010	mg/kg	0.5	2.9	11-JUN-98	CSG
ad - Total	6010	mg/kg	1.	27.	11-JUN-98	CSG

Detected
orted Detection Limit

Pete Ciarleglio
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ANALYTICAL REPORT

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15-JUN-1998

Sample Description: Soil Composite
Client ID: P-24/1-2'
Site/Plant : #6175
Date Collected: 03-JUN-98 11:30
Date Received: 05-JUN-98 14:39
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7438-24

ameter	Method	Units	RDL	Result	Analyzed	Analyst
'senic - Total	6010	mg/kg	0.5	84.0	11-JUN-98	CSG
ead - Total	6010	mg/kg	1.	714.	11-JUN-98	CSG

Detected
orted Detection Limit

Peter Ciarleglio, M.S., Q.A. Officer

RCI Project Number and Title #6175 / Covington & Assoc.
Contact/Address Rimmer Covington / Pass Christian, MS
Desired Turnaround Date Normal

RESOURCE CONSULTANTS

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FAX: (615) 370-4339

LAB USE ONLY RCI Log No.	SAMPLE DESCRIPTION Include all information for completely identifying each sample. Also include physical description: water, soil, groundwater, etc.	Date and Time Collected		Sample Type GRAB	Sample Type COMP	Number and Type of Containers	Field Pres.	Field pH	ANALYSIS REQUIRED Special Comments/Instructions, etc.	LAB USE ONLY (Upon Receipt) Preservative	pH	Temp deg. C	Head Space
	Test Pit 4 (2.5-3.5')	6/3/98	1210		✓	1-Bag			Arsenic, Lead				
	T-4 50N (1-2')		1220										
	T-4 100N		1230										
	T-4 50E		1240										
	T-4 100E		1250										
	T-4 50S		1300										
	T-4 100S		1310										
	T-4 50W		1320										
	T-4 100W		1330										
7439-1	* North End Background		1630										
-2	* South End Background		1630										

(* Run background samples first & call Rimmer w/results)

SIGNATURE REQUIRED OF ALL PERSONS HANDLING SAMPLES		SAMPLE TRANSPORT: METHOD AND CONDITION	DATE	TIME
Sample Collected By:	Rick Crume	Cooler	6/4/98	1300
Received By:				
eived By:				
Logged in RCI Lab By:		Temperature Upon Receipt in Lab:	6/5	1501
rned By:				
:				

ION: Goldenrod retained by Client/Project Manager, all others accompany sample shipment to Laboratory.

Form No. 0303

RCI Project Number and Title #6175 / Covington & Assoc.
Contact/Address Rimmer Covington / Pass Christian, MS
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LAB USE ONLY	SAMPLE DESCRIPTION	Date and Time Collected		Sample Type		Number and Type of Containers	Field		ANALYSIS REQUIRED	LAB USE ONLY (Upon Receipt)			
RCI Log No.	Include all information for completely identifying each sample. Also include physical description: water, soil, groundwater, etc.			GRAB	COMP		Pres.	pH	Special Comments/Instructions, etc	Preservative	pH	Temp deg. C	Head Space
	Test Pit 5 (3-5')	6/3/98	1340		✓	1-Bag			Arsenic, Lead				
	T-5 50N (1-2')	↓	1350		↓	↓			↓				
	T-5 100N		1400										
	T-5 50E		1410										
	T-5 100E		1420										
	T-5 50S		1430										
	T-5 100S		1440										
	T-5 50W		1450										
	T-5 100W		1500										

SIGNATURE REQUIRED OF ALL PERSONS HANDLING SAMPLES		SAMPLE TRANSPORT: METHOD AND CONDITION	DATE	TIME
Sample Collected By:	Rick Chume	Cooler	4/98	1300
Received By:				
Received By:				
Received/Logged in RCI Lab By:		Temperature Upon Receipt in Lab:		
Sample Returned By:				
Received By:				

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LAB USE ONLY	SAMPLE DESCRIPTION			Sample Type			Field		ANALYSIS REQUIRED	LAB USE ONLY (Upon Receipt)			
RCI Log No.	Include all information for completely identifying each sample. Also include physical description: water, soil, groundwater, etc.	Date and Time Collected		GRAB	COMP	Number and Type of Containers	Pres.	pH	Special Comments/Instructions, etc.	Preservative	pH	Temp deg. C	Head Space
	Test Pit 6 (2-3')	6/3/98	1510		✓	1-Bag			Arsenic, Lead				
	T-6 50N (1-2')		1520										
	T-6 100N		1530										
	T-6 50E		1540										
	T-6 100E		1550										
	T-6 50S		1600										
	T-6 100S		1610										
	T-6 50W		1620										
	T-6 100W		1630										

SIGNATURE REQUIRED OF ALL PERSONS HANDLING SAMPLES		SAMPLE TRANSPORT: METHOD AND CONDITION	DATE	TIME
Sample Collected By:	Rick Crumie	Cooler	6/4/98	1300
Received By:				
Received By:				
Received/Logged in RCI Lab By:		Temperature Upon Receipt in Lab:		
Sample Returned By:				
Received By:				

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LAB USE ONLY RCI Log No.	SAMPLE DESCRIPTION Include all information for completely identifying each sample. Also include physical description: water, soil, groundwater, etc.	Date and Time Collected	Sample Type GRAB	Sample Type COMP	Number and Type of Containers	Field Pres.	Field pH	ANALYSIS REQUIRED Special Comments/Instructions, etc.	LAB USE ONLY (Upon Receipt) Preservative	pH	Temp deg. C	Head Space
	Test Pit 9 (2-3')	6/3/98 1735		✓	1-Bag			Arsenic, Lead				
	T-9 50N (1-2')	1740										
	T-9 100N	1745										
	T-9 50E	1750										
	T-9 100E	1755										
	T-9 50S	1800										
	T-9 100S	1805										
	T-9 50W	1810										
	T-9 100W	1815										

SIGNATURE REQUIRED OF ALL PERSONS HANDLING SAMPLES		SAMPLE TRANSPORT: METHOD AND CONDITION	DATE	TIME
ample Collected By:	Rick Chunie	Cooler	6/4/98	1300
eceived By:				
eceived By:				
eceived/Logged in RCI Lab By:				
ample Returned By:		Temperature Upon Receipt in Lab:		
eceived By:				

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SAMPLE CHAIN OF CUSTODY RECORD

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RCI Project Number and Title #6175 / Covington & Assoc.

Contact/Address Rimmer Covington / Pass Christian, MS

Desired Turnaround Date Normal

LAB USE ONLY RCI Log No.	SAMPLE DESCRIPTION Include all information for completely identifying each sample. Also include physical description: water, soil, groundwater, etc.	Date and Time Collected	Sample Type GRAB	Sample Type COMP	Number and Type of Containers	Field Pres.	Field pH	ANALYSIS REQUIRED Special Comments/Instructions, etc.	LAB USE ONLY (Upon Receipt) Preservative	pH	Temp deg. C	Head Space
L7438-1	P- 1 (1-2')	6/3/98 0800		✓	1-Bag			Arsenic, Lead				
-2	P. 2 ↓	↓ 0810		↓	↓			↓				
-3	P-3	0815										
-4	P-4	0820										
-5	P-5	0830										
-6	P-6	0840										
-7	P-7	0850										
-8	P-8	1215										
-9	P-9	0900										
-10	P-10	0910										
-11	P-11	0920										
-12	P-12	0930										

SIGNATURE REQUIRED OF ALL PERSONS HANDLING SAMPLES		SAMPLE TRANSPORT: METHOD AND CONDITION	DATE	TIME
Sample Collected By:	Rick Crume	Cooler	6/4/98	1300
Received By:				
Received By:				
Received/Logged in RCI Lab By:	Teresa Grigsby	Temperature Upon Receipt in Lab:	6/5	1439
Sample Returned By:				
Received By:				

DISTRIBUTION: Goldenrod retained by Client/Project Manager, all others accompany sample shipment to Laboratory.

Form No 0303

Form No 0303

CHAIN OF CUSTODY RECORD

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FAX (615) 370-4339

RCI Project Number and Title #6175 / Covington & Assoc.

Contact/Address Rimmer Covington / Pass Christian, MS

Desired Turnaround Date Normal

LAB USE ONLY	SAMPLE DESCRIPTION	Date and Time Collected	Sample Type		Number and Type of Containers	Field		ANALYSIS REQUIRED	LAB USE ONLY (Upon Receipt)			
RCI Log No.	Include all information for completely identifying each sample. Also include physical description: water, soil, groundwater, etc.		GRAB	COMP		Pres.	pH	Special Comments/Instructions, etc.	Preservative	pH	Temp. Deg. C	Head Space
L7438-13	P-13 (1-2')	6/3/98 0940		✓	1-Bag			Arsenic, Lead				
-14	P-14	0950										
-15	P-15	1000										
-16	P-16	1010										
-17	P-17	1020										
-18	P-18	1030										
-19	P-19	1040										
-20	P-20	1050										
-21	P-21	1100										
-22	P-22	1110										
-23	P-23	1120										
-24	P-24 ↓	↓ 1130		↓	↓			↓				

SIGNATURE REQUIRED OF ALL PERSONS HANDLING SAMPLES		SAMPLE TRANSPORT: METHOD AND CONDITION	DATE	TIME
Sample Collected By:	Rick Crume	Cooler	6/4/98	1300
Received By:				
Received By:				
Received/Logged in RCI Lab By:		Temperature Upon Receipt in Lab:	6/5	1135
Sample Returned By:				
Received By:				

DISTRIBUTION: Goldenrod retained by Client/Project Manager, all others accompany sample shipment to Laboratory

Form No 0303

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ANALYTICAL REPORT

18-JUN-1998

mmer Covington
ton & Associates
vis Avenue
hristian, MS 39571

Sample Description: Groundwater Grab
Client ID: MW-1
Site/Plant : CAC 06-175.1
Date Collected: 10-JUN-98 12:10
Date Received: 11-JUN-98 14:59
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7478-1

ter	Method	Units	RDL	Result	Analyzed	Analyst
ate	9038	mg/l	1.	561.	18-JUN-98	HHA
mium - Total	6010	mg/l	0.002	0.014	16-JUN-98	CSG
- Total	6010	mg/l	0.002	1.94	16-JUN-98	CSG

Detected
ported Detection Limit

Peter Ciarleglio
Peter Ciarleglio, M.S., Q.A. Officer

Resource Analytical Solutions™
Environmental Laboratory Services

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ANALYTICAL REPORT

19-JUN-1998

Rimmer Covington
vington & Associates
2 Davis Avenue
ss Christian, MS 39571

Sample Description: Groundwater Grab
Client ID: MW-2
Site/Plant : CAC 06-175.1
Date Collected: 10-JUN-98 12:55
Date Received: 11-JUN-98 14:59
RAS Account No.: 8164.00
RAS Project No.: 8164.00
RAS Sample No.: L7478-2

ameter	Method	Units	RDL	Result	Analyzed	Analyst
ulfate	9038	mg/l	1.	600	18-JUN-98	HHA
hromium - Total	6010	mg/l	0.002	ND	16-JUN-98	CSG
ead - Total	6010	mg/l	0.002	0.002	16-JUN-98	CSG

Not Detected
-Reported Detection Limit

Pete Ciarleglio
Peter Ciarleglio, M.S., Q.A. Officer

SAMPLE CHAIN OF CUSTODY RECORD

Resource Analytical Solutions™
Environmental Laboratory Services

MAIL:
P.O. Box 1848
Brentwood, TN 37024-1848
Phone: (615) 373-5040

Delivery:
7121 CrossRoads Blvd.
Brentwood, TN 37027
Lab Fax: (615) 370-1026

RAS Project Number, Title and Site CAC 06-187.1 Gulfport Fertilizer

Contact/Address Alan Young CAC, 112 Davis Ave Pass Christian

Desired Turnaround Date Standard

Lab Use Only	SAMPLE DESCRIPTION	Date and Time Collected		Sample Type		Number and Type of Containers	Field		ANALYSIS REQUIRED	LAB USE ONLY (Upon Reciept)			
RAS Log No.	Include all Information for completely identifying each sample. Also include physical descriptions: water, soil, groundwater, etc.			GRAB	COMP		Pres.	pH	Special Comments/Instuctions, etc.	Preservative	pH	Chlorine	Head Space
	MW-1 GW	6/10/98				1-plastic 1 plastic	HNO3 none		Chromium, Lead Sulfates				
	MW-2 GW	6/11/98				1 plastic 1 plastic	HNO3 none		Chromium Lead, Sulfates				

SIGNATURE REQUIRED OF ALL PERSONS HANDLING SAMPLES		SAMPLE TRANSPORT: METHOD AND CONDITION		DATE	TIME
Sample Collected By:		Air Borne		6/10/98	
Received By:					
Received By:					
Logged In RAS Lab By:			Temperature Upon Receipt In Lab:		
Sample Returned By:					
Received By:					

Distribution: [illegible] Client Project Manager, all others accompany sample shipment to Laboratory

WELL SAMPLING FIELD DATA SHEET

DATE: 6/10/98	USER'S NAME: Alane Young	CITY: Gulfport
COMPANY NAME: CAC	RCI PROJECT NO. CAC 06-1751 / Gulfport Fertilizer	STATE: Mississippi

INITIAL FIELD CALIBRATION

pH Meter No.: Orion MDL. 250A Serial No.: 005644

Conductivity Meter No.: Orion MDL 124 Serial No.: SN 32247020

Turbidity Meter No.: HACH MDL. 2100P Serial No.: 920300000648

Purge Cal. Buffers	4 4.00	7 6.98	10 9.77	Temp 33.4 °C
Sample	4	7	10	Temp °C
Purge	Temp¹ 25.3 °C	Table	Meter 1449	Cl
Sample	Temp °C	Table	Meter	Cl
Purge Cal. Solution²	0.00 0.32	20.0 23.0	100 84.9	800 790
Sample	0.00	20.0	100	800

DATE:

WELL INFORMATION

Well No.	Top of Casing Elevation (Feet)	Well Depth (Bottom) (Feet)	DRAWGS Water Level (Feet)	Water Level Elevation (Feet)	Water Column (Feet)	Volume of Water in Casing (Gal.)³	Min. Volume to be Purged (Gal.)
MW-1		11.5	4.4		7.1		

Well Casing Construction:

Well Casing Diameter:

CALIBRATION FOR WELL VOLUME

πr^2 (Water Column x 7.481)

2" Well		4" Well		6" Well	
r^2 =	0.0069	r^2 =	0.0278	r^2 =	0.0625
π =	x 3.14	π =	x 3.14	π =	x 3.14
	0.220		0.0087		.0196
Gal =	x 7.48	Gal=	x 7.48	Gal =	x 7.48
	0.165		0.653		0.147
Water Column x		Water Column x	7.1	Water Column x	
Well Volumes x 3		Well Volumes x 3	4.63	Well Volumes x 3	
Min. Volume to be Purged		Min. Volume to be Purged	13.9	Min. Volume to be Purged	

[1] Orion meters are temperature compensated to 25°C. Meter should be set to 1408 at 25°C ± 5°C. Cole Parmer meters are temperature compensated to 25°C. YSI meter must have a correction factor of 1.00 ±0.5%. Also, the temperature must be corrected manually. Check calibration manual for further details.

[2] Turbidity Meter must be set according to the lab assigned calibration NTU's values for each standard.

[3] Field measurements must stabilize to within 5% before purging is complete or 3 volumes, whichever is greater.

DATE: 6/10/98

PURGE INFORMATION

	Purged Volume (Gal)	Time Purged (Min.)	Actual Time Purged	Field Temp³ (°C)	Field pH³	Field Conductivity³ (µmhos)	Field Turbidity³ (NTU)
11:45	5		11:40-	24.7	3.48	747	9.38
	9			24.8	3.50	762	200
	13						
11:55	14						
12:00	15			24.3	3.43	789	25.6
	25			24.8	3.65	818	49.4
	One Point Final Check						

12:15

Signature of Field Technician: Alan Young

Lab Manager Approval:

DATE:

SAMPLING INFORMATION

Time Sampled	Field Temp (°C)	Field pH	Field Conductivity (µmhos)	Field Turbidity³ (NTU)
12:10	24.8	3.65	818	49.4
One Point Final Check				

Signature of Field Technician:

Lab Manager Approval:

WELL SAMPLING FIELD DATA SHEET

DATE: 6/10/98	USER'S NAME: Alane Young	CITY: Gulfport	
COMPANY NAME: CAC	RCI PROJECT NO. CAC 06-175.1/Gulfport Fertilizer	STATE: Mississippi	

INITIAL FIELD CALIBRATION

pH Meter No.: Orion MDL 250 A Serial No.: 005644

Conductivity Meter No.: Orion MDL 124 Serial No.: SN 32247020

Turbidity Meter No.: HACH MDL 2100 P Serial No.: 9203000000648

Purge Cal. Buffers	4 4.00	7. 6.98	10 9.77	Temp 33.4 °C
Sample	4	7	10	Temp °C
Purge	Temp¹ 25.3 °C	Table	Meter 1449	Cl
Sample	Temp °C	Table	Meter	Cl
Purge Cal. Solution²	0.00 0.32	20.0 23.0	100 84.9	800 790
Sample	0.00	20.0	100	800

DATE:

WELL INFORMATION

Well No.	Top of Casing Elevation (Feet)	Well Depth (Bottom) (Feet)	Water Level (Feet)	Water Level Elevation (Feet)	Water Column (Feet)	Volume of Water in Casing (Gal.)	Min. Volume to be Purged (Gal.)
mw-2		12	4.9		7.1		

Well Casing Construction:

Well Casing Diameter:

CALIBRATION FOR WELL VOLUME

x r² (Water Column x 7.481)

2" Well		4" Well		6" Well	
r² =	0.0069	r² =	0.0278	r² =	0.0625
π =	x 3.14	π =	x 3.14	π =	x 3.14
	0.220		0.0087		.0196
Gal =	x 7.48	Gal=	x 7.48	Gal =	x 7.48
	0.165		0.653		0.147
Water Column x		Water Column x	7.1	Water Column x	
Well Volumes x 3		Well Volumes x 3	4.6	Well Volumes x 3	
Min. Volume to be Purged		Min. Volume to be Purged	13.9	Min. Volume to be Purged	

[1] Orion meters are temperature compensated to 25°C. Meter should be set to 1408 at 25°C ± 5°C. Cole Parmer meters are temperature compensated to 25°C. YSI meter must have a correction factor of 1.00 ±0.5%. Also, the temperature must be corrected manually. Check calibration manual for further details.

[2] Turbidity Meter must be set according to the lab assigned calibration NTU's values for each standard.

[3] Field measurements must stabilize to within 5% before purging is complete or 3 volumes, whichever is greater.

DATE: 6/10/98

PURGE INFORMATION

Purged Volume (Gal)	Time Purged (Min.)	Actual Time Purged	Field Temp³ (°C)	Field pH³	Field Conductivity³ (µmhos)	Field Turbidity³ (NTU)
		12:38				
5		12:43	24.4	5.42	928	47.6
10		12:45				
12.5		12:47	23.1	5.46	989	40.3
15						
17.5		12:52	23.3	5.46	949	13.1
One Point Final Check						

12:50

Signature of Field Technician: Alane Young

Lab Manager Approval:

DATE:

SAMPLING INFORMATION

Time Sampled	Field Temp (°C)	Field pH	Field Conductivity (µmhos)	Field Turbidity³ (NTU)
12:55	23.2	5.54	958	7.29
One Point Final Check				

Signature of Field Technician:

Lab Manager Approval:

20 gals
12:55
sampled

RECEIVED
JUN - 1 1999
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ENVIRONMENTAL RESOURCE CONSULTANTS

FILE COPY

REPORT

COVINGTON AND ASSOCIATES CORPORATION
Environmental Resource Consultants

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PHASE I ENVIRONMENTAL SITE ASSESSMENT

CASE STUDY:

Old Gulfport Fertilizer Co., Property
33.06 Acres in the East Half of Northwest Quarter
Section 33, T7S, R11 W, Harrison Co., Ms.

Prepared for

Mr. Andy J. Alfonso, Jr.

June 12, 1995

Prepared by:
COVINGTON AND ASSOCIATES CORPORATION
Delivery Address: 112 Davis Avenue
Mailing Address: P. O. Box 177
Pass Christian, Mississippi 39571
(601) 452-4999
FAX: (601) 452-0117

COVINGTON & ASSOCIATES CORPORATION

ENVIRONMENTAL RESOURCE CONSULTANTS

June 12, 1995

Mr. Andy J. Alfonso, Jr.
HANCOCK BANK
P. O. Box 4019
Gulfport, Mississippi 39502

Re: **EXECUTIVE SUMMARY**
Phase I ESA @ the Old Gulfport
Fertilizer Co. Property located in the
E/2 NW/4 Section 33, T7S, R11 West
Harrison County, Mississippi

Dear Mr. Alfonso,

Commencing on May 5, 1995, Covington And Associates Corporation (CAA) performed a Phase I Environmental Site Assessment to determine the presence, or the potential presence of hazardous residuals and other environmental concerns at the referenced property. Access approval and authority to proceed were granted via your authorization.

This firm responsibly identifies environmental liabilities that pose the threat of economic or regulatory hardship to our clients. Environmental concerns exceeding reasonable business risk are closely evaluated by CAA before deducing recommendations. The Findings & Conclusions section on page 18 of this report, summarizes significant observations that should be reviewed.

Specifically, the areas of concern are the presence of wetlands, radioactive materials, underground storage tanks or a tank bed, asbestos containing materials, and surface areas used in connection with the production of virgin sulfuric acid and superphosphate. The development of a work plan to expand the site inspection is recommended.

The following REPORT represents the findings of the assessment in full. We appreciate this opportunity to be of professional service to you. Thanks for your business.

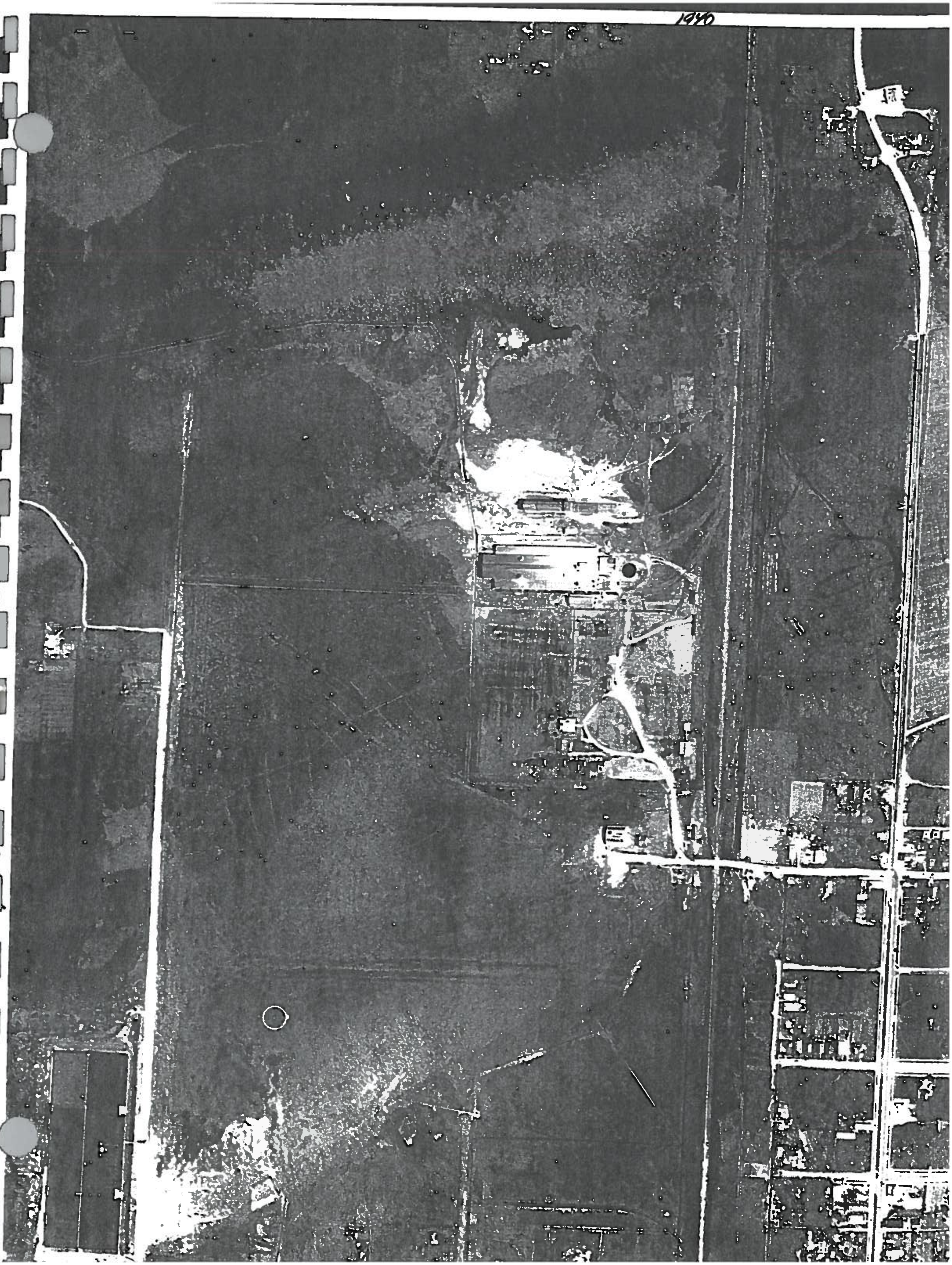
Best regards,
COVINGTON AND ASSOCIATES CORPORATION

Rimmer Covington, CPL/ESA #3476

DISTRIBUTION:

Mr. Andy J. Alfonso, Jr. - Three Originals

1940



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SECTION 1:
SCOPE OF SERVICES

This report constitutes the findings and conclusions of the Phase I Environmental Site Assessment (ESA) completed for Hancock Bank's inquiry into the property known as the Old Gulfport Fertilizer Co., site located in the E/2 NW/4 of Section 33, Township 7 South, Range 11 West, Harrison County (Gulfport), Mississippi 39501 and which is more particularly described in section 2.1 of this report.

This preliminary environmental site assessment was commenced on May 5, 1995 by Covington And Associates (CAA) to evaluate said property for the presence or the potential presence of environmental concerns. Included in this report are findings based on information obtained from a variety of public and private sources addressing site history, present and past operations, and potential off-site and on-site influences.

The following tasks were undertaken:

1. This report conforms with the ASTM E1527-93, Standard Practice for Environmental Assessments: Phase I Environmental Site Assessment Process as deemed appropriate by CAA.

2. The property description was proofed and compared to various maps and instruments in the chain of title.

3. A characterization of the property was developed utilizing the skills and experience of a CPL/ESA, a Professional Geologist; the U. S. Department of Agriculture, Soil Conservation Service and Forest Service; the U. S. Geological Survey, Water - Resources Investigations Report #87-4172 & #86-4364; the U. S. Geological Survey, Generalized Potentiometric Surface of Shallow Aquifers in Southern Mississippi, 1982 and #87-4257 and the U.S.G.S, "Gulfport, North" Topographic Quadrangle Map.

4. An historical profile of the property was developed by CAA personnel utilizing, 1982 & 1990 black and white aerial photography provided by the Harrison County Planning & Development Commission, 1966 & 1976 black and white aerial photography, 1985 color infrared photography provided by the Gulf Regional Planning commission and 1940 black and white aerial photography provided by Tobin Aerial Surveys, San Antonio, Texas; the U.S.G.S, "Gulfport,North" Topographic Quadrangle Map; the 1929 Tax Assessors Plats; current ownership records and maps of the Harrison County, Mississippi, Tax Assessors Office; instruments of record affecting the property and the adjacent properties through a limited title examination from records located at the Harrison County, Chancery Clerks Offices in Gulfport, Mississippi.

5. Pertinent regulatory agency information was reviewed.

6. Off-site reconnaissance was conducted by CAA personnel on June 3, 1995 to determine what if any off premises activities may be occurring in close proximity to the subject tract which could affect its environmental integrity.

7. On-site reconnaissance was conducted by CAA personnel on June 3, 1995 to evaluate through visual observation, the current physical condition of the subject tract and existing structures. Visual observations of the abutting properties were made from the interior of the subject tract and accessible public ways.

8. As a quality control measure, this report was subjected to a peer review by CAA's partners John Szabo, PE, Senior Consultant, Resource Consultants, Inc., Brentwood, Tennessee and E. Burton, Kemp, III, PG. .

Much of the information included in this report was obtained from a variety of public records, and personal interviews with public officials. Activities or issues which were considered, to the degree of the selected information deemed appropriate by the CAA representative at that time, included; site operations, fuels management, underground storage tanks (UST's), above ground storage tanks, past and present chemical, solvent, pesticide and herbicide use and storage practices, wastewater handling, transformers, asbestos, and records of staining or spills. The scope of work for this site assessment did not include borings, soil, surface water, or groundwater sampling, or chemical testing.

SECTION 2:
SITE PROPERTY DESCRIPTION & LOCATION MAP

2.1 Legal Description of Subject Site

The following description of the subject tract of land was proofed and compared to the Advalorem Tax records at the offices of the Harrison County, Tax Assessor, various plats, maps and instruments appearing in the chain of title, to - wit:

Harrison County, Mississippi
Section 33, Township 7 South, Range 11 West
City of Gulfport

That tract or parcel of land situated in the East half of the Northwest Quarter and more particularly described as follows to-wit:
Beginning at the Southwest corner of the Southeast Quarter of the northwest Quarter of said section 33, at which point there is a concrete monument; and running thence East along the South line of said forty acre tract 919.90 feet, more or less to the right-of-way of the Illinois Central Railroad Co., (formerly the Gulf and Ship Island Railroad), at which point of intersection of the right-of-way of said railroad there is a fixed concrete monument; thence North along said right-of-way of said railroad 1576.00 feet to a point, at which point there is a fixed concrete monument; thence West 907.90 feet, more or less, to a point on the West line of the Northeast Quarter of the northwest Quarter of said section 33, at which point there is a fixed concrete monument; thence South along the Wet line of the Northeast Quarter of the Northwest Quarter and the Southeast Quarter of the Northwest Quarter of said section 33, a distance of 1576.00 feet to the point of beginning and being the identical land conveyed by the Deposit Guaranty National Bank to Ernest Yeager & Sons, Inc.
Containing 33.06 acres, more or less.

Surface Owner: Hancock Bank
P. O. Box 4019
Gulfport, Mississippi

2.2 Site & Vicinity Characteristics (Natural Features)

2.2.1 Topographic Features

Topographically, the site is astride one of the many coastwise, east/west, parallel trending buried beach ridges. Elevations at the site vary from slightly above, +25 feet mean sea level near the center of the site to at or just below +25 feet mean sea level near the Northern limit of the property.

Surface drainage off-site is sufficient and is generally to the North into a low wetlands area. There is some drainage to the Southwest where additional wetlands are suspected. Drainage from the Northern wetlands is Northwest via several drainage ditches into

Turkey Creek; the drainage Southward is via a collection ditch and eventually into the Western extremities of Brickyard Bayou.

Flooding in the area is not considered critical since the high elevation precludes flooding during hurricane surges, and there are no streams which might spill over their banks.

The nearest major body of water is the Mississippi Sound, located about 1.75 miles to the South.

2.2.2 Geologic Features

Geologically, the site is located within a series of East/West, coastwise trending beach ridges. Specifically, the site is astride a buried beach ridge which comprise a part of the Gulfport ridge complex. As a result, there is variation of soil types due to drainage and modified hydrologic patterns. Soils at the site consist primarily of Harleston sandy loam which is well drained, exhibits moderate permeability, and slow runoff. Along the Northern limits of the property, Plummer loamy sand is found. This is a hydric soil, poorly drained with very slow run off. Along the West property line, Atmore silty loams are identified which are also hydric, poorly drained and exhibit slow runoff. In addition, there is a zone, located Southwest of the previous location of the phosphate rock processing building, that appears to be wetlands.

2.2.3 Hydrogeologic Features

There are several private and commercial wells within 1-2 miles of the site. In addition, there are several municipal wells within several miles of the site.

2.2.4 Discussion

There are no observed or anticipated problems from a surface water, flooding, or drainage standpoint associated with this site. However, there are two potential problem areas which should be further investigated and identified. The first is the potential for the presence of wetlands in area of planned development within the property. A wetland delineation, identifying the extent of the wetlands along the Northern and Western Property line, and identifying and delineating the suspect wetlands area Southwest of the old phosphate processing building, is recommended. This information can be used for land/property use planning, permitting and possible on-site mitigation.

2.3 Improvements On The Site

The property consists of mostly vacant land. Presently there is a red brick building on the site that was constructed in or about 1904. The only other structure is possibly a row of process "denning" rooms, or open ended fertilizer separation rooms or both. There are several concrete slabs over the site where structures once stood. Potable water is available by municipal water wells in the vicinity. A municipal sewerage system is available. The site is serviced with electric power lines.

2.4 Statement of Past Present Use

The subject property was an active site in commerce from approximately 1904 to sometime between about 1972 and 1978 (+/-68 years). The first recorded indication of industrial use of the property found by CAA is a Warranty Deed dated July 6, 1903 from J. T. Jones to the Gulfport Cotton Oil, Fertilizer & Manufacturing Co., and which covered the subject lands (Deed Book 56 @ Page 404). The instrument stated that "The grantee must complete the oil mill plant by January 1, 1904." On September 21, 1908 the Gulfport Cotton Oil Fertilizer & Manufacturing Co., conveyed the same to the Exporters Cotton Oil Company (Deed Book 88 @ Page 248). A site sketch and survey was included with this recorded instrument. The site sketch shows six dummy rail lines tied into the Illinois Central Railroad, what appears to be a sulfuric acid manufacturing configuration, what appears to be a phosphate fertilizer production facility, several oil tanks and other facilities used in connection with raw cotton bulk (possibly a cotton gin-see utilization break down on sketch) product handling. A copy of the sketch appears as appendix "E".

As to the raw cotton bulk product facility on the East side of the property:
The exact period that the cotton oil and product facility operated from 1904 to 1920 was not determined from the records. However, the existence of a "refinery shed" is noted in a land conveyance and on the previously mentioned site sketch. CAA did not find aerial photography of this site dated prior to April 13, 1940. The conveyance records show that for a period of about two years beginning in 1920 the cotton product facility was used as "The Continental Tire & Rubber Co., Manufacturers of Automobile Tires & Tubes". A Sanborn Fire Insurance Map dated 1921 further corroborates the land records with a sketch indicating the production configuration at that time. The land records, a 1929 Sanborn map and aerial photography dated after 1922 indicate the cessation of and the dismantling of the tire and rubber manufacturing facility. The 1929 Sanbom Fire Insurance Map appears as appendix "F". The site was not used for this purpose again.

As to the cotton gin facility in the Southeast corner of the property:
Both a 1940 aerial photograph and a 1950 Sanborn Fire Insurance map indicate the presence of a cotton ginning facility in the Southeast corner of the property. Note that the image of a cotton gin on the Sanborn map is faint and may be the remnant of an erasure. No lease or conveyance instruments indicating this use of the site were examined by CAA. Subsequent Sanborn maps and aerial photography examined do not show the cotton ginning facility. The 1950 Sanbom Fire Insurance Map appears as appendix "G". The 1940 aerial photograph appears as appendix "I". 1948 aerial photography of this site is available for review. Because of budget and time constraints CAA did not order a copy of the picture for this report.

As to the fertilizer production facilities:
As previously noted above, records indicate that at least the upper half of the subject tract was being used in connection with the production of sulfuric acid and superphosphate. The land records also show that this area was used for such first by The Gulfport Cotton Oil, Fertilizer & Manufacturing Co., from approximately 1904 until Exporters Cotton Oil Company took over the operations in 1908. That in 1914, Exporters Cotton Oil Co., lost the property through foreclosure. It is believed that from

1914 to approximately 1920, Gulfport Fertilizer Co., company operated the production facilities for Mell R. Wilkinson, The Lowery National Bank of Atlanta, or both. A 1921 Sanborn Fire Insurance map indicates that Gulfport Fertilizer Company was operating the facility at that time. By the year 1925, Gulfport Fertilizer Co., was the sole owner and operator of the facilities. The site was continuously used for sulfuric acid and superphosphate production by Gulfport Fertilizer Co., until sometime in the 1950's. Sanborn Fire Insurance maps from 1929 and 1950 indicate that the fertilizer manufacturing facilities were in full operation. In 1960 the Gulfport Fertilizer Co., relinquished ownership of the subject lands unto H & F Engineering Co., Inc., which lost the property through foreclosure to Deposit Guaranty National Bank within two years. On June 10, 1995 Mr. R. W. Hyde, III, son of R. W. Hyde, Jr., who was the owner of H & F Engineering Co., stated to CAA that his father was in the sewerage and drainage business and that he was never in the fertilizer business. CAA found no evidence that the site was used for any commercial purpose from approximately 1960 when H & F Engineering Co., owned the property for about two years, and during the period when Deposit Guaranty National Bank owned the property for about four years. In the year 1966, the Deposit Guaranty National Bank sold the subject lands to Ernest Yeager & Sons, Inc. Mr. Leroy Yeager, who was secretary treasurer of Ernest Yeager & Sons, Inc., in 1966, stated to CAA on June 9, 1995 that Ernest Yeager and Sons, Inc., acquired the property for investment purposes only and that they were never involved with any process activity at the site. A Sanborn map from 1967 indicates that the site was inactive at that time. In 1972 Ernest Yeager & Sons, Inc., granted a 15 year lease which covered approximately 4.00 acres to Best Concrete Products, Inc., for the purpose of manufacturing concrete block and masonry. A 1976 aerial photograph of the site indicated that the site was being used probably as the brick and masonry business, however the small objects in the photograph were not recognizable by CAA personnel. In or about the year 1982 the Hancock Bank secured the property through foreclosure proceedings. Since the year 1982 the property has not been occupied or operated for industrial or commercial purposes. Both the 1982 and 1990 aerial photographs examined by CAA indicated that the site was vacant except for a few remaining structures. The 1967 Sanborn map appears as appendix "H".

As to the remainder of the property:
Any one of the mapping or photograph references herein indicate the presence of four dwellings on the North end of the property, two garages, an office and four more dwellings on the South end.

As previously described, the aerial photography examined dated 1940, 1966, 1976, 1982 and 1990 corroborate the activities at the property as described above by the instruments of record, the Sanborn Fire Insurance Maps and the limited interviews. The periods when the cotton ginning, tire and rubber manufacturing were in operation and the peak of the superphosphate fertilizer production occurred more than forty years ago. CAA attempted to contact past owners and operators beginning with J. A. Parker (probably deceased) of Davison Gulfport Fertilizer Co., in Baltimore, Maryland; R. Y. Hyde, Jr., (deceased) of H & F Engineering Co., Inc., in Jackson, Mississippi; N.E. Gaston, G. E. Covington, Monroe Lindsey and D. P. Grandberry (all deceased) of Gulfport Fertilizer Co., in Gulfport, Mississippi; Virgil E. Yeager (deceased) president and Leroy Yeager, Secretary - Treasurer of Ernest Yeager and Sons, Inc., of Gulfport, Mississippi; and Shelton Baugh (unknown address or status) president of Best Concrete

Products, Inc. in Gulfport, Mississippi. Leroy Yeager is living in Wiggins, Mississippi (601/928-4937). R. W. Hyde, III resides in Jackson, Mississippi (601/956-7958). A copy of Gulfport Fertilizer Co., stationary appears in Deed Book 469 @ Page 315 and states at the heading "Manufacturers & Distributors" - "Sulfuric Acid - Superphosphate - Complete Fertilizers - Importers of Fertilizer Chemicals."

A listing of available aerial photography appears as appendix "D". Time and budget constraints did not allow for the review of all of the available photography. However, we do not feel that is necessary to review all of the photographs to determine prior use of the site.

The statements as recited above are for the sole purpose of establishing a record of the past and present use of said property from being raw and undeveloped land to the lands present use.

2.4.1 On-site Cultural Resource Issues

On June 8, 1995, Mr. Joseph Giliberti, a staff archaeologist at the Mississippi Department of Archives and History in Jackson, Mississippi compared the location of the subject site to proprietary archaeological mapping and stated to CAA that this property is not marked or known as a culturally significant site.

2.5 Adjacent Property Use

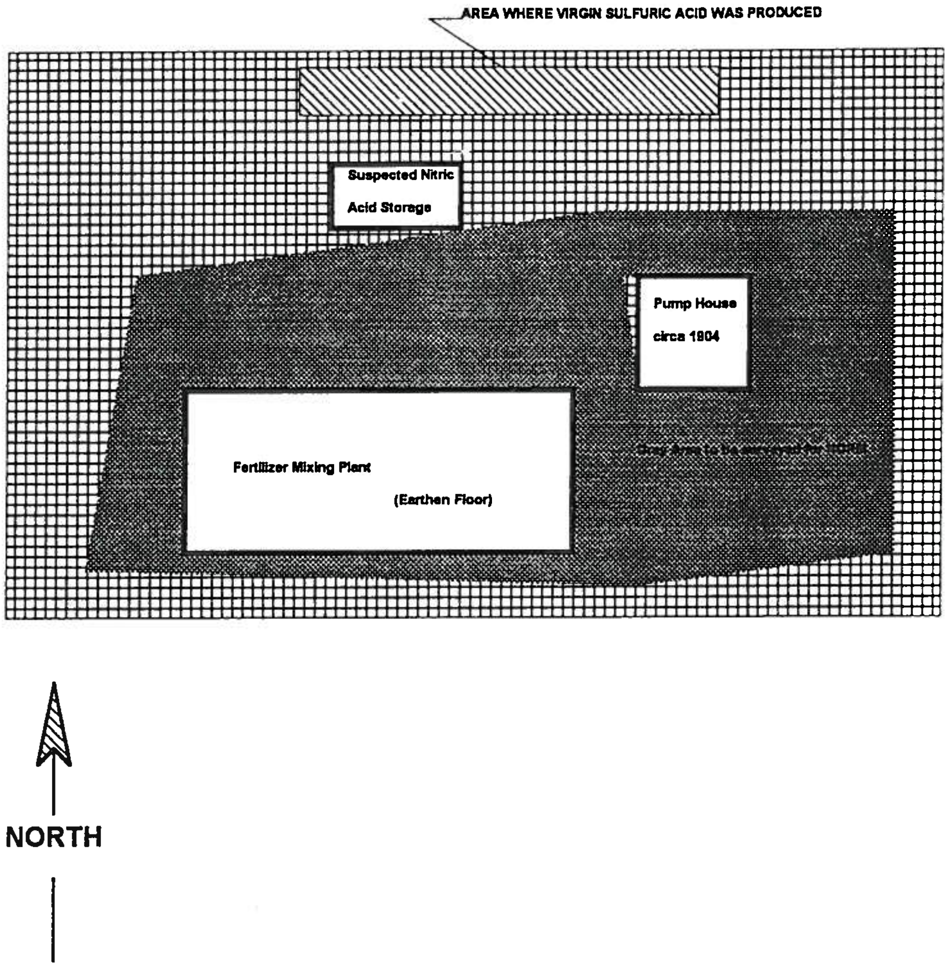
The immediately adjacent properties include vacant land and a low to middle income residential subdivision on the North side, the Illinois Central Railroad and yard on the East and Northeast side, and then several moving and storage and freight transport companies, a Coca Cola Bottling facility and others on the East side, vacant lands on the West side and CAE Plastic, Inc., and vacant lands on the South side.

A 1929 Harrison County Tax Assessors Map, the "Gulfport, North" Topographic Quadrangle Map and the series of aerial photography examined beginning in 1940 to 1990 confirms the Adjacent lands' past use and subsequent events to its present day status. Please note that according to a 1940 aerial photograph, the facility that bounds the subject site on the South side appears to have been the site of the first Gulfport Airport hangar facilities. The same aerial photograph indicates that except as stated above, all of the immediately adjacent lands were vacant at that time period. Subsequent photography examined beginning in the year 1966, indicates the light industrial use of the properties East of the railroad or approximately 200 to 300 feet East of the subject site (i.e. Coca Cola Bottling, moving, storage and freight transportation facilities) and the present plastics production facility on the South side.

2.6 Site Plan (Blow up of areas of concern)

Old Gulfport Fertilizer Company
City of Gulfport, County of Harrison, Mississippi

Not to Scale



2.7 Location Map

FOR LOCATION MAP

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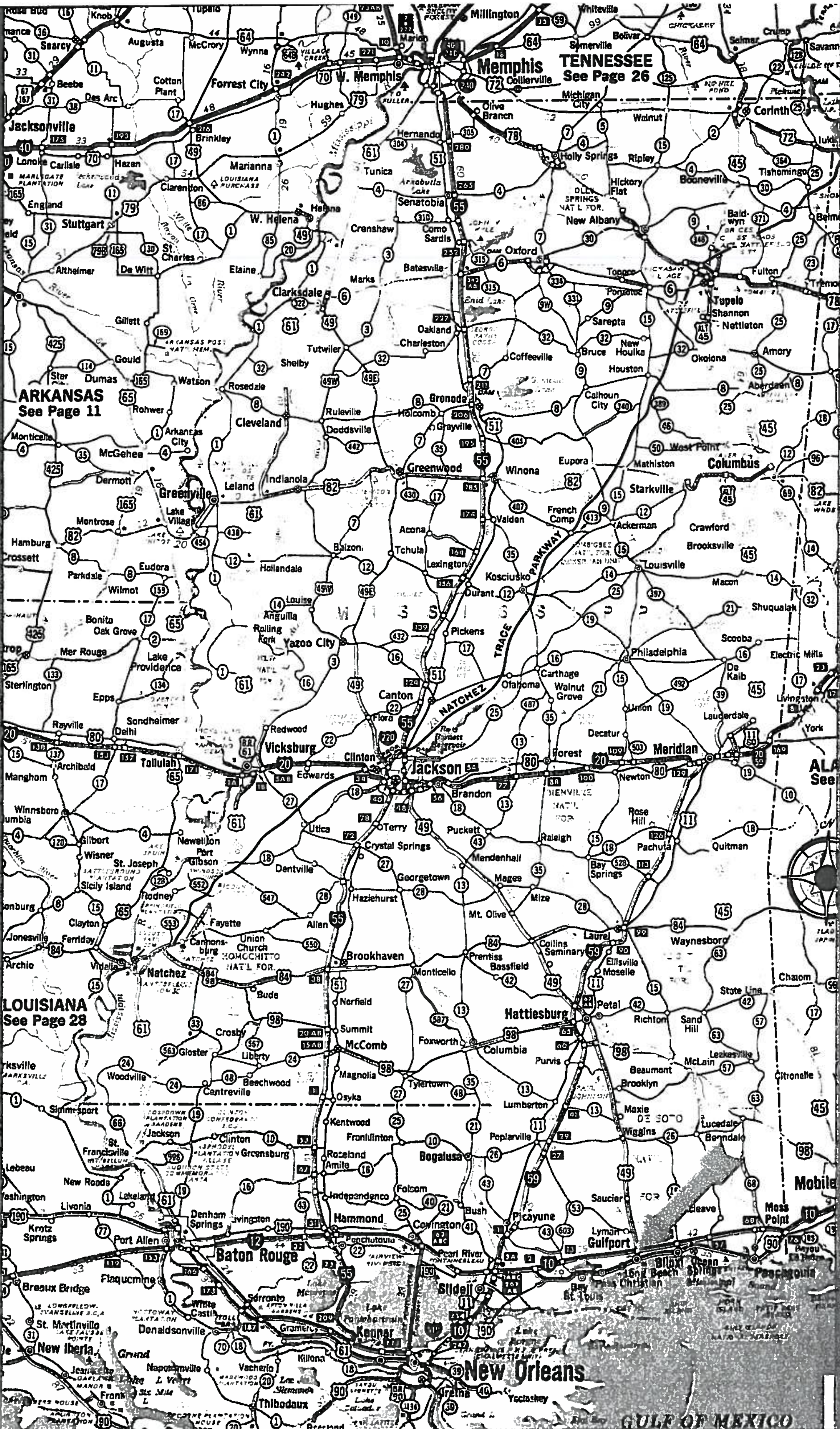
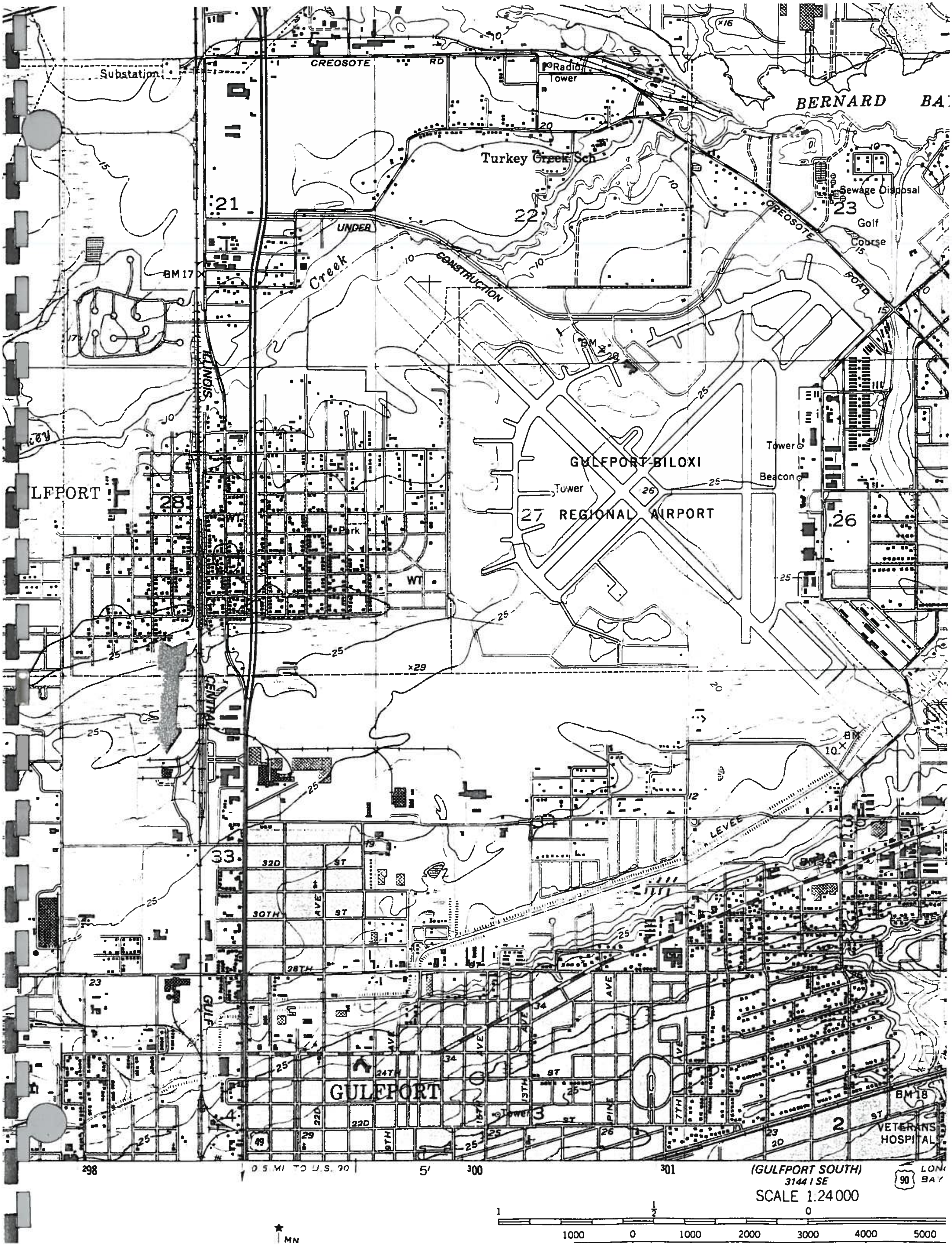

TENNESSEE
See Page 26
ARKANSAS
See Page 11
LOUISIANA
See Page 28
Memphis
W. Memphis
Millington
Whiteville
Somerville
Bolivar
Collierville
Olive Branch
Michigan City
Corinth
Selmer
Hernando
Holly Springs
Ripley
Walnut
Tunica
Senatobia
Como
Sardis
Batesville
Oxford
New Albany
Booneville
Tishomingo
Baldwyn
Tupelo
Shannon
Nettleton
Pontotoc
Fulton
Clarksdale
Marks
Crenshaw
Charleston
Oakland
Coffeeville
Bruce
Houston
Okolona
Amory
Aberdeen
Tutwiler
Shelby
Rosedale
Cleveland
Ruleville
Doddsville
Grenada
Holcomb
Grayville
Calhoun City
Eupora
West Point
Columbus
Mathiston
Starkville
Greenwood
Winona
Indianola
Leland
Greenville
Lake Village
Arkansas City
McGehee
Dermott
Montrose
Hamburg
Crossett
Eudora
Parkdale
Wilmot
Acona
Tchula
Lexington
Belzoni
Hollandale
Durant
Kosciusko
Ackerman
Louisville
Macon
Crawford
Brooksville
French Camp
Vaiden
Shuqualak
Louise
Anguilla
Rolling Fork
Yazoo City
Pickens
Philadelphia
Scooba
De Kalb
Electric Mills
Canton
Flora
Carthage
Walnut Grove
Union
Decatur
Lauderdale
Meridian
Forest
Newton
Clinton
Jackson
Vicksburg
Edwards
Brandon
Redwood
Tallulah
Delhi
Rayville
Sondheimer
Epps
Lake Providence
Oak Grove
Bonita
Mer Rouge
Sterlington
Archibald
Manghom
Winnsboro
Gilbert
Wisner
St. Joseph
Newellton
Port Gibson
Sicily Island
Rodney
Utica
Terry
Crystal Springs
Puckett
Raleigh
Rose Hill
Pachuta
Quitman
Bay Springs
Mendenhall
Magee
Mize
Dentville
Georgetown
Hazlehurst
Mt. Olive
Fayette
Allen
Union Church
Clayton
Ferriday
Vidalia
Natchez
Brookhaven
Monticello
Prentiss
Bassfield
Collins
Seminary
Laurel
Ellisville
Moselle
Waynesboro
State Line
Chatom
Bude
Norfield
Summit
McComb
Liberty
Gloster
Crosby
Centreville
Woodville
Beechwood
Magnolia
Osyka
Foxworth
Columbia
Hattiesburg
Petal
Richton
Sand Hill
Purvis
Tylertown
Lumberton
Beaumont
Brooklyn
McLain
Leakesville
Citronelle
Kentwood
Franklinton
Poplarville
Wiggins
Lucedale
Benndale
Roseland
Amite
Greensburg
Clinton
Jackson
St. Francisville
Simmesport
New Roads
Lobeau
Washington
Livonia
Lakeland
Krotz Springs
Port Allen
Baton Rouge
Denham Springs
Livingston
Independence
Hammond
Bogalusa
Folsom
Covington
Bush
Picayune
Saucier
Lyman
Gulfport
Biloxi
Ocean Springs
Pascagoula
Moss Point
Mobile
Pearl River
Slidell
Ponchatoula
Plaquemine
Breaux Bridge
St. Martinville
New Iberia
Donaldsonville
White Castle
Sorrento
Gramercy
Kenner
Killona
Vacherie
Napoleonville
Thibodaux
Franklin
New Orleans
Gretna
Bay St. Louis
Pass Christian
Long Beach
GULF OF MEXICO
MISSISSIPPI
NATCHEZ TRACE PARKWAY
Mississippi River
HOMOCHITTO NAT'L FOR.
BIENVILLE NAT'L FOR.
DE SOTO
Lake Pontchartrain


Substation
CREOSOTE RD
Radio Tower
BERNARD BA
Turkey Creek Sch
Sewage Disposal
21
22
23
Golf Course
UNDER CONSTRUCTION
CREOSOTE ROAD
Creek
BM 17
ILLINOIS
BM 20
GULFPORT-BILOXI REGIONAL AIRPORT
Tower
Beacon
26
27
28
LFPORT
WT
Park
CENTRAL
×29
BM 10
LEVEE
33
32D ST
30TH ST
28TH
AVE
GULF
BM 34
24TH
GULFPORT
22D
Tower
3
ST
PINE
7TH AVE
BM 18
2
VETERANS HOSPITAL
4
49
29
9TH
298
0.5 MI. TO U.S. 90
5'
300
301
(GULFPORT SOUTH) 3144 I SE
90
LONG BAY
SCALE 1:24 000
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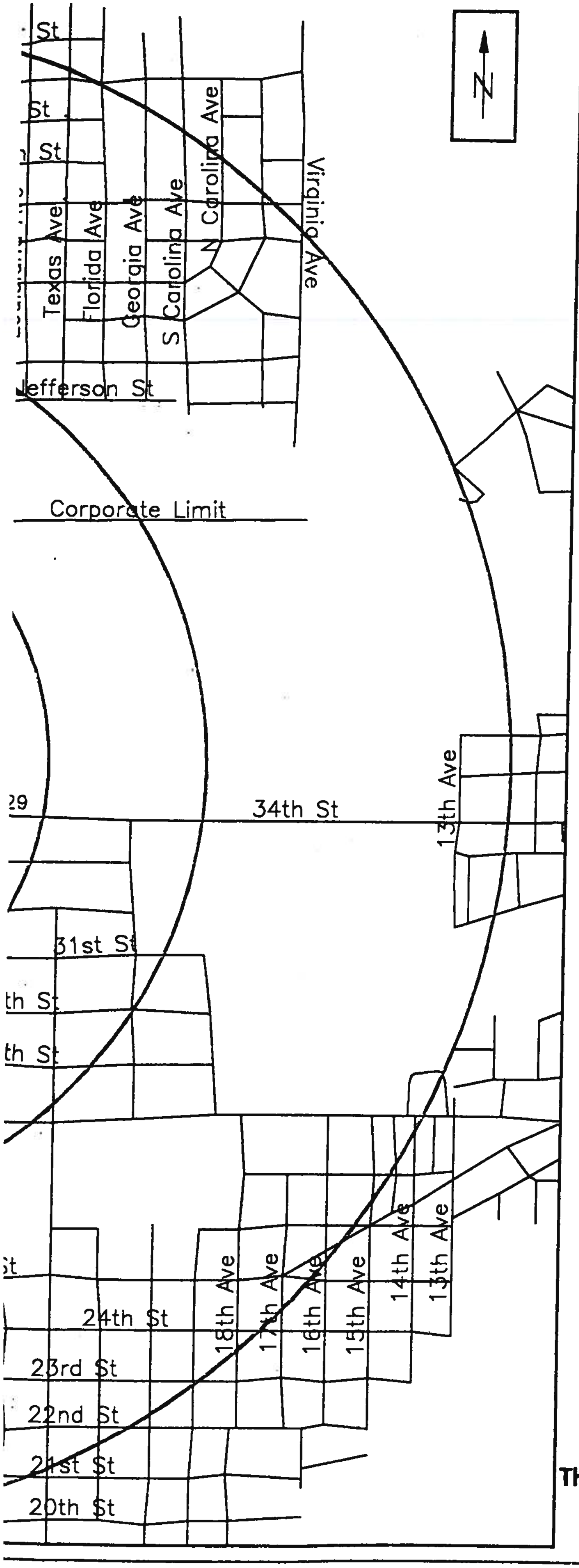


ERIIS
505 Huntmar Park Dr, Suite 200
Herndon, VA 22070
(703)834-0600 (800)989-0402
FAX: (703)834-0606

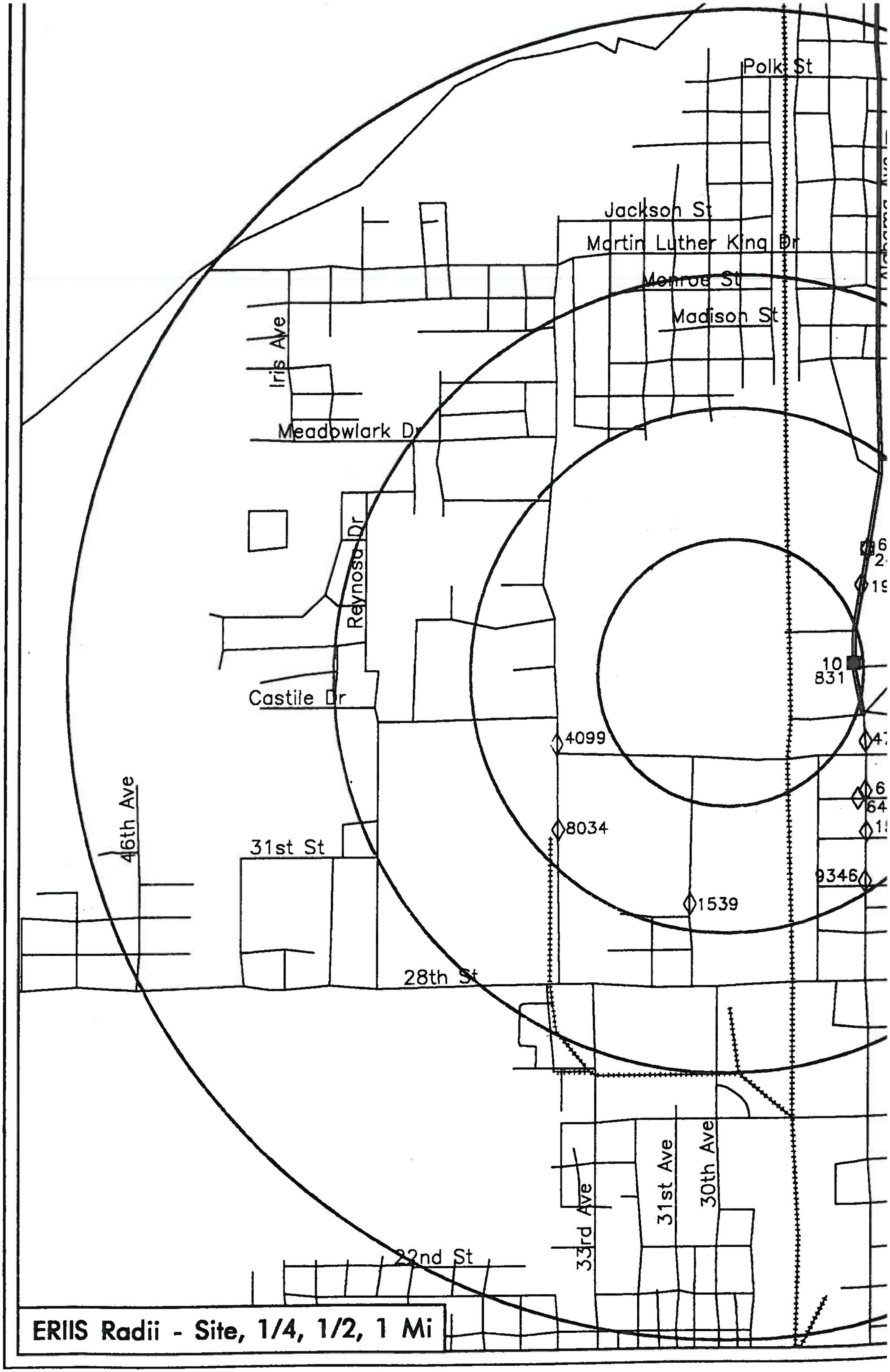
SITE INFORMATION

Gulfport, MS
Harrison County
Job Number: 31204A
Map Plotted: May 4, 1995

MAP LEGEND

— Hydrography
┼ Railroads
— Roads
▬ Highways
★ NPL 0 Sites
☐ RCRIS_TS 0 Sites
● CERCLIS 1 Site
○ NFRAP 0 Sites
☐ RCRIS_LG 0 Sites
☐ RCRIS_SG 2 Sites
☆ ERNS 0 Sites
✚ LUST 0 Sites
◊ UST 11 Sites

Miles
0 0.25 0.5



ERIIS Radii - Site, 1/4, 1/2, 1 Mi

ERIIS ENVIRONMENTAL DATA REPORT
COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, AND LIABILITY INFORMATION SYSTEM
CERCLIS - PLOTTABLE SITES - PAGE 1

ERIIS Report #31204A

May 4, 1995

ERIIS ID EPA ID	FACILITY	ADDRESS	COUNTY	DISTANCE FROM SITE	DIRECTION FROM SITE	MAP ID
28001000010 MS2120507379	USDA SEA IFA RESEARCH LAB	3505 25TH AVE GULFPORT, MS 39501-6921	HARRISON	0.000 MILES	NORTHEAST	10

SITE EVENT	START DATE	COMPLETION DATE	ACTION PRIORITY
DISCOVERY	/ /	09/27/1991	BLANK
PRELIMINARY ASSESSMENT	/ /	04/18/1988	NO FURTHER ACTION
SCREENING SITE INSPECTION	/ /	/ /	LOW
PRELIMINARY ASSESSMENT	09/03/1991	09/03/1991	LOW

DESCRIPTION: REPORTED UNDERRCRA 3010-PLACED ON FEDERAL FACILITY DOCKET

ERIIS ENVIRONMENTAL DATA REPORT
RESOURCE CONSERVATION AND RECOVERY INFORMATION SYSTEM
RCRIS_SG - PLOTTABLE SITES - PAGE 1

ERIIS ID EPA ID RCRA COMPLIANT	FACILITY NUMBER OF CORRECTIVE ACTION EVENTS NUMBER OF HIGH PRIORITY NCAPS	ADDRESS	RAATS ISSUE DATE RAATS ACTION/STATUS RAATS PENALTIES	DISTANCE FROM SITE	DIRECTION FROM SITE	MAP ID
28008000831 MS9123430598 Y	USDA APHIS BBEP NMRAL 0 0	3505 25TH AVE GULFPORT, MS 39501-6921 COUNTY: HARRISON	FACILITY NOT REPORTED IN RAATS	0.000 MILES	NORTHEAST	831

REPORTED WASTE CODES
U002
U003
U044
U056
U080
U112
U154
U211
U220

ERIIS ID EPA ID RCRA COMPLIANT	FACILITY NUMBER OF CORRECTIVE ACTION EVENTS NUMBER OF HIGH PRIORITY NCAPS	ADDRESS	RAATS ISSUE DATE RAATS ACTION/STATUS RAATS PENALTIES	DISTANCE FROM SITE	DIRECTION FROM SITE	MAP ID
28008000674 MSD985973064 Y	ROADWAY EXPRESS, INC. 0 0	3811 25TH AVE GULFPORT, MS 39501-6925 COUNTY: HARRISON	FACILITY NOT REPORTED IN RAATS	0.096 MILES	NORTHEAST	674

REPORTED WASTE CODES
D000
D001
D018

ERIIS ENVIRONMENTAL DATA REPORT
MISSISSIPPI UNDERGROUND STORAGE TANKS
UST - PLOTTABLE SITES - PAGE 1

ERIIS ID FACILITY ID OWNER ID	FACILITY	ADDRESS	OWNER	CONTACT	MAP ID
28010004760 0-005503 D/83	DIXIE OIL COMPANY #9 DISTANCE FROM SITE: 0.041 MILES DIRECTION FROM SITE: SOUTHEAST	3330 25TH AVE GULFPORT, MS 39501-6916 COUNTY: HARRISON	DIXIE OIL COMPANY OF ALABAMA 2918-22 5TH STREET MERIDIAN, 2918-22 5TH STREET	BILLY BLAINE	4760

TANK ID	CAPACITY(GALS.)	AGE(YRS.)	PRODUCT	STATUS	DATE REMOVED	MATERIAL OF CONSTRUCTION
001	6,000	14	Gasoline	Currently in Use		ASPHALT COAT/BARE STEEL
002	6,000	14	Gasoline	Currently in Use		ASPHALT COAT/BARE STEEL
003	4,000	14	Gasoline	Currently in Use		ASPHALT COAT/BARE STEEL
004	4,000	14	Gasoline	Currently in Use		ASPHALT COAT/BARE STEEL

ERIIS ID FACILITY ID OWNER ID	FACILITY	ADDRESS	OWNER	CONTACT	MAP ID
28010001905 0-002317 C/178	COAST COCA COLA BOTTLING CO INC DISTANCE FROM SITE: 0.046 MILES DIRECTION FROM SITE: NORTHEAST	3701 25TH AVE GULFPORT, MS 39501-6929 COUNTY: HARRISON	COAST COCA COLA BOTTLING CO INC 3701 25TH AVENUE GULFPORT, 3701 25TH AVENUE	ELBERT MULLIS	1905

TANK ID	CAPACITY(GALS.)	AGE(YRS.)	PRODUCT	STATUS	DATE REMOVED	MATERIAL OF CONSTRUCTION
001	15,000	19	Diesel	Removed from Ground	04-29-92	ASPHALT COAT/BARE STEEL
002	15,000	19	Diesel	Removed from Ground	04-29-92	ASPHALT COAT/BARE STEEL
003	8,000	19	Gasoline	Removed from Ground	04-29-92	ASPHALT COAT/BARE STEEL
004	2,000	19	Diesel	Removed from Ground	04-29-92	ASPHALT COAT/BARE STEEL
005	10,000	1	Gasoline	Currently in Use		CATHODIC PROTECTION
006	10,000	1	Diesel	Currently in Use		CATHODIC PROTECTION

ERIIS ID FACILITY ID OWNER ID	FACILITY	ADDRESS	OWNER	CONTACT	MAP ID
28010006431 0-007366 000	THOMPSON, STEVE DISTANCE FROM SITE: 0.094 MILES DIRECTION FROM SITE: SOUTHEAST	2510 32ND ST GULFPORT, MS 39501-5939 COUNTY: HARRISON	OWNERSHIP UNCERTAIN	NOT REPORTED	6431

TANK ID	CAPACITY(GALS.)	AGE(YRS.)	PRODUCT	STATUS	DATE REMOVED	MATERIAL OF CONSTRUCTION
001	7,000	UNK	Diesel	Closed in Ground		UNKNOWN

ERIIS ID FACILITY ID OWNER ID	FACILITY	ADDRESS	OWNER	CONTACT	MAP ID
28010010066 0-011391 S/443	DIXIE HIGHWAY EXPRESS DISTANCE FROM SITE: 0.095 MILES DIRECTION FROM SITE: SOUTHEAST	3211 25TH AVE GULFPORT, MS 39501-5910 COUNTY: HARRISON	S J E SMITH 15287 ST CHARLES GULFPORT, 15287 ST CHARLES	NOT REPORTED	66

TANK ID	CAPACITY(GALS.)	AGE(YRS.)	PRODUCT	STATUS	DATE REMOVED	MATERIAL OF CONSTRUCTION
001	6,000	11	Diesel	Removed from Ground	04-23-93	NOT REPORTED

ERIIS ID FACILITY ID OWNER ID	FACILITY	ADDRESS	OWNER	CONTACT	MAP ID
28010002445 0-002933 R/67	ROADWAY EXPRESS INC DISTANCE FROM SITE: 0.096 MILES DIRECTION FROM SITE: NORTHEAST	3811 25TH AVE GULFPORT, MS 39501-6925 COUNTY: HARRISON	ROADWAY EXPRESS INC 1077 GORGE BOULEVARD AKRON, 1077 GORGE BOULEVARD	REGINA R GODWIN	2445

TANK ID	CAPACITY(GALS.)	AGE(YRS.)	PRODUCT	STATUS	DATE REMOVED	MATERIAL OF CONSTRUCTION
001	3,000	23	Gasoline	Removed from Ground	04-14-92	ASPHALT COAT/BARE STEEL
002	3,000	23	Diesel	Removed from Ground	04-14-92	ASPHALT COAT/BARE STEEL

ERIIS ID FACILITY ID OWNER ID	FACILITY	ADDRESS	OWNER	CONTACT	MAP ID
28010004099 0-004773 T/818	THOMPSON/BOUTWELL PARTNERSHIP DISTANCE FROM SITE: 0.110 MILES DIRECTION FROM SITE: SOUTHWEST	3321 34TH AVE GULFPORT, MS 39501-6822 COUNTY: HARRISON	THOMPSON BOUTWELL PARTNERSHIP 710 PRAIRIE STREET WINNSBORO, 710 PRAIRIE STREET	STEVE D THOMPSON	4099

TANK ID	CAPACITY(GALS.)	AGE(YRS.)	PRODUCT	STATUS	DATE REMOVED	MATERIAL OF CONSTRUCTION
001	6,000	18	Diesel	Temporarily Out of Use		ASPHALT COAT/BARE STEEL
002	6,000	18	Diesel	Temporarily Out of Use		ASPHALT COAT/BARE STEEL

ERIIS ID FACILITY ID OWNER ID	FACILITY	ADDRESS	OWNER	CONTACT	MAP ID
28010001229 0-001536 1041	ANCHOR GLASS CONTAINER CORP DISTANCE FROM SITE: 0.147 MILES DIRECTION FROM SITE: SOUTHEAST	3450 GILES RD GULFPORT, MS 39501-7011 COUNTY: HARRISON	ANCHOR GLASS CONTAINER CORP #4 GILES ROAD GULFPORT, #4 GILES ROAD	NOT REPORTED	1229

TANK ID	CAPACITY(GALS.)	AGE(YRS.)	PRODUCT	STATUS	DATE REMOVED	MATERIAL OF CONSTRUCTION
001	UNK	23	Gasoline	Removed from Ground	07-01-B4	ASPHALT COAT/BARE STEEL

28010001567 0-001935 C/826	COMPONENTS BY ROBERT BATTLES INC DISTANCE FROM SITE: 0.153 MILES DIRECTION FROM SITE: SOUTHEAST	3110 25TH AVE GULFPORT, MS 39501-5907 COUNTY: HARRISON	COMPONENTS BY ROBERT BATTLES INC 12 BAYOU VIEW DRIVE GULFPORT, 12 BAYOU VIEW DRIVE	ROBERT J BATTLES	1567

TANK ID	CAPACITY(GALS.)	AGE(YRS.)	PRODUCT	STATUS	DATE REMOVED	MATERIAL OF CONSTRUCTION
001	500	9	Gasoline	Closed in Ground		ASPHALT COAT/BARE STEEL
002	1,000	23	Diesel	Removed from Ground		ASPHALT COAT/BARE STEEL

28010008034 0-009176 M/200	UNITED PARCEL SERVICE CENTER DISTANCE FROM SITE: 0.194 MILES DIRECTION FROM SITE: SOUTHWEST	3120 34TH AVE GULFPORT, MS 39501-6817 COUNTY: HARRISON	UNITED PARCEL SERVICE 605 EAST MCDOWELL ROAD JACKSON, 605 EAST MCDOWELL ROAD	RICK WINN	8034

TANK ID	CAPACITY(GALS.)	AGE(YRS.)	PRODUCT	STATUS	DATE REMOVED	MATERIAL OF CONSTRUCTION
001	10,000	13	Gasoline	Removed from Ground	06-15-93	ASPHALT COAT/BARE STEEL
002	10,000	13	Diesel	Removed from Ground	06-15-93	ASPHALT COAT/BARE STEEL
003	550	13	Used Oil	Removed from Ground	06-15-93	ASPHALT COAT/BARE STEEL

28010001539 0-001905 F/16	FAULKNER CONCRETE PIPE CO DISTANCE FROM SITE: 0.197 MILES DIRECTION FROM SITE: SOUTHWEST	3000 FAULKNER ST GULFPORT, MS 39501-5948 COUNTY: HARRISON	FAULKNER CONCRETE PIPE COMPANY DRAWER F HATTIESBURG, DRAWER F	NOT REPORTED	1539

TANK ID	CAPACITY(GALS.)	AGE(YRS.)	PRODUCT	STATUS	DATE REMOVED	MATERIAL OF CONSTRUCTION
001	1,000	23	Gasoline	Removed from Ground		ASPHALT COAT/BARE STEEL
002	1,000	23	Diesel	Removed from Ground		ASPHALT COAT/BARE STEEL

28010009346 0-010648 A/17	AT&T GULFPORT DISTANCE FROM SITE: 0.226 MILES DIRECTION FROM SITE: SOUTHEAST	3003 25TH AVE GULFPORT, MS 39501-5906 COUNTY: HARRISON	AT&T 1200 PEACHTREE ST, PROMENADE II ATLANTA, 1200 PEACHTREE ST, PROMENADE	SUSAN LARY	9346

TANK ID	CAPACITY(GALS.)	AGE(YRS.)	PRODUCT	STATUS	DATE REMOVED	MATERIAL OF CONSTRUCTION
001	2,000	6	Diesel	Currently in Use		ASPHALT COAT/BARE STEEL, COMPOSITE STEEL W/ FIBERGLASS

3.2 Regulatory Records Review

The following Federal records were searched followed by the search radius from the subject property:

CERCLIS **1/2 mile**

The Comprehensive Environmental Response, Compensation and Liability Information System (CERCLIS) is a compilation of records regarding those facilities which the EPA has identified as having actual or suspected uncontrolled releases of hazardous substances, contaminants, or pollutants as reported by states, municipalities, private companies, and private citizens.

One plotable site. See Grid Map followed by Data Report Sheet.

National Priority List/Superfund **1 mile**

The NPL, or Federal Superfund List is composed of the nation's most hazardous sites which require remediation. A site, to be included on the NPL, must either meet or surpass a predetermined hazard ranking systems score, or be chosen as a state's top priority site, or meet all three of the following criteria:

1) The U.S. Department of Health and Human Services issued a health advisory recommending that people be removed from the site to avoid exposure.
2) The EPA determines that the site represents a significant threat.
3) The EPA determines that remedial action is more cost effective than removal action.

No Occurrences

RCRA - Large Quantity Generators **1/4 mile**

No Occurrences

RCRA - Small Quantity Generators **1/4 mile**

Two plotable sites. See Grid Map followed by Data Report Sheet.

RCRA - Treatment, Storage or Disposal Facilities
1 mile

No Occurrences

RCRA - Transporters **1/4 mile**

The EPA's Resource Conservation and Recovery Act (RCRA) Program identifies and tracks hazardous waste from the point of generation to the point of disposal. The RCRA Facilities database is a compilation by the EPA of reporting facilities that generate, transport, treat, store or dispose of hazardous waste.

No Occurrences

ERNS **1/8 mile**

The Emergency Response Notification System (ERNS) is a national database used to collect information on reported accidental releases of oil and hazardous substances. The database contains information from spill reports made to federal authorities Including the EPA, the U.S. Coast Guard, the National Response Center and the Department of Transportation.

No Occurrences

The following State records were searched followed by the search radius from the subject:

SPL **1 mile**

The State Priority List is a generic name for databases maintained by states that contain sites considered to be actually or potentially contaminated and presenting a possible threat to human health and the environment. The sites are generally listed by the state to warn the public or as part of an investigation and clean up program managed by the state.

No Occurrences

LUST **1/2 mile**

This is a database maintained by state or local agencies of known or suspected leaking underground storage tanks.

No Occurrences

UST **1/4 mile**

This is a database maintained by state or local agencies of registered underground storage tanks.

Eleven plotable sites. See Grid Map followed by Data Report Sheet.

SWLF **1/2 mile**

This is a database maintained by state or local agencies of known Solid Waste Landfills, Incinerators, and transfer stations.

No Occurrences

OIL & GAS PRODUCTION AND EXPLORATION RECORDS
1 mile

This section identifies the location of well sites and production facilities associated with such well sites.

No Occurrences

3.3 Physical Setting Sources

Soil Survey Studies obtained from the U. S. Department of Agriculture, Soil Conservation Service and Forest Service; the U. S. Geological Survey, Water - Resources Investigations Report #87-4172 & #86-4364; the U. S. Geological Survey, Generalized Potentiometric Surface of Shallow Aquifers in Southern Mississippi, 1982 and #87-4257, the "Gulfport, North" topographic quadrangle map.

3.4 Historical Aerial Photography & Mapping Review

The following were examined:

1982 & 1990 black and white aerial photography provided by the Harrison County Planning & Development Commission, 1966 & 1976 black and white aerial photography, 1985 color infrared photography provided by the Gulf Regional Planning commission and 1940 black and white aerial photography provided by Tobin Aerial Surveys, San Antonio, Texas; the U.S.G.S, "Gulfport, North" Topographic Quadrangle Map which was compiled from aerial photographs taken in 1950, and from topography by planetable surveys in 1951, field checked in 1954 and photorevised in 1985. Sanborn Fire Insurance Maps from 1921, 1929, 1938, 1950, and 1967. The 1929 Harrison County Tax Assessors Map.

Of all the aerial photographs examined, the 1940 frame is the clearest. This photograph (appendix "I") was taken when the sulfuric acid and superphosphate production operations were in full operation and when the cotton gin was present on the property. All of the photographs indicate the apparent drainage pathways. Also, all of the photographs examined indicated the presence of low lands (potential wetlands) and large areas of dead or stressed vegetation both on-site and off-site.

All of the Sanborn Fire Insurance Maps clearly indicate the sulfuric acid production, superphosphate production and warehouse storage facilities.

Because of the small appearance, many objects were impossible for CAA personnel to identify on the aerial photographs. The statement of past and present use of the property is consistent with the appearance of the property in the aerial photography examined.

3.5 Other Historical Use Information Sources

The following were examined in whole or part:

Various instruments of record affecting the property and the adjacent properties through a limited title examination from records located at the Harrison County, Chancery Clerks Offices in Gulfport, Mississippi. The regulatory records review databases were provided by Environmental Risk Information & Imaging Services on 5/5/95 in report #31204A and which is made a part hereof as if copied in full.

SECTION 4:
AREA RECONNAISSANCE

4.1 Identification of Potential Off-Site Influences

The property immediately bounding the site on the South side is currently known as the CAE Plastics, Inc., custom injection molding facility. An operations history has not been developed for this site by CAA. CAA did not find any regulatory record indicating that the adjacent site is a risk. CAA was informed by Mr. Kirk Ladner that he removed two underground storage tanks from the site several years ago. CAA found no record of the closure from the state EPA database provided by ERIIS. Currently there is no visible sign of leaking or adverse influence to the subject site on the surface.

4.2 On-Site Reconnaissance

4.2.1 Grounds Survey

CAA subdivided the subject tract into a grid pattern and then attempted to physically survey the subject tract on a grid by grid basis. This grid type of inspection or survey is a standard procedural part of the CAA site assessment process. Most of the site is over run with very dense brush, grass and debris. Additionally, in an attempt to possibly clear the property years ago, long rows of debris were created which now have dense brush growing through them. These conditions made it difficult or impossible to thoroughly inspect certain areas of the site. CAA is satisfied that enough site specific information has been examined to make generalized conclusions about the site for this report. The area where a 100,000 gallon water reservoir existed (see the 1940 aerial photo and Sanborn maps) is covered with soil. The original pump house structure is in a bad state of repair. The area immediately behind the pump house contains a steel structural frame and several open concrete block chambers.

4.2.2 Asbestos Containing Materials

Small piles of asbestos containing transite debris are located on the South end of the property and at a few other locations on-site. The tile flooring in the red brick pump house is suspect for asbestos and should be tested prior to demolition or remodeling of the building.

4.2.3 Underground & Above Ground Storage Tanks

CAA found an old riveted vessel on the North end of the site that was probably a part of the fertilizer manufacturing process. It resembles an underground storage tank, but it is not. In or about the year 1973, Mr. James Alexander installed two underground storage tanks at the subject site for Shelton Baugh. The tanks were located just Northeast of the red brick pump house. There is no record that the UST's were ever registered, therefore there is no record that they were removed. According to Mr. Alexander the tanks were connected to small pump island. CAA will attempt to locate the tanks on a clearer aerial photograph and then physically in subsequent site investigations.

4.2.4 Storage of Hazardous Materials in Drums/Containers

CAA did not find evidence of such at the site.

4.2.5 Landfills on Site

CAA personnel did not visually observe any evidence indicating the presence of a landfill on the property.

4.2.6 Surface Impoundments on Site

CAA personnel did not visually observe any evidence indicating the presence of surface impoundments on the property except for the remnants of an old railroad scale on the East side.

4.2.7 Air Emissions From the Site

CAA personnel did not observe any current condition or regulatory enforcement record indicating that adverse air emissions are emanating from the site.

4.2.8 Waste Waters from the Site

CAA personnel did not observe any current condition or regulatory enforcement record indicating that regulated waste waters are originating from the site.

4.2.9 Utility Company Facilities (Transformers)

No power transformers were observed on or immediately next to the site. It is possible that some buried utility easements cross the property.

4.2.10 Evidence of Indiscriminate Dumping of Hazardous or Construction Materials

There are a few isolated areas where demolition debris is scattered. Particularly there is a large pile of used tire waste on the main drive to the site. Under Mississippi Code 17-17-17 waste tires must be disposed of properly. There are several convenient vehicles to accomplish this when the time comes.

4.2.11 Evidence of Soils, Groundwater or Surface Water Contamination

No monitoring/observation wells are located on the site. As documented throughout this report, the subject site was utilized for the production of sulfuric acid and superphosphate. Except for the surface areas where phosphogypsum was present, CAA did not observe any visual indication of such contamination. However, the process activities involved with these production activities occurred on the open ground for about fifty years or longer. The surface areas in the vicinity of the old cotton oil refinery, cotton gin, etc., did not display visual indications of contamination. However, demolition debris is present at their past on-site locations. There is a high potential for contamination of surface soil and nearsurface groundwater as a result of years of production of fertilizer and acid production on the barren ground. Existing vegetation shows no signs of stress, but the vegetative cover is sparse in some areas, particularly where phosphates, sulfuric acid, and other chemicals were handled. A full discussion of the potential contaminants is not within the scope of this report. We have included as appendix "K", a copy of the EPA Source Assessment:Phosphate Fertilizer Industry document produced in 1979. This document contains a detailed discussion on superphosphate production and the pollutants created during the processes. CAA will be recommending that a sampling investigation work plan be developed for this site.

4.2.12 Reserved for Assessments Inclusive of NORM

In brief, sulfuric acid was produced at the site. Phosphorus rock was brought to the site via railroad car, milled and then mixed (acidilized) with the acid to produce superphosphate fertilizer. Phosphorous contains Naturally Occurring Radioactive Materials (NORM) in the form of Radium 226, Uranium, and Thorium (all are isotopes). Three types of radiation are emitted from NORM. They are alpha (dust) particles, beta (dust) particles, and Gamma Rays. On June 6, 1995, CAA personnel took a Radiation Survey Instrument to the site to observe the instrument for indications of NORM. Background concentrations of 6 mR/hr were recorded on both the North and South ends of the property. Readings ranging from 15 mR/hr to 40 mR/hr were recorded. Typically, readings of twice background are considered "hot spots" for sampling. When sampled a certified laboratory will identify the type of isotope, whether is it producing Radon gas and at what rate, and quantify the material in pCi/gm. NORM of 5 pCi/gm or more is the action level. However, there are exemptions to this rule under 40 CFR 61.204. They are Phosphate and potash fertilizer; and Phosphogypsum for agricultural uses. Phosphogypsum is allowed an action level of 10 pCi/gm. CAA will be recommending a NORM survey of the site.

4.2.13 Hazardous Substance Identification/Inventory

N/A

4.2.14 Rubbish Disposal

N/A

4.2.15 Suspect Lead in Paint

Target structures for lead based paint hazards are those constructed from 1978 back. The potential presence of lead based paint on the existing structures is high. Since the structures are not going to be used as dwellings this is not an issue at this time. However, prior to the commencement of demolition work, the contractor should be notified so they may take appropriate worker safety precautions and inform the workers of the risks of transporting lead to their home environments.

4.2.16 Radon Testing

Under these circumstances, radon emanation would be determined during a NORM survey.

SECTION 5:
FINDINGS & CONCLUSIONS

We have performed a Phase I Environmental Site Assessment in conformance with the scope and limitations of ASTM Practice E 1527-93 for Mr. Andy J. Alfonso, Jr., representing Hancock Bank covering the property described in SECTION 2.1 of this report. This assessment is subject to the exclusions and limitations noted in SECTIONS 1 & 6 of this report. Based on the scope of work undertaken, and the review of selected records deemed appropriate by CAA representatives for the site at the time of this site assessment in May and June, 1995, the following characteristics were found as follows:

1. Throughout its history since 1904, the property was used to produce refined cotton oil and raw cotton bulk products, sulfuric acids, superphosphate, masonry products, tires, and for fertilizer chemical storage for about seventy years.
2. CAA representatives did not find any state or federal record of a hazardous substance release at the facility.

This assessment has revealed no evidence of recognized environmental risk conditions in connection with the property, except for:

- Small piles of asbestos containing transite debris are located on the South end of the property and at a few other locations on-site. The tile flooring in the red brick pump house is suspect for asbestos and should be tested prior to demolition or remodeling of the building. Only EPA accredited and licensed persons may perform this task.

- In or about the year 1973, Mr. James Alexander installed two underground storage tanks at the subject site for Shelton Baugh. The tanks were located just Northeast of the red brick pump house. There is no record that the UST's were ever registered, therefore there is no record that they were removed. According to Mr. Alexander the tanks were connected to a small pump island. The presence or exact past location of the UST's should be ascertained. The UST site should be closed in accordance with the laws. If the UST's are no longer present, then the tank bed should be tested for BTEX and TPH-Diesel range.

- There are many used tires on the main drive to the site. Under Mississippi Code 17-17-17 waste tires must be disposed of properly. There are several convenient vehicles to accomplish the proper disposal of the tire waste. This should be done but is not a priority. Incidentally, the site directly across 33rd street has several hundred tires within view of the street.

- As documented throughout this report the subject site was utilized for the production of sulfuric acid and superphosphate. The processes involved with these production activities occurred on the open ground for about fifty years or longer. There has been a long passage of time since these processes occurred. The potential for contaminants to <u>not</u> be present is unknown. Existing vegetation shows no signs of stress, but the vegetative cover is sparse in some areas, particularly where phosphates, sulfuric acid, and other chemicals were handled. A complete discussion for the identification of potential groundwater pollutants is not within the scope of this report. The surface areas in the vicinity of the old cotton oil refinery, cotton gin, etc.., did not display visual indications of contamination. However, demolition debris is present at their past on-site locations. We have included as appendix "K", a copy of the EPA Source Assessment:Phosphate Fertilizer Industry document produced in 1979. This document contains a full discussion on superphosphate production and the pollutants created during the processes. We have also included copies of two informative fax transmissions from the Mississippi Department of Agriculture and Commerce as appendix "J". A sampling investigation work plan should be developed for this site.

Among other things, the expanded investigation will address whether or not specific compounds associated with the sulfuric acid and superphosphate production leached into the subsurface and remain on-site.

- In brief, sulfuric acid was produced at the site. Phosphorus rock was brought to the site via railroad car, milled and then mixed (acidilized) with the acid to produce superphosphate fertilizer. Phosphorous contains Naturally Occurring Radioactive Materials (NORM) in the form of Radium 226, Uranium, and Thorium (all are isotopes). Three types of radiation are emitted from NORM. They are alpha (dust) particles, beta (dust) particles, and Gamma Rays. On June 6, 1995, CAA personnel took a Radiation Survey Instrument to the site to observe the instrument for indications of NORM. Background concentrations of 6 mR/hr were recorded on both the North and South ends of the property. Readings ranging from 15 mR/hr to 40 mR/hr were recorded. Typically, readings of twice background are considered "hot spots" for sampling. When sampled a certified laboratory will identify the type of isotope, whether is it producing Radon gas and at what rate, and quantify the material in pCi/gm. NORM of 5 pCi/gm or more is the action level. However, there are exemptions to this rule under 40 CFR 61.204. They are Phosphate and potash fertilizer; and Phosphogypsum for agricultural uses. Phosohypsoum is allowed an action level of 10 pCi/gm. A NORM survey should be performed to determine whether the NORM is exempt or whether other management options should be employed.

- The area is covered with dense underbrush and weeds. There are several long rows of debris that were created by earth moving machinery years ago. Grass and underbrush have pushed their way up and through these rows making it impossible to examine their contents. During the expanded inspection the rows should be spot checked for examination. This is true especially where facilities once stood next the rows of debris.

- Wetlands are present. A wetland delineation, identifying the extent of the wetlands along the Northern and Western Property line, and identifying and delineating the suspect wetlands area Southwest of and directly West of the old phosphate processing facilities, is recommended.

Signed this 12th day of June, 1995.

Rimmer Covington, CPL/ESA #3476

SECTION 6
EXCLUSIONS & LIMITATIONS

This report has been prepared solely for the use by Hancock Bank, (the Client) and may not be used by other parties for purposes of satisfying the requirements of an environmental site assessment or other purposes without first obtaining the expressed written consent of Covington And Associates Corporation (CAA). CAA shall bear no liability for any unauthorized used of the information contained in this report. In the event that new information not contained in this report is obtained relating to environmental or hazardous waste issues at the site or nearby, such information shall be brought to CAA attention promptly and we may, upon evaluation, modify the conclusions stated in this report. The evaluations, analyses and recommendations contained in this report represent CAA professional opinions and judgments based on the current, generally accepted engineering, geologic and technical practices for the nature and scope of this site inspection authorized by Hancock Bank. Covington & Associates has not conducted a geophysical survey to confirm or refute the potential presence of any subsurface structures. This site inspection is based on visual conditions observed in May and June 1995, records review as described herein or the selections of any information deemed appropriate by CAA representatives at the time of the site inspection whether stated in previous or subsequent sections of this report or not. The findings of this investigation are based on existing conditions at the site and surrounding areas at the time of our inspection. Work described in this report was limited in its scope and coverage due to conditions imposed by the Client. Limited visual observations and conclusions were possible to only those areas reasonably accessible. Access was not available to conduct interviews with the previous property owners/tenants and maintenance personnel. It was not always possible to obtain specific information on the normal practices of property owners and/or their tenants with regard to solid waste disposal, on-site use, generation, storage and/or disposal of chemicals or oil and hazardous materials, any privately obtained environmental monitoring data for the property, except where provided to CAA by Hancock Bank. Additionally, CAA., has relied on information provided by various officials and other parties as referenced herein. Although believed to be accurate, CAA has not attempted to independently verify the accuracy or completeness of information provided by officials and other parties which was received or reviewed during the course of completing these services. No other warranty, expressed or implied, is made. The information contained in this investigation is not intended to be all inclusive or to identify all potential concerns associated with the site investigation. It should be noted that any investigation cannot determine that a site is completely free of chemicals or toxic substances. Therefore, this investigation cannot certify that the site is "absolutely clean." This investigation is made to provide information to Hancock Bank, concerning conditions at the site. This report was prepared exclusively for the use of Hancock Bank Any other use is expressly prohibited without written consent from Covington & Associates.

SECTION 7:

APPENDIX "A"

USDA

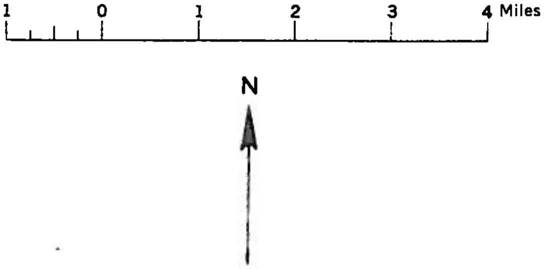
GENERAL SOIL MAP

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
FOREST SERVICE
MISSISSIPPI AGRICULTURAL AND FORESTRY EXPERIMENT STATION

GENERAL SOIL MAP

HARRISON COUNTY, MISSISSIPPI

Scale 1:126,720



SOIL ASSOCIATIONS *

SANDY SOILS ON UPLANDS

1	Eustis-Latonia-Lakeland association: Somewhat excessively drained and excessively drained soils that are sandy throughout and well-drained soils that have a loamy subsoil

LOAMY AND SANDY SOILS ON BROAD FLATS AND FLOOD PLAINS

2	Smithton-Plummer association: Poorly drained soils that have a loamy subsoil
3	Atmore-Harleston-Plummer association: Poorly drained and moderately well drained soils that have a loamy subsoil
4	Poarch-Plummer-Ocilla association: Well-drained, somewhat poorly drained, and poorly drained soils that have a loamy subsoil
5	Harleston-Smithton-Nugent association: Moderately well drained and poorly drained soils that have a loamy subsoil and excessively drained soils that are stratified with sandy and loamy material

LOAMY SOILS THAT HAVE A LOAMY SUBSOIL, ON UPLANDS

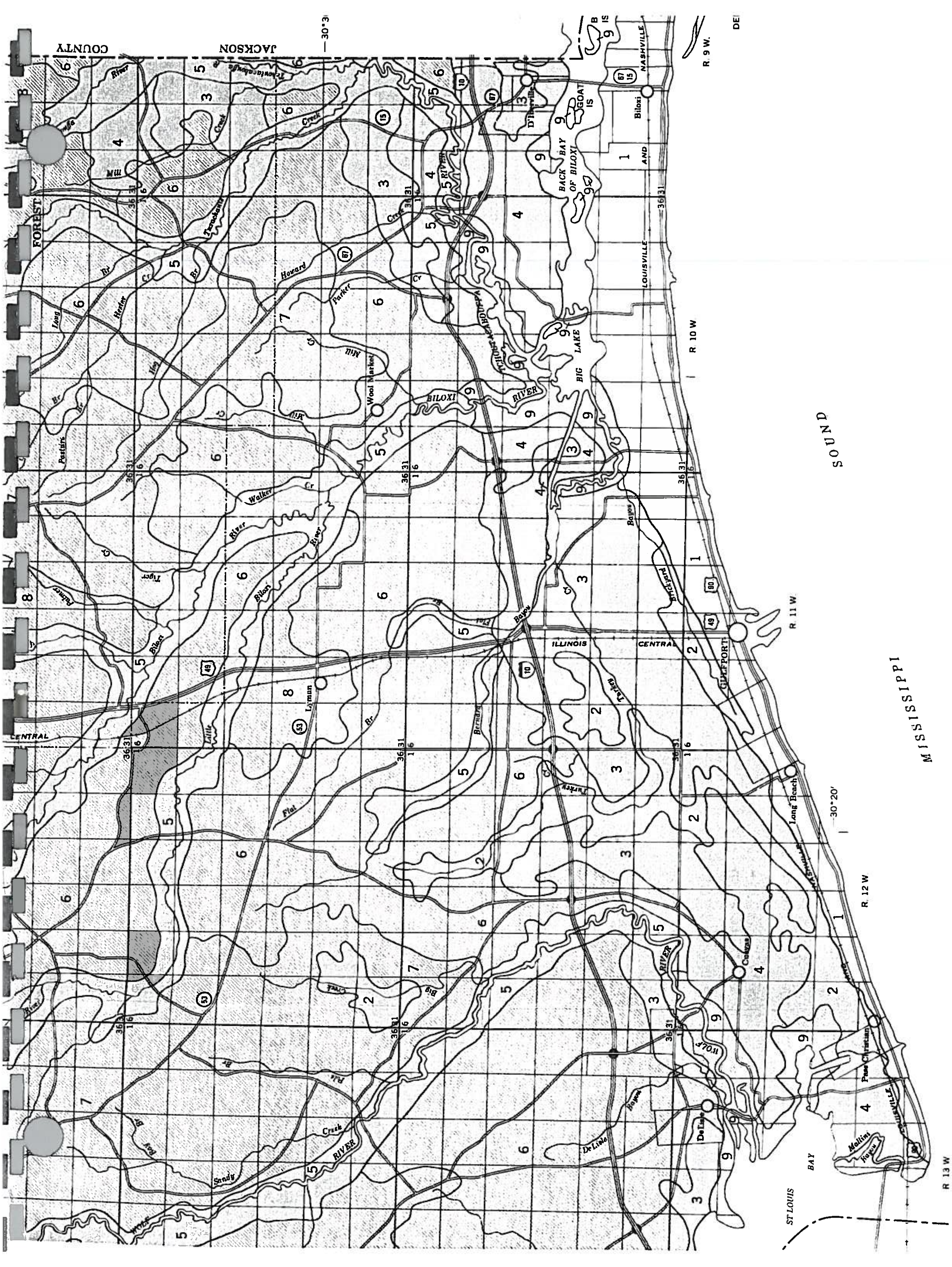
6	Poarch-Atmore-Harleston association: Well-drained soils on broad ridgetops, poorly drained soils on low wet flats, and moderately well drained soils on low ridges
7	Ruston-McLaurin-Saucier association: Well drained and moderately well drained soils on broad ridges and short side slopes
8	Saucier-Poarch-Atmore association: Well-drained to poorly drained soils on broad ridges and narrow side slopes

DOMINANTLY ORGANIC SOILS FLOODED BY SALT WATER

9	Handsboro association: Very poorly drained organic soils
10	Handsboro-St. Lucie association: Very poorly drained organic soils and excessively drained sandy soils

* Unless otherwise stated, texture refers to the surface layer of the major soils in each soil association.

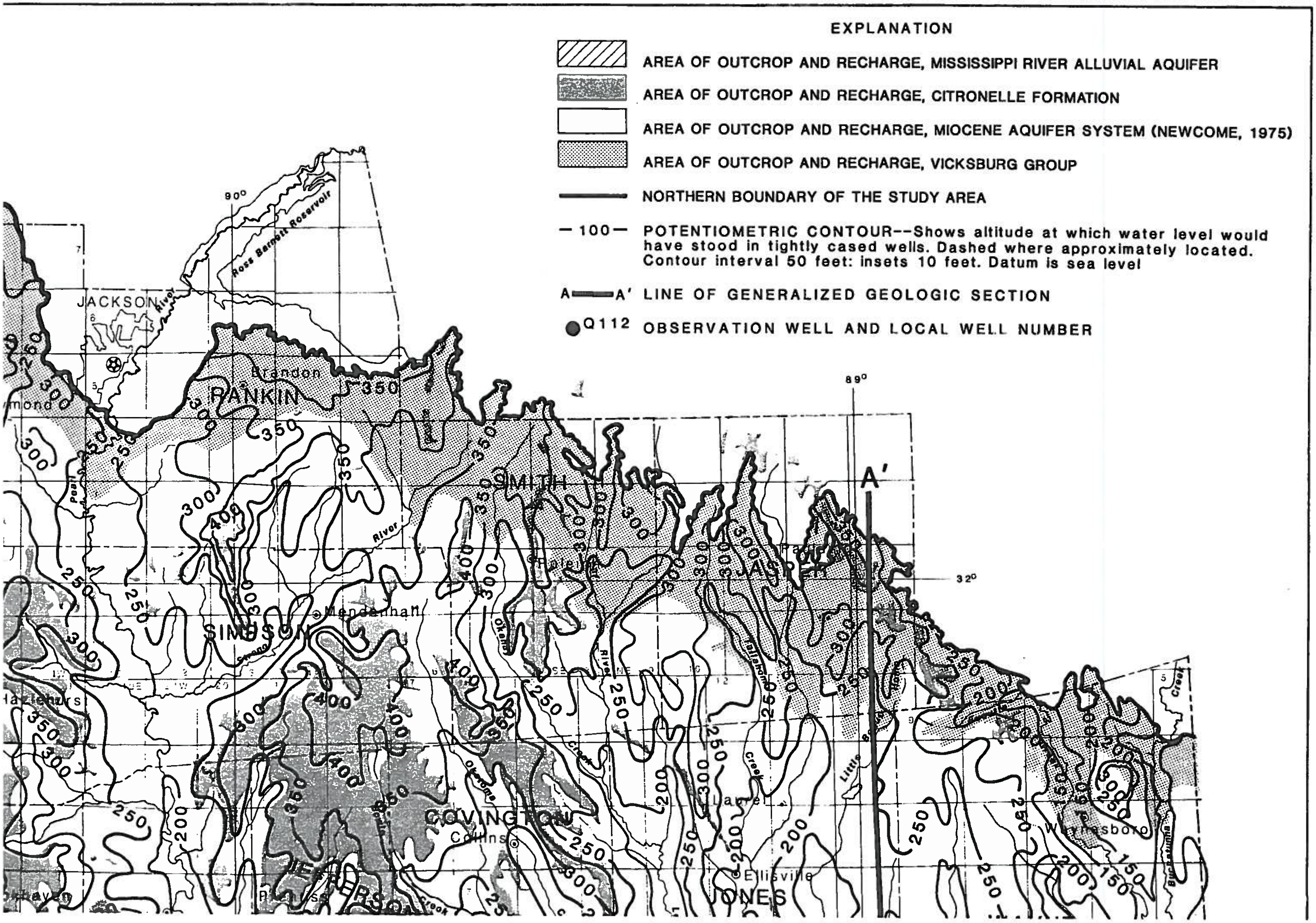
Compiled 1973


FOREST COUNTY
JACKSON COUNTY
30°3
CENTRAL
ILLINOIS CENTRAL
LOUISVILLE AND NASHVILLE
Biloxi
D'Iberville
GOAT IS
B IS
BACK BAY OF BILOXI
BIG LAKE
TCHOUTACABOUFFA RIVER
BILOXI RIVER
Wool Market
Lyman
GULFPORT
Long Beach
Pass Christian
DeLisle
Cuevas
WOLF RIVER
Little Biloxi River
Tuxachanie Creek
Mill Creek
Howard Cr
Parker Cr
Long Br
Heafer Cr
Hog Br
Pastures Br
Walker Cr
Tiger Cr
Palmer Cr
Flat Br
Bernard Bayou
Turkey Cr
Brickyard Bayou
Big Cr
Sandy Creek
Bayou DeLisle
Mallini Bayou
SOUND
MISSISSIPPI
ST LOUIS BAY
R 9 W.
R 10 W
R 11 W
R 12 W
R 13 W
30°20'
36 31
16
15
49
53
67
90
10
1
2
3
4
5
6
7
8
9

APPENDIX "B"

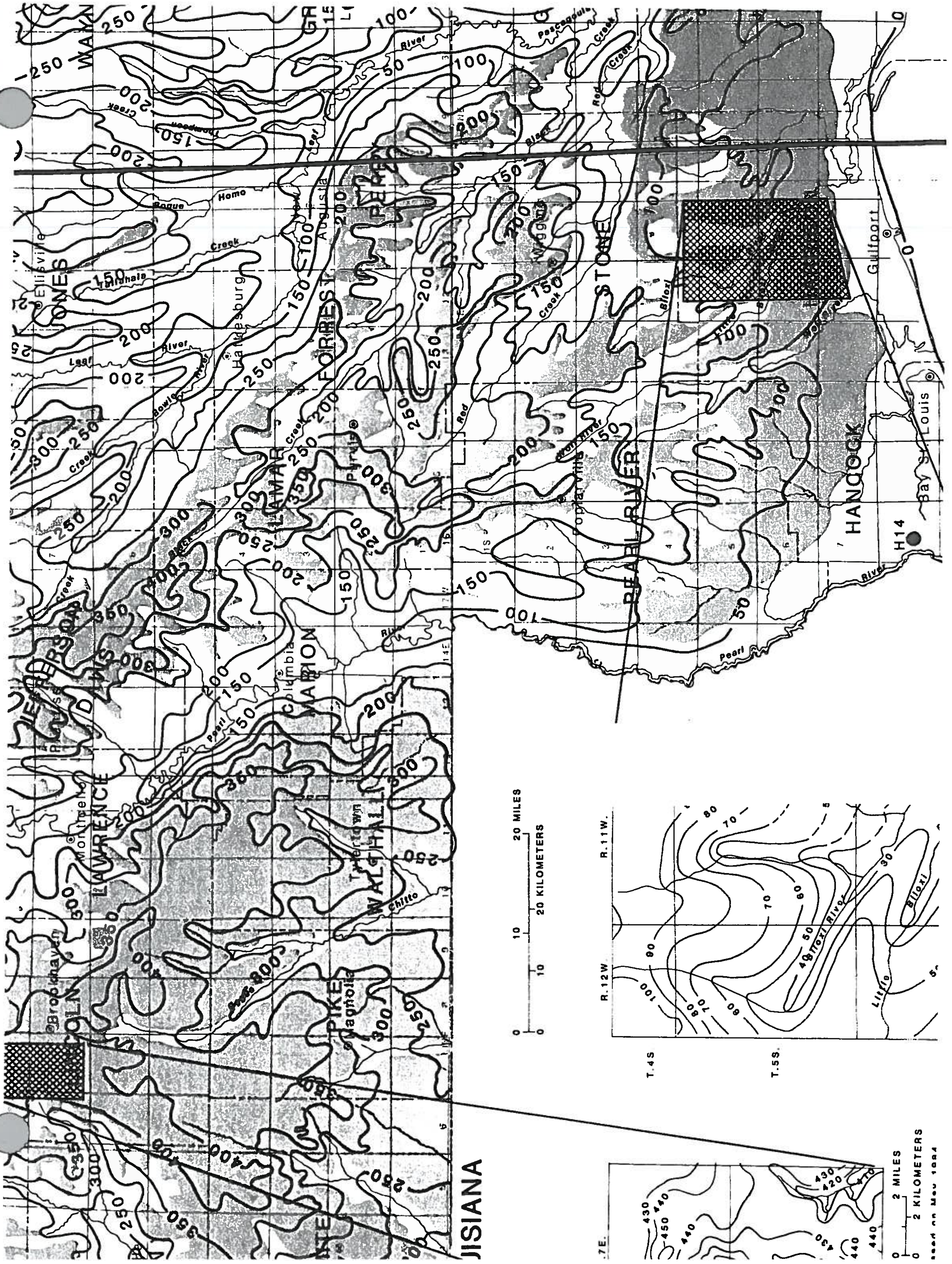
USDI

WATER - RESOURCES INVESTIGATION REPORT
#87-4257



EXPLANATION

▨	AREA OF OUTCROP AND RECHARGE, MISSISSIPPI RIVER ALLUVIAL AQUIFER
▩	AREA OF OUTCROP AND RECHARGE, CITRONELLE FORMATION
☐	AREA OF OUTCROP AND RECHARGE, MIOCENE AQUIFER SYSTEM (NEWCOME, 1975)
▒	AREA OF OUTCROP AND RECHARGE, VICKSBURG GROUP
—	NORTHERN BOUNDARY OF THE STUDY AREA
— 100 —	POTENTIOMETRIC CONTOUR--Shows altitude at which water level would have stood in tightly cased wells. Dashed where approximately located. Contour interval 50 feet: insets 10 feet. Datum is sea level
A——A'	LINE OF GENERALIZED GEOLOGIC SECTION
● Q112	OBSERVATION WELL AND LOCAL WELL NUMBER


JONES
FORREST
PERRY
STONE
LAMAR
MARION
PEARL RIVER
HANCOCK
LAWRENCE
PIKE
WALTHALL
Ellisville
Hattiesburg
Augusta
Wiggins
Purvis
Columbia
Poplarville
Gulfport
Bay St. Louis
Brookhaven
Monticello
Magnolia
Tylertown
Leaf River
Bowie River
Pearl River
Chitto
Red Creek
Black Creek
Biloxi
Wolf River
Pascagoula
Bogue Homo
Tallahala Creek
Thompson Creek
H14
0
50
100
150
200
250
300
350
400
0 10 20 MILES
0 10 20 KILOMETERS
R.12W.
R.11W.
T.4S
T.5S.
100
90
80
70
60
50
40
30
Biloxi River
Little
Biloxi
430
440
450
420
2 MILES
2 KILOMETERS

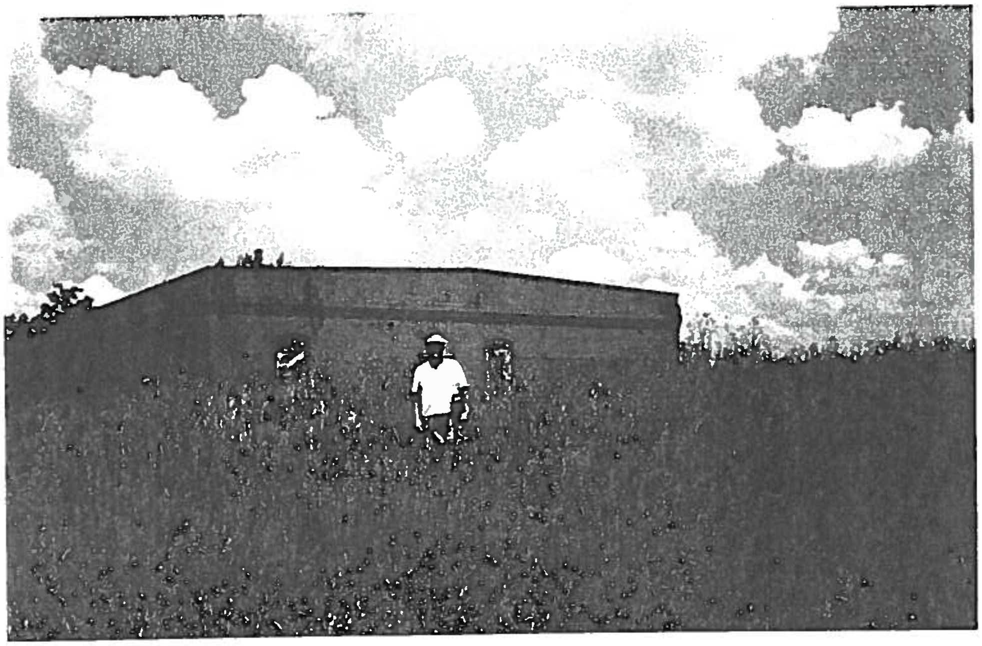
APPENDIX "C"

This is a picture of the very dense underbrush and grass at the site.

**This is a picture of one of the long rows of overgrown debris.
Notice the pipe protruding from the top.**

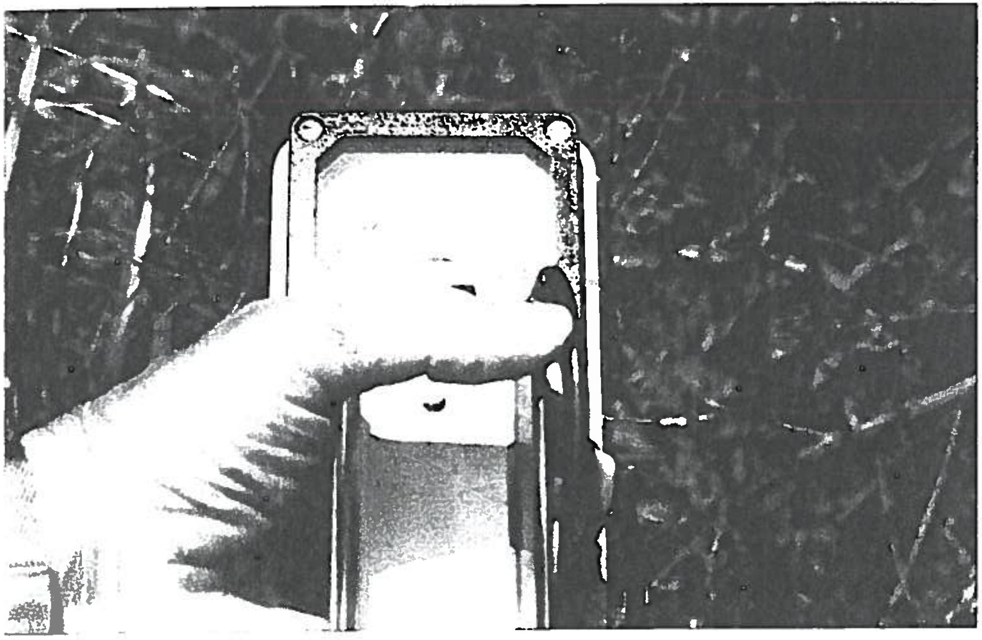
APPENDIX "C"

This is a picture of the suspect Asbestos Containing Material (Floor Tile).



The red pump house in the background was constructed in 1904. Burt Kemp is standing on the outer edge of the 100,000 gallon reservoir that has been filled in. Immediately in front of Burt Kemp is one of the NORM hot spots.

APPENDIX "C"



This is a Ludlam Radiation Survey Instrument. Notice the indicator needle pegged right.

Waste Tires on drive.

APPENDIX "C"

This is gypsum like material located in close proximity to the red brick building.

Another row of debris. Notice the area in the middle. Vegetation is present, but not like most other locations on-site. This is in the vicinity of the Sulfuric Acid plant.

age No. 1
05/15/95

AERIAL PHOTOGRAPHY SUMMARY
RECORD SYSTEM

Gulfport North

Appendix "D"

** AGENCY: Aero-Data Corp.

LAT	LONG	STATE/COUNTY	DATE	CODE	SCALE	FOCAL LENGTH	FILM TYPE	SENSOR CLASS	CLOUD COVER	QUAD COVER	REMARKS
302230	0890000	MS,Harrison	1985 Dec 03		00024000	6.00in	Black and White	Vertical Carto (Implies Stereo)	0	20	SAM-182
302230	0890000	MS	1986 Nov 21		00024000	6.00in	Black and White	Vertical Carto (Implies Stereo)	0	20	SAM-188

** AGENCY: Agricultural Stabilization and Conservation Service

LAT	LONG	STATE/COUNTY	DATE	CODE	SCALE	FOCAL LENGTH	FILM TYPE	SENSOR CLASS	CLOUD COVER	QUAD COVER	REMARKS
302230	0890000	MS,Harrison	1952 Feb 21	CZJ	00020000	8.25in	Black and White	Vertical Carto (Implies Stereo)	0	100	04
302230	0890000	MS,Harrison	1958 Jan 16	CZJ	00020000	8.25in	Black and White	Vertical Carto (Implies Stereo)	0	100	04
302230	0890000	MS,Harrison	1970 Feb 27	CZJ	00020000	8.25in	Black and White	Vertical Carto (Implies Stereo)	0	100	04
302230	0890000	MS,Harrison	1980 Apr 30		00040000	6.00in	Black and White	Vertical Carto (Implies Stereo)	0	100	31-78-7

** AGENCY: Metropolitan Aerial Surveys

LAT	LONG	STATE/COUNTY	DATE	CODE	SCALE	FOCAL LENGTH	FILM TYPE	SENSOR CLASS	CLOUD COVER	QUAD COVER	REMARKS
302230	0890000	MS	1985 Oct		00048000	3.46in	Black and White	Vertical Reconnaissance	0	20	GULFPORT MS

** AGENCY: National Aeronautics and Space Administration, Ames

LAT	LONG	STATE/COUNTY	DATE	CODE	SCALE	FOCAL LENGTH	FILM TYPE	SENSOR CLASS	CLOUD COVER	QUAD COVER	REMARKS
302230	0890000		1978 Oct 08	02690	00066625	12.0in	Color Infrared	Vertical Reconnaissance	0	30	578002690 3156 3163 0257 0059
302230	0890000		1978 Oct 08	02690	00066000	12.0in	Color Infrared	Vertical Reconnaissance	0	50	578002690 3152 3155 0257 0055
302230	0890000		1978 Oct 08	02690	00067000	12.0in	Color Infrared	Vertical Reconnaissance	0	60	578002690 3256 3256 0257 0159
302230	0890000		1978 Oct 08	02690	00066555	12.0in	Color Infrared	Vertical Reconnaissance	0	50	578002690 3245 3253 0257 0148
302230	0890000		1987 Nov 18	03694	00066500	12.0in	Color Infrared	Vertical Reconnaissance	0	40	587003694 3564 3565 0374 1174
302230	0890000		1987 Nov 18	03694	00066500	12.0in	Color Infrared	Vertical Reconnaissance	0	20	587003694 3566 3567 0374 1176
302230	0890000		1988 Nov 18	03809	00064076	12.0in	Color Infrared	Vertical Reconnaissance	0	70	588003809 5578 5603 0383 0839
302230	0890000		1988 Nov 22	03818	00065000	12.0in	Color Infrared	Vertical Reconnaissance	30	50	588003818 6326 6326 0387 0117
302230	0890000		1988 Nov 22	03818	00064500	12.0in	Color Infrared	Vertical Reconnaissance	0	20	588003818 6322 6325 0387 0113
302230	0890000		1988 Nov 22	03818	00065000	12.0in	Color Infrared	Vertical Reconnaissance	0	50	588003818 6327 6334 0387 0118

** AGENCY: National Aeronautics and Space Administration, JS

LAT	LONG	STATE/COUNTY	DATE	CODE	SCALE	FOCAL LENGTH	FILM TYPE	SENSOR CLASS	CLOUD COVER	QUAD COVER	REMARKS
302230	0890000		1969 Aug 19	1100	00065428	12.0in	Black and White	Vertical Reconnaissance	30	50	61100001C 0011 0017 0416 0009
302230	0890000		1969 Aug 19	1100	00125810	6.00in	Color	Vertical Reconnaissance	60	100	61100001A 4872 4880 0417 0284
302230	0890000		1969 Aug 19	1100	00124020	6.00in	Color Infrared	Vertical Reconnaissance	60	100	61100001B 5205 5215 0417 0509
302230	0890000		1970 Aug 18	1500	00052821	6.00in	Black and White	Vertical Reconnaissance	10	80	615000100 8292 8327 0565 0155
302230	0890000		1970 Aug 18	1500	00052353	6.00in	Color	Vertical Reconnaissance	10	80	615000110 1562 1596 0687 0446
302230	0890000		1970 Feb 17	1250	00122007	6.00in	Black and White	Vertical Reconnaissance	0	20	612500020 1348 1365 0437 0054
302230	0890000		1970 Feb 17	1250	00121667	6.00in	Black and White	Vertical Reconnaissance	0	100	612500020 1331 1347 0437 0037
302230	0890000		1970 Feb 17	1250	00119445	6.00in	Black and White	Vertical Reconnaissance	0	70	612500020 1312 1330 0437 0018
302230	0890000		1970 Feb 17	1250	00120677	6.00in	Color Infrared	Vertical Reconnaissance	0	80	612500010 0976 0988 0438 0014
302230	0890000		1970 Feb 17	1250	00062080	12.0in	Color Infrared	Vertical Reconnaissance	0	30	612500030 0016 0026 0438 0128
302230	0890000		1970 Feb 17	1250	00063148	12.0in	Color Infrared	Vertical Reconnaissance	0	100	612500030 0034 0049 0438 0146
302230	0890000		1970 Feb 17	1250	00121779	6.00in	Color Infrared	Vertical Reconnaissance	0	100	612500010 0996 1000 0438 0034
302230	0890000		1970 Feb 17	1250	00120750	6.00in	Color Infrared	Vertical Reconnaissance	0	20	612500010 1001 1013 0438 0039
302230	0890000		1970 Oct 31	1450	00064783	12.0in	Color Infrared	Vertical Reconnaissance	0	70	614500600 0128 0136 0464 0579
302230	0890000		1970 Oct 31	1450	00120891	6.00in	Color Infrared	Vertical Reconnaissance	0	60	614500590 8378 8395 0464 0119
302230	0890000		1970 Oct 31	1450	00121490	6.00in	Color Infrared	Vertical Reconnaissance	0	100	614500590 8400 8408 0464 0141
302230	0890000		1970 Oct 31	1450	00120891	6.00in	Color	Vertical Reconnaissance	0	60	614500580 8677 8694 0464 0344
302230	0890000		1970 Oct 31	1450	00121490	6.00in	Color	Vertical Reconnaissance	0	100	614500580 8699 8707 0464 0366
302230	0890000		1971 Nov 21	1910	00064822	12.0in	Color	Vertical Reconnaissance	0	20	619100460 0194 0195 0546 1619
302230	0890000		1971 Sep 30	1800	00120883	6.00in	Color Infrared	Vertical Reconnaissance	0	30	618000290 3222 3230 0514 0057
302230	0890000		1971 Sep 30	1800	00124732	6.00in	Color Infrared	Vertical Reconnaissance	0	100	618000290 3205 3209 0514 0040
302230	0890000		1971 Sep 30	1800	00119888	6.00in	Color Infrared	Vertical Reconnaissance	0	30	618000290 3216 3221 0514 0051
302230	0890000		1972 Jul 06	2060	00051838	6.00in	Color Infrared	Vertical Reconnaissance	0	30	620600270 0188 0199 0586 1144

```
LAT    LONG    STATE/COUNTY DATE        CODE  SCALE    FOCAL  FILM TYPE                SENSOR CLASS                    CLOUD QUAD  REMARKS
                                                       LENGTH                                                          COVER COVER
302230 0890000              1972 Jul 06 2060  00053765 6.00in Color Infrared           Vertical Reconnaissance         10    70    620600270 0160 0160 0586 1117
302230 0890000              1972 Jul 06 2060  00053359 6.00in Color Infrared           Vertical Reconnaissance         50    40    620600270 0161 0162 0586 1118
302230 0890000              1972 Jul 06 2060  00052811 6.00in Color Infrared           Vertical Reconnaissance         70    20    620600270 0158 0158 0586 1115
302230 0890000              1972 Jul 06 2060  00053850 6.00in Color Infrared           Vertical Reconnaissance         10    80    620600270 0219 0223 0586 1175
302230 0890000              1972 Mar 16 1940  00119110 6.00in Color Infrared           Vertical Reconnaissance         20    60    619400020 0136 0138 1265 0952
302230 0890000              1972 May 04 1990  00035803 6.00in Black and White          Vertical Reconnaissance         40    40    619900180 0131 0133 0560 0132
302230 0890000              1972 May 04 1990  00035803 6.00in Color                    Vertical Reconnaissance         40    40    619900170 0131 0133 0561 0132
302230 0890000              1973 Aug 23 2470  00041636 6.00in Color Infrared           Vertical Reconnaissance         10    60    624701060 0040 0050 0675 0262
302230 0890000              1973 Aug 24 2470  00024909 6.00in Color Infrared           Vertical Reconnaissance         0     50    624701060 0210 0228 0675 0432
302230 0890000              1973 Aug 24 2470  00042714 6.00in Color Infrared           Vertical Reconnaissance         0     70    624701060 0177 0188 0675 0399
302230 0890000              1973 Jan 14 2260  00023415 6.00in Color Infrared           Vertical Reconnaissance         30    40    622600230 0126 0128 0625 1727
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** AGENCY:  National Archives and Records Administration

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** AGENCY:  National Ocean Service

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 AGENCY:  U.S. Geological Survey

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AERIAL PHOTOGRAPHY SUMMARY
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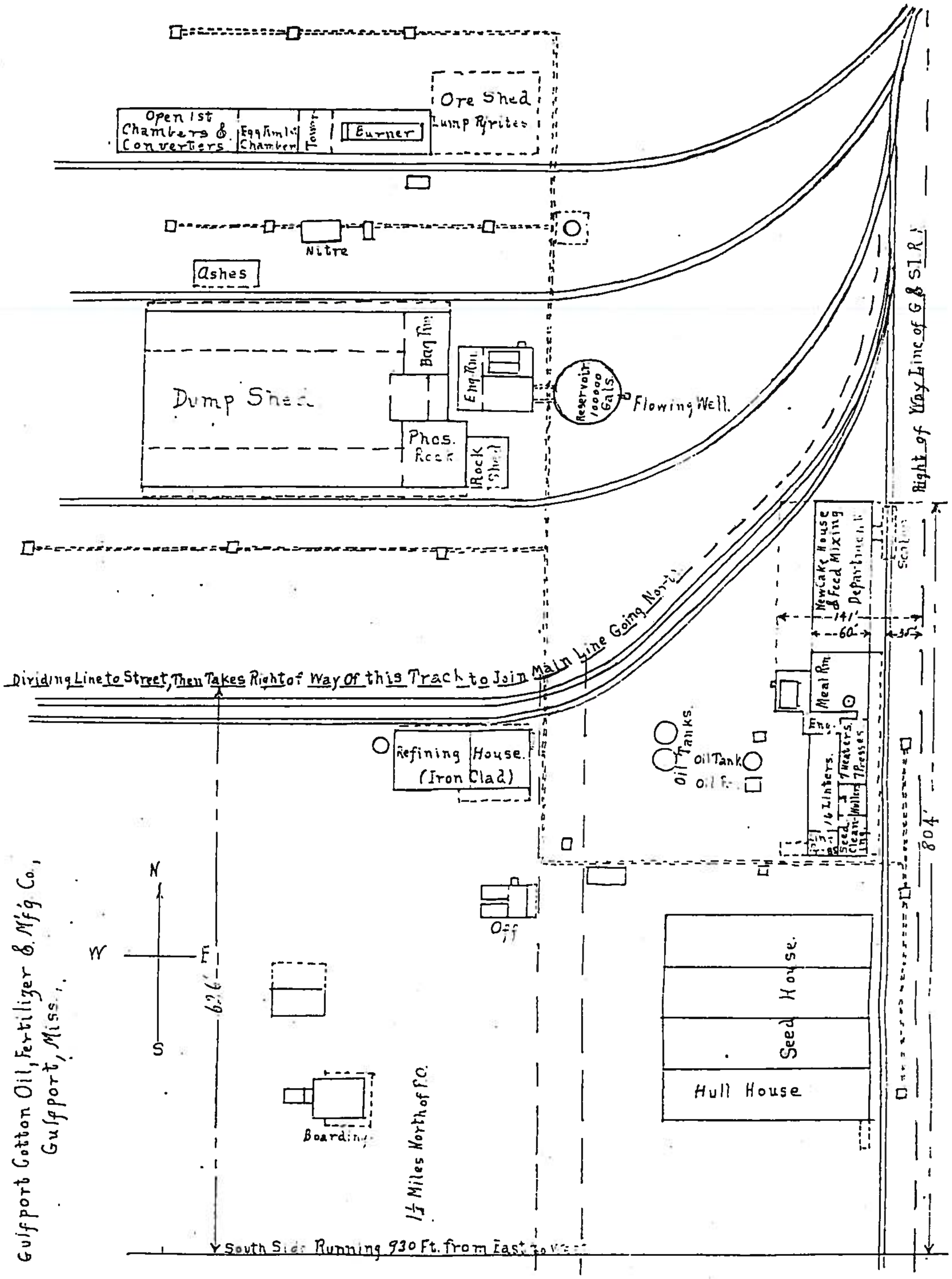


Fil...05
750 W.75
Cert..50
$1.30

The instrument of which the foregoing is a record was delivered to me to be recorded at 12 o'clock M. on October 14th, 1908; and recorded October 30th, 1908.

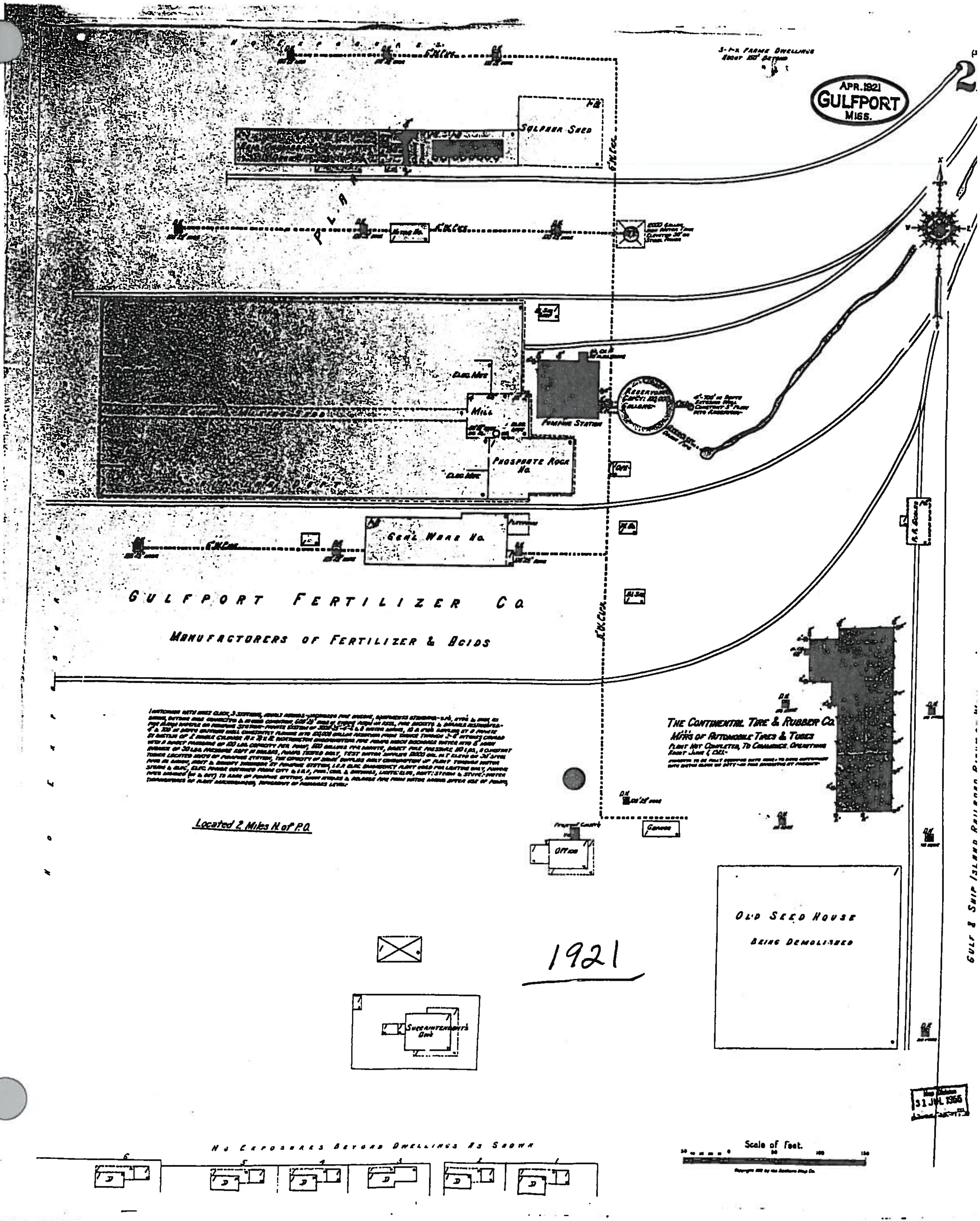
F S Hewes Clerk.

WARRANTY DEED.

88/248

In Consideration of the sum of Forty Dollars I (or we) do hereby Convey and Warrant unto A. K. Brashear a resident of Port Gibson, Miss., the following described property. Lots No. Fourteen (14) of Block No. Seven (7) of "South Olive Park" sub-division or addition to or near Gulfport, Harrison County, Mississippi, as per Official Plat of same on file in the Chancery Clerk's office of Harrison County, Mississippi.

AP "F"


APR. 1921
GULFPORT
MISS.
2
5-FR. FRAME DWELLINGS
ABOUT 150' BEYOND
SULPHUR SHED
6" W. PIPE
MILL
ELEC. MTRS.
PUMPING STATION
RESERVOIR
CAP'Y 100,000
GALLONS
PHOSPHATE ROCK HO.
GEN'L WARE HO.
GULFPORT FERTILIZER CO.
MANUFACTURERS OF FERTILIZER & ACIDS
Located 2 Miles N. of P.O.
THE CONTINENTAL TIRE & RUBBER CO.
MFR'S OF AUTOMOBILE TIRES & TUBES
PLANT NOT COMPLETED, TO COMMENCE OPERATIONS
ABOUT JUNE 1 1921
GARAGE
OFFICE
OLD SEED HOUSE
BEING DEMOLISHED
SUPERINTENDENT'S DWG.
GULF & SHIP ISLAND RAILROAD
NO EXPOSURES BEYOND DWELLINGS AS SHOWN
6
5
4
3
2
1
D
Scale of Feet.
50
0
50
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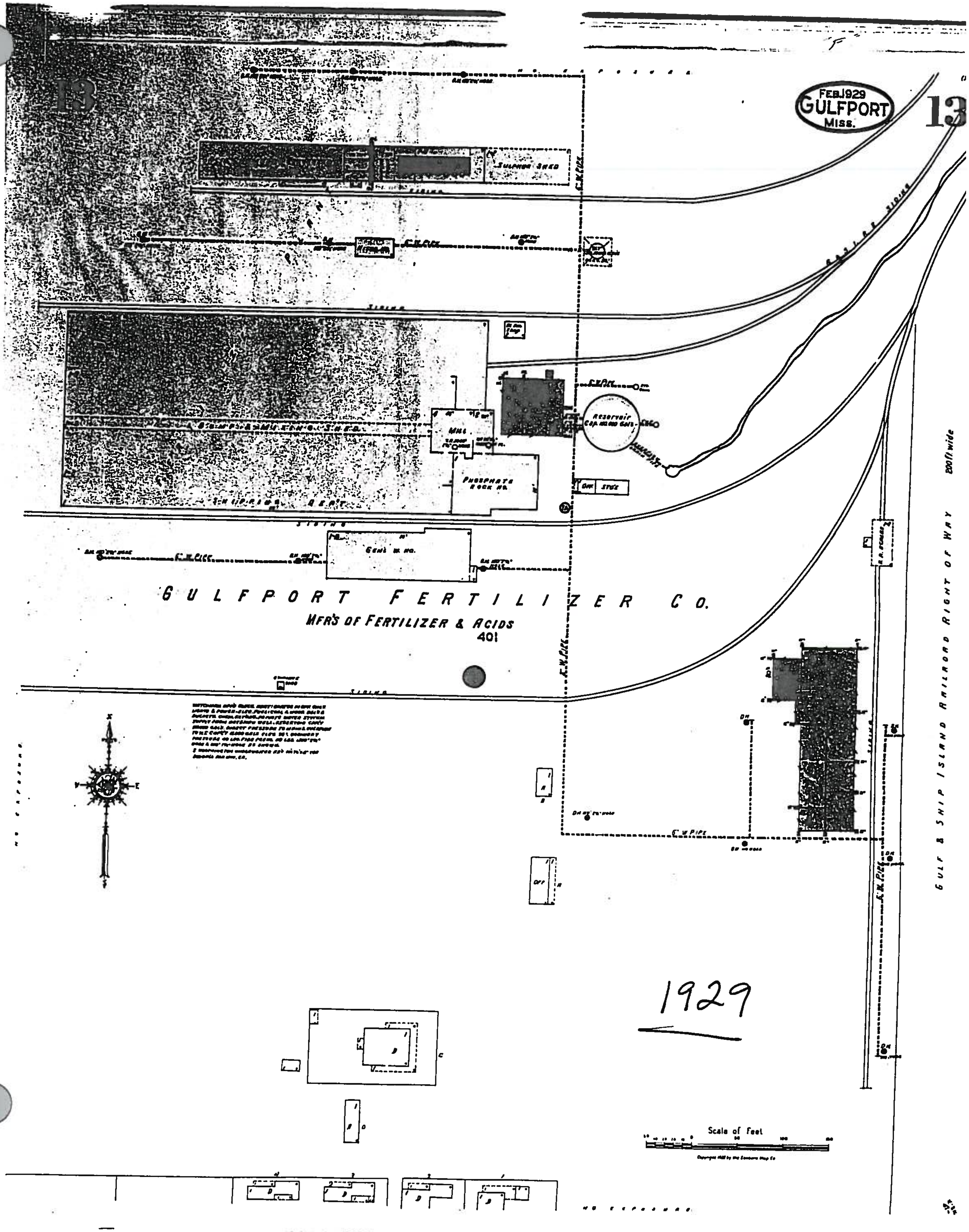
150
31 JUL 1966

1921

"F"


13
FEB 1929
GULFPORT
MISS.
13
SULPHUR SHED
SIDING
C.W. PIPE
SIDING
MILL
Reservoir
PHOSPHATE ROCK HO.
OFF.
STORE
SIDING
GEN'L W. HO.
C.W. PIPE
GULFPORT FERTILIZER CO.
MFR'S OF FERTILIZER & ACIDS
401
SIDING
N
E
W
C.W. PIPE
C.W. PIPE
OFF
SIDING
C.W. PIPE
GULF & SHIP ISLAND RAILROAD RIGHT OF WAY
200 ft wide
NO EXPOSURE
NO EXPOSURE
Scale of Feet

1929

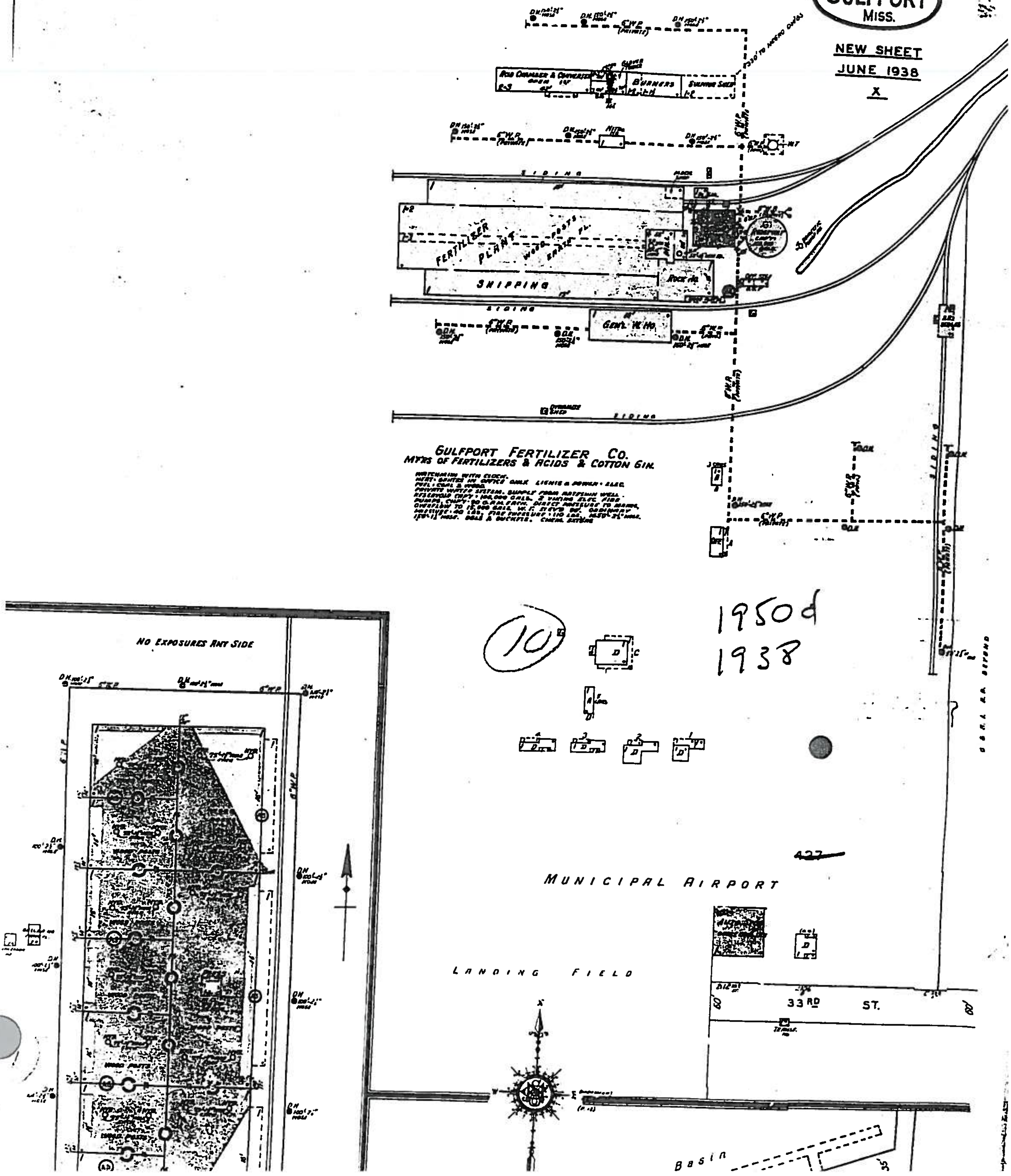
AP. "G"

509 . 504

13

FEB. 1929
GULFPORT
MISS.

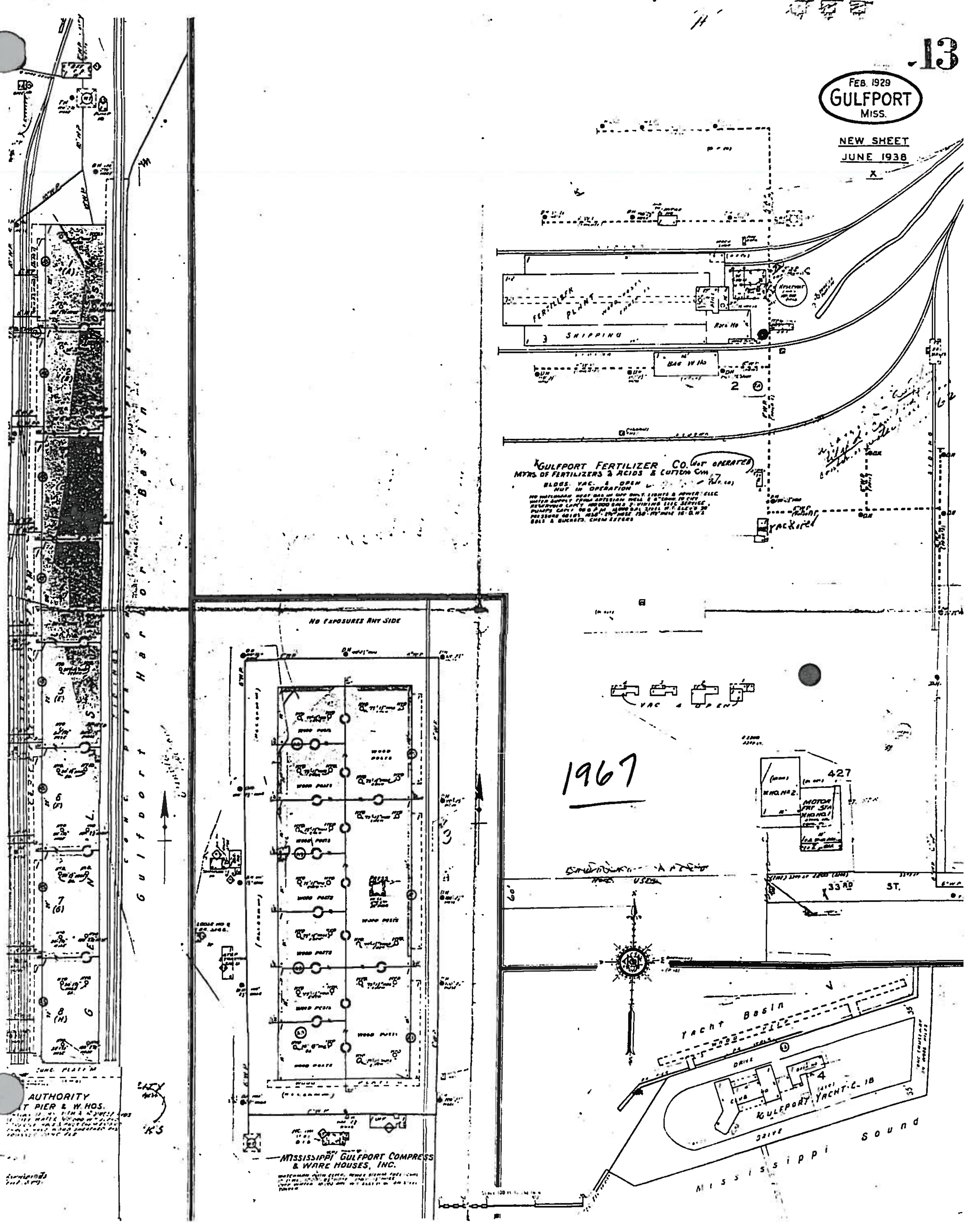
NEW SHEET
JUNE 1938
X



10

1950d
1938

App. "H"


13
FEB. 1929
GULFPORT
MISS.
NEW SHEET
JUNE 1938
FERTILIZER PLANT
SHIPPING
BAG W Ho
RESERVOIR
GULFPORT FERTILIZER CO. NOT OPERATED
MFRS. OF FERTILIZERS & ACIDS & COTTON GIN
BLDGS. VAC. & OPEN
NOT IN OPERATION
VACANT
SIDING
VAC & OPEN
1967
427
MOTOR FRT STA
WHO.NO.2
33RD ST.
60'
Yacht Basin
DRIVE
4
GULFPORT YACHT CLUB
Mississippi Sound
NO EXPOSURES ANY SIDE
WOOD POSTS
MISSISSIPPI GULFPORT COMPRESS
& WARE HOUSES, INC.
Gulfport Harbor
Basin
AUTHORITY
T PIER & W. HOS.
JUNC. PLATF'M
K'S
2

MAP
Mississippi
Agricultural
Products

MISSISSIPPI
DEPARTMENT
of
AGRICULTURE
and
COMMERCE
P. O. Box 1609
Jackson, Mississippi 39215-1609

JIM BUCK ROSS
COMMISSIONER

Att. "5"

Facsimile Transmission

Date: 5-9-95

Number of Pages: 8
(include this cover page)

To

Fax Number: 452-0117

Name: Rimmer Covington

Company:

Address:

From JOHN J. HALL, III
DIRECTOR

FEED, SEED & FERTILIZER DIVISION
BUREAU OF REGULATORY SERVICES

Office (601) 354-7063
Fax (601) 354-6001

Notes

Please see info.
of fertilizer Plants.
let me know if you should
more information.
John

U.S. FARMERS · Feed the World

Nelson

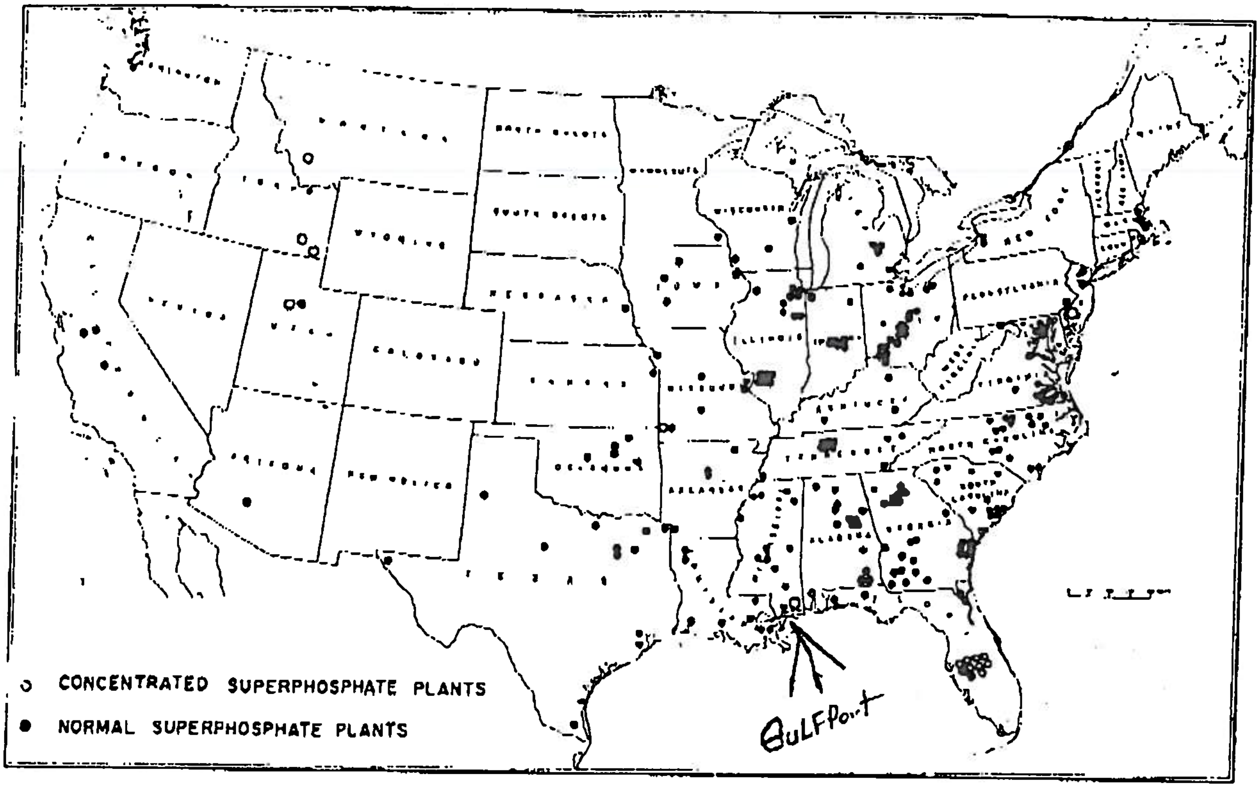


Figure 1.—Approximate locations of superphosphate plants in the United States. (Source: Geographical Directory of Fertilizer Plants. Commercial Fertilizer Year Book 99 (3-A): 132-192. September 1959.)

of sulfur are required per ton of superphosphate. Consequently, most concentrated superphosphate plants are located advantageously to raw materials sources, usually near a source of phosphate rock. Of the 15 concentrated superphosphate plants in the United States (fig. 1), 8 are located in the Florida phosphate field. Most of the remaining plants are located either in the western phosphate field or on waterways, to take advantage of low-cost barge transportation. As shown in figure 2, the principal market area for concentrated superphosphate includes the Central, Midwestern, and most of the Western States; most of this area is relatively distant from the production points.

Since size of marketing area is not a limiting factor, most concentrated superphosphate plants are designed for high production rate in order to obtain low operating cost. Capacities of plants range from about 100,000 tons annually to more than 500,000. Most plants have integrated facilities for grinding phosphate rock and for production of sulfuric and phosphoric acids.

RAW MATERIALS COSTS

Phosphate Rock

In 1959, about 90 percent of the phosphate rock used in superphosphate production was mined in Florida. Table 1 shows the price schedule in effect in the year ending June 30, 1962, as published by a large producer of Florida land pebble. Phosphate rock is priced on the basis of BPL (bone phosphate of lime) content. The higher grades command higher market prices, that is, a higher price per unit of BPL (equivalent to 0.458 lb. per unit P_2O_5). As shown in table 1, the unit price increases from about 7½ cents per unit for the lower grades to about 10½ cents for the higher grades.

The high grades of rock, 75 to 77 percent BPL, are used by most superphosphate manufacturers for acidulation because they yield a high-grade product. Costs of mixing, handling, and shipping a ton of superphosphate are about the same regardless of grade; therefore, an increase in grade reduces the overall cost per unit for production and distribution.

ordinary laborers to operate and maintain. This difficulty has been minimized in some plants by using manual control; results seem to have been satisfactory, although continuous attention by the operator is required.

Batch weighing into a pan mixer also requires less attention to calibration and less care to avoid rock flooding than does continuous weighing. Moreover, some grades of byproduct (spent) sulfuric acid are difficult to meter on a continuous basis.

Equipment Cost

The small mixers—cone and high-speed types—have an advantage in regard to cost. The units are relatively inexpensive, and, moreover, foundations and supporting structures can be of much lighter construction. Also, much less room is required. A high-speed mixer should cost more than a cone mixer since a stirrer and motor must be provided.

In comparing batch and continuous mixers, an important consideration is the higher cost of the continuous feeding equipment, which may cost twice as much as a batch-weighing installation. Some reduction can be obtained by using a manually controlled weigh belt, but the cost is still somewhat higher than for batch equipment.

Operation and Maintenance

Use of continuous mixers avoids the manual operation ordinarily associated with operation of a pan mixer. It is difficult to isolate mixer operating cost, however, since the operation of mixer and den is tied together in most plants. Paddle mixers do not require constant attention, but it is advisable to have an operator near a cone mixer, since accidental stoppage would cause the mixer to overflow. In most of the plants checked in this survey, an operator is assigned to the mixing area, no matter whether the operation is batch or continuous.

In power requirement, the cone mixer has a considerable advantage since it requires no power at all. Installed horsepower reported for typical installations of other mixers, in the 25- to 40-ton-per-hour range, are 15 for the pan mixer, 20 for the paddle type, and 3 for the high-speed mixer.

Maintenance cost probably is lower for the cone mixer than for any other type. There are no moving parts to wear, and replacement liners are inexpensive. Normal equipment replacement cost for feeding, weighing, and mixing is estimated at 1 to 2 cents per ton of product.

Effect on Properties of Superphosphate

Considerable difference in the characteristics of the superphosphate produced can result from the type of mixer used. Unfortunately, no quantitative data on these differences have been reported. A few large producers, who operate mixers of different types, have attempted to measure the differences, but other variables in plant operation have made the results inconclusive in the instances with which the authors are familiar.

It is generally accepted that the paddle mixer, because of the long retention time and the consequent opportunity for gases to escape, gives a relatively dense and granular superphosphate. The cone and high-speed mixers, at the other extreme of retention time, tend to make a very porous and finely divided superphosphate that can be dusty if very dry. The porosity is advantageous in ammoniation, but the fineness is a handicap in direct application.

DENNING

Most emphasis in the improvement of superphosphate plant design has been centered on the denning step. The den must receive a slurry, hold it during setting up in such a way that the slurry can be removed easily after setting, and provide means for removing the obnoxious gases evolved during the stay in the den. In meeting these requirements, plant designers have used a wide variety of container types and mechanical devices. Because of the emphasis on the den, processes generally have been named after the type of den used.

In the early days of the industry, many plants made superphosphate without a den. The acid and rock were mixed and the mixture discharged onto an open pile, a procedure known as the "open-dump" method. Many of the smaller plants made superphosphate in this way in this country, especially in the Southeast, and continued the practice for some time after dens were generally adopted in other areas. One of the main objections to operation without a den is the atmospheric pollution caused by fluorine compounds escaping from the superphosphate during the early stages of curing. Since most of the fluorine is evolved during the first half hour or so after mixing, use of a closed den with a scrubber system virtually eliminates this problem. It has also been reported that the open-dump method gave slow curing and drying, because the heat of reaction was dissipated

TVA
PO Box 1010
CTR1H
Muscle Shoals, AL 35660

Soil & W Cons – USDA [illegible]
& 9101 Agr
TVA

NC 1964

rapidly. The significance of this is not entirely clear, however, because of conflicting reports: in Europe, for example, some denning processes involve conditions conducive to aeration and rapid cooling, and it is claimed that this accelerates curing.

The first dens were simple wood or brick chambers fitted with a crude arrangement for exhausting the gases to a stack. The capacity was usually 30 to 50 tons, but a few dens were built that held 100 tons or more. This type of arrangement was an improvement over the open-dump practice, but it had a drawback—when the den was opened 3 or 4 hours after filling, the workers had to get in the den to dig out its contents. Enough residual gases remained to make this a very unpleasant task.

The next step in den development was provision for a mechanical device to excavate the superphosphate from the den chamber. This made it unnecessary for the operator to enter the den, and, in many instances, the den was so designed that air could be pulled through it to minimize escape of fluorine-bearing gases into the building. This type of denning is still common today.

Development of mechanical dens, which began around the turn of the century, resulted from the need to reduce labor cost, improve control of fluorine gases, and improve physical characteristics of the product. Both batch and continuous types were developed. The continuous types introduced a conveying step into the operation; that is, the acid-rock mixture was introduced into the den at one point, conveyed to another point during setting, and there cut out of the den. Many variations in the conveying step have been used, including horizontal, vertical, and circular movement.

The main design objectives in den construction are proper retention time, prevention of leakage (both of the superphosphate and of the evolved gases), low corrosion, and excavator operation such as to give good product quality. Another factor, important in some types of dens, is provision for expansion of the superphosphate during curing. Ginzburg (*12*) has reported data on this. In his tests, expansion began 25 minutes after mixing and continued for 35 minutes. Linear expansion was 12 percent and volumetric expansion 36 percent, with a resulting pressure of 14 to 21 pounds per square inch. The friction coefficients for fresh superphosphate were 0.5 and 0.7, respectively, for smooth steel and wood surfaces.

Stationary Dens

Most stationary dens now in use in this country are box or silo chambers made of reinforced concrete. Sizes of these range widely, from 20 to over 300 tons. In some plants, two or more box dens are arranged so that a single mixer can serve all of them. Practice varies widely as to retention time in the den. In some plants, excavation is started almost immediately after the last mixer batch is dumped in. In others, excavation is carried out during the succeeding shift or even the next day.

The main differences in stationary den operation are in excavation of the superphosphate, which varies from digging out manually to using a continuous cutter. Hand excavation has practically disappeared from the scene. In 218 normal superphosphate plants covered in the survey on which this book is based, only one was noted in which digging out by hand is still practiced. Most of those that were designed originally for hand excavation have been converted to allow the use of a mechanical excavator.

In some of the older dens the superphosphate was removed through slots in the bottom or side of the den. During filling of the den the slots were covered with planks. These planks had to be removed by hand prior to or during the excavation, a disagreeable and time-consuming operation. Today, practically all box dens are fitted either with a door in the side or with a removable cover, and the superphosphate is removed through these openings.

Mechanical devices for excavating are of the batch and continuous types; most of those used in this country are batch machines, such as draglines and cranes. The crane plants are few in number and are mainly old plants. Because of the high cost of a crane installation, these plants have been very large ones; they are located mainly on the eastern seaboard where the larger plants have been built. The crane plants are reported to have given economical operation in a day when production was at a high level and cost of construction was much lower than it is now. Under conditions today, the cost would be prohibitive in many situations. One of the largest crane plants in the country was converted recently to continuous operation (*3*).

Use of a crane has also been criticized on the grounds that dropping the crane bucket into the fresh superphosphate in the den tends to pack the material and make it undesirably dense (*34*). No data appear to be available on this point.

The dragline has become the most popular excavator in this country. It is relatively inexpensive as compared with a crane and is easily installed in an old plant. Whereas a crane requires a removable top to the den, the dragline requires only a door in the side. The door is opened after the mix has set up in the den and the superphosphate is pulled out with the dragline scraper, usually onto a conveyor system that carries it to the curing pile.

A motorized shovel is used in a few plants to excavate from the den. The increased exposure of the operator to fumes is undesirable. An early version of this type of operation has been described by Parrish and Ogilvie (*27*).

Several different types of continuous den excavators have been developed. One of these, the Wever (*36*), has been used in a few plants in this country. It consists of an arrangement of toothed chains mounted on a carriage that rolls on a track extending into the den. When the superphosphate is ready for cutting, a slit in the bottom of the den is uncovered and a narrow door in the end opened. The excavator is advanced on the tracks into the den, where it first cuts a hole for entry of the machine and then cuts sideward to the den walls. The cut superphosphate is dragged downward and discharged through the slot in the floor. High maintenance cost for this type of excavator has been reported.

Packard (*26*) reported the Keller excavator to be the first departure from hand excavation in England, where the excavator was first used about 1910; it has been used in Australia also. The device consisted of a set of scrapers mounted on a boom. When the superphosphate was ready for excavation, a door the width of the den was opened and the boom inserted over the surface of the superphosphate. The scrapers pulled the superphosphate out through the door of the den, and the boom was moved from side to side by movement of the excavator frame on transverse tracks in front of the den. The boom was lowered in the frame, as it cut downward through the den.

The Wenk den, used mainly in France (*27*), is another stationary den with a separate, continuous excavator. The den in this design is a horizontal cylinder with a lengthwise slot in the bottom. The cutter, a set of knives mounted on cross arms to form a cutter wheel, is mounted on a carriage that moves on tracks extending under the den. The cutter turns at 22 revolutions per minute and moves into the den at a rate of about 1¾ inches per minute. A typical size for a Wenk den is 9.8 feet in diameter by 19.6 feet in length; the capacity is about 40 tons. Over 2 hours are required for excavating.

Schucht (*31*) has described other excavators similar to the Wenk. The Pozzi differed only in that it was suspended from a track. The Parent rotated around an inclined shaft rather than a horizontal one.

Schucht has also described the Rema excavator system. The den has the shape of an inverted truncated cone and has a removable inner cylinder for introduction of the cutter after the superphosphate has set up. The cutter, something like an inverted umbrella, is suspended from above. In cutting, the bottom plate is removed and the cutter, with cutting ribs closed up against the shaft, is inserted into the den. As the cutter revolves, the ribs open out to conform to the cone shape of the den.

The Hovermann den, a somewhat different arrangement of stationary den and continuous cutter, is used to a limited extent in Europe. The den is a vertical concrete cylinder with vertical slots in the sides. When the superphosphate is ready for excavating, a rotary cutter lowered into the den cuts the superphosphate and pushes it out through the openings.

Mechanical Dens: Batch Type

The stationary den-excavator type of plant has several disadvantages. The compacting action of a crane bucket has been mentioned. Drag and scraper excavators are superior to the crane in regard to compacting effect, and some producers consider that the excavators give a product that is quite satisfactory. Others hold that batchwise excavation of any sort is undesirable, both because of the effect on condition and also because continuous attention of an operator is required. In any event, there has been a trend to excavation methods that are continuous and that involve a minimum of compacting action. The use of cutters that cut thin slices from the face of the superphosphate block in the den has come into general use. This type of operation allows better aeration and escape of gases, thus promoting drying and porosity of the product.

operator looks to phosphorus conversion to available forms in a month-old curing pile, where the rate of conversion is governed not so much by rock reactivity as by the ease of acid diffusion to the residual unattacked rock carried in the coarser grains of the rock used: the analytical chemist in the fertilizer control laboratory thinks of solubility in his test solvents as determined by procedures that are designed to indicate "how much," not "how rapid"; whereas the physical chemist more properly envisions reactivity as the fraction of substance dissolved in a fairly short period of time under suitable agitation with a large excess of sulfuric acid of the normal acidulation strength.

Confusion as to the meaning of rock reactivity can be dispelled only by the development of a suitable method for measuring it. Reliable measurement presupposes some understanding of the interplay of factors that govern it—chemical composition, mechanical composition, surface area, and porosity among others. Different aspects of the problem have been under study in the U.S. Department of Agriculture (*16, 17, 18, 32, 34, 53*) and elsewhere (*20, 26, 60, 61, ch. 5, 64*) for some time. A recent article (*61, ch. 6*) summarizes extant results that bear on the possible establishment of a scale of reactivity for phosphate rock. The reactivity order of the test samples of several varieties was found to be generally independent of the method of measurement. Ranked in the order of ascending reactivities the test phosphates are macrocrystalline apatite, Tennessee brown rock, Florida land pebble, Tunis rock, and steamed bonemeal (see table 2, ch. 5).

SULFURIC ACID

Types of Acid

The two general types of sulfuric acid used in superphosphate manufacture are virgin, or new, acid and spent acid. Virgin acid is produced from elemental sulfur, pyrites, and industrial gases. The contribution of these primary source materials to the total domestic production is shown in table 10. Abroad, acid is produced from gypsum. Plants, processes and practice for sulfuric acid manufacture are described by Duecker and West (*21*).

Spent acid is derived as a waste product in sundry industries that use large quantities of sulfuric acid in processing a great variety of products. In some instances the spent acid is sufficiently clean and of a suitable strength for phosphate rock acidulation, whereas, in other instances, it must be conditioned by suitable treatment for removal of substances that are unmanageable in the superphosphate process, or toxic to crops. The superphosphate industry, which is a heavy user of sulfuric acid, only slightly restricted by acid-purity requirements and widely dispersed geographically, provides convenient facilities for consumption of this valuable waste product from many places.

TABLE 10.—*Division of domestic sulfuric acid production among primary raw materials* [1]

Calendar year	Share in total production of new acid from—			Share in total production of reclaimed acid from sludge
	Elemental sulfur	Pyrites	Smelter and H_2S gas	
	Percent	*Percent*	*Percent*	*Percent*
1895	75	24	1	
1905	10	79	11	
1915	9	64	27	
1925	68	14	18	
1935	59	29	12	
1940	64	24	12	
1945	69	12	10	
1950	74	11	7	1
1955	72	10	8	4
1957	70	11	10	5
1959	81	7.8	5.5	5.6
1961	84	6.4	4.0	5.1

[1] From collected figures (*21, p. 6*) for period 1895–1957; from Kostor (*49*) and Horner (*40*) for 1959 and 1961, respectively.

Composition

Standard grades of sulfuric acid recognized by the Manufacturing Chemists' Association are given in table 11. In addition to the standard grades, are battery acids supplied in strengths ranging from 27.88 to 93.19 percent of H_2SO_4, the chemically pure acid that conforms to American Chemical Society specifications and runs between 95.5 and 96.5 percent of H_2SO_4, and the stabilized sulfur trioxide with minimum of 99 percent of SO_3 (*21, p. 397*). Commercial acids used in superphosphate manufacture are mainly 60° and 66° Baumé strengths. For use as a rock acidulant, the commercial acids are diluted to about 70 percent or less (*43, p. 175*).

Formerly, appreciable amounts of trace elements were expected in acid produced as a byproduct in

TABLE 11. —*Standard grades of sulfuric acid*[1]

Baumé scale (degree)	Specific gravity[2]	H_2SO_4
		Percent
52	1.5591	65.13
58	1.6667	74.36
60	1.7059	77.67
66	1.8354	93.19
	1.8437	98.00
	1.8391	100.00
	[3] 1.915–1.992	104.5–114.6

[1] Adopted by Manufacturing Chemists' Association (*50*).

[2] Determined at 60° F. in comparison with water at 60° F.

[3] Oleums, 20, 30, 40, and 65 percent.

TABLE 12.—*Copper and zinc contents of sulfuric acid*[1]

Source of acid	Location of factory	Date of production	H_2SO_4	Cu[2]	Zn[2]
		Year	*Percent*	*P.p.m.*	*P.p.m.*
Sulfur	Florida	1957	93	0.03	1
Sulfide ore	Utah	1957	93	.3	1
Do	Montana	1931	77	49	(3)
Do	Tennessee	1931	77	8	49

[1] Results of Clark and Hill (*19*).

[2] Content based on 100 percent H_2SO_4.

[3] Trace.

smelting metallic sulfides. The meager information available (table 12) seems to indicate that this acid is now cleaner in this respect than it was in the early 1930's.

Sulfuric acid, having many industrial uses, appears as spent acid in many different conditions. The ten most important consumer industries are listed in table 13. The more plentiful varieties of spent acid are alkylation sludge from petroleum refining and acids from alcohol manufacture, nitrating processes, and benzene production. Numerous other processes use acid in relatively small quantities. The spent acid from these sources carry organic impurities that are peculiar to the particular process. In most cases successful procedures for treating these acids for re-use in the process have been developed, but all too often the cost is prohibitive. Still, the waste must be disposed of. Hence, utilization in another industry, where conditioning is not required, is highly desirable. The superphosphate, phosphoric acid, and ammonium sulfate industries can utilize it in many instances. Some acids used in, or proposed for, superphosphate manufacture since 1940, which have come to the author's attention, are described in table 14.

TABLE 13.—*Distribution of domestic sulfuric acid consumption among industrial uses*[1]

Consumer industry	Acid (basis of 100 percent H_2SO_4) consumed in calendar year							
	1952		1957[3]		1959[3]		1961	
	Thousand short tons	*Percent of total*	*Thousand short tons*	*Percent of total*	*Thousand short tons*	*Percent of total*	*Thousand short tons*	*Percent of total*
Phosphatic fertilizers[2]	4,053	27.5	4,300	25.4	4,985	25.6	5,500	29.6
Chemicals not in other classes	1,245	8.5	1,300	7.6	1,425	7.7	1,600	8.6
Inorganic pigments	1,240	8.5	1,415	8.3	1,525	8.4	1,625	8.7
Iron and steel	838	5.6	1,000	5.9	1,100	6.0	930	5.0
Ammonium sulfate, synthetic	628	4.3	790	4.6	850	4.5	710	3.8
Ammonium sulfate, coke-oven	680	4.6	705	4.1	470	2.6	470	2.5
Other petroleum products	482	3.3	570	3.3	580	3.1	600	3.2
Rayon	529	3.6	505	3.0	480	2.6	455	2.4
Aluminum sulfate	360	2.5	465	2.7	485	2.6	480	2.6
Nonferrous metals	218	1.6	675	4.0	800	4.3	740	4.0
Use not classified	4,371	30.0	5,291	31.1	5,982	32.6	5,490	29.6
Gross total consumption	14,644	100.0	17,016	100.0	18,402	100.0	18,600	100.0

---

[1] Figures for years through 1959 are given by Koster (*49*); those for 1961, by Horner (*40*).

[2] Estimated quantities for different uses.

[3] Estimated tonnages of acid for years 1958 and 1960 are 4,275 and 5,450.

thus offsetting at least some of the advantage of the lower cost rock.

Phosphate rock is pulverized for use in superphosphate production. Although various degrees of fineness are used, 90 percent through 100 mesh appears to be the most common. Charges for grinding at the mines to various degrees of fineness are shown in the footnote in table 1.

Sulfuric Acid

Whether facilities for sulfuric acid manufacture are included as an integral part of a superphosphate plant depends primarily on whether acid can be purchased at a price competitive to the cost of manufacturing it and, to some extent, on the availability of acid for purchase. Owing to the higher costs associated with low volume operation, the small superphosphate plants usually can purchase their acid more economically than they can produce it. In some cases an economical size of acid plant may be achieved by producing acid for sale in addition to that required for superphosphate production. Sulfuric acid is manufactured by all of the larger producers of concentrated superphosphate and most of the larger producers of normal superphosphate.

Sulfuric acid usually is produced from crude sulfur. The price of domestic, crude sulfur in 1961 was $21 per net short ton f.o.b. cars at the mines or $22.32 per ton f.o.b. vessels at gulf ports. Table 2 gives the estimated cost of producing sulfuric acid in a contact plant with a capacity of 600 tons per day (100 percent basis). The estimated processing cost is $2.59 per ton of acid. If a delivered cost for sulfur of $26 per net ton is assumed the total production cost of acid is $11.53 per ton (100 per cent basis).

Sulfuric acid also is produced from smelter gas. This acid usually costs less than acid produced from crude sulfur, because of the byproduct cost status of the sulfur in the smelter gas.

TABLE 2.—*Estimated production cost of sulfuric acid in Florida in 1961* [1]

Item	Unit requirement, per ton of 100 percent H_2SO_4	Unit cost	Cost per ton of 100 percent H_2SO_4
Sulfur	0.344 ton	$21.00 per ton	$7.22
Freight	0.344 ton	5.00 per ton	1.72
Total			8.94
Operating labor	0.12 man-hr	2.25 per man-hr	0.27
Maintenance	6 percent of investment per yr		.61
Power	8 kw.-hr. per ton	0.01 per kw.-hr	.08
Water	10M gal	0.05 per M gal	.50
Supplies	15 percent of maintenance per yr		.09
Analyses	10 percent of labor		.03
Taxes	1 percent of investment per yr		.10
Insurance	1 percent of investment per yr		.10
Depreciation	15 yr		.67
Overhead	50 percent of labor		.14
Total			[2] 2.59
Grand total			11.53

[1] Assumptions:
(1) Contact acid plant;
(2) 600 tons per day of 100 percent H_2SO_4;
(3) Operate 330 days per year;
(4) Plant cost, $2,000,000;
(5) 95 percent sulfur recovery.

[2] No credit for byproduct steam.

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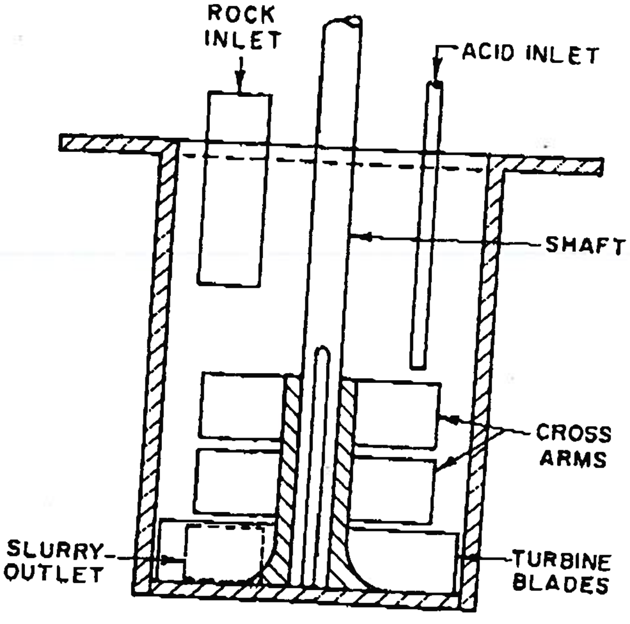

Figure 14.—Turbine-type mixer.

turbine. The slurry discharges through a slot in the side of the vessel near the bottom. Air drawn into the slurry by the turbine is claimed to "emulsify" the phosphate in the acid.

Nordengren (25) has described a mixer (fig. 15) that has some of the features of the turbine type. It is actually a batch mixer, but the retention time is so short (2 to 5 sec.) that it approaches continuous operation. Weighed batches of rock and acid are dumped in, subjected to intensive mixing by blades on a vertical shaft, and then released through an automatic valve. The only difference between this and a continuous turbine mixer appears to be the valving action, which serves to give the mix a few seconds' retention in the mixer.

Nordengren has also described a true continuous turbine mixer. Several horizontal thin blades are mounted on a vertical shaft rotating at 1,000 revolutions per minute. It is claimed that the product after curing is very porous and has a specific gravity of only 0.5.

Only one or two high-speed mixers are known to be in use in this country. Good mixing has been reported with relatively low power consumption.

Comparison and Status of Mixers

The batch pan mixer has been the standard for many years and the majority of superphosphate plants in this country still use this type. No good information is available as to the distribution between the various types. A rough estimate is as follows:

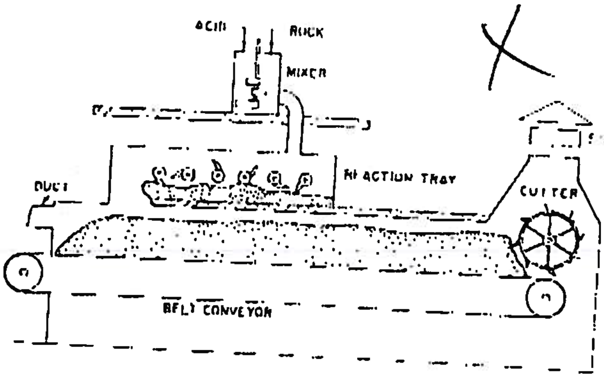

Figure 15.—Nordengren mixer and den.

Mixer type:	*Number of plants*
Pan (batch)	160
Paddle (continuous)	23
Cone (continuous)	30

In other countries the continuous type of mixer is used widely. A recent count shows about 90 Broadfield units and 40 high-speed mixers abroad; the Broadfields are scattered around the world but the high-speed units are concentrated in Europe. No information is available on the number of batch mixers abroad, and only a few instances of cone mixer installations have been reported.

The prevalence of pan mixers in this country is due in great part to the fact that most of the superphosphate plants are old; at the time they were built, other types of mixers had not been developed to the point of ready acceptance. Practically all the paddle mixers have been installed in the past 25 years and the cone mixers in the last 5 years. This is not to say, however, that a producer going into business today would not consider installation of a pan mixer. The pan type has advantages as well as disadvantages in comparison with other mixers. Some considerations that enter into the choice of a mixer for a particular situation are as follows.

Batch Versus Continuous Operation

The batch type of weighing associated with pan mixers has some advantage in that the equipment is simple to operate and maintain, and better control of the rock : acid ratio can be obtained with unskilled labor. In contrast to the batch hopper for weighing rock, a continuous, automatic weigh belt is a fairly complicated piece of equipment for

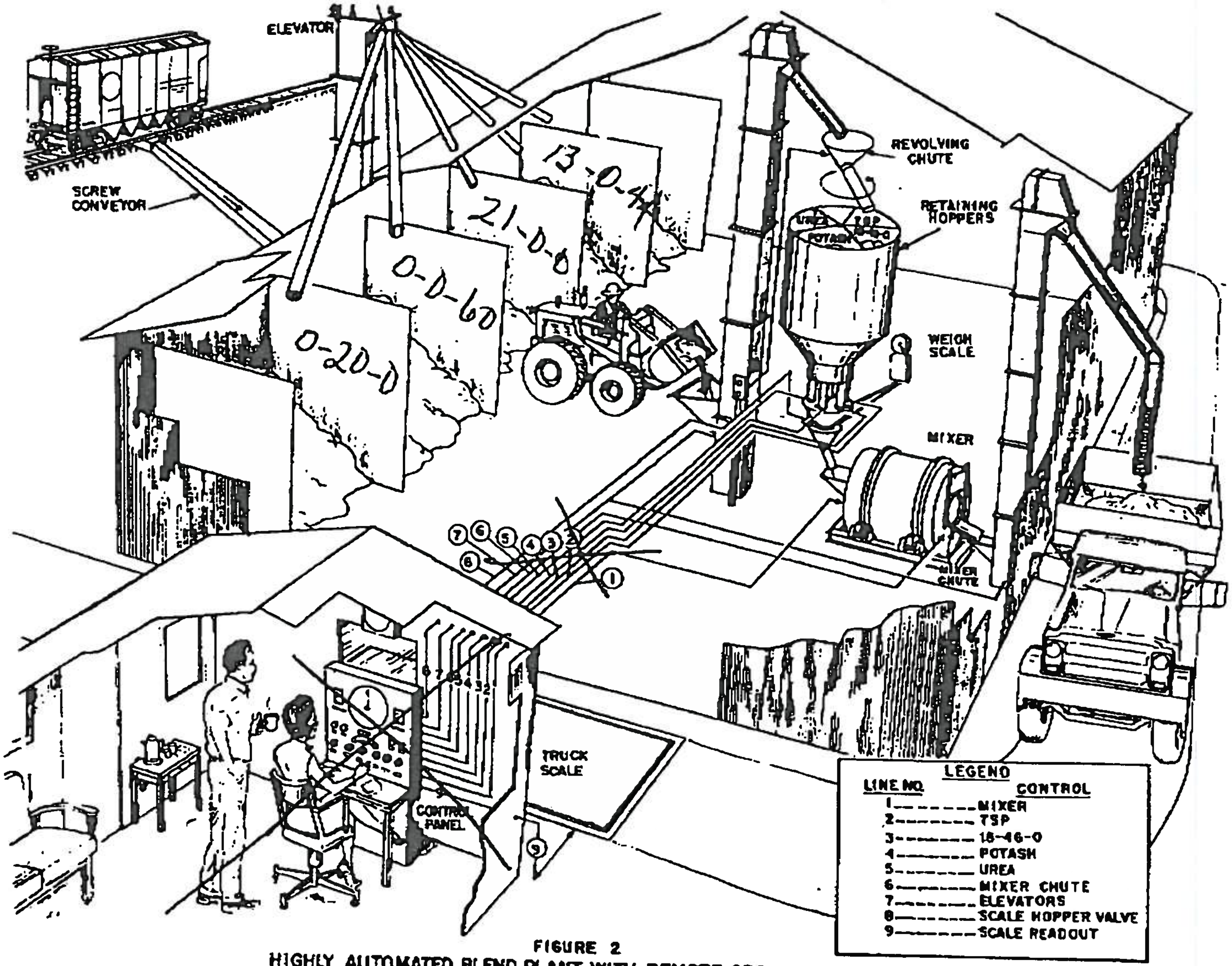

FIGURE 2
HIGHLY AUTOMATED BLEND PLANT WITH REMOTE OPERATING BOARD

Remove automation and, you have a 1950 plant

See list of materials

SECTION J. APPENDICES

Appendix 1

Some Fertilizer Materials Used in Blends

		Typical % Nutrient Content						
	Primary Nutrients*	N	P_2O_5	K_2O	S	Ca	Mg	Cl
	Ammonium nitrate	34	0	0				
X	Ammonium sulfate	21	0	0	24			
	Urea	46	0	0				
	Diammonium phosphate, (DAP)	18	46	0				
	Monoammonium phosphate (MAP)	11-13	48-55	0				
	Nitric phosphate	20	20	0				
X	Normal superphosphates	0	20	0	10	18		
	Triple superphosphate, TSP	0	46	0		14		
X	Potash, muriate	0	0	60				48
	Sulfate of potash	0	0	51	17			2
	Sulfate of potash magnesia	0	0	22	22		11	2
X	Potassium nitrate	13	0	44				0.5

*Hard granules or prills are needed which are size compatible.

Secondary Nutrients (available as powder and granules)

Gypsum (calcium sulfate) -- 22.5% Ca, 16.8% S

Magnesium oxide -- 44.5% Mg

Magnesium sulfate -- 16.0% Mg

X 1950 materials

App. "K" K

U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-300 681

Source Assessment Phosphate Fertilizer Industry

Monsanto Research Corp, Dayton, OH

Prepared for

Industrial Environmental Research Lab, Research Triangle Park, NC

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16. ABSTRACT

The report describes a study of air emissions, water effluents, and solid residues resulting from the manufacture of phosphate fertilizers. It includes the production of wet process phosphoric acid, superphosphoric acid, normal superphosphate, triple superphosphate, and ammonium phosphate. Air emissions from production of phosphate fertilizers include particulates, fluorides, ammonia, and sulfur oxides. Phosphate fertilizer plants control air emissions by a combination of cyclones, baghouses, and wet scrubbers. Material handling operations are generally enclosed to reduce fugitive particulate emissions. Only fluoride emissions from curing and storage at normal superphosphate plants are typically uncontrolled. Water effluents from the production operations arise from wet scrubbers, barometric condensers, steam ejectors, gypsum slurry, and acid sludge. Noncontact cooling water is normally segregated from other wastewater streams. Wastewaters are contaminated with phosphates, fluorides, sulfates and gypsum. Process water is discharged to large gypsum ponds for storage and recycle; it is normally not discharged to surface streams. Solid residues generated at phosphoric acid plants are gypsum from the filtration of wet process phosphoric acid, wet process phosphoric acid sludge, and solids suspended in the wet scrubber liquor.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group	
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Assessments	Fluorides	Stationary Sources	14B	
Industrial Processes	Ammonia	Phosphate Fertilizers	13H	
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Source Assessment:
Phosphate Fertilizer Industry

by

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Prepared for

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Washington, DC 20460

PREFACE

The Industrial Environmental Research Laboratory (IERL) of the U.S. Environmental Protection Agency (EPA) has the responsibility for insuring that pollution control technology is available for stationary sources to meet the requirements of the Clean Air Act, the Federal Water Pollution Control Act, and solid waste legislation. If control technology is unavailable, inadequate, or uneconomical, then financial support is provided for development of needed control techniques for industrial and extractive process industries. Approaches considered include: process modifications, feedstock modifications, add-on control devices, and complete process substitution. The scale of the control technology programs ranges from bench- to full-scale demonstration plants.

The Chemical Processes Branch of the Industrial Processes Division of IERL has the responsibility to develop control technology for a large number of operations (more than 500) in the chemical industries. As in any technical program, the first question to answer is, "Where are the unsolved problems?" This is a determination which should not be made on superficial information; consequently, each of the industries is being evaluated in detail to determine if there is, in EPA's judgement, sufficient environmental risk associated with the process to invest in the development of control technology. This report on the phosphate fertilizer industry contains data necessary to make that decision for the air, water, and solid waste discharges resulting from the production of phosphoric acid and superphosphoric acid, normal and triple superphosphate fertilizer, and granular ammonium phosphate fertilizer.

Monsanto Research Corporation has contracted with EPA to investigate the environmental impact of various industries which represent sources of pollution in accordance with EPA's reponsibility as outlined above. Dr. Robert C. Binning serves as Program Manager in this overall program entitled "Source Assessment," which includes investigation of sources in each of four categories: combustion, organic materials, inorganic materials, and open sources. Dr. Dale A. Denny of the Industrial Processes Division at Research Triangle Park serves as EPA Project Officer. In this study of the phosphate fertilizer industry. Dr. R. A. Venezia served as EPA Task Officer.

ABSTRACT

This report describes a study of air emissions, water effluents, and solid residues resulting from the manufacture of phosphate fertilizers. It includes the production of wet process phosphoric acid, superphosphoric acid, normal superphosphate, triple superphosphate, and ammonium phosphate. The potential environmental impact of the industry is evaluated on a multimedia basis.

Air emissions from production of phosphate fertilizers include particulates, fluorides, ammonia, and sulfur oxides. The potential environmental effect of these emissions is evaluated by calculating the source severity, defined as the ratio of the time-averaged maximum ground level concentration of a pollutant to a hazard factor. For particulate and sulfur oxide emissions, the hazard factor is the primary ambient air quality standard; for fluoride and ammonia emissions, it is a reduced threshold limit value. Source severity values for emissions from the wet scrubber system at an average phosphoric acid process are 0.18 for fluorides and below 0.05 for particulates and sulfur oxides. For superphosphoric acid, severity is 0.09 for fluoride and below 0.05 for particulates. For ammonium phosphate, severities are 0.43 for particulate, 0.45 for fluoride, and 0.09 for ammonia. For normal superphosphate, source severity ranges from 0.004 to 0.35 for particulate and from 0.18 to 7.2 for fluoride. For run-of-the-pile triple superphosphate, particulate source severity ranges from 0.009 to 0.04, and fluoride source severity is 0.77. For granular triple superphosphate, particulate source severity ranges from 0.004 to 0.06, fluoride source severity ranges from 0.12 to 0.36, and SO_x source severity is 0.11.

Phosphate fertilizer plants control air emissions by a combination of cyclones, baghouses, and wet scrubbers. Material handling operations are generally enclosed to reduce fugitive particulate emissions. Only fluoride emissions from curing and storage at normal superphosphate plants are typically uncontrolled.

Water effluents from the production operation arise from wet scrubbers, barometric condensers, steam jet ejectors, gypsum slurry, and acid sludge. Noncontact cooling water is normally segregated from other wastewater streams. Wastewaters are contaminated with phosphates, fluorides, sulfates, and gypsum. Process water is discharged to large gypsum ponds for storage and recycle; it is normally not discharged to surface streams.

Solid residues generated at phosphoric acid plants are gypsum from the filtration of wet process phosphoric acid, wet process phosphoric acid sludge, and solids suspended in the wet scrubber liquor. These solid waste residues are, for the most part, stored in ponds, stacked in piles, or stored in mining pits on site.

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Appendices

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ABBREVIATIONS AND SYMBOLS

AAQS -- ambient air quality standard

APP -- ammonium polyphosphate

BPL -- bone phosphate of lime or tricalcium phosphate

C_D -- concentration of particular pollutant, g/m^3

D -- distance downwind from source, m

DAP -- diammonium phosphate

e - 2.72

$E_{D/C}$ -- emission factor for dryer/cooler

E_P -- emission factor for product sizing and material transfer

$E_{R/A}$ -- emission factor for reactor/ammoniator-granulator

E_{TOTAL} -- composite emission factor

E_{TP} -- emission factor for total plant

F -- hazard factor

GNSP -- granular normal superphosphate

GTSP -- granular triple superphosphate

h - emission height, m

MAP -- monoammonium phosphate

$N_{D/C}$ -- number of emission factors for dryer/cooler

NEDS -- National Emissions Data System

NO_x -- nitrogen oxides

N_P -- number of emission factors for product sizing and material transfer

N-P-K -- nitrogen-phosphorus-potassium fertilizer

$N_{R/A}$ -- number of emission factors for reactor/ammoniator-granulator

NSP -- normal superphosphate

N_{TP} -- number of emission factors for total plant

P_2O_5 -- phosphorus pentoxide, used to express the phosphorus content of fertilizer

ABBREVIATIONS AND SYMBOLS (continued)

ppb -- parts per billion
Q -- mass emission rate, g/s
R -- amount of rock required to produce 1 metric ton of NSP
ROP -- run of pile
ROP-NSP -- run-of-pile normal superphosphate
ROP-TSP -- run-of-pile triple superphosphate
S -- source severity
SO_x -- sulfur oxides
SPA -- superphosphoric acid
t -- averaging time, min
t_o -- instantaneous averaging time, 3 min
TLV -- threshold limit value
TSP -- triple superphosphate
TVA -- Tennessee Valley Authority
$\bar{u}$ -- national average wind speed, 4.5 m/s
V_D -- wastewater effluent flow rate, m^3/s
V_R -- volumetric flow rate of receiving body above plant discharge, m^3/s
x -- downwind dispersion distance from a source of emissions
WPPA -- wet process phosphoric acid
$x_{0.1}$ -- downwind distance from an emission source at which $\bar{\chi}/F=0.1$
$x_{1.0}$ -- downwind distance from an emission source at which $\bar{\chi}/F=1.0$
π -- 3.14
σ_y -- $0.2089\ x^{0.9031}$
σ_z -- $0.113\ x^{0.911}$
χ -- downwind ground level concentration at reference coordinate with emission height of h
$\bar{\chi}$ -- time-averaged ground level concentration
χ_{max} -- instantaneous maximum ground level concentration
$\bar{\chi}_{max}$ -- time-averaged maximum ground level concentration

SECTION I

INTRODUCTION

The phosphate fertilizer industry converts insoluble phosphate rock into water soluble fertilizers that are rich in phosphorus and readily available for plant uptake. For this program, the phosphate fertilizer industry is considered to include the production of phosphoric acid by the wet process (reaction of phosphate rock with sulfuric acid), the concentration of phosphoric acid to superphosphoric acid, the production of normal and triple superphosphates, and the manufacture of granular ammonium phosphates. Phosphoric and superphosphoric acids serve as intermediates in the production of final fertilizer materials.

Historically, phosphate fertilizers have been one of the large volume chemicals produced in the United States. Production is concentrated in the state of Florida because of its extensive phosphate rock deposits. Until the early 1960's, superphosphates were the primary phosphate fertilizer material manufactured, but now ammonium phosphates predominate because of their higher overall nutrient content.

During phosphate fertilizer production, air emissions, water effluents, and solid residues are released into the environment. This assessment document characterizes these discharges and evaluates their potential environmental impact. The report contains a source description that defines process operations, process chemistry, plant production and capacity, and industry locations. Emission points are identified, emission species are characterized, and average emission rates are determined, all on a multimedia basis. Present and emerging control technologies are also considered in terms of their effectiveness, advantages/disadvantages, and extent of application. The final section of the report discusses the growth and nature of the phosphate fertilizer industry.

SECTION 2

SUMMARY

In 1975 the phosphate fertilizer industry in the United States consumed 26.1 x 10^6 metric tons of phosphate rock to produce approximately 4.89 x 10^6 metric tons of phosphate fertilizer. Final products included 0.44 x 10^6 metric tons of run-of-the-pile normal superphosphate, 0.90 x 10^6 metric tons of granular triple superphosphate, 0.60 x 10^6 metric tons of ammonium phosphates, all expressed in terms of their phosphorus pentoxide (P_2O_5) content. In addition, 6.29 x 10^6 metric tons of wet process phosphoric acid and 0.506 x 10^6 metric tons of superphosphoric acid were manufactured as phosphate fertilizer intermediates.

Phosphate fertilizers are produced at 121 plants located in 28 states. The number of plants producing each compound and the average production rates are given in Table 1. Approximately 30% of the plants are complexes producing more than one phosphate material. These same plants account for the majority of production volume. Florida, because of its large phosphate rock deposits, is the leader in number of plants (i.e., 16) and tonnage of materials manufactured.

TABLE 1. PRODUCTION STATISTICS FOR PHOSPHATE FERTILIZER PLANTS

Product	Number of plants	Average plant production rate, metric tons/yr (P_2O_5 basis)
Wet process phosphoric acid	36	175,000
Superphosphoric acid	9	56,200
Ammonium phosphate	48	75,000
Normal superphosphate	66	6,650
Granular triple superphosphate	13	69,100
Run-of-the-pile triple superphosphate	10	59,700
Total industry	121[a]	NA[b]

[a] Some plants produce more than one product.

[b] Not applicable.

Phosphate fertilizer production begins with phosphate rock containing 30% to 35% P_2O_5. This rock is crushed and mixed with aqueous sulfuric acid to produce phosphoric acid (28% to 32% P_2O_5). The reaction takes place in an attack vessel; in addition to phosphoric acid, insoluble calcium sulfate dihydrate (gypsum) and fluorine compounds are produced. Precipitated gypsum is filtered from the acid, sluiced with recycled pond water, and pumped to a gypsum pond. Fumes from the attack vessel are vented to a packed-bed wet scrubber for fluoride removal before they are vented to the atmosphere. The low quality (28% to 32% P_2O_5) acid is concentrated to 54% P_2O_5 by evaporation.

Superphosphoric acid (P_2O_5 greater than or equal to 66%) is produced by further concentrating the 54% wet process phosphoric acid using either vacuum evaporation with heat transfer surfaces or submerged combustion/direct heating. All processing steps are vented to a common scrubber system to remove fluorides and particulates. Gypsum pond water is used as the scrubbing liquid and then returned to the pond.

The term normal superphosphate is used to designate a fertilizer material containing from 16% to 21% P_2O_5 made by reacting ground phosphate rock and sulfuric acid. Rock and acid are mixed in a reaction vessel, held in an enclosed area (den) during the solidification process, and transferred to a storage pile for curing. Cyclones and baghouses are used to control particulate emissions from rock processing operations; scrubbers are used to reduce fluoride and particulate emissions from the reactor and den. However, no controls are normally employed on the curing building because of the lower level of emissions and typically small plant size.

Triple superphosphate designates a fertilizer material having a P_2O_5 content of over 40% made by reacting phosphate rock and phosphoric acid. There are two principal types of triple superphosphate: run-of-the-pile and granular. Run-of-the-pile material is essentially a nonuniform pulverized mass produced in a manner similar to that used for normal superphosphate production. In the production of granular triple superphosphate, a liquid mixture of rock and acid is distributed onto a bed of recycled fines in a granulator to produce a hard, uniform, pelletized granule. Cyclones, baghouses, and scrubbers are used to control particulate and fluoride emissions from the various processing steps.

In the manufacture of ammonium phosphates, phosphoric acid and ammonia are initially reacted in a preneutralizer to an ammonia/phosphoric acid mole ratio of approximately 1.4. The resulting slurry passes to an ammoniator-granulator, where the injection of additional ammonia causes further solidification. Ammonium phosphate granules are then dried, cooled, screened, and sent to product shipment. Exhaust streams from the preneutralizer and ammoniator-granulator pass through a primary scrubber in which phosphoric acid removes ammonia and particulate. Exhaust gases from the dryer, cooler, and screen go to cyclones for particulate removal. Materials collected in the primary cyclones are returned to the process. The exhaust is sent to primary scrubber and secondary scrubbers where recycled gypsum pond water is used as a scrubbing liquid to control fluoride emissions. The scrubber effluent is returned to the gypsum pond.

A summary of air emissions for the six production processes is presented in Table 2. For each emission point, the emission species and emission factors are reported. In addition to the process emissions at phosphate fertilizer plants, fluorine in the gypsum pond water is volatilized and emitted to the atmosphere as some form of fluoride.

In order to help evaluate the potential environmental impacts of air emissions and water effluents, certain criteria were used: source severity, affected population, and state and national emission burdens. The intent was to compare the relative impacts of a large number of source types studied. In evaluating potential environmental effects, average parameters have primarily been employed (e.g., emission factors, stack heights, population densities). A more detailed plant-by-plant evaluation was beyond the scope of the project and conclusions are not drawn with regard to actual environmental impacts at specific sites. In some cases, hazard factors used in the evaluation may be conservative due to a lack of more definitive health effects data.

Source severity (S) for air emissions compares the time-averaged maximum ground level concentration of an emitted pollutant, $\overline{\chi}_{max}$, to an estimated hazard factor, F, and is defined as $\overline{\chi}_{max}/F$. Values of $\overline{\chi}_{max}$ were calculated from average plants from accepted plume dispersion equations and the emission factors in Table 2. The hazard factor, F, is defined as the primary ambient air quality standard (AAQS) for criteria pollutants (particulates and sulfur dioxide). For fluoride and ammonia emissions, F is defined in terms of the reduced threshold limit value (TLV®): $F = TLV(8/24)(1/100)$, where the factor 8/24 corrects for 24-hr exposure and 1/100 is a safety factor. Calculated source severity values are shown in Table 2.

Values for $\overline{\chi}_{max}$ could not be determined for hydrogen fluoride emissions from gypsum ponds. Instead, plume dispersion equations were used to determine the distances downwind from the pond at which the time-averaged pollutant concentration, $\overline{\chi}$, divided by F was below 1.0 and 0.05.

The potential environmental impact was also measured by determining the population around a plant exposed to a contaminant concentration exceeding an acceptable level. The affected population is defined as the number of persons living in the area around an average plant where $\overline{\chi}$ divided by F is greater than 1.0. Plume dispersion equations are used to find this

TABLE 2. EMISSION CHARACTERISTICS FOR PHOSPHATE FERTILIZER PROCESSES AT AVERAGE PLANTS

Process	Emission point	Emission species	Controlled emission factor, g/kg P_2O_5	Source severity[a]	Affected population, persons	
					$\bar{S} > 1.0$	$\bar{S} > 0.05$
Phosphoric acid	Rock unloading	Particulate	0.15 ± 250%	0.41	0	64
	Rock transfer and storage	Particulate	0.045 ± 180%	0.040	0	2
	Wet scrubber system	Particulate	0.054 ± 164%	0.025	0	0
		Fluoride	0.010 ± 47%	0.18	0	159
		Sulfur oxides	0.032 ± 200%	0.011	0	0
Superphosphoric acid	Wet scrubber	Particulate	0.011 to 0.055	0.01	0	0
		Fluoride	0.0073[b]	0.09	0	28
Ammonium phosphate	Total process[c] emissions	Particulate	1.5 ± 69%	0.43	0	288
		Fluoride	0.038 ± 30%	0.44	0	285
		Ammonia	0.068 ± 75%	0.09	0	41
Normal superphosphate	Rock unloading	Particulate	0.28[b]	0.02	0	0
	Rock feeding	Particulate	0.055 ± 180%	0.004	0	0
	Mixer and den	Particulate	0.26 ± 86%	0.013	0	0
		Fluoride	0.10 ± 120%	0.18	0	529
	Curing building[d]	Particulate	3.6[b]	0.35	0	519
		Fluoride	1.9 ± 120%	7.2	539	13,021
Run-of-the-pile triple superphosphate	Rock unloading	Particulate	0.07[b]	0.04	0	5
	Rock feeding	Particulate	0.014 ± 170%	0.009	0	0
	Cone mixer, den, and curing building	Particulate	0.16 ± 50%	0.03	0	0
		Fluoride	0.10 ± 40%	0.77	0	1,178
Granular triple superphosphate	Rock unloading	Particulate	0.09[b]	0.06	0	15
	Rock feeding	Particulate	0.017 ± 180%	0.01	0	0
	Reactor, granulator dryer, cooler, and screens	Particulate	0.05 ± 320%	0.004	0	0
		Fluoride	0.12 ± 30%	0.36	0	1,356
		Sulfur oxides	1.86[e]	0.11	0	307
	Curing building	Particulate	0.10 ± 240%	0.02	0	0
		Fluoride	0.018 ± 40%	0.12	0	161
Fertilizer complex	Gypsum pond	Fluoride	0.50 (0.025 to 2.5)[f]	1.0 @D = 1300 m 0.05 @D = 6700 m	0	5,532

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[a] Severity for fluoride based on TLV for hydrogen fluoride of 2.0 mg/m³; severity for ammonia based on its TLV of 18 mg/m³.

[b] Only two data points.

[c] Average process controlled by integrated control system with a single emission point.

[d] Uncontrolled emission factors because curing building emissions are not normally controlled.

[e] Worst case estimate based on fuel oil sulfur content.

[f] Emissions from gypsum pond are uncontrolled and vary widely depending on pond conditions.

area, which is then multiplied by an average population density to determine the affected population. Due to uncertainties inherent in sampling and dispersion modeling methodologies, the number of persons exposed to a $\overline{\chi}/F$ ratio greater than 0.05 is also reported. Values for the affected population are reported in Table 2.

Another measure of potential environmental impact is the total mass of industry emissions of each criteria pollutant. These values were compared to total state and national emissions from all sources to find the emissions burden due to various segments of the phosphate fertilizer industry. The percent contributions to states' emissions burdens by wet process phosphoric acid plants ranged from 0.004% to 0.4% for particulates and from 0.0002% to 0.02% for sulfur dioxide. On a national basis, wet process phosphoric acid plants contributed 0.01% of the nation's particulate burden and less than 0.001% of the sulfur dioxide burden. Particulate emissions from superphosphoric acid plants contributed from less than 0.001% to 0.005% of each state's emissions burden. For normal and triple superphosphate production, it was found that in each state and on a national basis the particulate and sulfur oxide (SO_x) contribution to the respective emissions burden was less than 0.001%. Ammonium phosphate particulate emissions represent approximately 0.02% of the total national particulate emissions burden from all sources. On a statewide basis, ammonium phosphate production contributed 0.1% or more of the total statewide particulate emissions burden in only Florida (0.8%), Idaho (0.4%), and Louisiana (0.3%).

Environmental and economic concerns have prompted use of control devices in most facets of the wet process phosphoric and superphosphoric acid industry, with the exception of volatile emissions from the gypsum pond. Rock unloading, rock transfer, and rock charging operations are located in partially enclosed structures with ventilation systems venting to baghouses for rock recovery. Vaporous and particulate emissions issuing from the attack vessel, filtration system, and clarifier are all vented to a common venturi throad packed-bed wet scrubber. Recycled pond water is used in the scrubber to remove emission species and is then sent back to the gypsum pond. A similar wet scrubbing system is used as superphosphoric acid plants to remove fluoride and particulate emission species.

The types of air pollution control equipment used at superphosphate plants are varied; however, all plants have a basic emissions control system consisting of cyclones, baghouses, and wet scrubbers. All plants use cyclones and/or baghouses to control particulate emissions from the rock unloading and rock feeder systems. Wet scrubbers are used to control particulate and fluoride emissions from the mixer den, curing building, reactor, granulator, dryer, and cooler. These scrubbers also control SO_x emissions from the dryer at granular triple superphosphate plants when fuel oil is used. Only the fluoride emissions from the curing and storage building at normal superphosphate plants are uncontrolled.

Stack emission from all ammonium phosphate plants have some type of emission control. Cyclones are used for product recovery, and wet scrubbers are used for ammonia (NH_3), fluoride, and product recovery.

Based on industry production trends and forecasts, production of wet process phosphoric acid and superphosphoric acid are expected to increase at annual rates of 4% to 7% and 7% to 10%, respectively. Normal superphosphate production is expected to decline by 1% to 5% until about 1982 when industry production is expected to stabilize. Triple superphosphates, both granular and run-of-the-pile, are expected to maintain a moderate annual growth rate of 2%. Ammonium phosphate production from 1975 to 1980 is projected to grow at an annual rate of 7.5%, resulting in approximately 44% more production in 1980 than in 1975. If the current level of emission control is maintained, emissions from these production processes will increase or decrease in a similar fashion.

Sources of process wastewater from wet process phosphoric acid production include wet scrubber liquor, gypsum slurry water, and barometric condensers. Gypsum pond water normally supplies most of the water requirements for operation of wet scrubbers and barometric condensers and also for transferring the waste gypsum to a disposal area although variations do exist. Acid sludge, generated in acid clarification, contains substantial amounts of phosphate and is normally disposed of by blending into dry fertilizer. Cooling water may be recirculated gypsum pond water. If supplied by a segregated nonprocess system instead, it may be recycled or discharged. Steam condensate which is contaminated, such as that from barometric condensers and vacuum ejectors, is discharged to the gypsum pond. Uncontaminated steam condensate is discharged to receiving waters without treatment. Wastewater streams contain varying quantities of phosphoric acid (H_3PO_4), fluorides, sulfates, and gypsum.

Wastewater streams at superphosphoric acid plants come from barometric condensers, steam jet ejectors, and wet scrubbers. These streams contain quantities of H_3PO_4 and fluorides. Wastewater from superphosphoric acid plants is normally contained in a manner similar to that used at wet process phosphoric acid plants.

The only source of wastewater at normal and triple superphosphate fertilizer plants is the scrubber liquors. Scrubber systems use recycled water from the gypsum ponds or other holding reservoirs. Nearly all triple superphosphate plants are located at fertilizer complexes producing wet process phosphoric acid and, as a result, use gypsum pond water in their scrubber systems. More than 60% of normal superphosphate plants now practice fluorine recovery and thereby eliminate or greatly reduce the need for a pond.

Plants recovering fluosilicic acid consume the small amount of silica-containing liquid waste generated as a filler in fertilizer production.

Ammonium phosphate production facilities occasionally use secondary wet scrubbers to remove fluorides and other contaminants from process gas streams after preliminary scrubbing with a weak phosphoric acid solution for ammonia recovery. Secondary scrubbers use recycled water from gypsum ponds or other holding reservoirs.

In a study of over 70% of the plants in the phosphate fertilizer industry, nearly 75% reported no discharge of process wastewater. Of the 15 plants that reported a discharge, 12 reported a discharge only when necessitated by excessive rainfall. Several of these reported that they have not treated or discharged water for several years. In actual practice, discharge of contaminated process water from the recycle pond system is held to an absolute minimum due to treatment costs.

One plant was found to use river water on a once through basis for scrubbing air emissions and for cooling. Effluent from this plant is discharged without treatment.

Available wastewater discharge data from seven plants on file as of October 1976 at the Florida Department of Environmental Regulation were collected and analyzed by means of a water source severity relationship.

Source severity for water effluents compares the concentration of a particular pollutant after discharge and dilution in the receiving body with an estimated allowable concentration denoted as the hazard factor.

In determining the source severity of a plant, the discharge quantity is compared to the receiving body flow rate times the hazard factor according to the following equation:

$$S = \frac{V_D \, C_D}{\left(V_F + V_D\right) F} \tag{1}$$

where S = source severity for a particular pollutant
V_D = wastewater effluent flow rate, m^3/s
C_D = concentration of particular pollutant, g/m^3
V_R = volumetric flow rate of receiving body above plant discharge, m^3/s
F = hazard factor for particular pollutant, g/m^3

Severities for fluoride, phosphorus, and to a lesser degree ammonia-nitrogen in discharged waters were found in a number of cases to be above 1.0. This was due to the extremely low flow rates of the receiving bodies and should represent a worst case analysis for the small number of plants that do discharge.

Solid residues generated at phosphoric acid plants are gypsum from the filtration of wet process phosphoric acid, wet process phosphoric acid sludge, and solids suspended in the wet scrubber liquor. These solid waste residues are, for the most part stored in ponds, stacked in piles, or stored in mining pits on site. A small percentage (approximately equal to 1%) is used as a raw material for various products. Under normal conditions, the solid residues cause no adverse environmental effects. At normal and triple superphosphate plants, solid residues are in the form of slurries from the wet scrubber and are therefore included with wastewater treatment practices.

SECTION 3

SOURCE DESCRIPTION

A. OVERVIEW OF PHOSPHATE FERTILIZER INDUSTRY

Phosphorus is one of the major elements essential for normal plant growth (1). Naturally occurring phosphorus in phosphate rock in the form of tricalcium phosphate is almost completely insoluble in water (solubility in cold water equals 20 g/m^3 of water) (2). To enhance plant growth, the phosphate fertilizer industry converts insoluble phosphate rock into water-soluble fertilizer products.

1. Phosphate Rock Consumption in the United States

In 1975, 44,286,000 metric tons[a] of phosphate rock were mined in 16 states in the United States, as shown in Figure 1 (3). Phosphate rock mined in Florida accounted for approximately 78% of the U.S. production and about 29% of the total world's supply in 1975. Over 92% of this output came from the vast sedimentary land pebble deposit in Polk and Hillsborough counties east of Tampa, Florida. Approximately 5.7% of the phosphate rock was mined in Tennessee and 3.6% in North Carolina. Deposits in Tennessee are classified as brown, white, and blue rock; only the brown rock has been of commercial importance. Phosphate rock mined in the western states of Idaho, Montana, Wyoming, and Utah accounts for about 14% of the total ore mined in the United States (3).

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[a] 1 metric ton equals 10^6 grams; conversion factors and metric system prefixes are presented at the end of this report.

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(1) Riegel's Handbook of Industrial Chemistry, Seventh Edition. J. A. Kent, ed. Van Nostrand Reinhold Co., New York, New York, 1974. pp. 551-569.

(2) Handbook of Chemistry and Physics, 49th Edition, R. C. Weast, ed. The Chemical Rubber Co., Cleveland, Ohio, 1968. p. B-187.

(3) Stowasser, W. F. Phosphate-1977. Publication No. MCP-2, U.S. Department of the Interior, Bureau of Mines, Washington, D.C., May 1977. 18 pp.

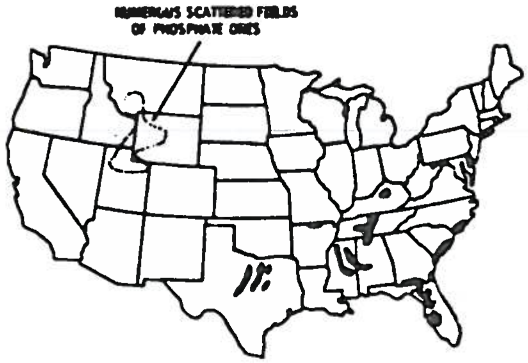

Figure 1. Location of major phosphate rock deposits in the United States (3).

Approximately 31,029,000 metric tons (70%) of the phosphate rock mined in 1975 were used in the United States to produce numerous phosphorus-containing materials (3). Figure 2 illustrates the 1975 consumption pattern for the various products obtained from phosphate rock. Significant quantities (15.9%) of phosphate rock were consumed in several nonagricultural markets such as the production of detergent builders and water treatment chemicals and the treatment of aluminum and ferrous metal surfaces, as well as in foods, beverages, pet foods, dentifrices, and fire control chemicals.

Agriculture-related industries producing phosphate fertilizers and animal feeds used 26,096,000 metric tons (84.1% of total production) of phosphate rock in 1975. Of this total, 22,754,000 metric tons (89.7%) were consumed for fertilizers, and 2,688,000 metric tons (10.3%) were used to produce animal feeds.

2. Types of Fertilizer Products

The schematic diagram of the phosphate fertilizer industry presented in Figure 3 (4) shows the conversion of insoluble phosphate ore into the soluble form necessary for plant consumption. Phosphate-bearing rock is mixed with sulfuric acid (H_2SO_4) to produce phosphoric acid, the building block for phosphate fertilizers.

As Figure 3 illustrates, numerous additional processes are used to produce phosphate fertilizer materials. These processes are in operation because of farmer demand for a wide variety of fertilizer mixtures.

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(4) Fullam, H. T., and B. P. Faulkner. Inorganic Fertilizer and Phosphate Mining Industries--Water Pollution and Control (PB 206 154). Grant 12020 FPD, U.S. Environmental Protection Agency, Cincinnati, Ohio, September 1971. 225 pp.

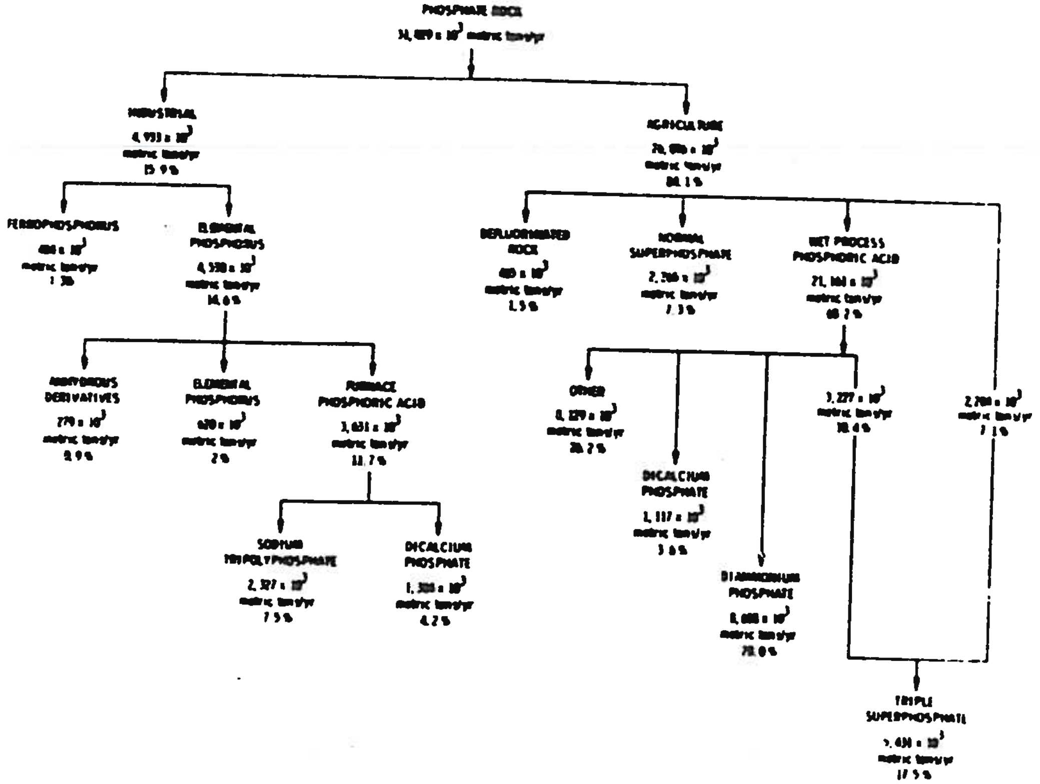

Figure 2. U.S. phosphate rock consumption pattern for various phosphorus products (3).

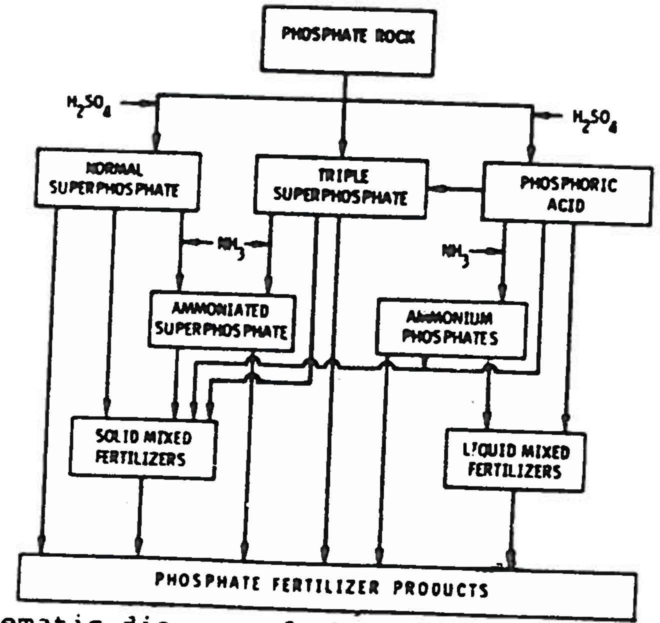

Figure 3. Schematic diagram of phosphate fertilizer industry (4).

Product fertilizers differ in the amount and chemical form of the three primary plant nutrients: nitrogen (N), phosphorus (P), and potassium (K). Normal and triple superphosphate contain only one plant nutrient--phosphorus. Ammoniated superphosphate and ammonium phosphates contain two nutrients--phosphorus and nitrogen, while solid and liquid-mixed fertilizers contain all three nutrients in varying N-P-K ratios.

For evaluative purposes, the phosphate fertilizer industry is divided into three segments: phosphoric acid and superphosphoric acid, normal and triple superphosphate, and granular ammonium phosphate. Ammoniated superphosphates and solid and liquid-mixed fertilizer segments of the industry were covered in a separate Source Assessment Document on fertilizer mixing plants (5).

a. Phosphoric Acid and Superphosphoric Acid--
In 1975, 6,979,400 metric tons of phosphoric acid [reported as equivalent (100%) phosphorus pentoxide (P_2O_5)] were produced in the United States (6). Of this total, the 36 plants shown in Figure 4 (7) produced 90% or 6,291,400 metric tons from phosphate rock using wet process technology (3, 6). This report does not cover those plants which produce phosphoric acid from elemental phosphorus (thermal process) because this high purity acid is no longer used to produce phosphate fertilizers (8). The phosphate fertilizer industry consumed 85% or 5,380,648 metric tons of the wet process acid produced. The remainder (14%) of the wet process acid was used for preparing phosphatic feed supplements for livestock and poultry.

Phosphoric acid used in the fertilizer industry is made by the reaction of aqueous (50% to 98%) sulfuric acid with crushed phosphate rock, hence the term "wet process." The reaction occurs in an attack vessel where, in addition to phosphoric acid, insoluble calcium sulfate dihydrate (gypsum) and fluorine compounds are produced. Precipitated gypsum is filtered from the acid, sluiced with recycled pond water, and pumped to a gypsum pond. Fumes from the attack vessel are vented to a packed-bed wet scrubber for fluoride removal before they are exhausted to

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(5) Rawlings, G. D., and R. B. Reznik. Source Assessment: Fertilizer Mixing Plants. EPA-600/2-76-032c, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, March 1976. 187 pp.

(6) Inorganic Chemicals 1976. M 28A(76)-14, U.S. Department of Commerce, Washington, D.C., August 1977. 30 pp.

(7) Hargett, N. World Fertilizer Capacity-Computer Printout. Tennessee Valley Authority, Muscle Shoals, Alabama, 1976.

(8) TVA Plans Early Closure of Furnaces; Cities Switch to Wet-Process Phosphoric. Chemical Marketing Reporter, 209(3), 1976.

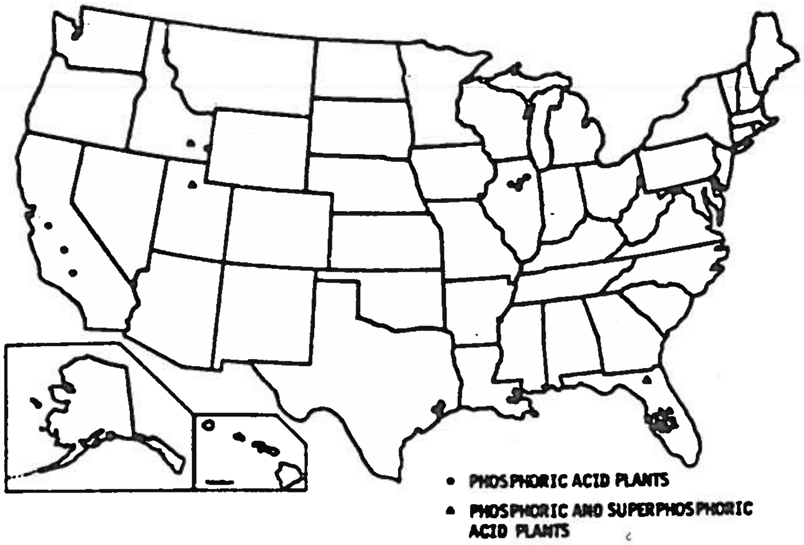

Figure 4. Location of wet process and superphosphoric acid plants (6).

the atmosphere. Low quality (28% to 30% P_2O_5 equivalent) phosphoric acid is then concentrated to 54% P_2O_5 equivalent by evaporating water from the solution.

Superphosphoric acid (P_2O_5 equivalent greater than or equal to 66%) is produced by further concentration of the 54% P_2O_5 phosphoric acid. Superphosphoric acid concentration is accomplished by either vacuum evaporation employing heat transfer surfaces or submerged combustion/direct heating. In 1975, approximately 505,900 metric tons of superphosphoric acid were produced by nine plants in six states in the United States, as shown in Figure 4 (6, 7) (Appendix A).

b. <u>Normal and Triple Superphosphate</u>--
Normal superphosphate (NSP), prepared by reacting ground phosphate rock with sulfuric acid, contains 16% to 22% available P_2O_5. Approximately 0.44 x 10^6 metric tons (P_2O_5 equivalent of NSP fertilizer were produced in 1975 (9).

Triple superphosphate (TSP), containing 45% to 55% available P_2O_5, is made by reacting ground phosphate rock with phosphoric acid. Two types of TSP are produced: run of the pile and granular. In 1975 approximately 0.60 x 10^6 metric tons (P_2O_5 equivalent), of run-of-the-pile triple superphosphate (ROP-TSP and

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(9) Inorganic Fertilizer Materials and Related Products. M28B(75)-13, U.S. Department of Commerce, Washington, D.C., December 1976. 6 pp.

0.90×10^6 metric tons of granular triple superphosphate (GTSP) were produced in the United States (9).

Geographical locations of the 66 NSP plants in the United States are shown in Figure 5 (7). NSP plants are located near consumers because it is cheaper to ship phosphate rock (approximately equal to 33% P_2O_5) to consumption areas than it is to ship NSP from the ore deposits. A description of each NSP plant is given in Appendix A.

The production of TSP, unlike that of NSP, occurs in plants located near phosphate rock deposits (Figure 6) (10). Eleven of the sixteen TSP plants are located in Florida, which accounts for approximately 78% of the U.S. production of phosphate-bearing rock. Among the 16 plants, 7 have facilities for producing both run-of-the-pile and granular grades of products; of the remaining 9 plants, 6 produce only GTSP and 3 produce only ROP-TSP (see Figure 6). Each of these plants is also described in Appendix A.

c. Ammonium Phosphate--

Ammonium phosphates are produced by reacting phosphoric acid with anhydrous ammonia. Both solid and liquid ammonium phosphate fertilizers are produced in the United States. In 1975, approximately 2.8×10^6 metric tons (P_2O_5 equivalent) of ammonium phosphates were produced by 48 plants located in 17 states, as shown in Figure 7 (7, 10, 11).

3. Raw Materials

Raw materials used in the phosphate fertilizer industry consist of phosphate rock, sulfuric acid, and anhydrous ammonia. Phosphate rock is a term broadly used to denote the group of minerals commercially valuable for their phosphorus content. The principal (greater than 80%) mineral constituent of phosphate rock is fluorapatite, $[Ca_3(PO_4)_2]_3 \cdot CaF_2$ (12). Also found in phosphate rock are iron oxides, aluminum oxides, magnesium, carbonates, carbon dioxide, calcium oxide, silicon oxides, and sulfates. A chemical analysis of phosphate rock samples from mines across the

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(10) Harre, E. A., M. N. Goodson, and J. D. Bridges. Fertilizer Trends 1976. Bulletin Y-111, National Fertilizer Development Center, Tennessee Valley Authority, Muscle Shoals, Alabama, March 1977. 45 pp.

(11) Final Guideline Document: Control of Fluoride Emissions from Existing Phosphate Fertilizer Plants. EPA-450/2-77-005 (PB 265 062), U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, March 1977. 277 pp.

(12) Atmospheric Emissions from Wet-Process Phosphoric Acid Manufacture. AP-57 (PB 192 222), U.S. Department of Health, Education, and Welfare, Raleigh, North Carolina, April 1970. 86 pp.

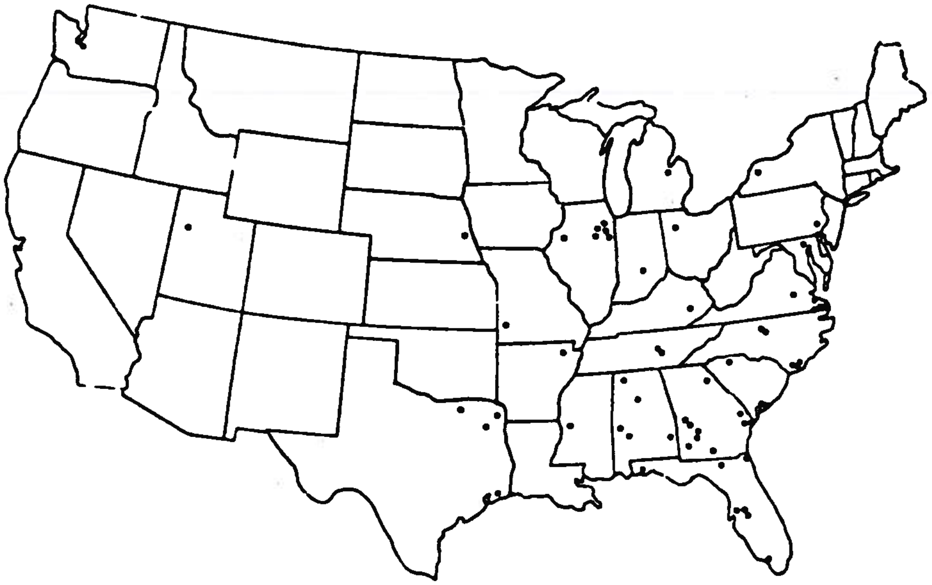

Figure 5. Location of NSP plants in the United States (7).

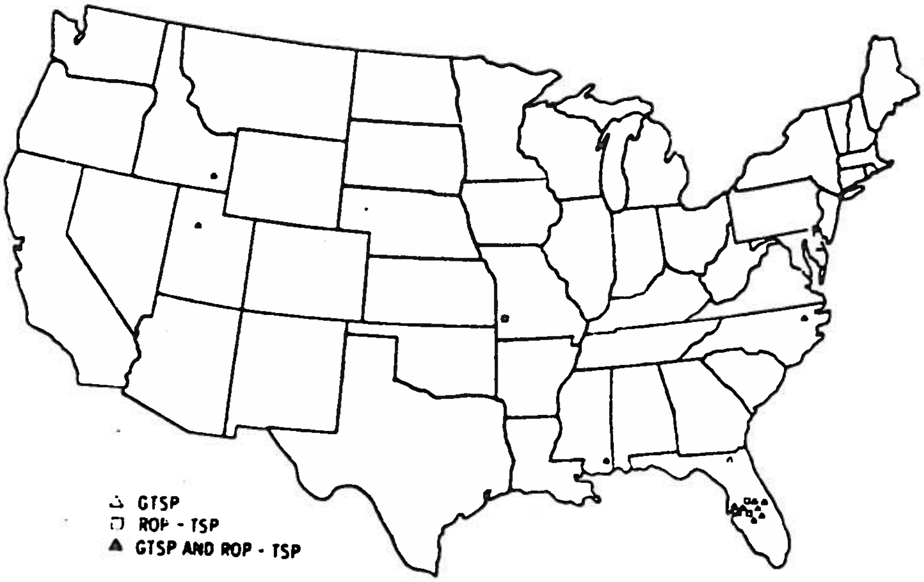

Figure 6. Location of TSP plants in the United States (10).

Figure 7. Location of ammonium phosphate plants in the United States (7, 10, 11).

United States is shown in Table 3 (13). Trace amounts of arsenic, lead, vanadium, and chromium which may be present in the rock are not listed. Uranium is also present in phosphate rock, with concentrations in the range of 40 g to 165 g of uranium per metric ton of rock. Table 4 (14) gives typical concentrations of radioactive elements in Florida phosphate mine products and wastes and phosphate fertilizer products and wastes.

Phosphorus content of the rock and/or products is commonly expressed in one of four ways:

- BPL [bone phosphate of lime or tricalcium phosphate, $Ca_3(PO_4)_2$].
- Phosphorus pentoxide (P_2O_5).
- Elemental phosphorus (P_4).
- Phosphoric acid (H_3PO_4).

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(13) Lowenheim, F. A. Phosphorus Compounds, Inorganic. In: Encyclopedia of Industrial Chemical Analysis, Volume 17, F. D. Snell and L. S. Ettre, eds. John Wiley & Sons, Inc., New York, New York, 1973. pp. 142-144.

(14) Guimond, F. J., and S. T. Windham. Radioactivity Distribution in Phosphate Products, By-Products, Effluents, and Wastes. ORP/CSD-75-3, U.S. Environmental Protection Agency, Washington, D.C., August 1975. 30 pp.

TABLE 3. REPRESENTATIVE ANALYSES OF COMMERCIAL PHOSPHATE ROCKS (13)
(percent reported as material shown)

Reprinted from Encyclopedia of Industrial Chemical Analysis. Vol. 17, by courtesy of John Wiley & Sons, Inc.

U.S. location and type	P_2O_5	CaO	MgO	Al_2O_3	Fe_2O_3	SiO_2	SO_3	F	Cl	CO_2	Organic carbon	Na_2O	K_2O	H_2O[a]
Florida:														
Land pebble, high grade	35.5	48.8	0.04	0.9	0.7	6.4	2.4	4.0	0.03	1.7	0.3	0.07	0.09	1.8
Hard rock, high grade	35.3	50.2	0.03	1.2	0.9	4.3	0.1	3.8	0.005	2.8	0.3	0.4	0.3	2.0
Hard rock, waste pond	23.0	28.5	0.4	14.0	2.9	19.8	0.01	2.1	0.005	1.4	0.3	0.1	0.4	7.0
Tennessee:														
Brown rock, high grade	34.4	49.2	0.02	1.2	2.5	5.9	0.7	3.8	0.01	2.0	0.2	0.2	0.3	1.4
Western states:														
Phosphoric rock, high grade	32.2	46.0	0.2	1.0	0.8	7.5	1.7	3.4	0.02	2.1	1.8	0.5	0.4	2.5
Phosphoric rock, low grade	19.0	23.3	1.4	5.9	4.0	27.4	1.9	1.8	_[b]	4.0	5.0	1.5	1.0	3.5

[a] After drying at 100°C for several hours. [b] Data not available.

TABLE 4. RADIUM (^{226}Ra), URANIUM, AND THORIUM CONCENTRATIONS IN PHOSPHATE MINE PRODUCTS AND WASTES AND PHOSPHATE FERTILIZER PRODUCTS AND BYPRODUCTS (14)[a] (pCi/g)[b]

Material	^{226}Ra	Uranium 234	Uranium 235	Uranium 238	Thorium 227	Thorium 228	Thorium 230	Thorium 232
Marketable rock	42	41	1.9	41	2.0	0.61	42.3	0.44
Slimes	45	42	2.6	44	2.3	1.2	48	1.4
Sand tailings	7.5	5.2	0.38	5.3	-[c]			
Phosphoric acid	1.3							
Gypsum	33	6.2	0.32	6.0	0.97	1.4	13	0.27
Normal superphosphate	25							
Diammonium phosphate	5.6	63	3.0	63	1.6	0.8	65	0.4
Triple superphosphate	21	58	2.8	58	1.2	0.9	48	1.3
Monoammonium phosphate	5.0	55	2.9	55				
Sodium fluorosilicate	0.28							
Animal feed	5.5							

[a] Plants using Florida phosphate rock.

[b] Picocuries per gram; 1 picocurie equals 0.037 becquerel.

[c] Blanks indicate no data obtained.

Table 5 shows the factors required to convert from one set of units to another. The common industry practice of reporting all phosphorus-containing materials in terms of the equivalent phosphorus pentoxide (P_2O_5) content is used throughout the remainder of this document. Table 6 illustrates acid concentrations reported in various units.

Offsite preparation of phosphate rock involves beneficiation to remove impurities, drying to remove moisture, and grinding to improve reactivity.

TABLE 5. CONVERSION FACTORS FOR PHOSPHORUS CONTENT UNITS

To convert from	To	Multiply by
% BPL	% P	0.1997
% BPL	% P_2O_5	0.4576
% P_2O_5	% P	0.4364
% P_2O_5	% BPL	2.1853
% P_2O_5	% H_3PO_4	1.381
% H_3PO_4	% P	0.316
% H_3PO_4	% P_2O_5	0.724
% P	% P_2O_5	2.2914
% P	% BPL	5.0073

TABLE 6. COMMON CONCENTRATIONS OF PURIFIED PHOSPHORIC ACID GRADES (percent)

Material	H_3PO_4	P_2O_5	P	Polyphosphate
Filtered production phosphoric acid	28	20	9	0
	41	30	13	0
Orthophosphoric acid	75	54	24	0
Superphosphoric acid	97	70	31	2.2
	100	72	31	10

Sulfuric acid used in the wet process is either made in a captive plant or piped from a nearby sulfuric acid manufacturer. Virgin acid made from brimstone (native sulfur) or pyrites (sulfur bearing ores) is normally used. The use of byproduct sulfuric acid from other processes may introduce impurities that cause poor quality gypsum crystal formation and odor problems (15).

4. Rock Preparation

Phosphate rock that has been mined and beneficiated is in general too coarse to be used directly in acidulation. The major fraction of the phosphate rock (more than 98%) ranges in size from pebbles 25 mm in diameter down to 100-μm material (4). The rock is therefore processed through equipment to mechanically reduce it to the particle size needed for improved reactivity during the acidulation process (smaller than 150 μm).

Preliminary drying to remove moisture is necessary to prepare the rock for grinding (Figure 8). Direct-fired rotary kilns 8 m to 30 m long and 2 m to 3 m in diameter are used to dry phosphate

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(15) Phosphoric Acid, Volume I, A. V. Slack, ed. Marcel Dekker, Inc., New York, New York, 1968. 1159 pp.

rock (16). These dryers use natural gas or fuel oil as fuel and are fired countercurrently. In recent years, the fluidized-bed type of dryer has gained prominent importance because of its fuel savings and increased throughput.

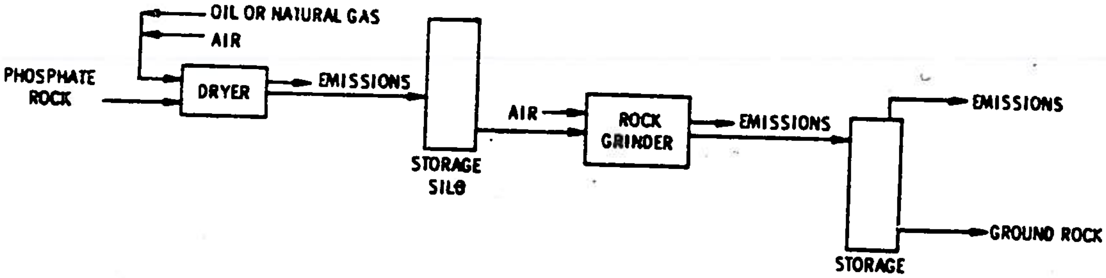

Figure 8. Preparation of phosphate rock for acidulation.

Size reduction is accomplished with ball, roll, or bowl mills. Rock is fed into the mills and mechanically ground to a fineness located between the particle size levels of 80% through a 150-μm and 95% through a 74-μm screen. After the rock enters the mill system, all flow through the sizing and reclamation circuits is by pneumatic means. Air is constantly exhausted from the mill system to prevent precipitation of moisture which is released from the rock during grinding.

Future rock grinding operations may utilize a wet grinding circuit rather than the current dry grinding practice. This change would eliminate the gas effluent streams associated with both rock drying and grinding operations and result in lower capital costs (17).

Phosphate rock arrives at the phosphate fertilizer plant in either a ground or unground form. For economic reasons, the trend has been toward more processing at the point where the rock is mined, especially at smaller plants (18).

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(16) Heller, A. N., S. T. Cuffe, and D. R. Goodwin. Inorganic Chemical Industry. In: Air Pollution, Volume III: Sources of Air Pollution and Their Control, A. C. Stern, ed. Academic Press, New York, New York, 1968. pp. 221-231.

(17) Martin, E. E. Development Document for Effluent Limitations Guidelines and New Source Performance Standards for the Basic Fertilizer Chemicals Segment of the Fertilizer Manufacturing Point Source Category. EPA-440/1-74-011-a (PB 238 652), U.S. Environmental Protection Agency, Washington, D.C., March 1974. 170 pp.

(18) Caro, J. H. Characterization of Superphosphate. In: Superphosphate: Its History, Chemistry, and Manufacture. U.S. Department of Agriculture, Washington, D.C., December 1964. pp. 272-284.

Ground rock requires tight, fully enclosed material handling equipment to reduce the loss of rock and prevent excessive air emissions. General shipping practice includes the use of enclosed, hopper-bottom railroad cars of the type developed for hauling cement and other finely ground material. Little (less than 5%) ground rock is carried by ship or barge because of handling losses that would be incurred.

In a typical system, ground rock is unloaded from the hopper-bottom cars into a receiving hopper located directly under the track. A vibrator is used to keep the rock flowing freely. An underground screw or belt conveyor carries the rock to storage silos. A typical rock unloading facility is shown in Figure 9. The unloading station, transfer conveyors, and storage silos are enclosed and all ventilation points are equipped with dust collectors.

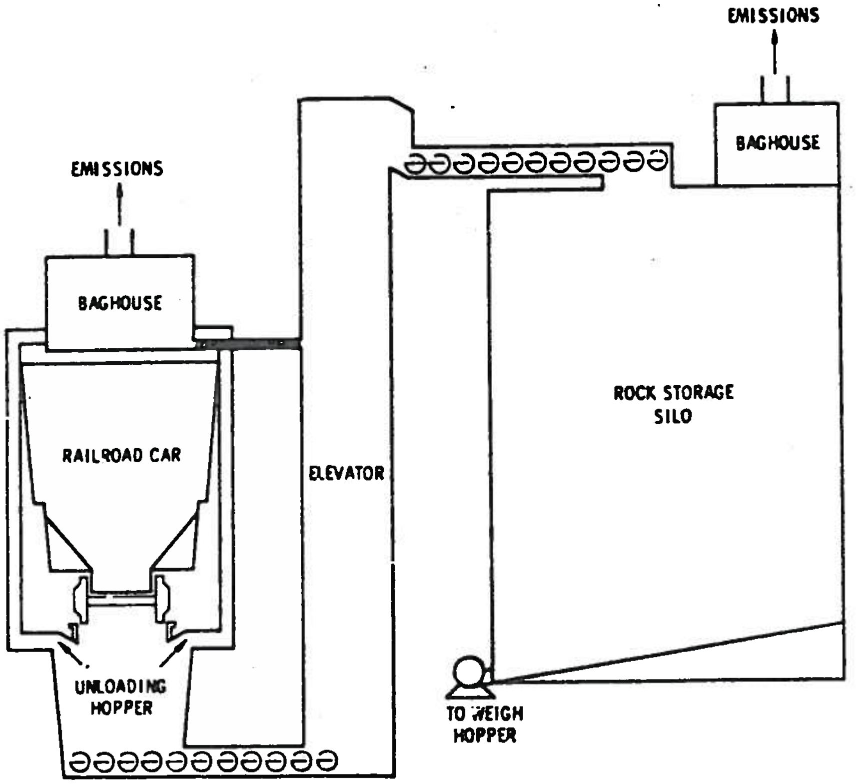

Figure 9. Raw material unloading and storage.

B. WET PROCESS PHOSPHORIC ACID PRODUCTION

1. Process Chemistry

In the wet process production of phosphoric acid, sulfuric acid and the tricalcium phosphate portion of the phosphate rock react to form phosphoric acid and gypsum (17).

$$Ca_3(PO_4)_2 + 3H_2SO_4 + 6H_2O \longrightarrow 2H_3PO_4 + 3(CaSO_4 \cdot 2H_2O) \qquad (2)$$

This chemistry is straightforward; however, two factors influence operating conditions at individual plants: the composition of the phosphate rock and the physical form of the byproduct calcium sulfate.

a. Effects of Phosphate Rock Composition--
Side reactions occur during acidulation, and the quantity of products found depends on the amounts and composition of other chemical constituents in the phosphate rock (see Table 3). These generally undesirable side reactions form precipitates and sludges which foul operating, handling, transfer, and storage equipment (19). Excessive amounts of impurities also increase acid viscosity, which affects handling operations. Metals such as iron, aluminum, and magnesium form water-insoluble phosphate salts, which tie up useful phosphate and remain as suspended solid impurities in product acids. Trace metals (arsenic, lead, and heavy metals) also contaminate the acid. Carbonates, fluorine, and silica likewise are troublesome materials (19). Carbonates react with sulfuric acid to produce carbon dioxide, which contributes to foaming. The calcium fluoride constituent of the fluorapatite ore reacts with sulfuric acid to produce hydrogen fluoride according to the following reaction:

$$CaF_2 + H_2SO_4 \longrightarrow 2HF + CaSO_4 \qquad (3)$$

In addition, calcium fluoride reacts with phosphoric acid according to the following reaction (17, 20):

$$CaF_2 + 2H_3PO_4 \longrightarrow Ca(H_2PO_4)_2 + 2HF \qquad (4)$$

The hydrogen fluoride can evolve as a gas or react with silica in the following manner (17, 20):

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(19) Dahlgren, S. E. Chemistry of Wet-Process Phosphoric Acid Manufacture. In: Phosphoric Acid, Volume I, A. V. Slack, ed. Marcel Dekker, Inc., New York, New York, 1968. pp. 91-154.

(20) Evaluation of Emissions and Control Techniques for Reducing Fluoride Emissions from Gypsum Ponds in the Phosphoric Acid Industry. Contract 68-02-1330, Task 3, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, November 1976. 218 pp.

$$SiO_2 + 6HF \rightarrow H_2SiF_6 + 2H_2O \tag{5}$$

During acid concentration steps, fluosilicic acid (H_2SiF_6) in the phosphoric acid solution can dissociate according to the following reaction (17, 20):

$$H_2SiF_6 \rightarrow SiF_4 + 2HF \tag{6}$$

Fluosilicic acid can also combine with sodium or potassium to yield fluosilicate salts, which form scale and sludge in the processing equipment.

b. <u>Physical Form of Calcium Sulfate</u>--
The popular process for phosphoric acid production is based on the quick formation of calcium sulfate dihydrate or gypsum ($CaSO_4 \cdot 2H_2O$). It is also possible to precipitate calcium sulfate as the hemihydrate ($CaSO_4 \cdot 1/2H_2O$) or the anhydrite ($CaSO_4$). The dihydrate processes offer basic advantages--less severe operating conditions, lower rates of corrosion, better filterability, and lower capital cost--which outweigh advantages in the hemihydrate and anhydrite processes. An alternative dihydrate process which does not involve direct formation of the dihydrate utilizes the initial formation of calcium sulfate in the hemihydrate form and its subsequent hydration to gypsum. Figure 10 (21) shows the precipitation of calcium sulfates in phosphoric acid.

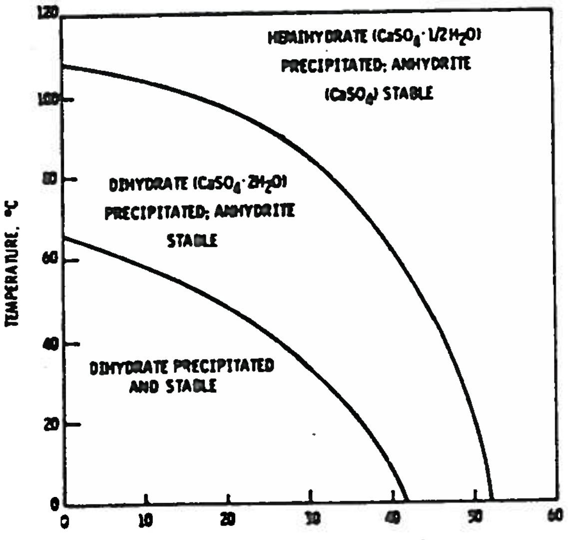

Figure 10. Precipitation and stability of calcium sulfates in phosphoric acid (21).

Reprinted from Chemistry and Technology of Fertilizers by courtesy of John Wiley & Sons, Inc.

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(21) Slack, A. V. Chemistry and Technology of Fertilizers. John Wiley & Sons, Inc., New York, New York, 1967. pp. 69-97.

The entire reaction, then, between the major (more than 90%) phosphate rock constituents and sulfuric acid is as follows (17):

$$Ca_{10}(PO_4)_6F_2CaCO_3 + 11H_2SO_4 + 11nH_2O \longrightarrow 6H_3PO_4 + 11CaSO_4 \cdot nH_2O + 2HF + H_2O + CO_2 \qquad (7)$$

where n may equal 0, 1/2, or 2 depending on the degree of hydration of the calcium sulfate. Table 7 shows weight percent values of compounds found in filtered wet process phosphoric acid (WPPA) (22). Table 8 gives an elemental analysis of commercial (concentrated) acid (21).

2. Process Description

Phosphoric acid can be produced by one of two methods: hydration of phosphorus oxide derived from burning elemental phosphorus in air (thermal process) or digestion of phosphate rock with a mineral acid such as sulfuric acid (wet process). The acid produced by the thermal process is known as furnace grade acid and, by the nature of the process, is higher purity acid. Furnace grade acid, used for animal feeds, detergents, fire retardant chemicals, and other industrial phosphorus products, is no longer used to produce phosphate fertilizers (8).

The second, or wet process, method produces merchant grade phosphoric acid. Merchant grade acid contains more impurities than does furnace grade acid. Currently, all phosphate fertilizer production in the United States uses WPPA.

WPPA production methods differ principally in the degree of hydration of the calcium sulfate. The degree of hydration is a function of the temperature and phosphorus pentoxide concentration of the acidulation slurry (see Figure 10). Calcium sulfate can be precipitated in the dihydrate form (gypsum), hemihydrate form, or anhydrous form. Currently, all WPPA plants in the United States use the dihydrate process. The hemihydrate and anhydrite processes find limited use in Europe and Japan.

A schematic diagram of the basic dihydrate process for producing orthophosphoric acid by the wet process method is shown in Figure 11. Production of the acid involves four unit operations: raw material feed preparation, phosphate rock digestion, filtration, and concentration. The following sections contain detailed process descriptions of each of these four operations.

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(22) Lehr, J. R. Purification of Wet Process Acid. In: Phosphoric Acid, Volume I, A. V. Slack, ed. Marcel Dekker, Inc., New York, New York, 1968. pp. 637-686.

TABLE 7. TYPICAL COMPOSITION OF FILTERED WPPA (22, 23)
(weight percent)

Rock source	Acid composition										Composition of suspended solid
	P_2O_5	CaO	F	Al_2O_3	Fe_2O_3	MgO	K_2O	Na_2O	SiO_2	SO_3	
Florida[a]	27.3	0.15	1.7	0.6	1.1	0.28	0.03	0.08		1.2	A, B, C
[b]	28.4	0.1	1.5	1.1	2.0					3.9	
[b]	31.2	1.0	1.4	0.8	1.7					0.2	
[b]	26.3	0.4	2.0	0.5	1.1				1.1	1.0	
[b]	30.2	0.1	2.0	1.9	1.1				1.6	3.1	
[c]	30.0	1.26	2.36	1.08	0.86		0.06	0.01	1.21	3.72	
[c,d]	27.0 to 31.9	0.01 to 0.8	0.9 to 3.1	0.2 to 1.6	0.8 to 2.4				0.2 to 0.6	0.4 to 4.6	A, C
Western[a]	23.2	0.22	1.2	0.8	0.6	0.33	0.05	0.13		1.0	A, C
[c]	30.0	0.21	1.36	1.01	0.42	0.05	0.06	0.01	0.74	2.63	
Tennessee[c]	30.0	0.37	2.54	2.66	2.27		0.07	0.43	0.1	1.49	

[a] Composition of clear, supernatant acid after cessation of precipitation; compounds identified in solids: A = $CaSO_4 \cdot 2H_2O$, B = $Ca_4SO_4(AlF_6)(SiF_6)OH \cdot 12H_2O$, C = $(Na, K)_2SiF_6$.

[b] Compositions of acids include any suspended solid material in shipped acids.

[c] Data taken from Table II of Reference 23 and recalculated to 30% P_2O_5 basis for comparison.

[d] Composite analyses of 21 product acids.

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(23) Hill, W. L., H. L. Marshall, and K. D. Jacob. Composition of Crude Phosphoric Acid Prepared by Sulfuric Acid Process. Industrial and Engineering Chemistry, 24(9):1064-1068, 1932.

TABLE 8. TYPICAL COMPOSITION OF COMMERCIAL PHOSPHORIC ACID (21)
(weight percent)

Reprinted from Chemistry and Technology of Fertilizers
by courtesy of John Wiley & Sons, Inc.

Component	Sample					Average
	A	B	C	D	E	
P_2O_5 equivalent	54.8	53.4	52.8	53.4	52.1	53.3
Calcium	0.01	0.01	0.05	0.1	0.03	0.06
Iron	0.7	0.8	0.7	1.2	0.5	0.78
Aluminum	0.7	0.3	0.4	0.6	0.6	0.58
Magnesium	0.3	0.2	0.3	0.3	0.2	0.26
Chromium	0.03	0.01	0.01	0.01	0.04	0.02
Vanadium	0.04	0.01	0.01	0.02	0.04	0.02
Sodium	0.03	1.9	0.04	0.2	0.1	0.45
Potassium	0.07	0.1	0.03	0.01	0.1	0.06
Fluoride	0.7	0.3	0.4	0.9	0.5	0.56
Sulfite	3.0	1.8	2.8	1.5	2.2	2.3
Silica	0.2	0.2	0.2	0.1	0.1	0.16
Carbon	0.1	0.04	0.8	0.2	0.04	0.24
Solid[b]	1.7	5.1	8.3	2.9	0.5	3.7

[a] Filtered WPPA is concentrated by evaporation to yield commercial acid.

[b] Filtered material, not washed, or dried.

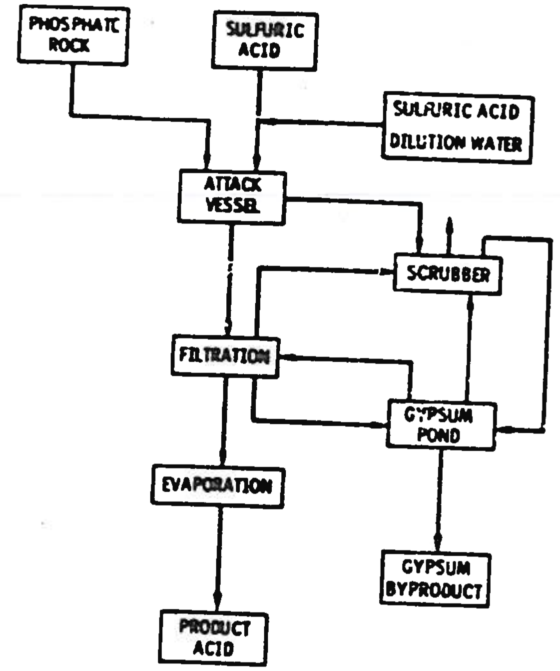

Figure 11. Wet process for production of phosphoric acid.

a. Raw Material Feed Preparation--
Phosphate rock is delivered to the plant site by railroad hopper cars. Unloading of these cars takes place in a three-sided shed where the ore drops out of the bottom of the railroad car and is conveyed to rock storage silos.

An exhaust system is installed in the unloading and transfer areas to remove phosphate rock dust from the air. The exhaust stream is passed through a baghouse before it is discharged to the atmosphere. From the silos, the rock is classified by screening (60% to 80% less than 74 µm) or by air separation and is passed on to the acidulator.

In addition to phosphate rock, sulfuric acid (93% to 98% H_2SO_4) is delivered to the plant site. This acid is piped to storage tanks from adjacent sulfuric acid plants.

b. Phosphate Rock Digestion--
The key feature in a phosphoric acid plant is the acidulator, the reaction vessel where phosphate rock is digested with sulfuric acid to produce orthophosphoric acid (28% to 30% P_2O_5) and gypsum. Before the 1960's, the digestion section consisted of a series of separate reaction vessels. Today, all wet process acid plants use a single tank design consisting of multiple compartments or

stages (24). The types of acidulation systems currently in use in the United States include the Prayon, Prayon/Davy Powergas, Dorr-Oliver, Singmaster and Breyer, and Swenson.

Each system design varies in terms of the number and location of agitators and recirculation mechanisms and in the locations of rock and sulfuric acid injection points. In the United States, approximately 75% of all wet process acid trains use the Prayon or a combined Prayon/Dorr-Oliver system. As Figure 12 illustrates, each of the systems uses different equipment, but the basic process and resulting product and byproducts remain the same.

Phosphate rock and sulfuric acid are added to recirculating slurry in the acidulator. Approximately 3.35 metric tons of 70% BPL (32% P_2O_5) phosphate rock and 2.75 metric tons of 93% to 98% sulfuric acid are required to produce 1.0 metric ton of H_3PO_4 (100% P_2O_5 basis) (24). Some processes use dilute sulfuric acid; the range of concentrations is 50% to 98% sulfuric acid. The higher concentrations of sulfuric acid are generally preferred because they remove excess water that must be evaporated during the concentration step.

Average retention time in the reactor system ranges from 5.5 hr to 8 hr (21). In all systems, recirculation of slurry is required in order to reduce the adverse effects on the process caused by fluctuations in rock analysis and incomplete mixing. The recycled slurry also gives the control of supersaturation necessary for good growth of gypsum crystals. In multicompartment systems such as the Prayon single tank reactor, the recycle: product ratios range from 10:1 to 20:1 (24).

Acidulation of rock and dilution of sulfuric acid produce heat: 163 kJ to 469 kJ per mole of fluorapatite (19). The reaction slurry must be cooled to prevent formation of other hydrated crystal forms of calcium sulfate. Three methods of cooling are used: blowing air into the slurry, flowing air across the slurry, and vacuum flash cooling. Another approach, used by Prayon, is to apply sulfuric acid which is already diluted and cooled. When the heat of reaction and heat of dilution of sulfuric acid are removed by flash cooling (Figure 13), submerged slurry pumps lift the slurry from the attack tank and introduce it into the bottom of a distributor in the flash cooler. A large slurry surface in the top of the cooler flashes off water; the cooled slurry then overflows the inner and outer edges of the distributor and returns to the attack tank.

Vapors from the flash cooler are condensed in a barometric condenser and sent to a hot well. Noncondensables are removed by

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(24) Lutz, W. A., and C. J. Pratt. Principles of Design and Operation. In: Phosphoric Acid, Volume I, A. V. Slack, ed. Marcel Dekker, Inc., New York, New York, 1968. pp. 158-208.

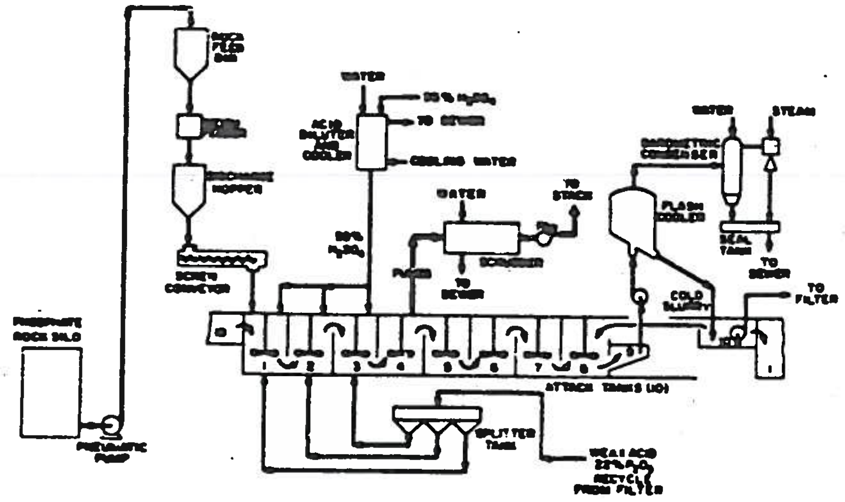

Figure 12a. Flow diagram for Prayon phosphoric acid plant.

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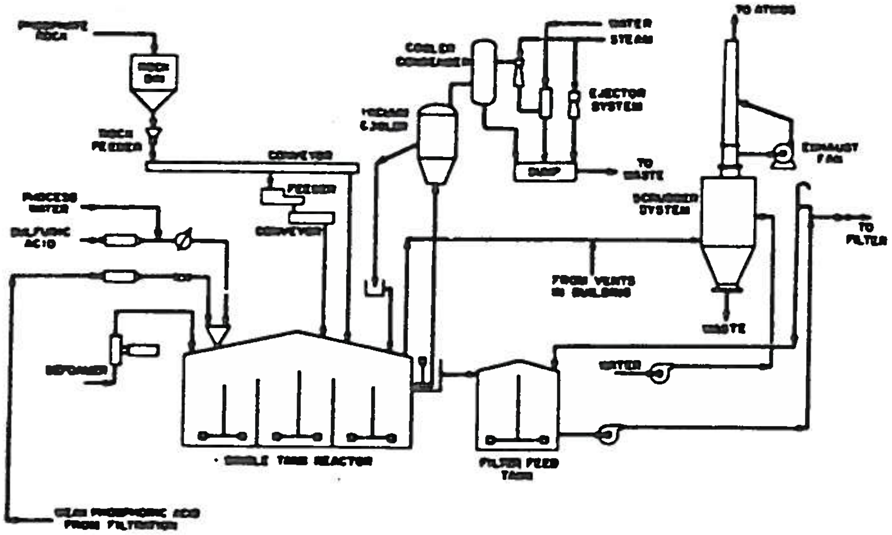

Figure 12b. Dorr-Oliver reaction system (vacuum cooled).

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Figure 12. Digestion system designs (24).

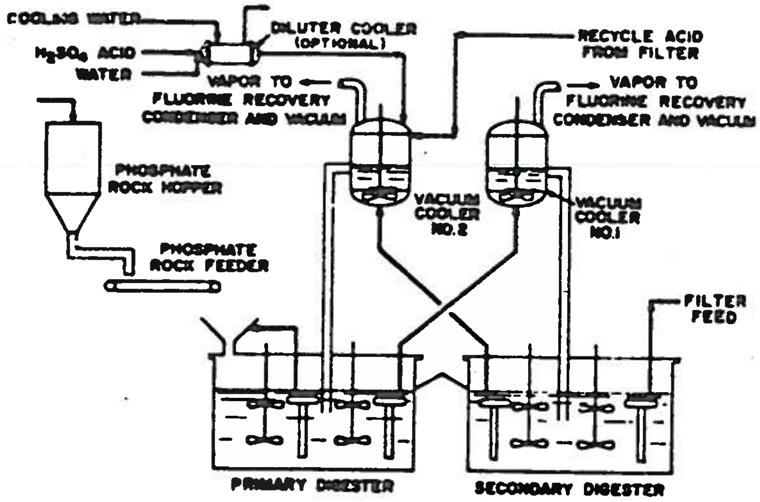

Figure 12c. Flow diagram for Singmaster and Bryer dihydrate phosphoric acid process.

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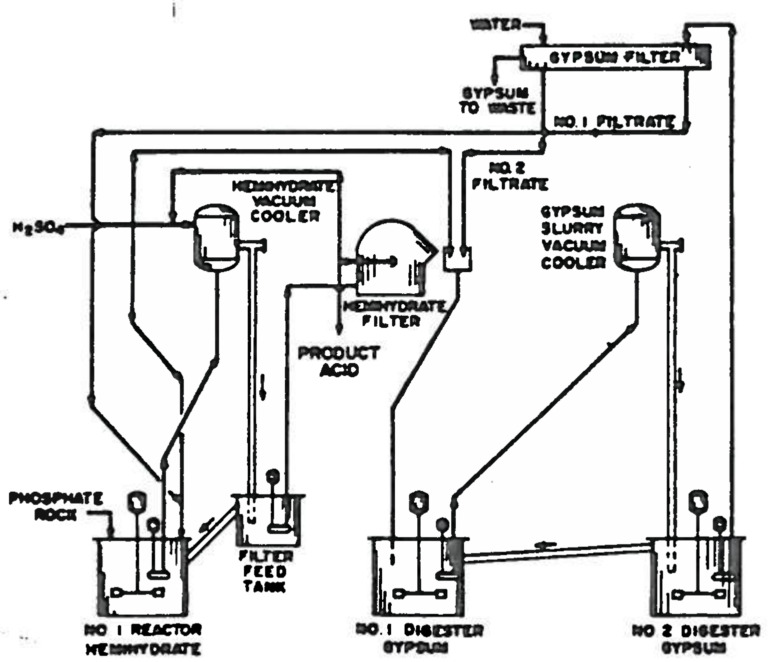

Figure 12d. Flow diagram of Singmaster and Breyer hemihydrate-dihydrate process.

Reprinted from Phosphoric Acid, Volume I, A. V. Slack, editor, p. 364, by courtesy of Marcel Dekker, Inc.

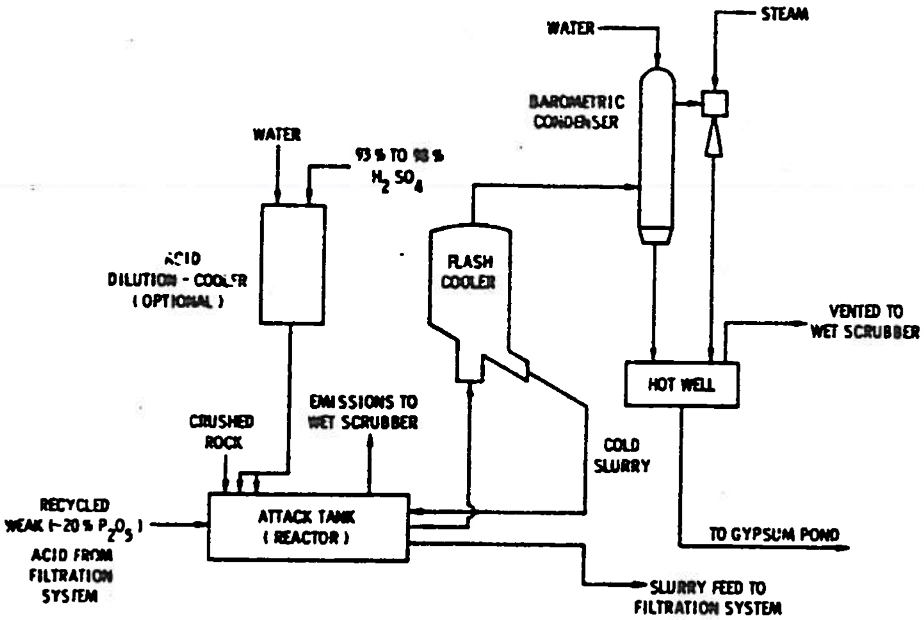

Figure 13. Phosphate rock digester and cooling system.

steam ejection and also vented to the hot well. Fumes from the hot well may be vented to the wet scrubber, while the water slurry is discharged to the gypsum pond.

c. Filtration--
Slurry from the final stage of the reactor system is continuously withdrawn and pumped to a horizontal, rotary, tilting pan type of vacuum filter to separate gypsum solids from the liquid (32% P_2O_5) phosphoric acid. Two diagrams of this type of filtration system are shown in Figures 14 (12) and 15 (15). Slurry is discharged onto the filter, the undiluted mother liquor is collected, and the remaining slurry is subsequently washed by three continuous, countercurrent stages to remove phosphoric acid liquids. The cake is dried by suction, the filter pan is inverted, and the cake is washed from the filter with recycled gypsum pond water. Gypsum slurry then flows to the holding pond for cooling and solid settling. The filter cloth is washed, dried by suction, and is then ready for the next cycle.

Acid from the first four stages of filtration is delivered to the vacuum receivers and then to a multicompartment filtrate seal tank. Undiluted mother liquor is pumped to a surge tank and then to the concentration process. Water and acid from the second and third washes are recycled to the preceding wash stage. Weak acid from the first wash is delivered to the attack vessel. Vapors from the vacuum receivers are cooled and vented to the wet scrubber system. Cooling water and condensed vapors are used to wash the cloth filter in the final stage of the filtration process.

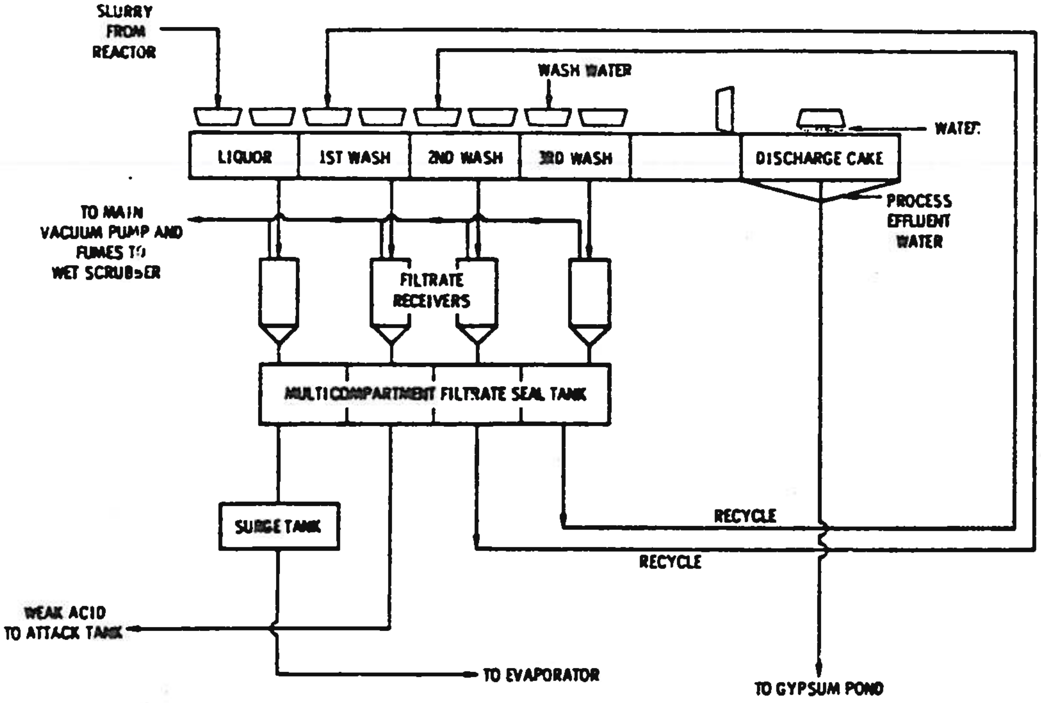

Figure 14. Tilting pan filtration system (12).

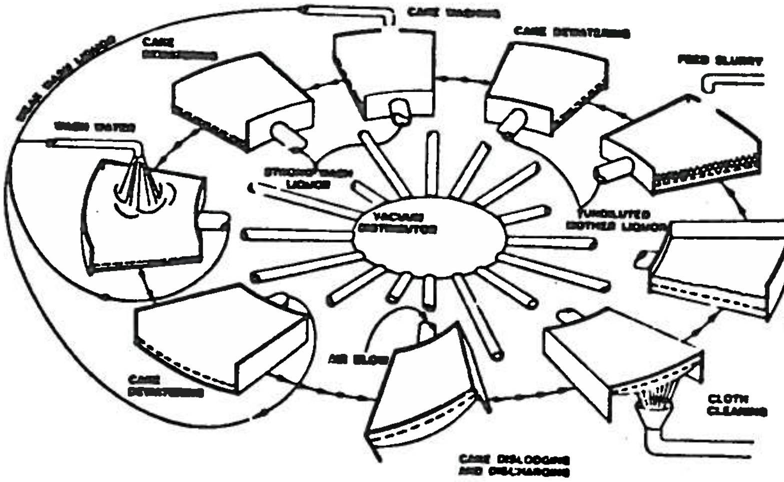

Figure 15. Operating cycle of rotary horizontal tilting pan filter (15).

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d. Concentration--

Phosphoric acid (32% P_2O_5) from the first filtration stage is concentrated to 54% P_2O_5 by vacuum evaporation of water. The acid is circulated, first through a shell-and-tube heat exchanger, then through a series of three flash chambers at 10 kPa to 20 kPa pressure (25, 26) separated by shell-and-tube exchangers, as shown in Figure 16 (12). The flash chambers serve to provide comparatively large liquid surface areas where water vapor can be released with minimum phosphoric acid entrainment.

Minor acid impurities, such as compounds containing fluorine, volatilize with the water vapor. The evolved vapors containing fluorine compounds and phosphoric acid pass to a barometric condenser, from which the condensed vapors, process cooling water, and condensed steam flow to a hot well. From the hot well, the water is recycled back to the barometric condenser that is used in connection with the acid flash cooler. Vapors from the hot well are vented to the wet scrubber system.

A variety of minor acid impurities such as iron and aluminum phosphates, soluble gypsum, and fluosilicates form supersaturated solutions in 54% P_2O_5 phosphoric acid and will precipitate during storage. These precipitates, in turn, cause problems in tank car unloading and customer processing. It is therefore necessary to remove these precipitated impurities before the acid is sold. As previously illustrated in Tables 7 and 8, there is a large reduction in impurities between the filtered and product acids.

The process used in the United States for removal of precipitated solids from 54% P_2O_5 phosphoric acid involves only physical treatment of the acid rather than the more complicated and expensive solvent extraction processes utilized in Europe and Mexico (27). Precipitated impurities are physically separated from the acid by settling and/or centrifugation.

Sludge is either sent to the gypsum pond, processed into a low quality fertilizer, or recycled to the evaporator feed tank. Recirculation of the sludge adds precipitated solids to the evaporator feed, providing crystal surfaces in the acid. Because salts coming out of solution during the evaporation process tend to deposit on these crystals rather than on evaporator surfaces, scaling is reduced. The clarified acid is then stored at ambient temperatures.

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(25) Cleanup Pays Off for Fertilizer Plant. Environmental Science and Technology, 6(5):400-401, 1972.

(26) Banford, C. R. IMC's New Plant Shows Off Latest H_3PO_4 Know-How. Chemical Engineering, 70(11):100-102, 1963.

(27) Legal, C. C., and O. D. Myrick, Jr. History and Status of Phosphoric Acid. In: Phosphoric Acid, Volume I., A. V. Slack, ed. Marcel Dekker, Inc., New York, New York, 1968. pp. 1-89.

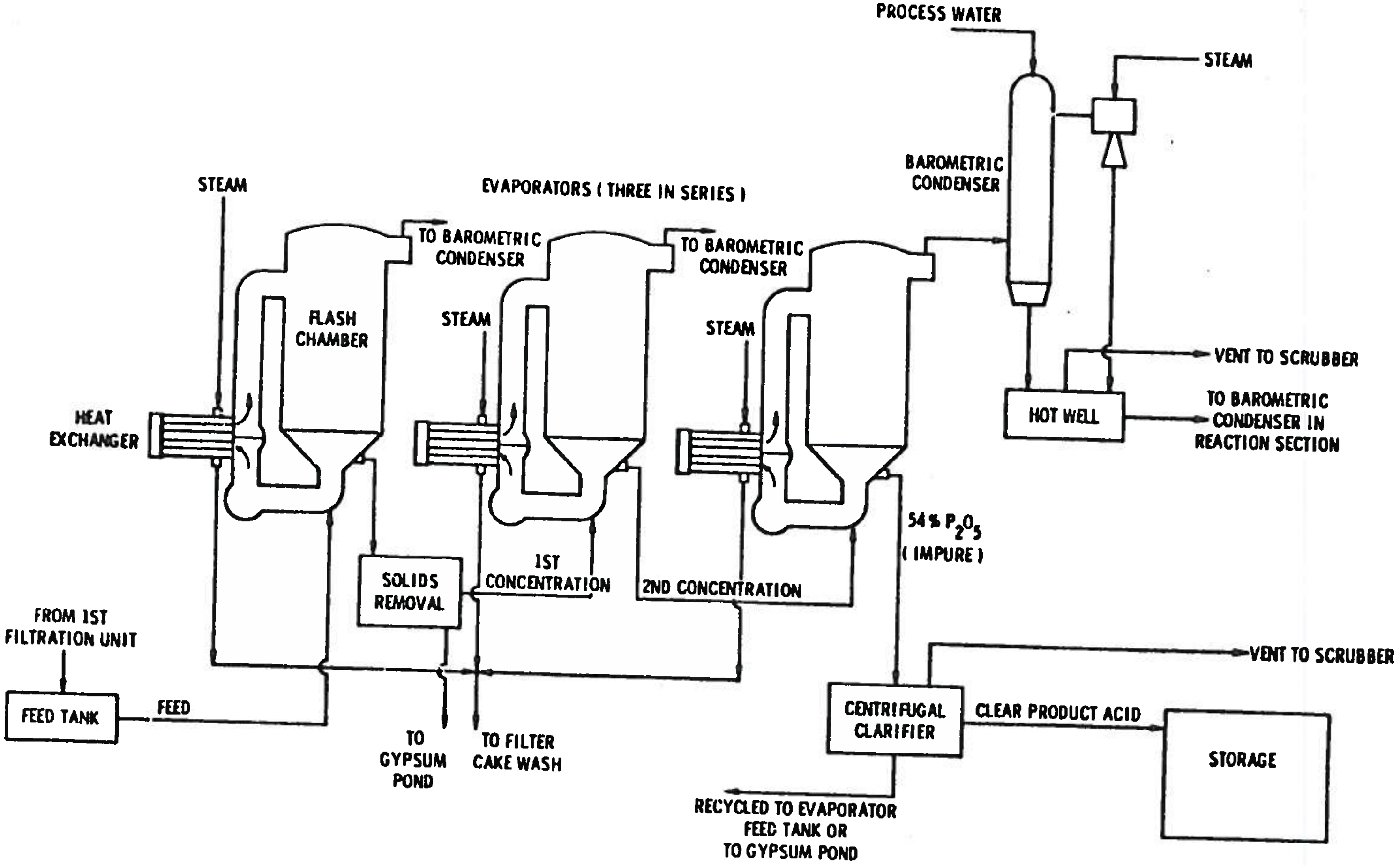

Figure 16. Concentration and clarification (12).

3. Gypsum Ponds

Gypsum ponds are used not only as settling basins for calcium sulfate dihydrate ($CaSO_4 \bullet 2H_2O$), but can be used as cooling, storage, and reconditioning ponds for all contaminated process water streams in the plant or complex. Cooled and clarified supernatant water from the pond can be recycled to supply over 80% of the water requirements for the plant (4).

A typical range of equilibrium compositions of gypsum pond water is given in Table 9 (4, 20, 28). Impurities approach equilibrium concentration in individual ponds over a period of 3 yr to 5 yr as the water is recycled. These concentrations are then maintained by either volatilization and/or precipitation.

TABLE 9. EQUILIBRIUM CONCENTRATION RANGES OF GYPSUM POND WATER (4,20, 28) (g/m³)

Contaminant	Concentration
P_2O_5 equivalent	6,00 to 12,000
Fluoride	3,000 to 10,000
Sulfate	2,000 to 4,000
Calcium	350 to 1,200
Ammonia	0 to 100
Nitrate	0 to 100
Silica	∿1,600
Aluminum	100 to 500
Iron	70 to 300
pH	1.0 to 1.8

4. Industry Characterization

All 36 WPPA plants in the United States (7) use the same basic processes described in previous sections. Specific equipment and operating conditions vary from plant to plant. General industry practice has included use of closed water recycle systems and a single scrubber unit for the collective emission sources, although variations do exist. One plant, located on the Mississippi River and lacking available land area for a gypsum pond, was designed for use of river water on a once through basis for scrubbing air emissions, for operation of the barometric condenser, and for meeting cooling requirements.

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(28) Huffstutler, K. K. Pollution Problems in Phosphoric Acid Production. In: Phosphoric Acid, Volume I, A. V. Slack, ed. Marcel Dekker, Inc., New York, New York, 1968. pp. 727-739.

The 36 WPPA plants have production capacities which range from 6,480 to 751,300 metric tons of P_2O_5 per year, with an average plant capacity of 251,600 metric tons of P_2O_5 per year or 699 metric tons of P_2O_5 per day (see Appendix A). Individual plant capacities vary throughout the range as shown in Table 10 and illustrated in Figure 17. Average plant production was calculated by dividing the total annual wet process phosphoric acid production for 1975 (6,290,000 metric tons of P_2O_5 per year) by the total number of WPPA plants, i.e., 36. An average WPPA plant was therefore defined as producing 175,000 metric tons of P_2O_5 per year or 486 metric tons of P_2O_5 per day.

TABLE 10. DISTRIBUTION OF WPPA PLANTS BY PRODUCTION CAPACITY

Individual plant capacity, 10^3 metric tons P_2O_5/yr	Number of plants	Combined capacity for all plants in category, 10^3 metric tons P_2O_5/yr	Percent of total capacity
>700	1	751.3	8.3
600 to 700	3	2,023	22.3
500 to 600	2	1,187	13.1
400 to 500	3	1,358	15.0
300 to 400	1	326.5	3.6
200 to 300	7	1,720	19.0
100 to 200	9	1,297	14.3
<100	10	394.2	4.4
Total	36	9,057	100

Approximately 4 to 5 metric tons of gypsum are formed for every metric ton of P_2O_5 (20). The magnitude of this waste is an indication of the size of gypsum ponds, which also serve as holding ponds for the process water, necessary for plant operation. One reported rule of thumb for sizing is 0.00223 km^2 per daily metric ton of P_2O_5 production (20). An average plant, producing 486 metric tons P_2O_5 daily, would require a gypsum pond of 1.08 km^2 (263 acres).

The locations of the 36 phosphoric acid plants are listed in Table A-2 of Appendix A, which also gives information on the population densities in counties where the plants are located. A distribution of plants by county population density is shown in Table 11. The predominant population density range is 40 to 49 persons/km^2; the median value for the 36 plants is 46.1 persons/km^2. This value is used for the population density around an average plant.

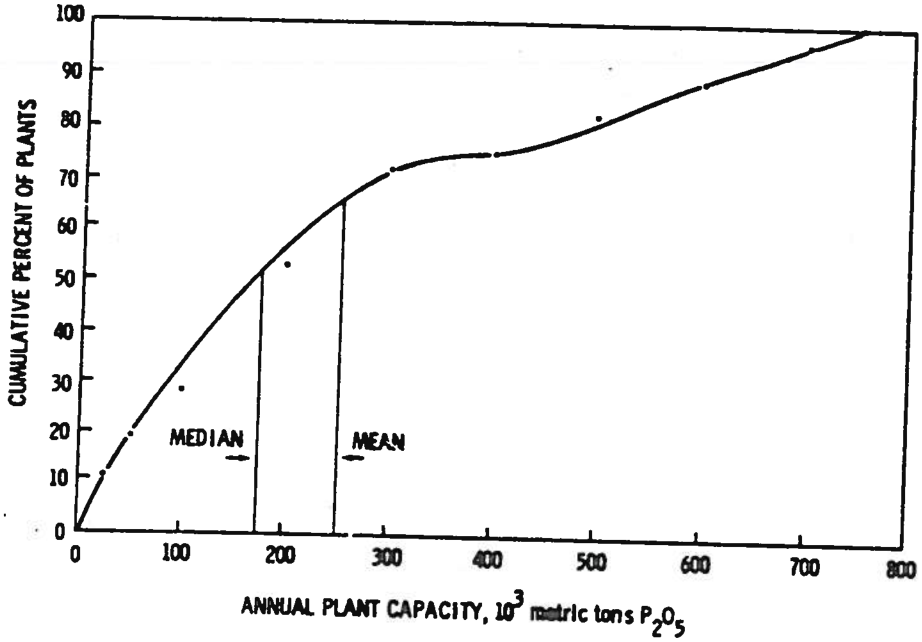

Figure 17. Distribution of WPPA plants by capacity.

TABLE 11. DISTRIBUTION OF WPPA PLANTS BY COUNTY POPULATION DENSITY

Population density, persons/km^2	Number of plants	Percent of total plants
0 to 9	4	11.1
10 to 19	5	13.9
20 to 29	2	5.6
30 to 39	4	11.1
40 to 49	14	38.9
50 to 99	1	2.8
100 to 299	3	8.3
300 to 500	3	8.3
Total	36	100

C. SUPERPHOSPHORIC ACID PRODUCTION

1. Process Chemistry

Superphosphoric acid is produced by dehydrating "wet process" phosphoric acid. When phosphoric acid is heated to elevated temperatures, molecular dehydration occurs and the molecules combine to form polyphosphoric acid chains as shown in Equation 8 (29).

$$x\ H_3PO_4 \xrightarrow{\Delta} H_{x+2}\,P_x\,O_{3x+1} + (x - 1)H_2O \qquad (8)$$

As an example, tripolyphosphoric acid is formed as follows (29):

$$3H_3PO_4 \xrightarrow{\Delta} H_5P_3O_{10} + 2H_2O \qquad (9)$$

The resulting product is a mixture of phosphoric acid (H_3PO_4) and polyphosphoric acid chains of varying lengths; this mixture is called superphosphoric acid. If temperature or retention time is increased, a higher degree of dehydration is obtained. Product composition is affected in that the amount of phosphoric acid decreases while the average chain length of the polymeric acids increases. Wet process superphosphoric acid is concentrated to 68.5% to 72% P_2O_5 (27). At this degree of hydration, the P_2O_5 in the acid is approximately 40% remaining as phosphoric acid (H_3PO_4), 40% as pyrophosphoric acid ($H_4P_2O_5$), 5% as tripolyphosphoric acid, and 15% as longer chain acids (27).

Wet process superphosphoric acid differs from pure superphosphoric acid produced from electric-furnace phosphorus primarily in the chemistry associated with the impurities in the wet acid. Major impurities in wet process superphosphoric acid are calcium, iron, aluminum, magnesium, potassium, sodium, fluorine (hydrogen fluoride [HF], fluosilicic acid [H_2SiF_6], silicon tetrafluoride [SiF_4]), and sulfate (29). Minor amounts of chromium, tin, manganese, vanadium, uranium, and arsenic are also found. The composition of superphosphoric acid typically produced from Florida phosphate rock is shown in Table 12 (15).

Iron and aluminum impurities in wet process acid reach their lowest solubility at about 54% P_2O_5, the normal feed concentration to the superphosphoric acid process. In the product superphosphoric acid, pyrophosphoric acid acts to sequester trivalent iron and aluminum impurities and hold them in solution.

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(29) Muehlberg, P. E., J. T. Reding, and B. P. Shepherd. Draft Report: The Phosphate Rock and Basic Fertilizer Materials Industry. Contract 68-02-1329, Task 8, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, May 1976. 205 pp.

TABLE 12. COMPOSITION OF SUPERPHOSPHORIC ACID (15)
(percent)

Reprinted from Phosphoric Acid, Volume I, A. V. Slack, editor, p. 1083, by courtesy of Marcel Dekker, Inc.

Constituent	Typical content	Range
Total P_2O_5	69.60	69 to 70
Ortho-P_2O_5	42.50	42 to 45
Nonortho-P_2O_5	27.10	
Fe_2O_3	2.50	
Al_2O_3	2.05	
Combined Fe_2O_3 and Al_2O_3	4.55	4 to 5
Fluorine	0.51	
CaO	0.15	
SO_3	2.44	
Conversion to polyphosphate, %	29.0	

NOTE.—Blanks indicate data not available.

2. Process Description

a. Submerged Combustion--

Two commercial processes are used for the production of superphosphoric acid from wet process acid: submerged combustion and vacuum evaporation. Currently, in the United States only two plants (Allied Chemical Corp. and Occidental Petroleum Corp.), accounting for approximately 26% of the superphosphoric acid production capacity, use submerged combustion.

The submerged combustion process was pioneered by the Tennessee Valley Authority (TVA). Wet acid is dehydrated by bubbling hot combustion gases through a pool of the acid. Combustion gases are supplied by burning natural gas in a separate chamber. The combustion gases are diluted with air to maintain a gas temperature of 925°C for introduction into the acid evaporator. After passage through the acid, the hot combustion gases are sent to a separator to recover entrained acid droplets and then sent to a wet scrubber emissions control system.

Clarified acid containing 54% P_2O_5 is continuously fed to the evaporator from storage, and acid containing 72% P_2O_5 is withdrawn from the evaporator to product holding tanks. Acid cooling is accomplished by circulating water through stainless steel cooling tubes in the product tanks. Superphosphoric acid production can be controlled by regulation of the natural gas and air flows to the combustion chamber, by the feed rate of acid to the evaporator, or by the amount of excess air used in the combustion process.

b. Vacuum Evaporation--
Most plants in the United States (approximately 74%) employ vacuum evaporation utilizing heat transfer surfaces in the production of superphosphoric acid (15, 21). Two popular types of evaporators used are the falling film evaporator developed by Stauffer Chemical Co. and the forced circulation evaporator developed by Swenson Evaporator Co. In the seven plants which use vacuum evaporation, approximately 60% of superphosphoric acid production is by the Stauffer process. The remaining 40% uses the Swenson design.

In the Stauffer process, clarified 54% P_2O_5 phosphoric acid is continuously fed to the evaporator recycle tank where it mixes with superphosphoric acid from the evaporator. Some of the mixture (approximately 1.2%) is drawn off as product acid, but most (approximately 98.8%) is pumped to the top of the evaporator and is distributed across the heat exchanger tube bundle. The falling acid, heated by high-pressure steam condensing on the outside of the tubes, evaporates. The vapors and dehydrated acid then enter the separator section where entrained acid mist is removed. Product acid flows to the recycle tank, and the vapor is drawn off, condensed in a barometric condenser, and delivered to a hot well. Noncondensables are removed by a two-stage steam ejector and are vented to the hot well. Superphosphoric acid flows to the recycle tank where it is mixed with more 54% P_2O_5 phosphoric acid and recycled or removed as product. The approximate recycle to feed acid ratio is 80:1. The product stream is cooled and stored before shipping. Both the hot well and cooling tank are vented to wet scrubbing systems.

The Swenson process utilizes closed heat exchanger tubes filled with heat exchanger fluid to provide the heat of reaction. Feed acid (54% P_2O_5) pumped into the evaporating system mixes with recycled superphosphoric acid. As the acid leaves the exchanger tube bundle and enters the flash chamber, evaporation begins. Vapors are removed by a barometric condenser. Condensed materials and noncondensed vapors are delivered to a hot well. Product acid flows toward the bottom of the flash chamber where part (approximately 0.6%) is removed to a cooling tank and the rest (99.4%) is recycled. An approximate recycle to feed ratio is 150:1 (compared with 80:1 for the Stauffer process).

Cooling in both systems is accomplished by circulating water through stainless steel tubes in the holding tank.

3. Industry Characterization

Nine plants in the United States produce wet process superphosphoric acid. These plants have production capacities which range from 12,960 to 295,000 metric tons of P_2O_5 per year, with an average plant capacity of 115,900 metric tons of P_2O_5 per year or 320 metric tons of P_2O_5 per day (see Appendix A). Plant capacity distributions for those plants producing superphosphoric acid are given in Table 13 and Figure 18. Average plant production was calculated by dividing the total annual wet process superphosphoric and production for 1975 (506,000 metric tons of P_2O_5) by the total number of SPA plants. An average SPA plant was therefore defined as producing 56,200 metric tons of P_2O_5 per year or 156 metric tons per day.

TABLE 13. DISTRIBUTION OF SPA PLANTS BY PRODUCTION CAPACITY

Individual plant capacity, 10^3 metric tons P_2O_5/yr	Number of plants	Combined capacity for all plants in category, 10^3 metric tons P_2O_5/yr	Percent of total capacity
>200	1	295	28.3
150 to 200	3	479	45.9
100 to 150	1	124	11.9
50 t0 100	1	65.2	6.3
<50	3	79.6	
Total	9	1042.8	100

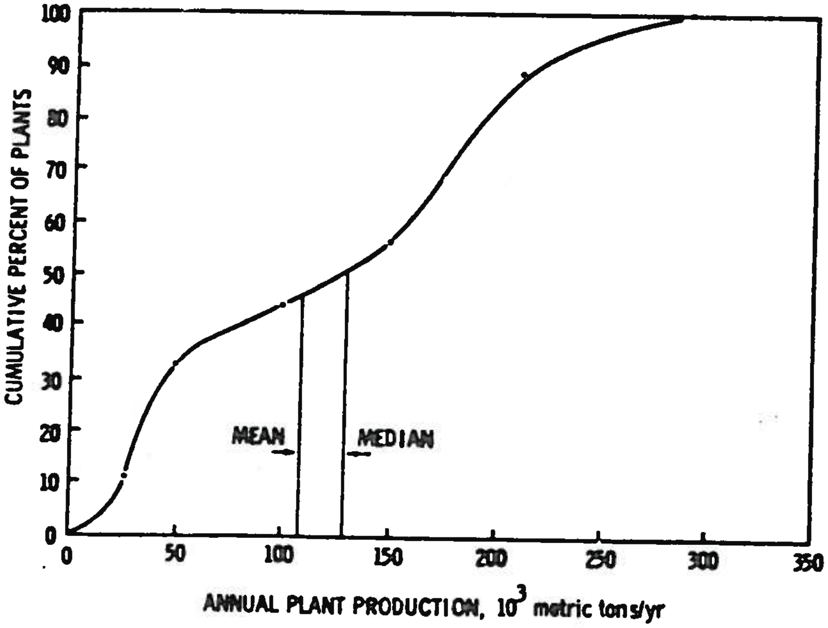

Figure 18. Distribution of SPA plants by capacity.

The population densities of the counties where the nine superphosphoric acid plants are located range from 2.9 to 385.9 persons/km², is used for the population density around an average plant (Table 14).

TABLE 14. DISTRIBUTION OF SPA PLANTS BY COUNTY POPULATION DENSITY

Population density, persons/km²	Number of plants	Percent of total plants
0 to 9	2	22.2
10 to 19	2	22.2
20 to 39	0	
40 to 49	3	33.3
236	1	11.1
386	1	11.1
Total	9	100

D. NORMAL SUPERPHOSPHATE PRODUCTION

1. Process Chemistry

Phosphate rock is composed of phosphate in the form of the mineral fluorapatite ($[Ca_3(PO_4)_2]_3 \cdot CaF_2$). Phosphate in this form is only slightly soluble in water, thus reducing its availability for plant growth.

NSP, containing from 16% to 21% P_2O_5, is prepared by reacting ground phosphate rock with 65% to 75% sulfuric acid. The primary objective of this acidulation process is to convert the fluorapatite in phosphate rock to soluble monocalcium phosphate, a form readily available to plants. While the overall chemistry is complex due to the composition of the rock, the major reaction involving phosphate may be stated simply as (4):

$$\underset{\substack{\text{Fluorapatite}\\ \text{(phosphate rock)}}}{[Ca_3(PO_4)_2]_3\cdot CaF_2} + \underset{\substack{\text{Sulfuric}\\ \text{acid}}}{7H_2SO_4} + \underset{\text{Water}}{3H_2O} \longrightarrow \underset{\substack{\text{Monocalcium}\\ \text{phosphate}\\ \text{monohydrate}}}{3[CaH_4(PO_4)_2\cdot H_2O]} + \underset{\substack{\text{Calcium}\\ \text{sulfate}}}{7CaSO_4} + \underset{\substack{\text{Hydrogen}\\ \text{fluoride}}}{2HF} \qquad (10)$$

2. Process Description

NSP is prepared by reacting ground phosphate rock with 65% to 75% sulfuric acid. Rock and acid are mixed in a reaction vessel, held in an enclosed area (den) while the reaction mixture solidifies, and then transferred to a storage pile for curing. A generalized flow diagram of the process for the production of NSP is shown in Figure 19 (4).

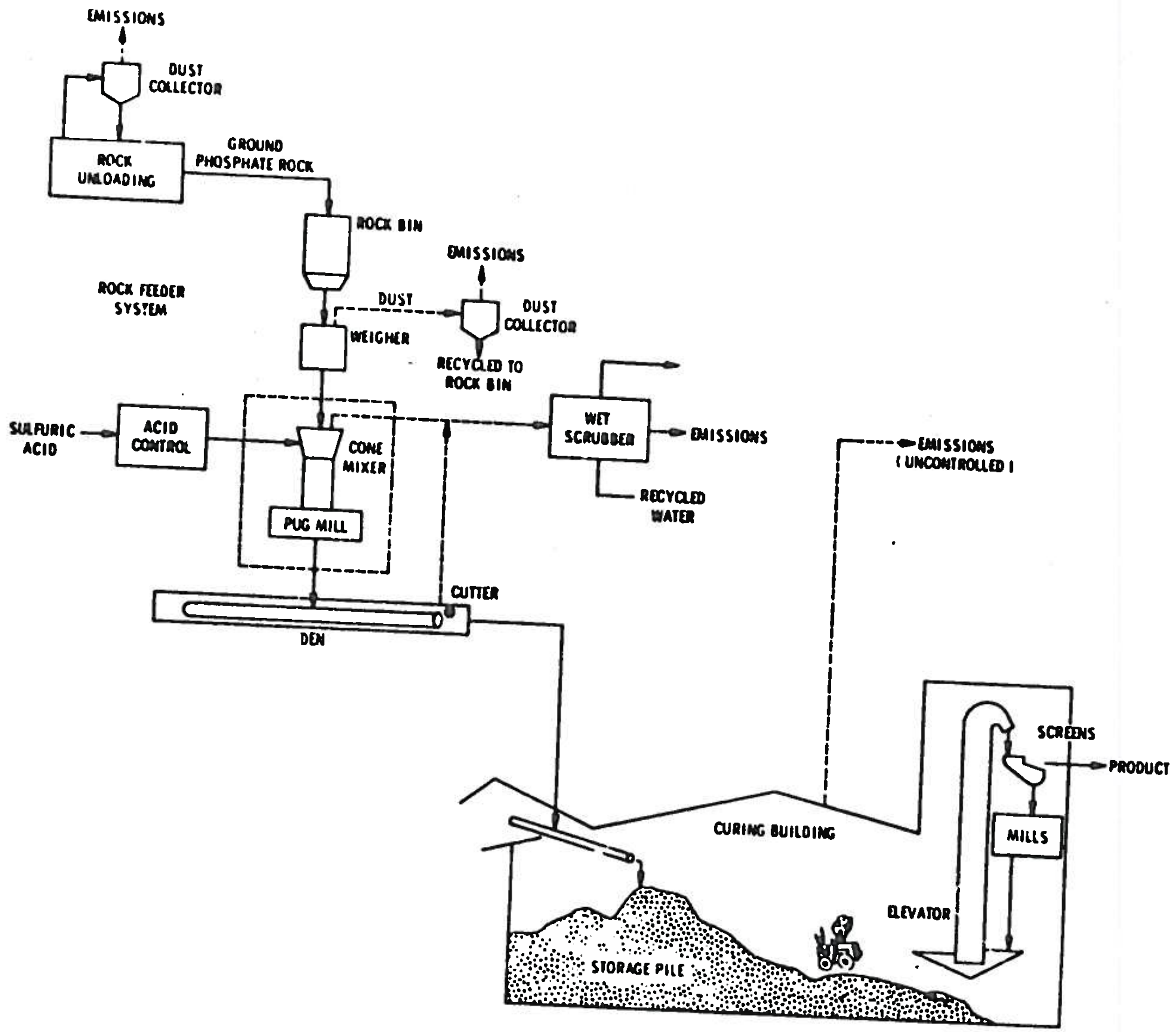

Figure 19. ROP-NSP production facility (4).

Mixing of the phosphate rock and sulfuric acid (acidulation) takes place in either a pan or cone mixer. The pan mixer, used in conjunction with a batch den and largely replaced by the cone mixer, is fitted with slowly rotating plows. Larger units are capable of handling a 2-metric ton batch of material (16).

The cone mixer, developed by the TVA, has come into use in more than 80% of the plants because of its relatively low capital expense, low maintenance cost, simple operation, and lack of moving parts (16). Sulfuric acid is fed into the cone tangentially in order to provide the necessary mixing action. Fresh superphosphate discharges from the cone mixer to a pugmill for additional mixing of acid and rock before discharge to a den. This type of mixer is suitable for use with either a batch or continuous den.

Plants are described as batch or continuous, depending upon the type of den used. In a continuous den, solidification and concurrent evolution of reaction gas take place on a slow-moving conveyor (den) enroute to the curing area. The low travel speed allows about 1 hr for the solidification process to occur before the material reaches the end of the belt. A cutting knife then slices the solidified material from the belt. NSP as it comes from the den is uncured and must be held in a curing building for a period of between 2 wk and 6 wk to permit acidulation to go to completion.

A batch den is a closed compartment except for a vent that releases reaction gases. Batch dens commonly used in this country have capacities ranging from 35 to 275 metric tons (16). After a setting period, ranging from 1.5 hr up to 10 hr, the solidified NSP material must be removed from the den and transferred to storage. Dens operate either automatically, with a cutting wheel that shaves the solidified mass from the den, or manually, with a mechanical cutter, a drag line, or a crane.

Following curing, the product can be ground and bagged for sale, or it can be granulated for sale as granulated superphosphate or granular mixed fertilizer. Granular mixed fertilizers are described in a separate report entitled "Source Assessment: Fertilizer Mixing Plants" and are therefore not included in the present discussion (5).

In producing a granular normal superphosphate (GNSP) material, the hardened ROP product is first fed to a pulverizer where it is crushed, ground, and screened. Screened material is then sent to a rotary drum granulator. Steam or water is added, if needed, to aid in granulation. The mixture then passes through a rotary dryer where it is dried to set its form and sufficient moisture is removed to eliminate the chance of the pellets binding together. The material then goes through a rotary cooler and on to storage bins for sale as bagged or bulk product.

In some cases, the ROP-NSP material is granulated before curing in a similar operation.

Sources of emissions at an NSP plant include the mixer, den, and curing building. Emissions of fluoride and particulate from the mixer and den are controlled by scrubbing with recycled water. Fluorides evolved during curing and particulates released from fertilizer handling operations (including screening and milling in the product storage building) are uncontrolled at a typical plant. The ground rock unloading, transfer, and storage facilities together with the process rock weighers and feeders comprise an additional source of particulate emissions. These emissions are controlled by baghouse collectors.

3. Industry Characterization

Only a small portion (less than 10%) of total NSP production is applied directly as ROP-NSP or GNSP product (30). GNSP accounts for less than 5% of total NSP production, and emissions from this plant type are therefore not considered. Most of the NSP material is sent to a fertilizer mixing plant and used in the preparation of fertilizers containing more than one of the following nutrients: nitrogen, phosphorus, and potassium.

An average NSP plant is defined as one that produces 6,650 metric tons of P_2O_5 per year of run-of-the-pile grade fertilizer. The average NSP plant is located in a county having a population density of 426 persons/km^2. (See Appendix A for a complete list of plant capacities and locations.) Because individual plant production statistics are not available, the average plant production rate was calculated by dividing the total annual NSP production for 1975 (439,000 metric tons P_2O_5 per year) by the total number of NSP plants; i.e., 66.

E. TRIPLE SUPERPHOSPHATE PRODUCTION

1. Process Chemistry

TSP, 45% to 49% P_2O_5, contains between 2.5 and 3 times more P_2O_5 than normal superphosphate. This higher P_2O_5 content product is achieved through the use of phosphoric acid in place of sulfuric acid as shown in the following equation (31):

$$\underset{\substack{\text{Fluorapatite}\\\text{(phosphate rock)}}}{[Ca_3(PO_4)_2]_3\cdot CaF_2} + \underset{\substack{\text{Phosphoric}\\\text{acid}}}{14H_3PO_4} + \underset{\text{Water}}{10H_2O} \longrightarrow \underset{\substack{\text{Monocalcium}\\\text{phosphate}\\\text{monohydrate}}}{10[CaH_4(PO_4)_2\cdot H_2O]} + \underset{\substack{\text{Hydrogen}\\\text{fluoride}}}{2HF} \qquad (11)$$

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(30) Personal communication with Ed Harre, Tennessee Valley Authority, Muscle Shoals, Alabama, 14 April 1977.

(31) Background Information for Standards of Performance: Phosphate Fertilizer Industry, Vol. 1--Proposed Standards. EPA-450/2-74-019a (PB 237 606), U.S. Environmental Protection Agency, Raleigh, North Carolina, October 1974. 140 pp.

Higher grade TSP materials (with 54% to 55% P_2O_5) have been manufactured by the TVA but only on an experimental basis (9, 32).

2. Process Description

Two principal types of TSP are produced: ROP-TSP and GTSP. Physical characteristics and processing conditions differ for the two materials. ROP material is essentially a nonuniform pulverized mass. In contrast, GTSP is a hard, uniform, pelletized granule. The ROP process is used for approximately 40% of total TSP production, and the granular process is used for the remaining 60%. Some overlap occurs as a portion of the ROP product is consumed in producing a GTSP product.

a. Run-of-Pile Triple Superphosphate--

The ROP-TSP production process as shown in Figure 20 is essentially identical to the NSP process except that phosphoric acid rather than sulfuric acid is used for acidulation (31). Mixing of the ground rock and phosphoric acid (50% to 54% P_2O_5 content) occurs in a cone mixer. The majority of plants (more than 90%) in the United States use the TVA cone mixer. This mixer has no moving parts, and mixing is accomplished by the swirling action of rock and acid streams introduced simultaneously into the cone. The resulting viscous slurry, on discharge from the mixer, quickly (in 15 s to 30 s) becomes plastic and begins to solidify. Solidification, together with the concurrent evolution of reaction gases, takes place on a slow-moving conveyor (den) enroute to the curing area.

On its way to the curing building, the mix may pass through several mixers or plungers that increase contact between the rock and acid and help to release trapped gases. Solidified material takes on a honeycomb appearance because of the copious evolution of gas throughout the mass. At the point of discharge from the den, the material passes through a rotary mechanical cutter that breaks up the solid mass. Coarse ROP product is sent to a storage pile where it is cured for a period of 3 wk to 5 wk. Final ROP product is then mined from the "pile" in the curing shed, and subsequently crushed, screened, and shipped in bulk (4, 16, 31).

This method of production gives a material that is nonuniform in particle size with consequent inferior handling characteristics. As a result, over 90% of all ROP-TSP is later granulated, either by the process described in the next section, or at fertilizer mixing plants that produce nitrogen-phosphorus-potassium (N-P-K) fertilizers (5). The remaining ROP-TSP is used as direct application fertilizer. Sources of air emissions and emission species

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(32) Gartrell, F. E., and J. C. Barber. Pollution Control Interrelationships. Chemical Engineering Progress, 62(10); 44-47, 1966.

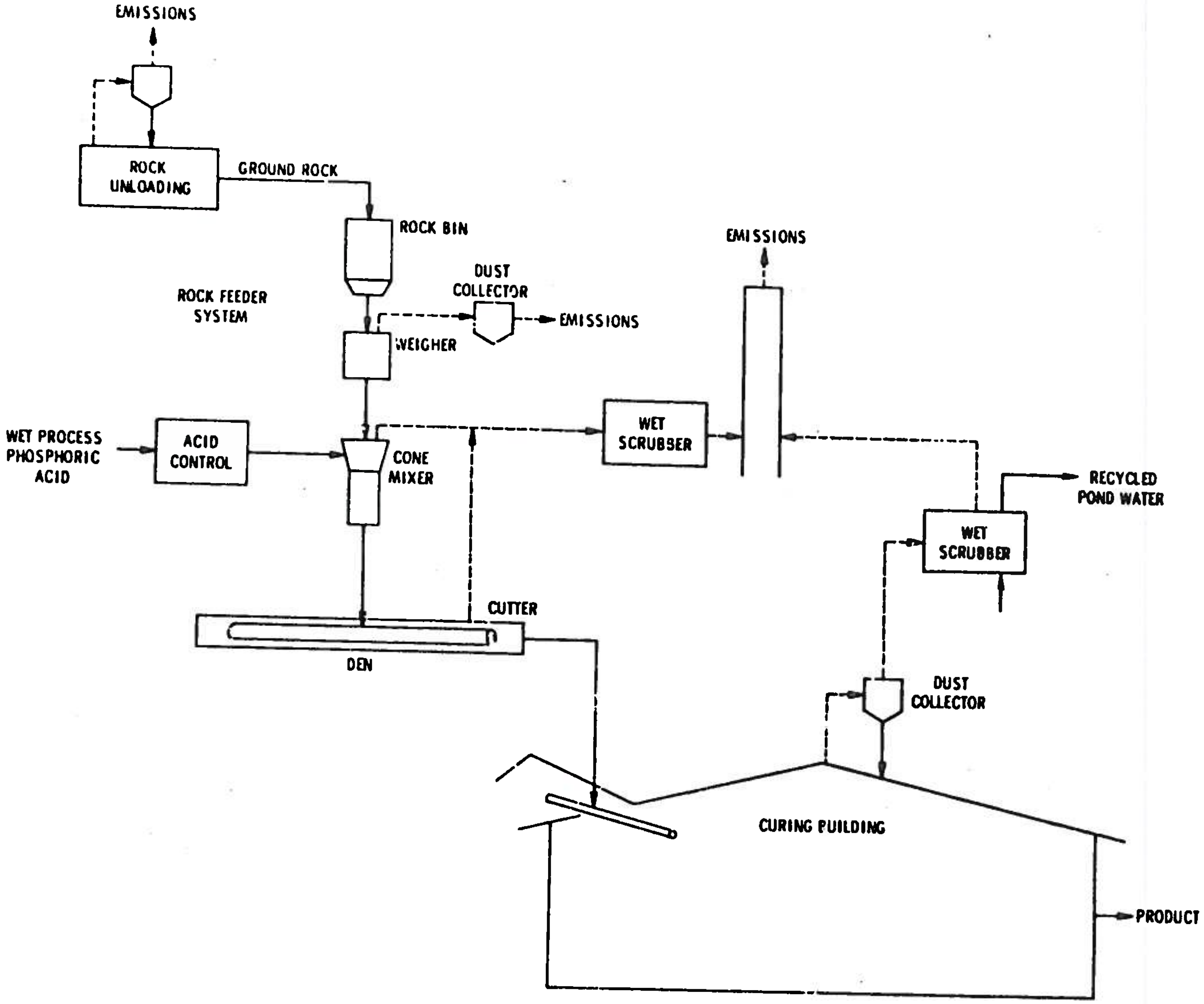

Figure 20. ROP-TSP production facility (31).

at a typical ROP-TSP production facility are similar to those described for an NSP plant. Emissions of fluoride vapors and particulates from the cone mixer, den, and curing building are controlled by wet scrubbers using recirculated pond water. Particulate emissions from ground rock storage and transfer facilities are controlled by baghouse collectors.

b. Granular Triple Superphosphate--
Granulation is employed as a means of improving the storage and handling properties of fertilizer materials. This process yields larger, more uniform particles (mean particle diameters between 1 mm and 4 mm) either by agglomeration of ROP material or by direct granulation of raw product slurry.

(1) GTSP from ROP-TSP--A generalized flow diagram of the process for the production of GTSP from cured ROP-TSP is shown in Figure 21 (4, 16, 31). Less than 10% of the GTSP consumed in the United States is currently produced by this method.

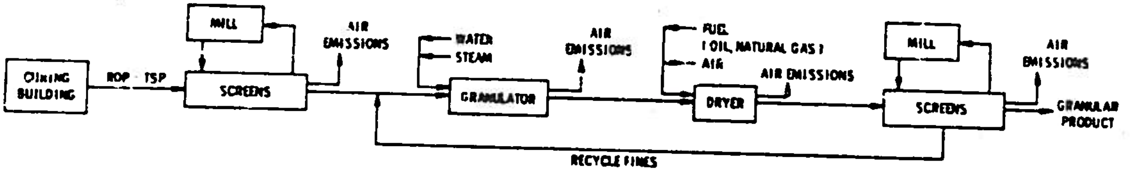

Figure 21. Production of GTSP from cured ROP-TSP (4, 16, 31).

In this process, cured ROP-TSP product is removed from storage and sent to a pulverizer where it is ground and screened. The screened material is then sent to a rotary drum granulator. The addition of steam and water aids the granulation process. The resultant wet granules are discharged to an air dryer where water is evaporated to give a hard, dense, granular product. The discharge from the dryer is screened, and acceptable product is sent to storage. Oversized material is recycled to the pulverizer and undersized to the granulator.

(2) Basic GTSP Process--Two methods for the direct production of GTSP are currently available: 1) Dorr-Oliver slurry granulation process and 2) TVA one-step granulation process. Direct granulation using the Dorr-Oliver process accounts for over 90% of total GTSP production, whereas the one-step process developed by the TVA during the past 10 yr to 15 yr remains experimental (4, 17, 31). The Dorr-Oliver slurry granulation process is illustrated in Figure 22 (16, 31). In this process, phosphate rock, ground to a fineness located between specific particle size levels (80% through a 150-µm screen and 95% through a 75-µm screen), is mixed with phosphoric acid in a reactor or mixing tank. The phosphoric acid used in this process is appreciably lower in concentration (40% P_2O_5) than that used in ROP-TSP manufacture because the

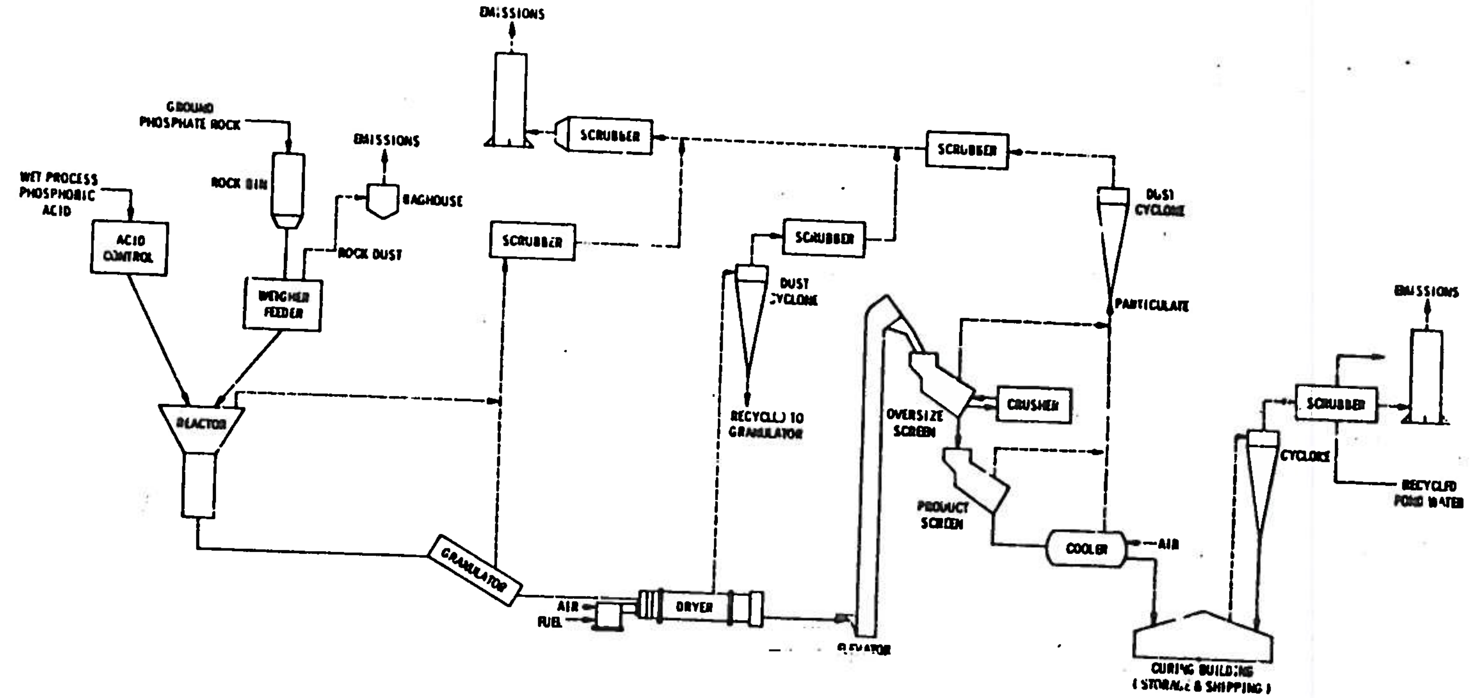

Figure 22. Dorr-Oliver slurry granulation process for TSP (16, 31).

lower strength acid maintains the slurry in a fluid state during a mixing period of 1 hr to 2 hr (17, 20, 33). A thin slurry is continuously removed and distributed onto dried, recycled fines where it coats out on the granule surfaces and builds up the granule size.

Pugmills and rotating drum granulators are used in the granulation process. A pugmill is composed of a U-shaped trough carrying twin contrarotating shafts upon which are mounted strong blades or paddles. Their action agitates, shears, and kneads the solid-liquid mix, and transports the material along the trough.

The basic rotary drum granulator consists of an open-end, slightly inclined rotary cylinder, with retaining rings at each end and a scraper or cutter mounted inside the drum shell. Drums vary in diameter from 2 m to 3 m and in length from 3 m to 6 m. A rolling bed of dry GTSP material is maintained in the unit while the liquid slurry is introduced through horizontal, multioutlet distributor pipes set lengthwise in the drum under the bed.

Slurry-wetted granules then discharge onto a rotary dryer where excess water is evaporated and the chemical reaction is accelerated to completion by the dryer heat. Dried granules are then sized on vibrating screens. Oversized particles are crushed and recirculated to the screen, while undersized (smaller than 1 mm) particles are recycled to the granulator. Product-sized (1 mm to 4 mm) granules are cooled in a countercurrent rotary drum cooler. The product is then sent to a storage pile for curing. After a curing period of 3 days to 5 days, granules are removed from storage, screened, bagged and shipped (31).

In the TVA one-step granulation process, ground phosphate rock and recycled fines are fed directly into the acidulation drum along with concentrated phosphoric acid and steam. Granulation occurs in this revolving cylindrical reactor. The use of steam accelerates the reaction and ensures an even distribution of moisture in the mix. A more concentrated phosphoric acid (containing 72.5% P_2O_5) can be used, resulting in a higher grade granular product containing about 54% available P_2O_5 (32). After granulation occurs in the reaction cylinder, granules are screened, cooled, and sent to storage in a manner similar to that described for the Dorr-Oliver process.

Emissions of fluorine compounds, SO_x, and dust particles occur during the production of GTSP by the Dorr-Oliver process (16, 31). Silicon tetrafluoride and hydrogen fluoride are released by the acidulation reaction and evolve from the reactor, granulator,

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(33) Final Guideline Document: Control of Fluoride Emissions From Existing Phosphate Fertilizer Plants. EPA-450/2-77-005 (PB 265 062), U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, March 1977. 277 pp.

dryer, and cooler. Evolution of fluorides continues at a lower rate in the curing building as the reaction proceeds. SO_x enter the dryer exhaust stream as a result of the sulfur composition of the fuel oil. Sources of particulate emissions include the reactor, granulator, dryer, cooler, screens, mills, and transfer conveyors. Additional emissions of particulate result from the unloading, storage, and transfer of ground phosphate rock.

At a typical plant, emissions from the reactor and granulator are controlled by scrubbing the effluent gas with recycled pond water. Emissions from the dryer, cooler, screens, mills, product transfer systems, and storage building are sent to a cyclone separator for removal of a portion of the dust loading before being sent to wet scrubbers (31). Baghouses are used to control the fine rock particulate caused by the preliminary ground rock handling activities.

3. Industry Characterization

For TSP production, two distinct plant types are considered: ROP-TSP and GTSP.

a. Run-of-Pile Triple Superphosphate

An average ROP-TSP plant produces 59,700 metric tons of P_2O_5 per year and is located in a county having a population density of 86.1 persons/km². Average plant production was obtained by dividing the total amount of ROP-TSP produced in 1975 (597,110 metric tons P_2O_5 per year) by the total number of ROP-TSP plants; i.e., 10.

b. Granular Triple Superphosphate

An average GTSP plant is defined as one that produces 69,100 metric tons of P_2O_5 per year by the Dorr-Oliver slurry granulation process and is located in a county having a population density of 73.8 persons/km². The average plant production rate was calculated by dividing the total amount of GTSP produced in 1975 (898,900 metric tons P_2O_5 per year) by the total number of GTSP plants; i.e., 13.

F. AMMONIUM PHOSPHATE PRODUCTION

1. Source Definition

Ammonium phosphates are produced by reacting phosphoric acid with anhydrous ammonia. Both solid and liquid ammonium phosphate fertilizers are produced in the United States. Ammoniated superphosphates are also produced by adding NSP or TSP to the mixture. In this study, only granulation of phosphoric acid with anhydrous ammonia by ammoniation-granulation to produce granular fertilizers will be discussed. An environmental source assessment of the production of liquid ammonium phosphates and ammoniated superphosphates is separately reported in Reference 5.

Approximately 99% of ammonium phosphates are used as fertilizers, with the remaining quantity consumed in fire retardants; as additives to livestock feed; in manufacture of yeast, vinegar, and bread improvers; in flux for soldering; and for sugar purification (34, 35). As fertilizers, product nutrient analyses for typical ammonium phosphates range from 11% to 21% nitrogen and 20% to 55% P_2O_5 (1). Important ammonium phosphate fertilizer grades in the United States are

Primarily monoammonium phosphates (MAP)

11-48-0   11-55-0
13-52-0   16-20-0

Primarily diammonium phosphates (DAP)

16-48-0   18-46-0

where N-P-K analysis represents

N = percentage of available nitrogen
P = percentage of available P_2O_5
K = percentage of soluble potassium oxide (K_2O)

In 1975, 84% (on a P_2O_5 basis) of the ammonium phosphates produced consisted of DAP grade (9). When used as fertilizers, ammonium phosphates are either used directly or blended with other fertilizers, either in liquid or solid form, to produce mixed fertilizers. However, due to the nature of various reporting systems and the complexity of the fertilizer industry, it is impossible to extract amounts of ammonium phosphates used for each application (5).

Emissions from production of mixed fertilizers using granular ammonium phosphates are addressed in "Source Assessment: Fertilizer Mixing Plants" (5). Consequently, this document will discuss emissions from production of granular ammonium phosphates and will encompass process operations from feeding of raw materials to loading of product for shipment.

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(34) David, M. L., J. M. Malk, and C. C. Jones. Economic Analysis of Effluent Guidelines Fertilizer Industry. EPA-230/2-74-010 (PB 241 315), U.S. Environmental Protection Agency, Washington, D.C., January 1974.

(35) The Condensed Chemical Dictionary, Eighth Edition, G. G. Hawley, ed. Van Nostrand Reinhold Company, New York, New York, 1971. p. 54.

2. Process Chemistry

The ternary solubility diagram (ammonia-phosphoric acid-water) presented in Figure 23 (36) identifies four potential anhydrous salts of ammonia and phosphoric acid having $NH_3:H_3PO_4$ mole ratios of 7:3, 2:1, 1:1, and 1:2. $NH_4H_2PO_4$ (MAP, mole ratic 1:1) and $(NH_4)_2HPO_4$ (DAP, mole ratio 2:1) are salts of commercial fertilizer importance. These desired products are obtained by operating along the solubility boundary at required conditions; i.e., operation along the segment marked DAP yields DAP, while operation along the segment marked MAP yields MAP. Lines from the solubility curve to the right-hand border on Figure 23 represent paths along which solution composition would change during crystallization or solution (36).

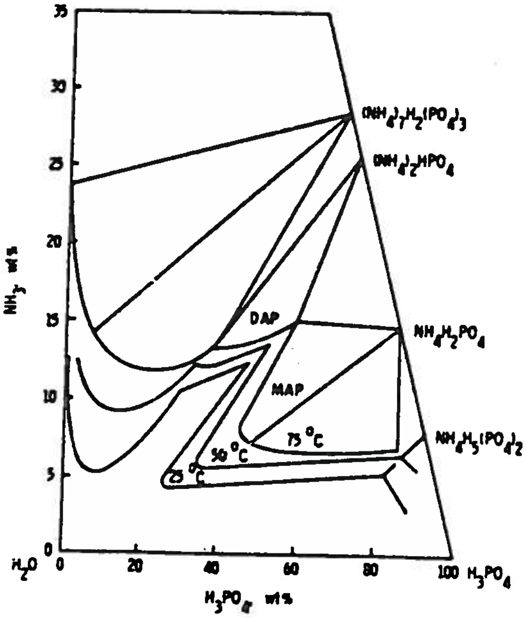

Figure 23. Solubility boundaries for the ammonia-phosphoric acid-water system (36).

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Production of commercial ammonium phosphates is based on four exothermic reactions. MAP is produced from 1 mole of phosphoric acid and 1 mole of ammonia, yielding a product having 12.2%

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(36) Chemistry and Technology of Fertilizers. V. Sauchelli, ed. Reinhold Publishing Corp., New York, New York, 1960. pp. 251-268.

nitrogen (N) and 61.7% available phosphorus (P_2O_5); i.e., 12-62-0, while releasing 105 kJ/mole (37, 38).

$$H_3PO_4 + NH_3 \longrightarrow NH_4H_2PO_4 \qquad (12)$$

DAP production combines 1 mole of phosphoric acid with 2 moles of ammonia yielding a product having 21.2% nitrogen and 53.8% available phosphorus; i.e., 21-54-0, while releasing 159 kJ/mole (37, 38).

$$H_3PO_4 + 2NH_3 \longrightarrow (NH_4)_2HPO_4 \qquad (13)$$

MAP also reacts with ammonia to produce DAP and 54 kJ/mole (37, 38).

$$NH_4H_2PO_4 + NH_3 \longrightarrow (NH_4)_2HPO_4 \qquad (14)$$

To attain various desired product analyses, sulfuric acid is added in appropriate quantities and reacts with ammonia to form ammonium sulfate and to release 138 kJ/mole (17, 37, 38).

$$H_2SO_4 + 2NH_3 \longrightarrow (NH_4)_2SO_4 \qquad (15)$$

Properties of pure crystalline MAP and DAP are listed in Table 15 (36, 37, 39) and presented in Figure 24.

Analyses of raw materials for ammonium phosphate manufacture are presented in Table 16. Ammonium phosphates can be made from either furnace process phosphoric acid or WPPA. Impurities in WPPA prevent production of fertilizers having analyses equivalent to pure MAP or DAP composition. For some products, e.g., 16-20-0, diluents such as sulfuric acid are added to phosphoric acid by design to reduce available phosphorus content of product to desired levels. Commercial grades of ammonium phosphate range from MAP grade 11-48-0 to DAP grade 18-46-0. Intermediate grades identified earlier are either mixtures of MAP and DAP or diluted MAP or DAP.

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(37) Waggaman, W. H. Phosphoric Acid, Phosphates, and Phosphatic Fertilizers, Second Edition. Reinhold Publishing Corp., New York, New York, 1952. pp. 308-344.

(38) Himmelblau, D. M. Basic Principles and Calculations in Chemical Engineering, Second Edition. Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1967. pp. 449-454.

(39) Kirk-Othmer Encyclopedia of Chemical Technology, Second Edition, Vol. 9. John Wiley & Sons, Inc., New York, New York, 1966. pp. 46-132.

TABLE 15. PROPERTIES OF PURE AMMONIUM PHOSPHATES (36, 37, 39)

Property	MAP	DAP
N, %	12.2	21.2
P_2O_5, % available	61.7	53.8
Heat of formation, kJ/mole	-1,450.8	-1,573.7
Specific gravity at 19°C	1.803	1.619
Solubility, g/100 g H_2O:		
At 20°C	37.4	69.0
At 40°C	56.7	81.0
At 75°C	108.8	108.7
Dissociation pressure, Pa:		
At 100°C	Negligible	670
At 125°C	6.7	4,000

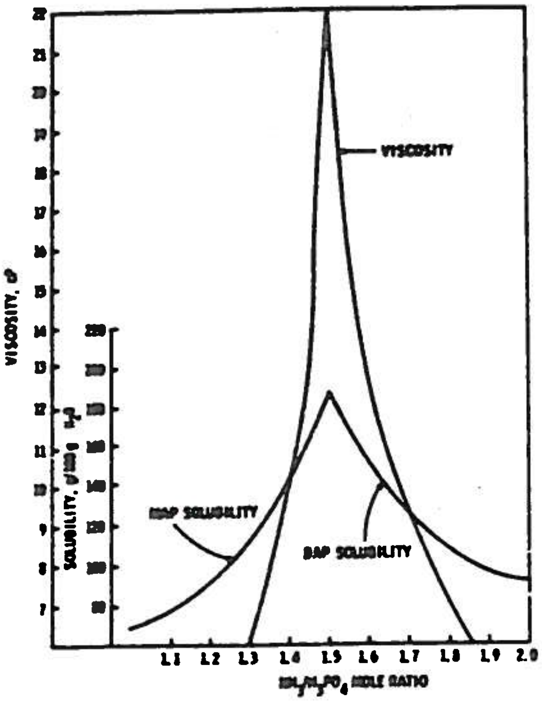

Figure 24. Ammonium phosphate solubility and viscosity as a function of NH_3:H_3PO_4 mole ratio (36).

Reprinted from The Chemistry and Technology of Fertilizers by courtesy of the American Chemical Society.

TABLE 16. COMPOSITION OF AMMONIUM PHOSPHATE RAW MATERIALS (22, 37, 40, 41)

Component	Composition, wt %			Furnace process phosphoric acid,[a] ppm
	Anhydrous ammonia	WPPA (average)		
		Filtered	Concentrated	
NH_3	99.9	-[b]		
P_2O_5		28.7	53.3	54.32 wt %
Ca		0.30	0.06	0.0
Fe		0.45	0.78	2
Al		0.29	0.52	0.0
Mg		0.13	0.26	
Cr			0.02	0.2
V			0.02	
Na		0.05	0.45	0.01 wt %
K		0.02	0.06	0.0
F		1.82	0.56	0.4
SO_3		2.11	2.3	0.0
SiO_2		0.79	0.16	0.0
C			0.24	
Solids			3.7	
Cl				2
Pb				0.2
Cu				0.1
As				

[a] Commercial food-grade phosphoric acid.

[b] Blanks indicate data not applicable.

3. Process Description

Two basic mixer designs are used by ammoniation-granulation plants: pugmill ammoniator and rotary-drum ammoniator. Approximately 95% of ammoniation-granulation plants in the United States use a rotary-drum mixer developed and patented by the TVA (5). The primary product of this technology is 18-46-0, consisting primarily of DAP. Ammonium phosphate products having a lower $NH_3:H_3PO_4$ mole ratio are made using the Dorr-Oliver process or variations of it. The degree of ammoniation utilized with this technology ranges from an $NH_3:H_3PO_4$ mole ratio of 1.0 to 1.8, and the primary product is 16-48-0, a product containing approximately one-third MAP and two-thirds DAP.

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(40) Slack, A. V. Fertilizer Developments and Trends. Noyes Development Corp., Park Ridge, New Jersey, 1968. pp. 77-274.

(41) Kirk-Othmer Encyclopedia of Chemical Technology, Second Edition, Vol. 15. John Wiley & Sons, Inc., New York, New York, 1968. p. 260.

a. TVA Process--

A general process flow diagram of the TVA ammonium phosphate process is presented in Figure 25. Phosphoric acid is mixed in an acid surge tank with 93% sulfuric acid (used for product analysis control) along with recycle and acid from wet scrubbers. Mixed acids have a P_2O_5 content of 40% to 45% (42). This analysis is attained by mixing unconcentrated filtered WPPA, 28.7% P_2O_5, and concentrated WPPA, 53.3% P_2O_5 (see Table 16) (11, 40).

Mixed acids are then partially neutralized with liquid or gaseous anhydrous ammonia in an brick-lined acid reactor. In this agitated atmospheric pressure tank, the mole ratio of $NH_3:H_3PO_4$ is maintained at 1.3:1.0 to 1.5:1.0 (16, 39, 42-44). All phosphoric acid and approximately 70% of ammonia are introduced in this vessel (45). In this molar range, ammonium phosphates are most soluble, allowing further concentration of solution while maintaining adequate flow characteristics (Figure 24). Heat of reaction is used in this vessel to maintain a temperature of 100°C to 120°C and to evaporate excess water (39, 43). A slurry which is primarily MAP and contains 18% to 22% water is produced and flows through steam-traced lines to the ammoniator-granulator (43). To assure no leakage from the reactor, the vessel is ventilated with outside air. In theory, the reactor could be designed without ventilation or atmospheric discharge, but in practice, ventilation rates of 57 to 71 m^3/min (standard conditions) are common. Ventilation rate is determined by reactor mechanical design, not process requirements (45). Ammonia-rich offgases from the reactor at 77°C to 82°C are wet scrubbed before exhausting to the atmosphere (45). Primary scrubbers use raw material-mixed acids as scrubbing liquor, and secondary scrubbers use gypsum pond water as scrubbing liquor.

The basic rotary-drum ammoniator-granulator, Figure 26, consists of an open-end, slightly inclined rotary cylinder with retaining rings at each end and a scraper or cutter mounted inside the drum

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(42) Shreve, R. N. Chemical Process Industries, Third Edition. McGraw-Hill Book Company, New York, New York, 1967. pp. 274-277.

(43) Chopey, N. P. Diammonium Phosphate: New Plant Ushers in Process Refinements. Chemical Engineering, 69(6):148-150, 1962.

(44) Vandegrift, A. E., L. J. Shannon, E. W. Lawless, P. G. Gorman, E. E. Sallee, and M. Reichel. Particulate Pollutant System Study, Vol. 3--Handbook of Emission Properties. APTD-0745 (PB 203 522), U.S. Environmental Protection Agency, Durham, North Carolina, 1971. pp. 313-335.

(45) Hardison, L. C. Air Pollution Control Technology and Costs in Seven Selected Areas. EPA-450/3-73-010 (PB 231 757), U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, December 1973. pp. 11-192.

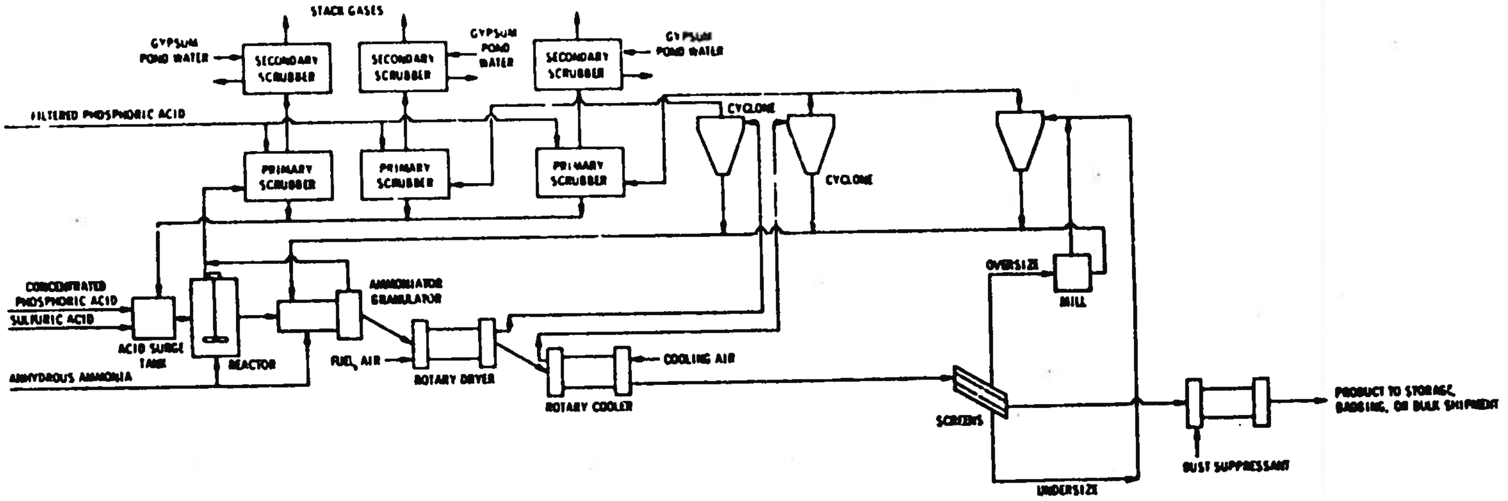

Figure 25. TVA ammonium phosphate process flow diagram.

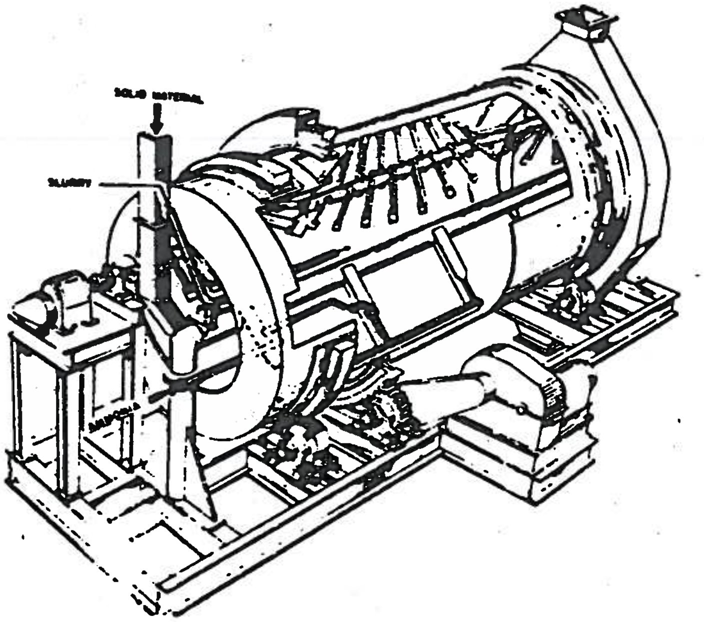

Figure 26. TVA rotary ammoniator-granulator (5).

shell. Drums vary in diameter from 2 m to 3 m and in length from 3 m to 6 m. A rolling bed of recycled solids is maintained in the unit; slurry from the reactor is distributed above the bed while the remaining ammonia (approximately 30%) is sparged underneath to bring the final NH_3:H_3PO_4 mole ratio from 1.8:1.0 to 2.0:1.0 (5, 45). Granulation by agglomeration and by coating particles with slurry takes place in the rotating drum and is completed in the dryer. Recycle rates of 2.5 to 4.0 kg recycle/kg product are typical for this type of unit (39). As with the reactor, the granulator theoretically could be designed without ventilation, but to prevent [illegible] leakage, approximately 8.5×10^{-4} m^3 (standard conditions) per metric ton P_2O_5 air inleakage into the granulator around inlet and outlet connections is allowed (45).

Temperature of granular DAP in the rotary drum reaches 85°C to 105°C, while temperature of offgases reaches 38°C to 77°C (5, 43, 45). Ammonia-rich offgases pass through a wet scrubber before exhausting to the atmosphere.

Moist DAP granules are transferred to a rotary oil- or gas-fired cocurrent dryer which reduces product moisture content to below 2%, and then product is cooled to below 35°C. Cooling minimizes caking and product dissociation during storage (see Table 15)

(43, 46). Temperature of offgases from the dryer ranges from 82°C to 104°C, and temperature of offgases from the cooler ranges from 4°C to 27°C (5, 45). Before exhausting to the atmosphere, these offgases pass through cyclones and wet scrubbers.

Cooled granules pass to a double-deck screen in which oversize and undersize particles are separated from product-sized particles (42, 47). Some plants screen the product before cooling (42, 44). DAP product ranges in granule size from 1 mm to 4 mm, with a typical product size distribution presented in Figure 27 (5, 48). The oversize are crushed, mixed with the undersize, and recycled to the ammoniator-granulator. To reduce DAP dustiness, some manufacturers coat product granules with 0.5% by weight of 10-wt lubricating oil using a rotating dust suppressant system similar to that shown in Figure 28 (46, 49). DAP is either stored, bagged, or bulk loaded for shipment.

b. Dorr-Oliver Process--

A general process flow diagram of the Dorr-Oliver process is presented in Figure 29. Phosphoric acid (24% to 36% P_2O_5) (37) or a mixture with sulfuric acid is fed to a series of agitated reactors in which acids react with liquid or gaseous anhydrous ammonia feed. The bulk of the reaction takes place in the first reactor, with additional vessels used for pH adjustment of resulting slurry (37). Reactor offgases are scrubbed with raw phosphoric acid feed prior to exhausting to the atmosphere (17).

Thick slurry from the final reactor flows to a pugmill (blunger) where recycled fines are added and product is granulated (39, 40). A blunger, Figure 30, is an inclined vessel with parallel contrarotating shafts having blades to facilitate slurry mixing and progress through the vessel. Recycle ratios range from 6 to 12 kg recycle/kg product (37, 39). These ratios are higher than those for processes having further ammoniation during granulation for two reacons: 1) less water is evaporated in the blunger

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(46) Achorn, F. P., and H. L. Balay. Systems for Controlling Dust in Fertilizer Plants. In: TVA Fertilizer Conference, Tennessee Valley Authority Bulletin Y-78, Muscle Shoals, Alabama, August 1974. pp. 55-62.

(47) Phosphate Fertilizer Plants Final Guideline Document Availability. Federal Register, 42(40):12022-12023, 1977.

(48) Hoffmeister, G. Quality Control in a Bulk Blending Plant. In: TVA Fertilizer Bulk Blending Conference, Tennessee Valley Authority Bulletin Y-62, Muscle Shoals, Alabama, August 1973. pp. 59-70.

(49) Barber, J. C. Environmental Control in Bulk Blanding Plants. 1. Control of Air Emissions. In: TVA Fertilizer Bulk Blending Conference, Tennessee Valley Authority Bulletin Y-62, Muscle Shoals, Alabama, August 1973. pp. 39-46.

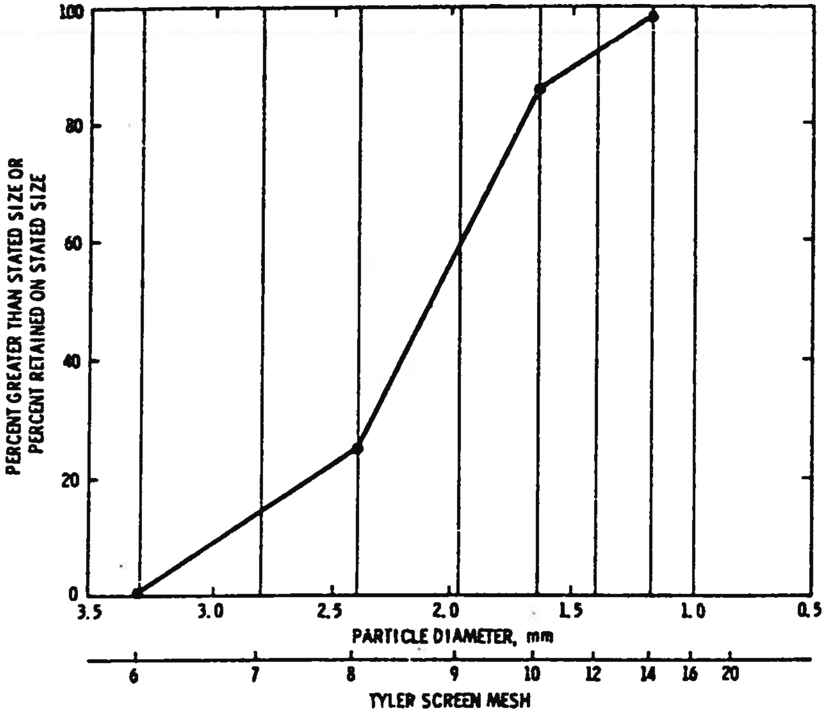

Figure 27. Cumulative screen analysis of DAP (48).

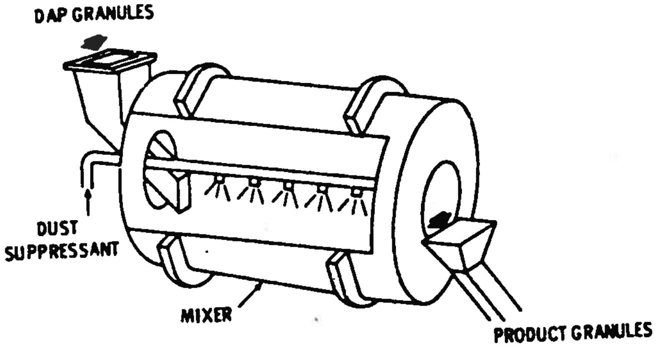

Figure 28. Product dust control system (49).

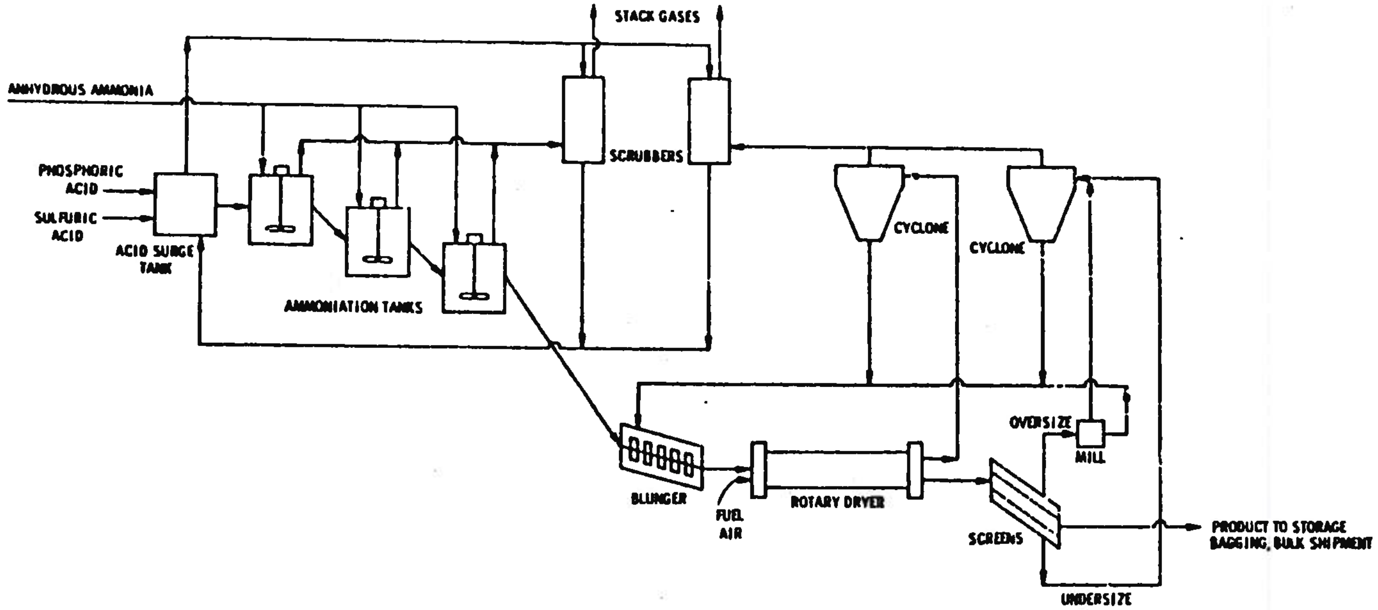

Figure 29. Dorr-Oliver ammonium phosphate process flow diagram.

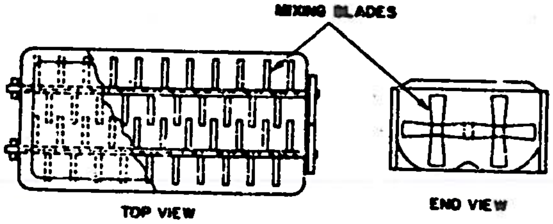

Figure 30. Diagram of pugmill (blunger); top and end views (1).

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during granulation and 2) at a lower $NH_3:H_3PO_4$ mole ratio, product slurry has higher solubility (see Figure 24) (39).

Slurry-coated granules are then dryed in a cocurrent rotary dryer. Product is then sized, e.g., 2.4 mm to 1.7 mm granules, and oversize are crushed, mixed with undersize, and recycled to the blunger (36). Product is sent to bulk storage for bagging or bulk shipment. Offgases are vented to the atmosphere through a cyclone and wet scrubber (16).

4. Industry Characterization

Recent production history of the ammonium phosphate fertilizer industry is presented in Figure 31. Reported production data are for MAP and DAP materials and their processed combinations with ammonium sulfate. Ammonium phosphates produced in combination with potash salts to make complete mixtures are excluded. Also excluded are nitrophosphates, calcium metaphosphates, sodium phosphates, and wet-base goods (made by treating phosphate rock and some organic nitrogenous materials with sulfuric acid) (9).

All production and capacity data in this report are presented as metric tons of P_2O_5. The relationship between metric tons of P_2O_5 and metric tons of gross fertilizer product is a function of fertilizer nutrient analysis and is therefore variable from plant to plant and within each plant as a function of time. A general conversion factor for the entire industry in 1975 was (see Appendix A) (50-61).

$$\text{Gross fertilizer (metric tons)} = 2.49[P_2O_5 \text{ (metric tons)}] \qquad (16)$$

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(49) Inorganic Fertilizer Materials and Related Products. M28B(75)-11, U.S. Department of Commerce, Washington, D.C., January 1976. 6 pp.

(50) Inorganic Fertilizer Materials and Related Products. M28B(75)-12, U.S. Department of Commerce, Washington, D.C., February 1976. 6 pp.

(continued)

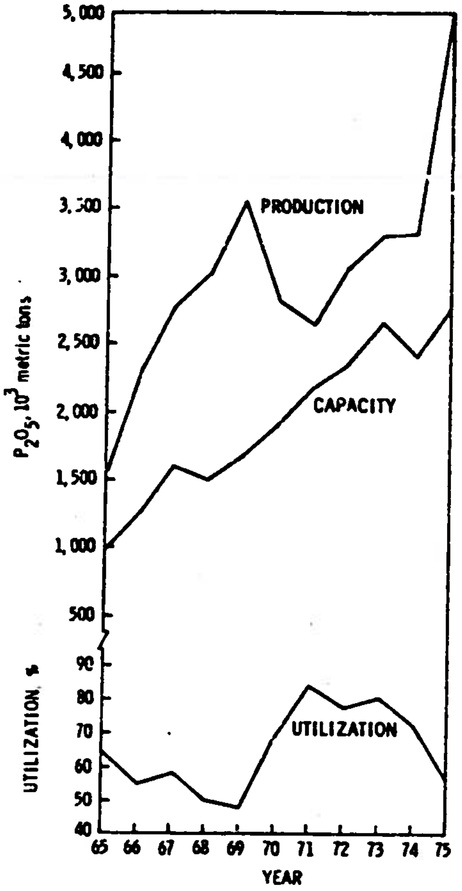

Figure 31. Recent history of ammonium phosphate capacity and production (7, 9-11, 34).

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(52) Inorganic Fertilizer Materials and Related Products. M28B(76)-1, U.S. Department of Commerce, Washington, D.C., March 1976. 6 pp.

(53) Inorganic Fertilizer Materials and Related Products. M28(76)-2, U.S. Department of Commerce, Washington, D.C., April 1976. 6 pp.

(54) Inorganic Fertilizer Materials and Related Products. M28(76)-3, U.S. Department of Commerce, Washington, D.C., May 1976. 6 pp.

(55) Inorganic Fertilizer Materials and Related Products. M28(76)-4, U.S. Department of Commerce, Washington, D.C., June 1976. 6 pp.

(56) Inorganic Fertilizer Materials and Related Products. M28(76)-5, U.S. Department of Commerce, Washington, D.C.,

(continued)

From 1965 to 1975, ammonium phosphate production grew from 0.983 x 10^6 metric tons P_2O_5 to 2.767 x 10^6 metric tons P_2O_5 (an annual growth rate of approximately 11%), while capacity grew from 1.512 x 10^6 metric tons P_2O_5 to 4.926 x 10^6 metric tons P_2O_5 (an annual growth rate of approximately 12%). Over that period, plant utilization rates varied from 47% to 83%, ending in 1975 at 56%. For the period 1970 to 1975, the average annual utilization rate was 73%.

In 1975, 35 companies in the United States operated 48 ammonium phosphate plants in 17 states (see Appendix A). Distribution of plants and capacity by state in Table 17 (7, 10, 11) indicates that Florida is the largest ammonium phosphate-producing state (25% of plants nationally having 43% of national capacity). Florida and Louisiana, with 35% of ammonium phosphate plants, have 67% of national capacity. As shown in Table 18, 8 of the 35 companies have an annual capacity of over 200,000 metric tons P_2O_5; combined, they represent 64% of total national capacity.

A cumulative distribution of ammonium phosphate plants and capacity in 1975 is presented in Figure 32. The distribution shows that many small plants collectively represent a small fraction of capacity while a few large plants represent a large fraction of capacity. From the graph, 50% of the plants each have annual capacity of less than approximately 65,000 metric tons P_2O_5, but these plants represent only approximately 15% of total national capacity. Conversely, 50% of national capacity is represented by plants each having annual capacity of less than approximately 180,000 metric tons P_2O_5. Approximately 83% of plants are below this size. Mean plant capacity in 1975 was 103,000 metric tons P_2O_5.

(continued)

July 1976. 6 pp.

(57) Inorganic Fertilizer Materials and Related Products. M28(76)-6, U.S. Department of Commerce, Washington, D.C., August 1976. 6 pp.

(58) Inorganic Fertilizer Materials and Related Products. M28(76)-7, U.S. Department of Commerce, Washington, D.C., September 1976. 6 pp.

(59) Inorganic Fertilizer Materials and Related Products. M28(76)-8, U.S. Department of Commerce, Washington, D.C., October 1976. 6 pp.

(60) Inorganic Fertilizer Materials and Related Products. M28(76)-9, U.S. Department of Commerce, Washington, D.C., November 1976. 6 pp.

(61) Inorganic Fertilizer Materials and Related Products. M28(76)-10, U.S. Department of Commerce, Washington, D.C., December 1976.

TABLE 17. 1975 DISTRIBUTION OF AMMONIUM PHOSPHATE CAPACITY BY STATE (7, 10, 11)

State	Capacity, 10^3 metric tons P_2O_5	Percent of national capacity	Number of plants
Florida	2,101	43	12
Louisiana	1,173	24	5
Texas	293	6	4
Idaho	262	5	4
Iowa	228	5	2
Mississippi	139	3	1
California	118	2	7
Illinois	114	2	1
North Carolina	92	2	1
Alabama	86	2	2
Missouri	84	2	1
Utah	65	1	2
Minnesota	63	1	1
Arkansas	45	1	1
Washington	27	<1	1
Michigan	25	<1	2
Arizona	11	<1	1
Total	4,926	100	48

TABLE 18. COMPANIES HAVING AMMONIUM PHOSPHATE CAPACITY $\geq$200,000 METRIC TONS P_2O_5 IN 1975 (7, 10, 11)

Company	Capacity, 10^3 metric tons P_2O_5	Percent of national capacity
CF Industries, Inc.	827	17
Williams Companies, Agrico Chemical Co., Subsidiary	729	15
Beker Industries	328	7
Occidental Petroleum Corp., Occidental Chemical Co., Subsidiary	300	6
Gardinier, Inc.	272	6
Farmland Industries, Inc.	248	5
IMC Chemicals Corp.	227	5
Olin Corp.	209	4

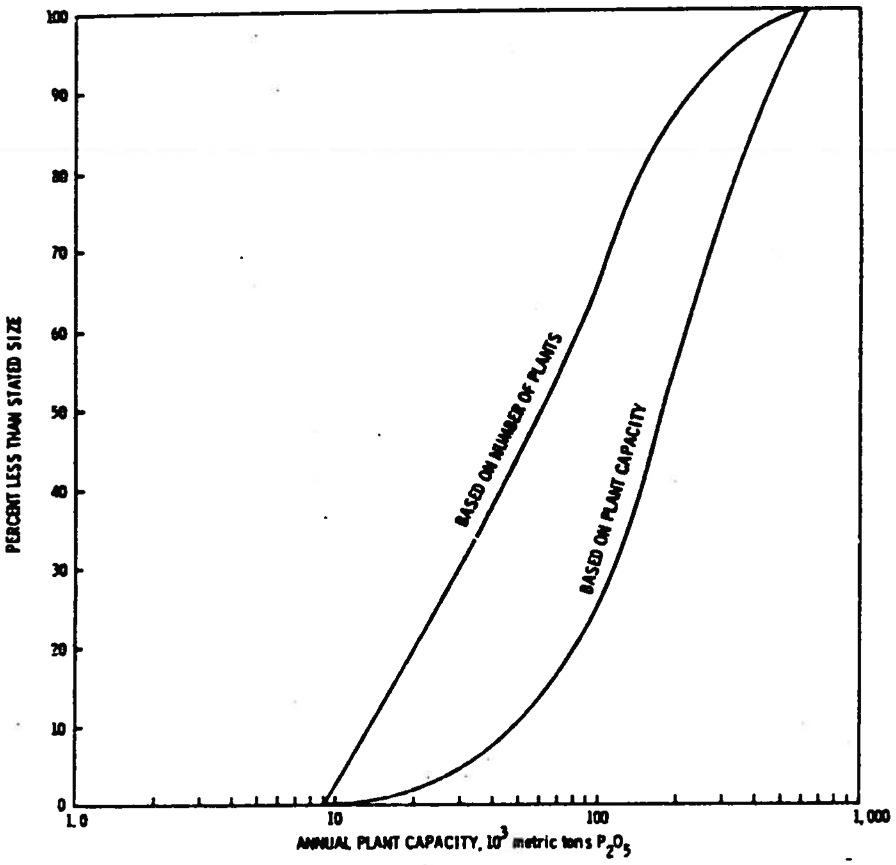

Figure 32. Cumulative distribution of ammonium phosphate plants and capacity in 1975 (7, 10, 11).

As previously mentioned, DAP production using TVA technology with WPPA is representative of the ammonium phosphate industry. An average DAP plant is similar to the one illustrated in Figure 25 and has average parameters. The average plant has a capacity of 103,000 metric tons/yr P_2O_5 and an average annual utilization factor of 73%, yielding an annual production rate of 75,000 metric tons P_2O_5 (Appendix A).

Ammonium phosphate production facilities are located in counties with population densities ranging from 1 person/km² to 1686 persons/km² (Appendix A).

The average plant is located in a county with a population density of 82 persons/km² based on a plant capacity weighted average.

SECTION 4

AIR EMISSIONS

A. WET PROCESS PHOSPHORIC ACID

Production of WPPA generates a variety of gaseous and particulate emission species. These emissions arise from five unit operations in the production process: rock unloading, rock storage and conveying, acidulation, filtration, and evaporation. These unit operations, however, release emissions to the atmosphere in only three locations, as shown in Figure 33: rock unloading, rock storage and conveying, and wet scrubber system. In this study, phosphoric acid production was defined to begin with the unloading of ground rock; however, most large plants in Florida grind their rock on site.

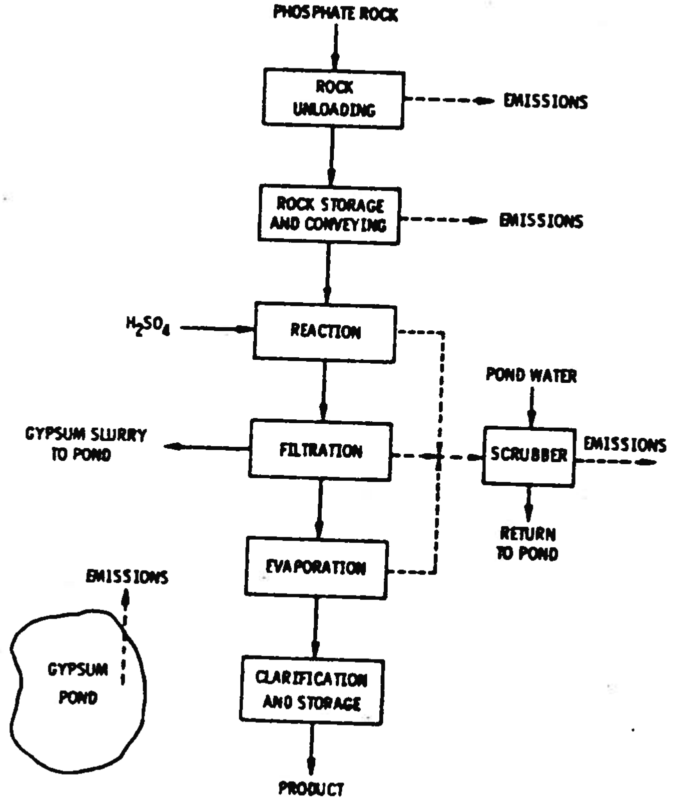

Figure 33. Schematic of emission points in WPPA manufacture.

Another source of air emissions at phosphate fertilizer plants is the gypsum pond. Water-soluble fluoride compounds are separated from phosphate rock in the reactor, and a portion is carried to the gypsum pond along with calcium sulfate from the filtration operation. Volatile fluorine compounds evolve from the pond at variable rates depending on gypsum pond characteristics.

1. Raw Materials Handling

Ground phosphate rock transported to the plant by railroad hopper cars or hopper trucks is delivered to rock storage bins and elevated feed bins by combination screw conveyors, bucket elevators, belt conveyors, and pneumatic conveyors. Elevated feed bins allow use of gravity flow to batch weigh hoppers. A small fixed hopper and oversized screw conveyor convert the batch weighings to a uniform feed to the reactor. To properly control rock dust emissions, conveyors, feeders, hoppers, and storage bins are enclosed and vented to dust abatement equipment, typically a baghouse. The unloading shed is also enclosed and equipped with a bag collector for rock recovery and particulate emissions control.

Phosphate rock is ground to 60% to 80% less than 74 µm (minus 200 mesh) for WPPA manufacture. Because no reaction has taken place, the particulate composition is that of the raw material, phosphate rock (17, 22).

Limited data exist on emissions from baghouses associated with rock handling at production facilities. However, some data concerning these emissions, available in public files from the Florida Department of Environmental Regulations, are tabulated in Appendix B.

The controlled particulate emission factor for rock unloading is 0.15 g/kg P_2O_5 ± 250% based on averaging data in Appendix B. Uncertainty associated with the emission factor is calculated using the "Student t" test at a 95% confidence level.

For rock transfer and charging to the reactor, the controlled emission factor ranges from 0.012 to 0.10 g/kg P_2O_5 with an average value of 0.045 g/kg P_2O_5 ± 180% (see Appendix B for data).

The average value and standard deviation for the height of rock unloading emissions is 12 ± 3 m. For rock transfer, the average value is 21 ± 6 m (Appendix B). These values do not necessarily represent stack heights, but an elevated point in the plant where particulates are exhausted. These values will hereafter be referred to as stack heights.

2. Wet Scrubber System

Three operations responsible for creating emission species are discussed concurrently in this section: phosphate rock acidulation, filtration and evaporation. To comply with strict criteria governing emissions, particularly of fluoride compounds, all phosphoric acid plants employ various types of wet scrubbers as control devices. Plants for which emissions data were available have these three unit operations housed under one roof, with one wet scrubber collecting emissions from the operations. For this reason, one controlled emission factor for each emission species is obtained for the multiunit process, based on an average vent height for the wet scrubber system of 29 m (Appendix B). The sources and species of emissions are described below.

a. Fluoride--

Gaseous fluoride emissions consist of silicon tetrafluoride generated in the reaction and evaporation processes. Hydrogen fluoride formed in the reactor is converted to SiF_4 according to the reaction (45):

$$4HF + SiO_2 \longrightarrow 2H_2O + SiF_4 \qquad (17)$$

The reaction favors the formation of SIF_4 at temperatures lower than 100°C.

Phosphate rock typically contains 3.0% to 4.0% (by weight) fluorine which is variably distributed in the product acid, gypsum slurry, and gaseous emissions (20). Table 19 shows two material balances depicting final distributions of the fluorine from the rock. To reduce air emissions, the plants utilize wet scrubbers. Silicon tetrafluoride is removed through reaction with water to form aqueous fluosilicic acid, and hydrogen fluoride is removed from the gaseous stream in the form of aqueous hydrofluoric acid and silicon tetrafluoride.

In 14 plants that represent approximately 50% of total phosphoric acid production, fluorine is recovered in the form of fluosilicic acid, fluorides, fluosilicates, or byproducts (7). The other 22 plants regard the fluorine materials as waste and pump the fluorine-laden scrubbing water with the gypsum slurry to the settling pond. Consequently, emission factors for total fluorine from the scrubber's gaseous exhaust stream were divided into two groups based on whether or not fluorine recovery was practiced (Appendix B). Comparison of the two sets of data indicate that the emission factors are not significantly different. For example, two plants without fluorine recovery have emissions of 0.0033 and 0.0042 g/kg P_2O_5, which compares with two plants with recovery of fluorine which have emission factors of 0.0033 and 0.0055 g/kg P_2O_5. One plant recovering fluorine has an emission factor of 0.011 g/kg P_2O_5 which compares with three plants not recovering fluorine with emission factors of 0.012 g/kg P_2O_5 and

TABLE 19. FLUORINE MATERIAL BALANCES FOR WPPA MANUFACTURE

Material balance	Fluorine, 10^6 g/day Phosphate rock	Product acid	Gypsum slurry and process H_2O	Air emission	Plant daily production, metric tons P_2O_5	Fluorine emission factor, g/kg P_2O_5
A[a]	48.3	36.5	11.8	0.004	368	0.011
B[b]	127	16.3	110.7	0.009	907	0.010

[a] Data obtained from the public files at the Florida Department of Environmental Regulations in Winter Haven, October 1976.

[b] Data from Reference 62.

one with 0.011 g/kg P_2O_5. One plant not recovering fluorine has a reported emission factor of 0.035, which is high. However, this is a very small plant with a capacity of only 6 metric tons per hour P_2O_5 and is no doubt an old plant with a less efficient scrubber. Emission factors probably depend more on the type and efficiency of scrubber used, scrubber operation, and the use of fresh water tail gas scrubbers than on whether fluorine recovery is practiced. Plants practicing fluorine recovery send less volatile fluorine to their pond systems and might have lower total fluorine emissions from their ponds.

An average emission factor for the wet scrubber system was calculated by averaging data from nine plants with 15 trains (Appendix B) with emission factors from the two material balances shown in Table 19. Controlled emission factors at individual plants range from 0.0025 to 0.035 g/kg P_2O_5. The average fluorine emission factor for the wet scrubber system, calculated by averaging all industry data, is 0.01 g/kg P_2O_5 ± 40%.

b. Particulate--

Particulate emissions generated in the reactor consist of unreacted phosphate rock, with lesser amounts of insoluble phosphate salts and calcium sulfate. This dust is physically entrained in reactor gases vented to the scrubber. Lack of data precludes estimating the relative amounts of species in particulate emissions. Some particulate matter contains silica (SiO_2) which is formed when silicon tetrafluoride reacts with water to

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(62) King, W. R., and J. K. Ferrell. Fluoride Emissions from Phosphoric Acid Plant Gypsum Ponds. EPA-650/2-74-021, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, October 1974. 329 pp.

form fluosilicic acid and silica. The fact that these emissions are insoluble in water partially explains their existence in the scrubbed vapor streams.

Source test measurements for particulate emissions range from 0.0011 to 0.17 g/kg P_2O_5 as shown in Appendix B. The average emission factor is 0.054 g/kg P_2O_5 ± 164% based on data from five plants representing 16% of total U.S. production.

c. Sulfur Oxides--
The origin of SO_x emissions in WPPA manufacture is not clear. The emissions can result from dissolved sulfur dioxide in the sulfuric acid or from reactions of the phosphate rock with sulfuric acid (12). These gases are rarely measured at acid plants.

Data from a Public Health Service document (12) and from one plant reporting SO_x emissions (Appendix B) gave a range of emission factors of 0.0077 to 0.058 g/kg P_2O_5 (see Appendix B). An average of these figures gives an emission factor of 0.032 g/kg P_2O_5 ± 240%.

d. Phosphates--
Phosphate emissions consist of phosphate rock, various phosphates, and phosphoric acid mist. During particulate analysis of stack gases, all of these emission species are collected, with various efficiencies, on the filter paper.

Emissions data were obtained from one WPPA plant. In this series of three tests (Appendix B), the filter paper was removed and the particulates and gases were passed through three water-filled gas bubblers. The solution was then analyzed for total phosphorus content and reported as grams of P_2O_5 per kilogram of P_2O_5 produced.

Comparison of these three source test measurements at one plant with the range of total particulates emitted at the other plants indicates that approximately 80% of the particulate matter consists of water-soluble phosphorus compounds.

Because phosphate emissions are in particulate form, phosphate emission factors were not separately calculated; they are included with the particulate emission factor.

3. Gypsum Pond Emissions

Emissions of volatile fluorine, hydrogen fluoride, and silicon tetrafluoride from gypsum ponds have been the subject of numerous studies (20, 62-65). An EPA report (20) presents a critical review of the major studies reporting gypsum pond fluoride emissions.

After close scrutiny of the data, emissions from gypsum ponds were found to range from 11 to 1,100 kg F/(km²-day) [0.1 to 10 lb/(acre-day)] with an average value of 220 kg F/(km²-day). This results in an emission factor of 0.025 to 2.5 g F/kg of P_2O_5 for an average plant producing 486 metric tons of P_2O_5 with a typical gypsum pond of 1.11 km². The average emission factor is 0.50 g F/kg of P_2O_5 (20).

At the end of August 1977, a field program was carried out near Bartow, Florida, with the cooperation of EPA for measuring fluoride emissions from a gypsum pond (66). Average fluoride emission rates from the pond were estimated to be in the range of 440 to 1,100 kg F/(km²-day) [4 to 10 lb/(acre-day)]. Data collected by remote optical sensing indicate that fluoride emissions from the gypsum pond consisted entirely of hydrogen fluoride. The silicon tetrafluoride concentration was below the detectable threshold of 0.5 ppb. Results from this study, however, are still preliminary and may be subject to change in the final report.

4. Emission Summary

Emission factors and stack heights for WPPA manufacture are summarized in Table 20 for each emission point. The corresponding errors are based on the "Student t" test at 95% confidence (67). Data used to generate this table are presented in Appendix B.

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(63) English, M. Fluorine Recovery from Phosphatic Fertilizer Manufacture. Chemical Process Engineering, 48(12):43-47, 1967.

(64) Bowers, Q. D. Disposal as Waste Material--U.S. Practice. in: Phosphoric Acid, Volume I, A. V. Slack, ed. Marcel Dekker, Inc., New York, New York, 1968. pp. 505-510.

(65) Huggstutler, K. K., and W. E. Starnes. Sources and Quantities of Fluorides Evolved with the Manufacture of Fertilizer and Related Products. Journal of the Air Pollution Control Association, 11(12):682-684, 1966.

(66) Preliminary Report: Remote Monitoring of Fluoride Emission from Gypsum Ponds. EPA-69/01-4145, Task 10, U.S. Environmental Protection Agency, Washington, D.C., November 1977. 35 pp.

(67) Volk, W. Applied Statistics for Engineers, Second Edition. McGraw-Hill Book Co., New York, New York, 1969. 110 pp.

TABLE 20. AVERAGE STACK HEIGHTS AND CONTROLLED EMISSION FACTORS FOR WET PROCESS PHOSPHORIC ACID AND SUPERPHOSPHORIC ACID PLANTS

Emission point	Stack height, m	Emission factor, g/kg P_2O_5		
		Total fluoride	Particulate	SO_x
Wet process phosphoric acid:				
Rock unloading	12	0	0.15 ± 250%	0
Rock transfer and conveying	21	0	0.045 ± 180%	0
Wet scrubber system:	29	0.010 ± 40%	0.054 ± 164%	0.032 ± 200%
Gypsum pond		0.025 to 2.5 avg 0.50	0	0
Superphosphoric acid:				
Wet scrubber	21	0.0073[a]	0.011 to 0.055	0

[a] Only two data points.

B. SUPERPHOSPHORIC ACID

The most popular process (at about 75% of existing plants) for dehydration of 54% P_2O_5 phosphoric acid to produce greater than 66% P_2O_5 superphosphoric acid involves the use of heat transfer surfaces. Although some (approximately 25%) manufacturers use submerged combustion, its large volume of effluent gases makes this process unattractive due to the cost of extensive scrubbing facilities. Expansion of this process is unlikely (31). Consequently, only vacuum evaporation processes are evaluated in this report.

Emission species from superphosphoric acid plants include fluorine compounds and particulates. Fluorine is evolved in the form of hydrogen fluoride. Particulates are limited to liquid phosphoric acid aerosols and mists produced by the condensation process. The falling film evaporator (see Section 3) can generate aerosols which are submicrometer in size (45).

Two plants for which fluorine emissions data were available use vacuum evaporation processes. The barometric condenser, hot well, and product cooling tank are vented to a two-state wet scrubber. Fluorine emission factors from these plants are 0.0036 and 0.011 g/kg P_2O_5, with an average value of 0.0073 g/kg P_2O_5 (Appendix B).

One plant reported particulate emissions ranging from 0.011 to 0.055 g/kg P_2O_5.

The average stack height for the plant emissions is 21 m (Appendix B). Emission factors and stack height for superphosphoric acid manufacture are included in Table 20.

C. NORMAL SUPERPHOSPHATE

Emission points at NSP production facilities include the mixer, den, and curing building. Emissions are also generated by materials storage and handling operations. A list of emission points at an average plant and corresponding emission species follows:

- Ground rock unloading and feeder system--particulate.
- Mixer and den--fluoride compounds and particulate.
- Curing building--fluoride compounds and particulate.

Particulate emissions from materials storage and handling operations result from unloading hopper-bottom railroad cars and transporting the ground phosphate rock to the superphosphate plant by screw conveyors, belt conveyors, and bucket elevators. Additional emissions issue from the product storage and curing building as a result of fertilizer handling and shipping operations within the building. Typical composition analyses of superphosphate fertilizers are given in Table 21 (13, 18, 20). Concentrations of radioactive elements in phosphate fertilizer products were reported in Table 4.

Fluorides enter the NSP production process in the phosphate rock and are released as a result of the acidulation reaction. During acidulation, the calcium fluoride content of the rock is attacked by the acid (sulfuric or phosphoric), resulting in formation of hydrofluoric acid. This in turn reacts with silica found in the rock to form silicon tetrafluoride which hydrolyzes to form fluosilcic acid. The reaction sequence leading to the formation of fluosilicic acid is given below:

$$\text{Phosphate rock} + \text{acid} \longrightarrow HF \quad (18)$$

$$4HF + SiO_2 \longrightarrow SiF_4 + 2H_2O \quad (19)$$

$$3SiF_4 + 2H_2O \longrightarrow 2H_2SiF_6 + SiO_2 \quad (20)$$

Some of the hydrogen fluoride and silicon tetrafluoride are volatilized during the process leading to fluoride emissions. Fluoride vapors that evolve as hydrogen fluoride and silicon tetrafluoride are released from the mixer, den, and curing building. Fluorine is also present as a constituent of the rock and fertilizer particulate matter. Between 1.5 kg and 9.0 kg of fluorides per metric ton of NSP (Appendix C) are relased during the production and curing operations. Emissions of fluoride and particulate from the mixer and den are controlled by scrubbing with water. Scrubber liquor may be recirculated pond water or a weak solution of fluosilicic acid. Nearly two-thirds of the NSP plants presently practice fluorine recovery, thereby eliminating or greatly reducing the need for a pond. No measurements are available for fugitive fluoride emissions from those NSP plants that make use of a pond system, but such emissions will be less than fluoride emissions from those gypsum ponds discussed in the section on WPPA manufacture.

TABLE 21. TYPICAL CHEMICAL COMPOSITION OF FLORIDA NORMAL SUPERPHOSPHATE AND TRIPLE SUPERPHOSPHATE FERTILIZER (13, 18, 20)

Component[a]	Expressed as	Units	NSP content[b]		TSP content[b]	
			Range	Average	Range	Average
Aluminum	Al_2O_3	percent	0.21 to 1.16	0.72	1.20 to 1.95	1.68
Arsenic	As	ppm	4.1 to 30.6	12.5	10.5 to 14.3	12.2
Ash (acid-insoluble)	Ash	percent	2.00 to 13.65	4.45	2.50 to 4.90	3.55
Boron	B	ppm	<3 to 30	11	29 to 115	80
Calcium, total	CaO	percent	27.20 to 31.13	29.52	16.60 to 21.57	19.65
Calcium, water soluble	CaO	percent	10.19 to 14.90	13.10	14.60 to 16.80	
Carbon, organic	C	percent	0.21 to 0.27	0.24		
Carbon dioxide	CO_2	percent	0 to 0.44	0.066	0 to 0.22	0.11
Chlorine	Cl	percent	-[c]	0.80	<0.1	
Chromium	Cr	ppm	70 to 72	71	0 to 890	513
Cobalt	Co	ppm	0 to 2.8	1.3	2.4 to 4.8	3.4
Copper	Cu	ppm	28 to 64	47	3 to 22	11
Fluorine	F	percent	1.41 to 2.15	1.74	2.00 to 3.49	2.47
Free acid	H_3PO_4	percent	1.30 to 2.15	1.71	0.19 to 3.85	2.6
Free acid-free water ratio	H_3PO_4/H_2O		0.12 to 1.19	0.58	0.06 to 1.59	0.8
Iodine	I	ppm	16 to 50	33		
Iron	Fe_2O_3	percent	0.38 to 1.37	0.67	0.92 to 2.00	1.59
Lead	Pb	ppm	8 to 20	14	0 to 65	26
Lithuim	Li	ppm	-[c]	2		
Magnesium, total	MgO	percent	0.04 to 0.12	0.07	0.05 to 1.00	0.38
Magnesium, water soluble	MgO	percent	-[c]	0.03		
Manganese	Mn	ppm	65 to 95	77	110 to 300	214
Molybdenum	Mo	ppm	-[c]	1.6	3.7 to 16.8	8.0
Nitrogen	N	percent	-[c]	0.1	0.06 to 0.40	0.26
Phosphorus, total	P_2O_5	percent	16 to 21	20	45 to 49	48
Potassium	K_2O	percent	0.16 to 0.24	0.20	0 to 0.57	0.35
Selenium	Se	ppm	0 to 1.5	0.6	-[c]	<0.8
Silicon	SiO_2	percent	4.00 to 4.54	4.35	0.60 to 7.37	4.42
Silver	Ag	ppm	15 to 20	18		
Sodium	Na_2O	percent	0.05 to 0.13	0.11	0.13 to 1.79	0.97
Sulfur, total	SO_3	percent	26.58 to 30.55	28.99	2.12 to 4.95	3.01
Sulfur, water soluble	SO_3	percent	6.37 to 13.49	10.67	1.65 to 5.77	2.98
Titanium	Ti	ppm	54 to 270	162	0 to 599	300
Vanadium	V	ppm	20 to 71	46	0 to 3,875	2,515
Water, reported as "moisture"	H_2O	percent	2.3 to 8.3	5.64	0.87 to 6.30	3.4
Water, free	H_2O	percent	1.09 to 5.71	3.65	0.88 to 4.42	2.57
Water of crystallization	H_2O	percent	2.44 to 5.14	3.55	1.29 to 6.26	3.47
Zinc	Zn	ppm	50 to 200	134	0 to 320	102

[a] Radium, uranium and thorium are reported in Table 4.

[b] Blanks indicate component not analyzed.

[c] Average based on one to two measurements.

Source test data from fertilizer plants were collected from published literature and sampling data on file as of October 1976 at the Florida Department of Environmental Regulation in Winter Haven. Raw data used to establish emission factors are given in Appendix B.

Emission factors for the emission species at NSP plants as a function of emission point are shown in Table 22. Emission factors for the mixer-den and the curing building were calculated by averaging the appropriate values in Appendix B. Data were available for only one set of four tests for controlled fluoride emissions from the product curing building. Because most (more than 85%) curing buildings remain uncontrolled, the fluoride emission factors were normalized to uncontrolled emissions using the fluoride control efficiency of 97% reported by Plant A. The low volumes of fertilizer materials handled by these storage facilities and the decline in industry production levels for NSP make control devices economically impractical.

TABLE 22. EMISSION FACTORS FOR AN AVERAGE NSP PLANT BASED ON CONTROLLED EMISSION SOURCES

	Emission factor, g/kg P_2O_5	
Emission source	Particulates	Fluorides[a]
Rock unloading	0.28[b]	-[c]
Rock feeding	0.055 ± 180%	-[c]
Mixer and den	0.26 ± 86%	0.10 ± 120%
Curing building[d]	3.6[b]	1.9 ± 120%

[a] Fluoride released as a vapor.

[b] Based on two sets of data; therefore 95% confidence limits could not be determined.

[c] Not emitted from this source.

[d] Uncontrolled emission factors since curing building emissions are not controlled at an average plant.

Particulate emissions due to the rock unloading, storage, and transfer operations and the fertilizer handling and shipping activities occurring in the product curing building were not available for NSP plants. Emission factors for the rock unloading and storage activities and for the ground rock weighers and feeders are developed in Appendix B from emission factors for similar activities occurring at GTSP production facilities. In order to obtain an estimate of the particulate emissions arising from fertilizer handling and shipping operations occurring in the curing building, two measurements for controlled particulate emissions from the combined shipping, screening, and milling of ROP-TSP were used (Appendix B).

Error limits shown in Table 22 and developed in Appendix B were established by applying a "Student t" test to the input data (66). The "t" test is applied because the sample sizes are fewer than 30 in number and thus may not be normally distributed. The statistical data used to establish the error limits are shown in Appendix B.

As an aid in determining the reliability of reported fluorine emission measurements, mass balances are developed in Appendix C for the production of NSP. Between 7.5 g F/kg P_2O_5 and 45 g F/kg P_2O_5 (depending on the fluoride concentration of the NSP product) are released during the production and curing operations. Based on data from the Florida Department of Environmental Regulation, a scrubber control efficiency of 99% for fluoride removal was used. Controlled fluoride emissions would then range from 0.07 g F/kg P_2O_5 to 0.45 g F/kg P_2O_5. This compares favorably with our values of 0.1 g F/kg P_2O_5 and 0.05 g F/kg P_2O_5 developed for controlled emissions from the mixer-den and curing building, respectively (Table 22).

D. TRIPLE SUPERPHOSPHATE

1. Run-of-the-Pile Triple Superphosphate

The process for production of ROP-TSP is similar to that for NSP. Emission points and emission species therefore closely resemble those from NSP production facilities; namely,

- Ground rock unloading and feeder system--particulate.
- Mixer and den--fluoride compounds and particulate.
- Curing building--fluoride compounds and particulate.
- Gypsum pond--fluoride compounds.

TSP manufacture differs from that of NSP in that WPPA is used for acidulation in place of sulfuric acid. As a result, fluorides enter the TSP production process not only as a constituent of the rock but also as an impurity in the phosphoric acid.

Emissions of fluorides are controlled by wet scrubbers that discharge a fluoride-containing wastewater stream to holding ponds. Water in the ponds is recycled for use in the scrubbers. Gaseous fluoride is also emitted from the ponds used as reservoirs to hold contaiminated scrubber water. The development of emission factors for the gypsum ponds is covered under WPPA manufacture, and will therefore not be considered here.

Emission factors for the emission species from ROP-TSP plants are given in Table 23. The raw data used to compile these factors are presented in Appendix B.

TABLE 23. EMISSION FACTORS FOR AN AVERAGE ROP-TSP PLANT BASED ON CONTROLLED EMISSION SOURCES

Emission source	Emission factor, g/kg P_2O_5 Particulates	Fluorides[a]
Rock unloading	0.07[b]	-[c]
Rock feeding	0.014 ± 170%	-[c]
Cone mixer, den, curing building	0.16 ± 50%	0.10 ± 40%

[a] Fluoride released as a vapor.

[b] Based on two sets of data; therefore 95% confidence limits could not be calculated.

[c] Not emitted from this source.

The fluoride emission factor in Table 23 was averaged from source test data available for Plants A and B, Appendix B. Fluoride emissions data from Plant C did not take into account emissions from the curing building and were not included in the averaging procedure. Emissions from the mixer, den, and curing building at a typical plant are vented to a common stack; therefore, individual emission factors for each source were not developed.

In order to estimate particulate emissions for mixing-denning-curing-shipping operations, source test data for mixing-denning and screening-milling at Plant C (Appendix B) were utilized. Particulate emissions data from fertilizer screening and milling operations were used in deriving the curing building emission factor, because these activities represent the major source of particulates from a curing building. Particulate emission factors for the ground rock unloading and transfer operations were developed from Appendix B using emission factors for similar activities occurring at GTSP production facilities.

An estimated 8 g F/kg P_2O_5 are released during the production and curing of ROP-TSP. This value is based on a material balance developed in Appendix C. A scrubber efficiency of 99% would result in a controlled emission factor of 0.08 g F/kg P_2O_5. This value can be compared to the average controlled emission factor of 0.10 g F/kg P_2O_5 based on actual source tests.

2. Granular Triple Superphosphate

Five plant operations release emissions at TSP plants using the Dorr-Oliver direct granulation process. They are described in detail in Section 3. The emission points and the emission species associated with each are as follows:

- Ground rock unloading and feeder system--particulate.
- Reactor and granulator--fluoride compounds and particulate.
- Dryer and cooler--SO_x, fluoride compounds, and particulates.
- Screens and oversize mills--particulate.
- Storage and shipping--fluoride compounds and particulate.

Fluorides enter the TSP process in the phosphate rock and the WPPA and are volatilized and evolved during the acidulation reaction. Evolution of fluoride vapors continues throughout the manufacturing process and during storage as the reaction proceeds to near completion. Emissions of fluorides are in the form of the water-soluble gases, silicon tetrafluoride, and hydrogen fluoride. Fluorine is also released as a constituent of the rock and fertilizer particulate matter.

An estimated 7 g of fluoride vapors per metric ton of GTSP (Appendix B) are released during production and curing. The control of fluoride emissions is accomplished by scrubbing the exhaust gas streams with recycled pond water. Fluoride emissions from gypsum ponds are considered in the section on the manufacture of WPPA.

In addition to fluoride compounds and dust particles, the dryer exhaust contains SO_x. These emissions result from the combustion of fuel oil containing sulfur.

To calculate emission factors, source test data from GTSP plants were collected from published literature and sampling data on file at the Florida Department of Environmental Regulation in Winter Haven. The raw data used to establish emission factors are given in Appendix B.

Emission factors at GTSP plants as a function of emission point are shown in Table 24. Emissions from the reactor, granulator, dryer, cooler, screens, and mills at an average plant are vented to a common stack. As a result, individual emission factors were not developed for separate segments of the production process.

There are no source test data for SO_x emissions from the dryer. Estimates of uncontrolled SO_x emissions were calculated by Plants A and E (Appendix B) on the basis of fuel oil consumption and sulfur content.

A check on the reliability of fluoride emission measurements can be made by comparing the estimated fluoride release based on a mass balance. On this basis (Appendix C), an estimated 15.2 g F/kg P_2O_5 are released during the production and curing of GTSP. A scrubber efficiency of 99% would result in a controlled emission factor of 0.152 g F/kg P_2O_5. This can be compared with the

TABLE 24. EMISSION FACTORS FOR AN AVERAGE GTSP PLANT BASED ON CONTROLLED EMISSION SOURCES

Emission source	Emission factor, g/kg P_2O_5 Particulates	Fluorides[a]	SO_x
Rock unloading	0.09[b]	-[c]	-[c]
Rock feeding	0.017 ± 180%	-[c]	-[c]
Reactor, granulator, dryer, cooler, screens	0.05 ± 320%	0.12 ± 30%	1.86[d]
Curing building	0.10 ± 240%	0.018 ± 40%	-[c]

[a] Fluoride released as a vapor.

[b] Based on two sets of data; therefore, 95% confidence limits could not be calculated.

[c] Not emitted from this source.

[d] Worst case estimate based on fuel oil sulfur content.

controlled emission of 0.156 g F/kg P_2O_5 developed by adding average measured values of 0.099 g F/kg and 0.57 g F/kg from the reactor-den and curing building, respectively.

E. AMMONIUM PHOSPHATES

Air emissions from production of ammonium phosphate fertilizers by ammoniation-granulation of phosphoric acid and ammonia result from six process operations. Emission sources and their related emission species are:

- Reactor--ammonia, fluorides.
- Ammoniator-granulator--ammonia, fluorides, particulates.
- Dryer--ammonia, fluorides, particulates, combustion gases.
- Cooler--ammonia, fluorides, particulates.
- Product sizing and material transfer--particulates.
- Gypsum pond--fluorides.

Ammonia emissions are volatilized from the reactor and ammoniator-granulator due to incomplete chemical reactions and excess free ammonia. Ammonia emitted from the dryer and cooler is due to dissocation of fertilizer product. Particulate emissions result from entrainment of MAP and DAP dusts in ventilation air streams. Particulate emission species may also include ammonium fluoride and ammonium fluosilicates (45).

Fluoride emissions originate from the fluoride content of phosphoric acid. Air emissions are formed based on the following set of equilibrium reactions:

$$H_2SiF_6 \rightleftarrows 2\ HF + SiF_4 \qquad (21)$$

$$4\ HF + SiO_2 \rightleftarrows H_2O + SiF_4 \qquad (22)$$

At operating temperatures associated with MAP and DAP production, emissions of silicon tetrafluoride are favored over hydrogen fluoride (45).

Dryer offgases contain natural gas or fuel oil combustion products. EPA found combustion product pollutants in such minor concentrations that they were dismissed from consideration during EPA's development of background information for air standards for the phosphate fertilizer industry (31). Therefore, these emission species will not be considered further in this study.

Emissions from the first five emission points reach the atmosphere through a stack, while gypsum pond emissions are fugitive. Although there are six emission sources, there may be fewer emission points because some plants combine flue gases from multiple sources for subsequent emission control.

Emission factors were developed for air emission species from each emission point from data in published literature and from sampling data on file at the Florida Department of Environmental Regulation, Winter Haven, Florida. Raw data used to calculate emission factors were compiled and are presented in Appendix B. Emission factors are reported in the literature in units of grams per kilogram of P_2O_5 input, grams per kilogram of P_2O_5 output, and grams per kilogram of product. All P_2O_5, except losses due to emissions, is assumed to reach the product. Therefore, input and output emission factors are equivalent. For those emission factors expressed as grams per kilogram of product, a 46% P_2O_5 content was assumed. All emission factors developed for this study are expressed in units of grams per kilogram of P_2O_5.

Emission factors presented in Table 25 were calculated by averaging appropriate values from Appendix B. Due to the nature of both emissions data and pollution control practices at plants, emissions from the reactor and ammoniator-granulator were combined and reported as from one emission point. Dryer and cooler emissions were treated in the same manner. Table 25 also shows 95% confidence intervals associated with each emission factor as calculated by the "Student t" method.

As Appendix B indicates, 53% of the raw data are from plants which collectively report all air emissions as "total plant" emissions. Therefore, total plant emission factors were calculated from these data and are also shown in Table 25. Because emission factors for individual emission species from the three process-related emission points are similar in magnitude to those reported as total plant emissions, a total plant emission factor for each emissions species was calculated from all data in Appendix B according to the following equation:

$$E_{Total} = \frac{\left(E_{R/A} + E_{D/C} + E_P\right)\left(N_{R/A} + N_{D/C} + N_P\right) + E_{TP}\ N_{TP}}{N_{R/A} + N_{D/C} + N_P + N_{TP}} \qquad (23)$$

TABLE 25. EMISSION FACTORS DEVELOPED FROM SOURCE TEST DATA GIVEN IN APPENDIX B

	Controlled emission factors	
Emission point[a]	Mean, g/kg P_2O_5	95% Confidence interval, % of mean
Reactor/ammoniator-granulator:		
Fluoride (as F)	0.023	±80
Particulate	0.76	±90
Ammonia	–[b]	–[b]
Dryer/cooler:		
Fluoride (as F)	0.015	±160
Particulate	0.75	±60
Ammonia	–[b]	–[b]
Product sizing and material transfer:		
Fluoride (as F)	0.001	–[c]
Particulate	0.03	–[c]
Ammonia	–[b]	–[b]
Reported as total plant emissions:		
Fluoride (as F)	0.038[d]	±30
Particulate	0.15[e]	±120
Ammonia	0.068	±75

[a] Fugitive emissions are included in the text.

[b] No information available; although ammonia is emitted from these unit operations, it is reported as a total plant emission.

[c] Emission factor represents only 1 sample.

[d] A fluoride emission guideline of 0.03 g/kg P_2O_5 input has been promulgated by EPA (47).

[e] Based on limited data from only 2 plants.

where $E_{R/A}$, $E_{D/C}$, E_P, and E_{TP} are emission factors from raw data for the reactor/ammoniator-granulator, dryer/cooler, product sizing and material transfer, and total plant, respectively. $N_{R/A}$, $N_{D/C}$, N_P, and N_{TP} are the corresponding number of samples used to generate each emission factor. This calculation results in the following total plant stack emission factors:

Particulates: 1.5 g/kg P_2O_5 ± 69%[a]

Fluoride (as F): 0.038 g/kg P_2O_5 ± 30%[b]

Ammonia: 0.068 g/kg P_2O_5 ± 75%

Information on fluoride emissions from the gypsum pond is reported in the section on WPPA manufacture. One-half of the 48 ammonium phosphate plants are located at fertilizer complexes producing WPPA. No measurements are available for fugitive fluoride emissions from ponds located at plants producing only ammonium phosphates. However, pond systems at ammonium phosphate plants not located at fertilizer complexes are proportionately smaller and would have lower fluoride emissions than those at complexes.

F. POTENTIAL ENVIRONMENTAL EFFECTS

The source assessment program employs certain criteria to help evaluate the relative impacts of the source types studied. These parameters are source severity, affected population, state and national emission burdens, and growth factor. In evaluating potential environmental effects, average parameters have been employed (e.g., emission factors, stack heights, population densities). A more detailed plant-by-plant evaluation was beyond the scope of the project and conclusions are not drawn with regards to actual environmental impacts at specific plant sites.

1. Source Severity

Source severity compares the time-averaged maximum ground level concentration of an emitted pollutant, $\overline{\chi}_{max}$, to an estimated hazard factor, F (Equation 24).

$$S = \frac{\overline{\chi}_{max}}{F} \qquad (24)$$

The hazard factor, F, is defined as the primary ambient air quality standards presently exist for particulates, sulfur oxides (SO_x), nitrogen oxidants (NO_x), carbon monoxide (CO), hydrocarbons,[c] and oxidants. For noncriteria emission species (fluoride and ammonia), F is derived from the threshold limit value (TLV®)

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[a] Estimated uncertainty based on process-related emissions.

[b] Estimated uncertainty based on total plant emissions.

[c] The value of 160 μg/m³ used for the primary ambient air quality standard for hydrocarbons in this report is a recommended guideline for meeting the primary ambient air quality standard for photochemical oxidants.

for the chemical substance (68) as TLV (8/24)(1/100). The factor 8/24 corrects for 24-hr exposure and 1/100 is a safety factor. In the calculation of source severity a conservative safety factor is used due to the lack of definitive health effects data.

The time-averaged maximum downwind ground level concentration of each emission species is given by (69):

$$\bar{\chi}_{max} = \chi_{max}\left(\frac{t_o}{t}\right)^{0.17} \qquad (25)$$

where

$$\chi_{max} = \frac{2\,Q}{\pi e \bar{u} h^2} \qquad (26)$$

and χ_{max} = short-term (i.e., 3 min) maximum ground level concentration, g/m^3

t_o = instantaneous averaging time, 3 min

t = averaging time, 1,440 min

Q = emission rate, g/s

π = 3.14

e = 2.72

$\bar{u}$ = average wind speed, m/s

h = stack height, m

For criteria pollutants, the averaging time, t, is the same as that for the corresponding ambient air quality standard. For noncriteria emission species, t is 1,440 min (24 hr). A wind speed of 4.5 m/s is used for $\bar{u}$.

The equation for χ_{max} (Equation 26) is derived from the general plume dispersion equation for an elevated source (69). For fugitive emissions occurring at ground level (i.e., from materials handling operations or from the gypsum pond), a special form of the Gaussian plume dispersion equation is developed, taking the following form (69, 70):

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(68) TLVs® Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment with Intended Changes for 1976. American Conference of Governmental Industrial Hygienists, Cincinnati, Ohio, 1976. 94 pp.

(69) Turner, D. B. Workbook of Atmospheric Dispersion Estimates. Public Health Service Publication No. 999-AP-26, U.S. Department of Health, Education, and Welfare, Cincinnati, Ohio, 1969. 62 pp.

(70) Reznik, R. B. Source Assessment: Flat Glass Manufacturing Plants. EPA-600/2-76-032b, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, March 1976. 147 pp.

$$\chi = \frac{Q}{\pi \sigma_y \sigma_z \bar{u}} \tag{27}$$

where χ = ground level downwind pollutant concentration, g/m^3
σ_y = 0.2089 $x^{0.9031}$
σ_z = 0.113 $x^{0.911}$
Q = emission rate, g/s
π = 3.14
$\bar{x}$ = average wind speed, m/s
x = radial distance downwind from the source, m

Values of x are then calculated to determine at what distance downwind from the source the severity falls below 0.05 and 1.0 for an average emission factor.

The 24-hr ambient air quality standards of 260 μg/m^3 for particulates and 365 μg/m^3 for SO$_x$ were used as hazard factors to calculate source severities. For fluoride emissions, a TLV of 2.0 mg/m^3 (based on hydrogen fluoride) was used to calculate F for use in source severity calculations. The corresponding TLV for ammonia is 18 mg/m^3 (68).

The source severity calculation does not consider the distance at which maximum ground level concentrations of an emitted pollutant occurs. In some cases, depending on individual plant layouts, the point of maximum severity may occur within plant boundaries. As mentioned earlier this parameter is used as a basis for comparing a large number of emission sources, and a detailed plant-by-plant analysis was not conducted.

a. <u>Phosphoric Acid and Superphosphoric Acid Plants</u>--
Values for $\bar{\chi}_{max}$ and S were calculated for each emission point at an average plant. These values are presented in Table 26. Source severities were also calculated for each plant based on average emission factors and stack heights. Plant production rates used in severity calculations were derived for phosphoric acid and superphosphoric acid plants by multiplying plant capacity data in Appendix A by utilization factors of 0.70 and 0.49, respectively, obtained by dividing 1975 annual productions by available industry capacities. The resulting severity distributions are presented in Figures 34, 35, and 36 for particulate emissions from rock handling operations at WPPA plants, for particulate and fluoride emissions from the wet scrubber at WPPA plants, and for fluoride emissions from superphosphoric acid plants, respectively. Each severity distribution is plotted as cumulative percent of the number of plants versus severity for each emissions species from each emission point.

Source severity distributions were not calculated for SO$_x$ emissions from the wet scrubber at WPPA plants or for particulate emissions from superphosphoric acid plants because of the smaller amount of emissions data.

TABLE 26. VALUES FOR $\bar{X}_{max}$ AND SOURCE SEVERITIES FOR EMISSIONS FROM AN AVERAGE WET PROCESS PHOSPHORIC ACID AND SUPERPHOSPHORIC ACID PLANT

	$\bar{X}_{max}$, µg/m³			Source severity		
Emission point	Total fluoride	Particulate	SO_x	Total fluoride	Particulate	SO_x
Wet process phosphoric acid:						
Rock unloading	0[a]	106	0	0[a]	0.41	0
Rock transfer and conveying	0	10.4	0	0	0.040	0
Wet scrubber system	1.2	6.5	3.9	0.18	0.025	0.011
Gypsum pond	_[b]	0	0	_[b]	0	0
Superphosphoric acid:						
Wet scrubber	0.55	2.5	0	0.09	0.01	0

[a] Zero indicates this species is not emitted from this source.

[b] Not applicable.

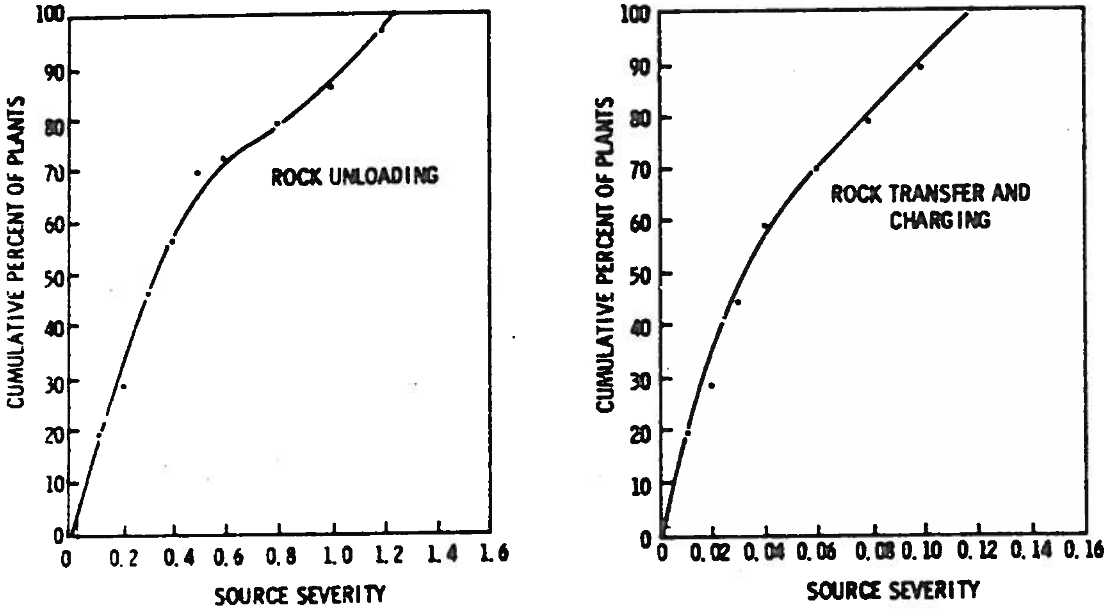

Figure 34. Source severity distribution of particulate emissions from rock handling operations at WPPA plants.

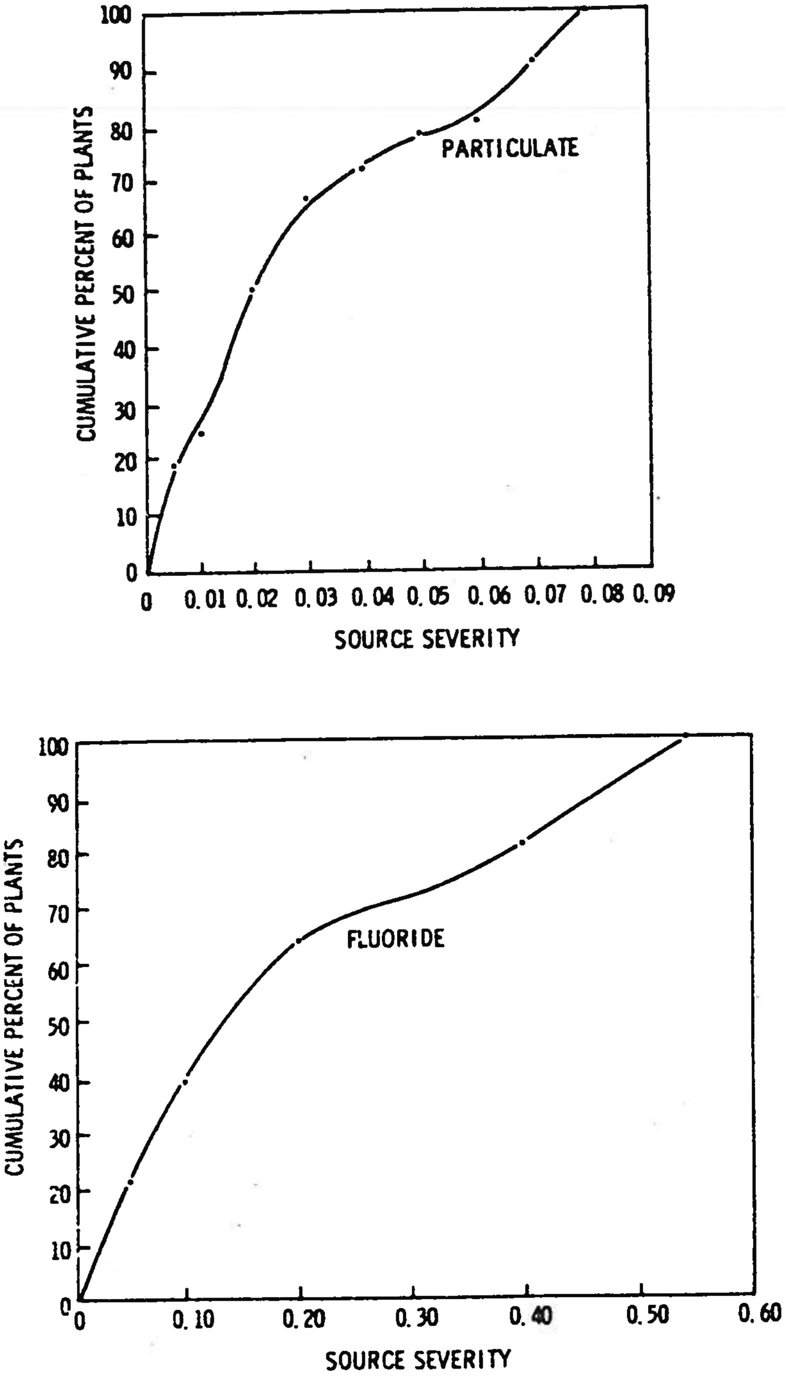

Figure 35. Source severity distribution of particulate and fluoride emissions from the wet scrubber at WPPA plants.

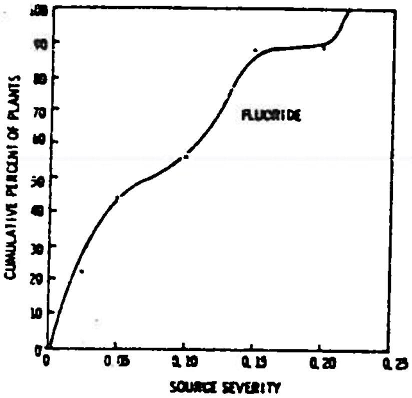

Figure 36. Source severity distribution of fluoride emissions from superphosphoric acid plants.

Because no stack height is associated with fluoride emissions from gypsum ponds, source severity had to be calculated differently. From Equations 25 and 27 and for 24-hr averaging times, the value of $\bar{\chi}$ divided by F yielded the graph shown in Figure 37. Dashed lines give the change in $\bar{\chi}$/F with distance from the center of a typical gypsum pond for emission rates of 11 and 1,100 kg F/(km²-day) [0.1 and 10 lb/(acre-day)]. The solid line is for an average emission factor of 220 kg F/(km²-day). Fluoride emissions from the gypsum pond are treated as a point source located at the center of the pond and represent a worst case analysis. Note that the value of $\bar{\chi}$/F falls below 1.0 at approximately 1300 m from the center of the pond for an average emission rate, and it falls below 0.05 at approximately 6700 m. A severity distribution for fluoride emissions from the gypsum pond at individual WPPA plants is presented in Figure 38, based on an average emission factor. Table 27 presents severity ranges for each species and emission point and also shows the percentage of plants having a source severity exceeding 0.05 and 1.0.

b. Normal Superhphosphate and Triple Superphosphate Plants--Table 28 presents the values of $\bar{\chi}_{max}$ and S for each emission point and for each emission species from three average superphosphate plants. Values are based on the current level of emission control at these plants.

Average stack heights in Table 28 were developed from stack heights for individual plants reported in Appendix B. A stack height of 15 m was determined from plant data for emissions from the baghouses controlling rock unloading and transfer operations. Emissions from the NSP curing building at an average plant are not controlled; they are exhausted from the building by ducts along one side. The height of the curing building, 12 m, was therefore used as the stack height for this source.

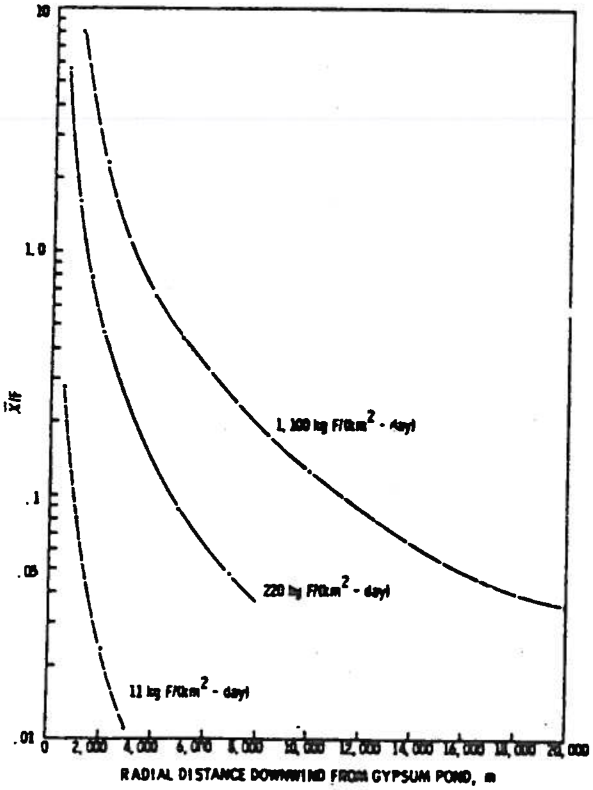

Figure 37. $\overline{\chi}/F$ as a function of radial distance downwind from gypsum pond.

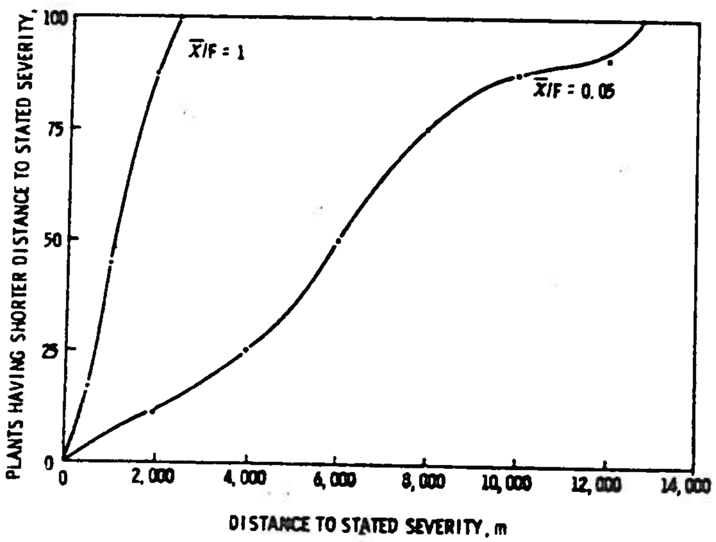

Figure 38. Distribution of distance to stated severity for fluoride emissions from the gypsum pond at WPPA plants.

TABLE 27. RANGE OF SOURCE SEVERITIES AND PERCENTAGE OF WET PROCESS PHOSPHORIC ACID AND SUPERPHOSPHORIC ACID PLANTS HAVING SEVERITIES GREATER THAN 0.05 OR 1.0

Emission point	Species	Source severity, S Minimum	Source severity, S Maximum	Percentage of plants $S > 0.05$	Percentage of plants $S > 1.0$
Wet process phosphoric acid:					
Rock unloading	Particulate	0.011	1.26	86	14
Rock transfer and conveying	Particulate	0.001	0.12	28	0
Wet scrubber system	Particulate	<0.001	0.078	19	0
	Total fluoride	0.005	0.56	78	0
	SO_x	<0.001	0.01	–[a]	–[a]
Superphosphoric acid:					
Wet scrubber	Particulate	<0.001	<0.001	–[a]	–[a]
	Total fluoride	0.01	0.32	65	0

[a] Distribution was not calculated because of the small amount of emissions data available.

TABLE 28. MAXIMUM GROUND LEVEL CONCENTRATIONS AND SOURCE SEVERITIES OF CONTROLLED EMISSION SPECIES FROM AVERAGE SUPERPHOSPHATE PLANTS

Emission source category	Average stack height, m	$\bar{X}_{max}$, µg/m³ Fluoride	$\bar{X}_{max}$, µg/m³ SO_x as SO_2[a,b]	$\bar{X}_{max}$, µg/m³ Particulate	S Fluoride[c]	S SO_x as SO_2[a,b]	S Particulate[b]
NSP plants:							
Rock unloading	15	–[d]		4.9			0.02
Rock feeders	15			1.0			0.004
Mixer and den	18	1.2		3.0	0.18		0.01
Curing building[e]	12	50		92	7.2		0.35
GTSP plants:							
Rock unloading	15			16			0.062
Rock feeders	15			3.0			0.012
Reactor, granulator, screen, cooler, dryer	44	2.5	39	1.1	0.36	0.11	0.0042
Curing building	30	0.81		4.6	0.12		0.018
ROP-TSP plants:							
Cone mixer, den, storage building	26	5.3		8.1	0.77		0.031
Rock feeders	15			2.2			0.009
Rock unloading	15			11			0.042

[a] For worst case analysis, based on uncontrolled emission factor.

[b] Primary ambient air quality 24-hr standard for particulates equals 0.26 mg/m³; for SO_x it equals 0.365 mg/m³.

[c] TLV equals 2.0 mg/m³; F equals 6.7 µg/m³. [d] Blanks indicate emission species not emitted from the source category.

[e] Uncontrolled emissions.

To complement the source severity values based on plants representative of the industry, source severity distributions for the whole industry were calculated for all species emitted from each emission point. Plant production rates used in severity calculations were derived by multiplying plant capacity data in Appendix A by utilization factors of 0.66 and 0.65 for normal superphosphate and triple superphosphate plants, respectively, obtained by dividing 1975 productions by available industry capacities. Where actual stack heights were unknown, the average stack heights shown in Table 28 were used. A graphic representation of this result is shown in Figure 39, presented as the cumulative percent of plants with a source severity less than a specific value. Those emission points and associated emission species not illustrated in Figure 39 had source severities for all plants less than 0.01. Table 29 presents severity ranges for each species and each emission point and also shows the percentage of plants having a source severity exceeding 0.05 and 1.0.

Because no source test data were available for SO_x emissions from the dryer at GTSP plants, an emission factor was developed based on fuel analysis and consumption. Values of $\bar{\chi}_{max}$ and S for SO_x emissions are based on a worst case analysis assuming no control, even though some control results when effluent gas streams are scrubbed by acidic pond water before discharge.

c. Ammonium Phosphate Plants--

Table 30 presents values for $\bar{\chi}_{max}$ and source severity for stack emissions from an average plant. Although some plants have multiple emission points, this evaluation sums all stack emission factors and assumes a single emission point having a stack height of 24 m. This simplification can be justified by examining the variation in stack heights from individual emission points in Table 31 (71). Variation in stack heights between emission points is well within one standard deviation of the mean.

In order to illustrate potential environmental impact of air emissions from the entire industry, source severity distributions were calculated and are presented in Figures 40 through 42.

Table 32 presents severity ranges for each species and each emission point and also shows the percentage of plants having a source severity exceeding 0.05 and 1.0.

2. Total Emissions

Potential environmental effects of the emissions from phosphate fertilizer plants can also be evaluated by determining the total

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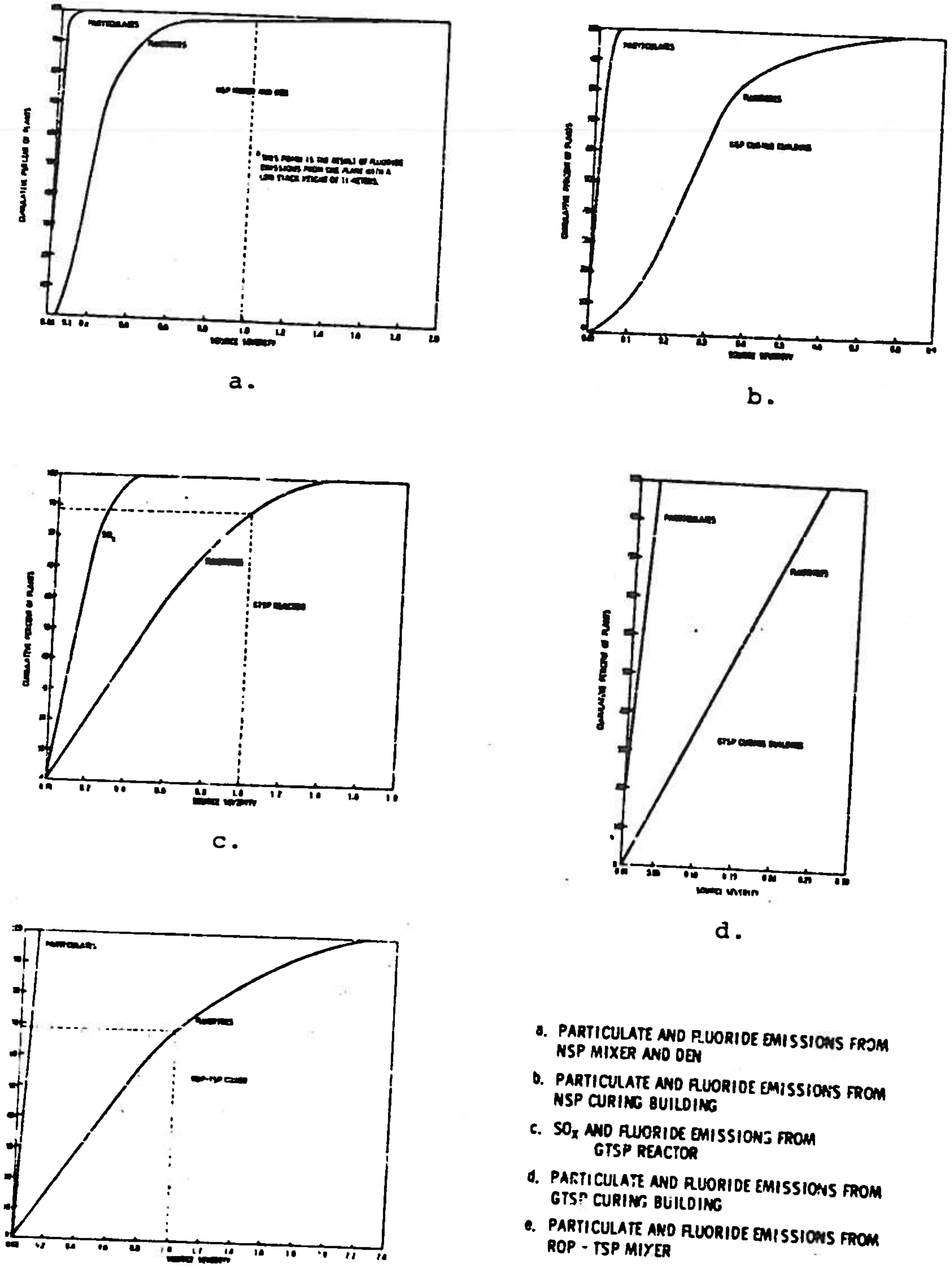
(71) National Emissions Data System Point Source Listing. SCC 3-01-030-01, 3-01-030-02, 3-01-030-99, 1976. 190 pp.



a.

b.

c.

d.

e.

a. PARTICULATE AND FLUORIDE EMISSIONS FROM NSP MIXER AND DEN

b. PARTICULATE AND FLUORIDE EMISSIONS FROM NSP CURING BUILDING

c. SO_x AND FLUORIDE EMISSIONS FROM GTSP REACTOR

d. PARTICULATE AND FLUORIDE EMISSIONS FROM GTSP CURING BUILDING

e. PARTICULATE AND FLUORIDE EMISSIONS FROM ROP - TSP MIXER

Figure 39. Cumulative source severity distributions.

TABLE 29. RANGE OF SOURCE SEVERITIES AND PERCENTAGE OF PLANTS HAVING SEVERITIES GREATER THAN 0.05 OR 1.0

Emission point	Species	Source severity		Percentage of plants	
		Minimum	Maximum	S > 0.05	S > 1.0
NSP:					
Rock unloading	Particulate			0	0
Rock feeding	Particulate			0	0
Mixer and den	Particulate	0.0036	0.13	3	0
	Fluoride	0.054	1.93	100	2
Curing building	Particulate	0.0046	0.057	2	0
	Fluoride	0.011	0.82	95	0
ROP-TSP:					
Rock unloading	Particulate			0	0
Rock feeding	Particulate			0	0
Cone mixer, den, curing building	Particulate	0.0065	0.093	30	0
	Fluoride	0.16	2.28	100	60
GTSP:					
Rock unloading	Particulate			0	0
Rock feeding	Particulate			0	0
Reactor, granulator, dryer, cooler, screens	Particulate			0	0
	Fluoride	0.063	1.45	100	12
	SO_x	0.018	0.41	76	0
Curing building	Particulate	0.0038	0.035	0	0
	Fluoride	0.027	0.25	85	0

NOTE.—Blanks indicate that the source severity for all plants is less than 0.01.

TABLE 30. MAXIMUM GROUND LEVEL CONCENTRATION AND SEVERITY FOR AN AVERAGE DAP PLANT

Species	Stack emissions from total plant		
	TLV, mg/m³	$\bar{\chi}_{max}$, μg/m³	S
Fluoride (as F)	2.0	2.9	0.44
Particulate	0.26[a]	110	0.43
Ammonia	18	5.2	0.09

[a] Primary ambient air quality standard.

TABLE 31. VARIATION IN EMISSION SOURCE STACK HEIGHTS (71)

Source	Mean stack height, m	Standard deviation, m
Ammoniation-granulation	25[a]	9.4
Cooler/dryer	23[b]	9.3
Combined all stack height data	24	9.3

[a] Average of 49 stack heights.

[b] Average of 51 stack heights.

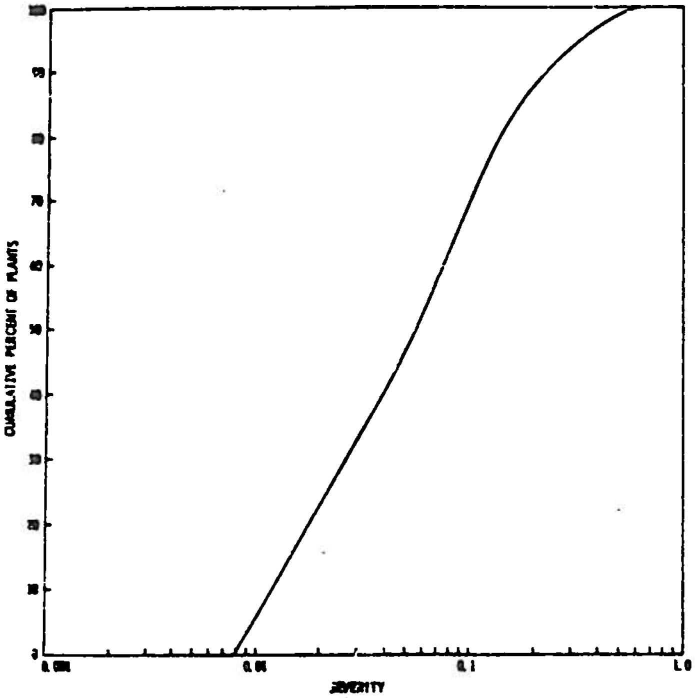


Figure 40. Severity distribution for total plant ammonia emissions.

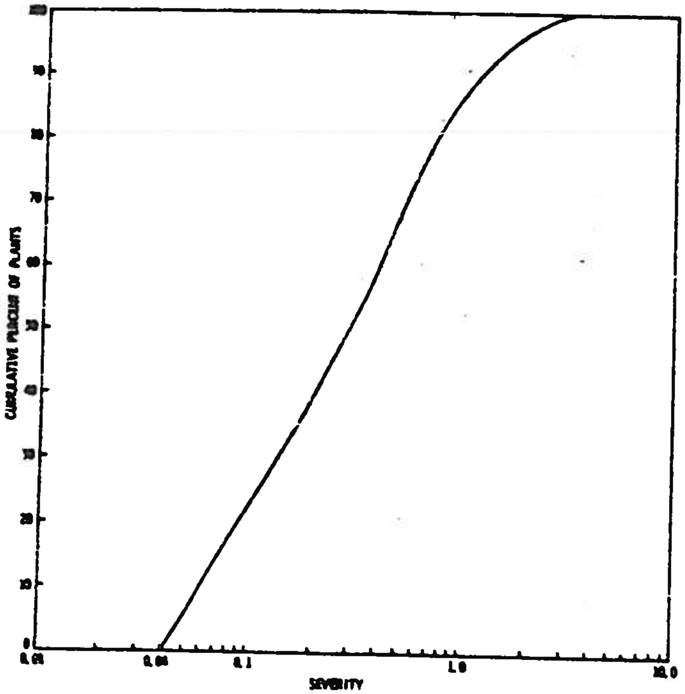


Figure 41. Severity distribution for total plant particulate emissions.

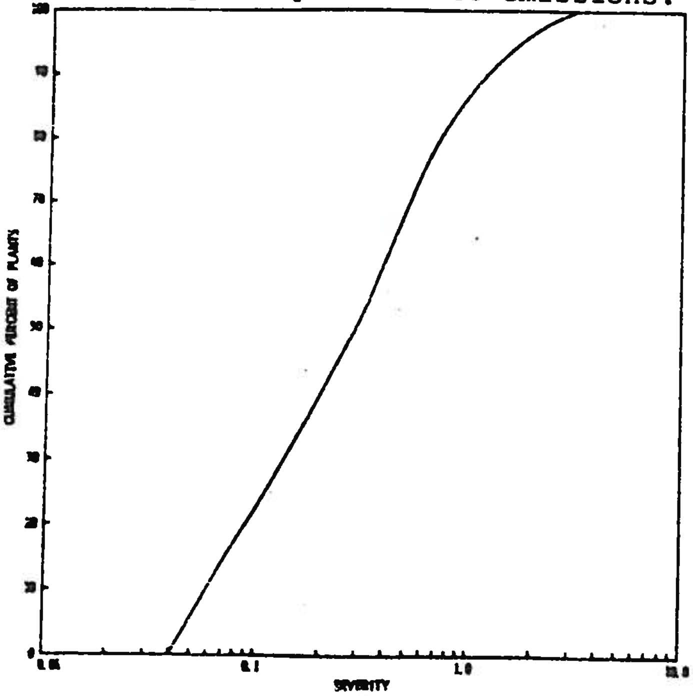


Figure 42. Severity distribution for total plant fluoride emissions.

TABLE 32. SEVERITY DISTRIBUTION SUMMARY

Emission point	Species	S Minimum	S Maximum	Percentage of plants S > 0.05	Percentage of plants S > 0.1
Total plant	Fluoride (as F)	0.04	2.9	90	10
	Particulate	0.04	2.9	90	10
	Ammonia	0.008	0.59	52	0

mass of each emission species emitted. A comparison with total particulate and SO_x emissions on a state-by-state and national basis can be made. Table D-1 in Appendix D shows the state emission burdens for the five criteria pollutants as reported in the National Emissions Data System (NEDS) (72). Table D-2 in Appendix D is an updated version of the NEDS data as computed by Monsanto Research Corporation under contract with EPA (73). Table D-2 was used for computations shown in Tables 33 through 39, which are presented and discussed later in this report.

a. Phosphoric Acid and Superphosphoric Acid Plants--Total emissions from WPPA and superphosphoric acid manufacture are shown in Table 33. These were calculated by multiplying each emission factor at an emission point (Table 20) by the 1975 total annual production for the two chemicals: 6,291,000 metric tons for WPPA and 506,000 metric tons for superphosphoric acid.

The masses of emissions for criteria pollutants at WPPA (particulates and SO_x) and superphosphoric acid (particulaes) plants were calculated on a state-by-state basis for comparison with each state's total emissions burden. The resulting percentage of state burden for the industries and the contribution to the national burden are shown in Tables 34 and 35. The total mass of fluoride on a state-by-state basis is also included in the tables for completeness.

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(72) 1972 National Emissions Report; National Emissions Data System (NEDS) of the Aerometric and Emissions Reporting System (AEROS). EPA-450/2-74-012, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, June 1974. 422 pp.

(73) Eimutis, E. C., and R. P. Quill. State-by-State Listing of Source Types that Exceed the Third Decision Criterion, Special Project Report. Contract 68-02-1874, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, July 7, 1975. pp. 1-3.

TABLE 33. TOTAL ANNUAL MASS OF EMISSIONS FROM WET-PROCESS PHOSPHORIC ACID AND SUPERPHOSPHORIC ACID PLANTS
(metric tons per year)

Emission point	Total fluoride	Particulate	SO_x
Wet process phosphoric acid:			
Rock unloading	0	912	0
Rock transport	0	281	0
Wet scrubber system	62	342	198
Gypsum pond	160 to 16,000	0	0
Superphosphoric acid:			
Wet scrubber	3.7	5.7 to 28	0

TABLE 34. WPPA INDUSTRY CONTRIBUTIONS TO STATE AND NATIONAL ATMOSPHERIC EMISSIONS

State	Number of plants	Total 1975 state production, 10^3 metric tons	Mass of emissions, metric tons/yr: Total fluoride[b]	Mass of emissions, metric tons/yr: Particulate	Mass of emissions, metric tons/yr: SO_x	Percent of state and national emissions[a]: Particulate	Percent of state and national emissions[a]: SO_x
Arkansas	1	35	1.2 to 84	8.4	1.1	0.006	0.0005
California	5	140	4.9 to 350	35	4.5	0.004	0.0002
Florida	13	3,384	122 to 8,400	855	108	0.4	0.006
Idaho	3	350	12 to 840	88	11.2	0.15	0.02
Illinois	4	250	9 to 660	66	8.3	0.006	0.0002
Iowa	1	155	5.4 to 390	40	5.0	0.02	0.001
Louisiana	4	1,060	37 to 2,700	260	34	0.07	0.015
Mississippi	1	142	4.8 to 345	35	4.5	0.02	0.002
North Carolina	1	470	17 to 1,140	118	15	0.02	0.0007
Texas	2	250	8.4 to 625	63	8.0	0.01	0.0004
Utah	1	45	1.6 to 114	11.5	1.4	0.02	0.0005
United States	36	6,291	222 to 16,000	1,540	200	0.01	0.0003

[a] Total state and national emissions data used in this calculation are given in Appendix C as obtained from References 72 and 73. State emission summary data were available only for criteria pollutants, not for fluoride.

[b] The range of fluoride emissions was based on wet scrubber emission factor (0.010 g/kg P_2O_5) plus gypsum pond emission factor range (0.025 to 2.5 g/kg P_2O_5).

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(30) 1972 National Emissions Report. EPA-450/2-74-012, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, June 1974. 422 pp.

(31) Eimutis, E. C., and R. P. Quill. State-by-State Listing of Source Types that Exceed the Third Decision Criterion, Special Project Report. Contract 68-02-1874, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, July 7, 1975. pp. 1-3.

TABLE 35. SUPERPHOSPHORIC ACID INDUSTRY CONTRIBUTIONS TO STATE AND NATIONAL ATMOSPHERIC EMISSIONS

State	Number of plants	Total 1975 state production, 10^3 metric tons	Mass of emissions, metric tons/yr		Percent of state and national particulate emissions[b]
			Total fluoride[a]	Particulate	
Florida	3	220	1.6	12.1	0.005
Idaho	2	38	0.28	2.1	0.004
Louisiana	1	73	0.53	4.0	0.001
North Carolina	1	142	1.0	7.8	0.002
Texas	1	13	0.10	0.70	<0.001
Utah	1	20	0.15	1.1	0.001
United States	9	506	3.7	28	<0.001

[a] Based on upper limit emission factor of 0.055 g/kg P_2O_5.

[b] Total state and national emissions data used in this calculation are given in Appendix C as obtained from References 72 and 73. State emissions summary data were available only for criteria pollutants, not for fluoride.

b. Normal Superphosphate and Triple Superphosphate Plants--
The annual mass of emissions from all superphosphate plants in the United States is given in Table 36. A comparison with the total particulate and SO_x emissions in the United States in 1975 is included.

The mass of emissions from superphosphate plants on a state-by-state basis was also calculated, and resulting values were compared to each state's emissions burden. Tables 37, 38, and 39 show the results of this analysis.

c. Ammonium Phosphate Plants--
Mass emissions for each type of pollutant were found by multiplying average emission factors developed previously in this report by 1975 total production of 2.767 x 10^6 metric tons of P_2O_5. These values are approximately 4,150 metric tons of particulate, 105 metric tons of fluoride, and 190 metric tons of ammonia.

The mass of particulate emissions from ammonium phosphate plants on a state-by-state and national basis was compared to state and national emissions of particulates from all sources. State-by-state particulate emissions were estimated by apportioning national emissions according to the statewise plant capacity distribution in Appendix A. Table 40 shows the results of this comparison.

In 1975 an estimated 4,150 metric tons of particulates were emitted from ammonium phosphate manufacture, while in 1972 nationwide particulate emission loading from all sources was 17,872,000 metric tons (72). Thus the ammonium phosphate industry

TABLE 36. ANNUAL MASS OF EMISSIONS FROM SUPERPHOSPHATE PLANTS IN THE UNITED STATES

(metric tons per year)

Emission source category	Mass of emissions Fluoride	 SO_x as SO_2	 Particulate
NSP plants:			
Rock unloading			120
Rock feeders			24
Mixer and den	44		110
Curing building	830		1,600
Total plant	874		1,854
GTSP plants:			
Rock unloading			81
Rock feeders			15
Reactor, granulator, screens, cooler, dryer	110	1,700	45
Curing building	16		90
Total plant	126	1,700	231
ROP-TSP plants:			
Cone mixer, den, storage	60		96
Rock feeders			8
Rock unloading	—		42
Total plant	60		146
Total superphosphate industry	1,060	1,700	2,231

NOTE.—Blanks indicate species not emitted from this source category.

TABLE 37. CONTRIBUTION TO STATE PARTICULATE EMISSIONS BURDENS DUE TO EMISSIONS FROM NSP PLANTS

State	State production, metric tons/yr P_2O_5	Particulate emissions, metric tons/yr	Percent of state particulate burden
Alabama	29,600	124	0.00006
Arkansas	3,480	15	0.000009
Florida	44,700	188	0.00008
Georgia	66,800	280	0.0001
Illinois	58,700	246	0.00007
Indiana	8,130	34	0.00002
Kentucky	10,400	44	0.00002
Maryland	6,390	27	0.00004
Michigan	6,970	29	0.00001
Mississippi	3,480	15	0.00001
Missouri	8,710	37	0.00001
Nebraska	6,970	29	0.00001
New York	6,390	27	0.00001
North Carolina	43,000	180	0.00008
Ohio	6,390	27	0.000009
Pennsylvania	10,500	44	0.00001
South Carolina	25,600	107	0.00009
Tennessee	16,800	71	0.00004
Texas	22,600	95	0.00001
Utah	1,740	7	0.00003
Virginia	45,300	190	0.0001
Washington	6,390	27	0.00001
U.S. total	439,040	1,843	0.0014

TABLE 38. CONTRIBUTION TO STATE PARTICULATE EMISSIONS BURDENS DUE TO EMISSIONS FROM ROP-TSP PLANTS

State	State production, metric tons/yr P_2O_5	Particulate emissions, metric tons/yr	Percent of state particulate burden
Florida	477,200	116	0.00005
Idaho	17,730	4	0.000002
Missouri	26,240	6	0.000002
North Carolina	65,440	16	0.000007
Utah	10,500	3	0.000001
U.S. total	597,110	145	0.0001

TABLE 39. CONTRIBUTION TO STATE PARTICULATE AND SO_x EMISSIONS BURDENS DUE TO EMISSIONS FROM GTSP PLANTS

State	State production, metric tons/yr	Mass of emissions, metric tons/yr		Percent of state burden	
		Particulate	SO_x	Particulate	SO_x
Florida	706,200	181	1,313	0.00007	0.0007
Idaho	22,510	6	42	0.00002	0.0007
Mississippi	73,490	19	137	0.00001	0.0005
North Carolina	83,290	21	155	0.00001	0.00007
Utah	13,410	3	25	0.000001	0.00009
U.S. total	898,900	230	1,672	0.00018	0.003

TABLE 40. ESTIMATED MASS OF PARTICULATE EMISSIONS FROM AMMONIUM PHOSPHATE PLANTS

State	Percent of national production	Particulate emissions, metric tons: From ammonium phosphate plants	Particulate emissions, metric tons: From all sources (72)	Contribution to total emissions, %
Alabama	2	72	1,178,642	<0.1
Arizona	<1	9	72,684	<0.1
Arkansas	1	38	137,817	<0.1
California	2	99	1,006,452	<0.1
Florida	43	1,770	226,460	<0.1
Idaho	5	221	55,499	0.8
Illinois	2	96	1,143,027	0.4
Iowa	5	192	216,493	<0.1
Louisiana	24	988	380,551	0.1
Michigan	<1	21	705,921	0.3
Minnesota	1	53	266,730	<0.1
Mississippi	3	117	168,355	<0.1
Missouri	2	71	202,438	<0.1
North Carolina	2	78	481,026	0.1
Texas	6	247	549,408	<0.1
Utah	1	55	71,693	<0.1
Washington	<1	23	161,937	0.1
U.S. total	100	4,150	17,872,000	<0.1

contributed approximately 0.02% of total national particulate emissions. Similar information on a statewise basis is presented in Table 40. In no state do ammonium phosphate particulate emissions represent over 1% of statewide particulate emissions, while particulate emissions from ammonium phosphate production are responsible for more than 0.1% of total statewide particulate emissions in only 3 of the 17 producing states.

3. Affected Population

The number of persons living in the area around a plant who are exposed to a contaminant concentration exceeding a given level is denoted as the affected population. Plume dispersion equations are used to determine the area where the average ground level concentration, $\overline{\chi}$, exceeds a given value. In the source assessment program two reference values are used, $\overline{\chi}/F = 1.0$ and $\overline{\chi}/F = 0.05$. This area, so determined, is then multiplied by an average population density to determine the affected population.

Disperson equations predict that $\overline{\chi}$ varies with the distance, x, downwind from a source. For elevated sources, $\overline{\chi}$ is zero at the source (where X equals 0), increases to some maximum value, $\overline{\chi}_{max}$, as X increases and then falls back to zero as X approaches infinity. Therefore, a plot of $\overline{\chi}$ versus X will have the appearance illustrated in Figure 43.

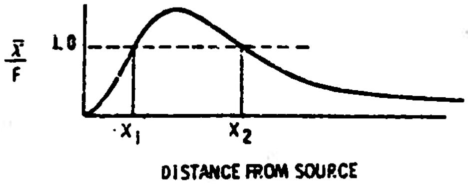

Figure 43. $\overline{\chi}$/F as a function of distance from an elevated source.

For fugitive emissions where the stack height is zero, the value of $\overline{\chi}$/F is a maximum at the source and decreases with distance downwind according to Figure 44.

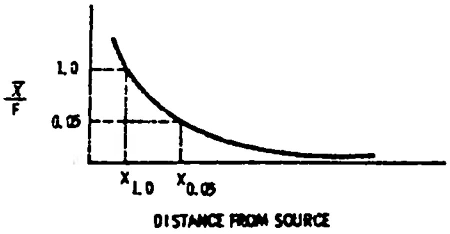

Figure 44. General distribution of $\overline{\chi}$/F as a function of distance for a ground level source.

The value for the population density around a representative plant is determined by averaging county population densities in which actual plants are located. However, because the population patterns within a given county may vary significantly, the actual population density in the immediate vicinity of individual plants may be lower than this average. Conclusions, therefore, should not be drawn with regard to actual environmental impacts at individual plant sites.

Due to uncertainties inherent in sampling and dispersion modeling methodologies, the number of persons around a representative plant exposed to a $\overline{\chi}$/F ratio greater than 0.05 is reported in addition to $\overline{\chi}/F > 1.0$. The mathematical derivation of the affected population calculation is presented in Reference 69.

a. Phosphoric and Superphosphoric Acid Plants--
The county population density around average WPPA and superphosphoric acid plants is 46.1 persons/km². The affected population values for these emission species and sources where the ratio of $\overline{\chi}$ to F exceeds 0.05 and 1.0 are given in Table 41. Affected population values for SO_x were zero and are not shown in the table.

TABLE 41. AFFECTED POPULATION VALUES FOR EMISSIONS FROM WET PROCESS PHOSPHORIC ACID AND SUPERPHOSPHORIC ACID PLANTS

	Affected population, persons			
	Fluoride		Particulates	
Emission source	$\bar{\chi}/F>0.05$	$\bar{\chi}/F>1.0$	$\bar{\chi}/F>0.05$	$\bar{\chi}/F>1.0$
Wet process phosphoric acid:				
Rock unloading	0	0	64	0
Rock transfer and charging	0	0	2	0
Wet scrubber	159	0	0	0
Gypsum pond	5,532	0	0	0
Superphosphoric acid:				
Wet scrubber	28	0	0	0

In calculating affected population values for fluoride emissions from a typical gypsum pond, it was assumed that no one lived within 2,000 m of the edge of the pond, or 2,600 m of the center of the pond. The value of $\bar{\chi}/F$ drops below 1.0 at 1,300 m from the center of the pond, resulting in no affected population. The value of $\bar{\chi}/F$ drops below 0.05 at 6,700 m from the center of the pond, resulting in an affected population value of 5,532 persons.

b. Normal Superphosphate and Triple Superphosphate--Affected population values for emissions from average superphosphate plants are shown in Table 42 for those emission points with at least one pollutant which has source severity greater than or equal to 0.05. For those emissions with source severity less than 0.05, there is no population affected by a ground level concentration for which $\bar{\chi}/F$ is greater than or equal to 0.05.

TABLE 42. AFFECTED POPULATION VALUES FROM SUPERPHOSPHATE PLANTS

	Affected population, persons					
	$\bar{\chi}/F>0.05$			$\bar{\chi}/F>1.0$		
Emission source	Particulate	Fluoride	SO_x	Particulate	Fluoride	SO_x
NSP:						
Mixer and den	0	529		0	0	
Curing building	519	13,021		0	539	
ROP-TSP:						
Cone mixer, den, curing building	0	1,178		0	0	
Rock unloading	5			0		
GTSP:						
Reactor, granulator, dryer, cooler, screens	0	1,356	307	0	0	0
Curing building	0	161		0	0	
Rock unloading	15			0		

NOTE.—Blanks indicate no emission of the species for the source.

c. Ammonium Phosphate Plants--

Results of affected population calculations for the average source are presented in Table 43. The average population density was 82 persons/km².

TABLE 43. AFFECTED POPULATION VALUES FROM AMMONIUM PHOSPHATE PLANTS

	Affected population, persons					
	Fluoride		Particulate		Ammonia	
Emission source	$\overline{\chi}/F>0.05$	$\overline{\chi}/F>1.0$	$\overline{\chi}/F>0.05$	$\overline{\chi}/F>1.0$	$\overline{\chi}/F>0.05$	$\overline{\chi}/F>1.0$
Total plant stack emission	285	0	288	0	41	0

G. AIR POLLUTION CONTROL TECHNOLOGY

1. Phosphoric Acid and Superphosphoric Acid

Environmental and economic concerns have prompted use of control devices in most facets of the WPPA and superphosphoric acid industry, with the exception of volatile emissions from the gypsum pond. The problem of pollutant abatement in the industry is generally approached by using add-on devices. Process modifications are not employed because of the delicate balance of operating conditions required to produce filterable gypsum crystals. Process technology has been developed to recover fluoride and gypsum byproducts, offering a more economically attractive way for the WPPA industry to reduce wastes.

The following sections discuss various controls and byproduct recovery processes currently in use to reduce air pollutant levels.

a. Dust Control in Raw Materials Handling Operations--

Enclosed operation and baghouses are typical methods of control at ground phosphate rock unloading stations. Satisfactory control of dust emissions from unloading hopper-bottom railroad cars or trucks is achieved by baghouses which realize high efficiency in collection of this size particle (60% to 80% of the rock is less than 74 μm (24). Efficiencies are reported to be greater than 99% (74).

Feed hoppers, storage bins, and conveyors are also enclosed to reduce particulate emissions and moisture contamination of the rock. When transport of ground rock from storage bin to feed hopper is accomplished by pneumatic conveyors, a cyclone separator and baghouse are located at the destination for control of bulk material and discharged dust.

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(74) Seinfeld, J. H. Air Pollution: Physical and Chemical Fundamentals. McGraw-Hill Book Co., New York, New York, 1975. 523 pp.

Future rock grinding operations may utilize a wet grinding circuit rather than the current dry grinding practice. Wet grinding, because it also means wet rock receipt and storage, leads to a reduction in particulate emissions as well as energy savings by eliminating a rock drying step.

b. WPPA Wet Scrubber Systems--
Of the available types of pollution control, wet scrubbers have been the exclusive choice for treatment of contaminated process vapors generated in the digester, filter, and evaporator. These scrubbers combine the ability to absorb gaseous fluorides and remove particulates by impaction on the liquid droplets. Problems in scrubber efficiency result from deposition of hydrated silica within water nozzles or scrubber packing, which affects liquid-vapor contact.

Crossflow packed scrubbers provided high absorption capabilities and tend to operate free from plugging when preceded by a spray section (28). When gases enter the spray section, hot vapors are cooled, high concentrations of fluorides and particulates are reduced, and reaction takes place between the water and silicon tetrafluoride in the gas.

$$3SiF_4 + 2H_2O \longrightarrow 2H_2SiF_6 + SiO_2 \qquad (30)$$

The silica (SiO_2) precipitates in the form of a hydrated gel [$Si(OH)_4$].

$$SiO_2 + 2H_2O \longrightarrow Si(OH)_4 \qquad (31)$$

When fluoride and particulate loading is substantially reduced, gas passes through the more efficient stage, a cross-flow packed scrubber, where the remaining hydrogen fluoride and particulates are removed (28). The crossflow design, with scrubbing spray normal to the direction of the gas flow, washes precipitates off the packing to prevent plugging. The collected deposits are near the front of the packed bed, which is more heavily irrigated to reduce solids buildup (75). Overall efficiencies for a spray-crossflow packed scrubber have been reported to be greater than 99% (31). A diagram of this scrubber design is presented in Figure 45.(31).

Although venturi scrubbers provide effective contact and gas absorption, they have a major disadvantage in that a high pressure drop (2.5 kPa to 12.4 kPa) and corresponding high energy requirement are necessary to meet the given standards for emissions (15). A venturi may be used instead of a spray tower upstream from the packed scrubber described in the previous paragraph, or in conjunction with a cyclonic spray tower.

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(75) Environmental Engineers' Handbook, Volume 2, Air Pollution, B. G. Liptak, ed. Chilton Book Co., Radnor, Pennsylvania. 1974. 1340 pp.

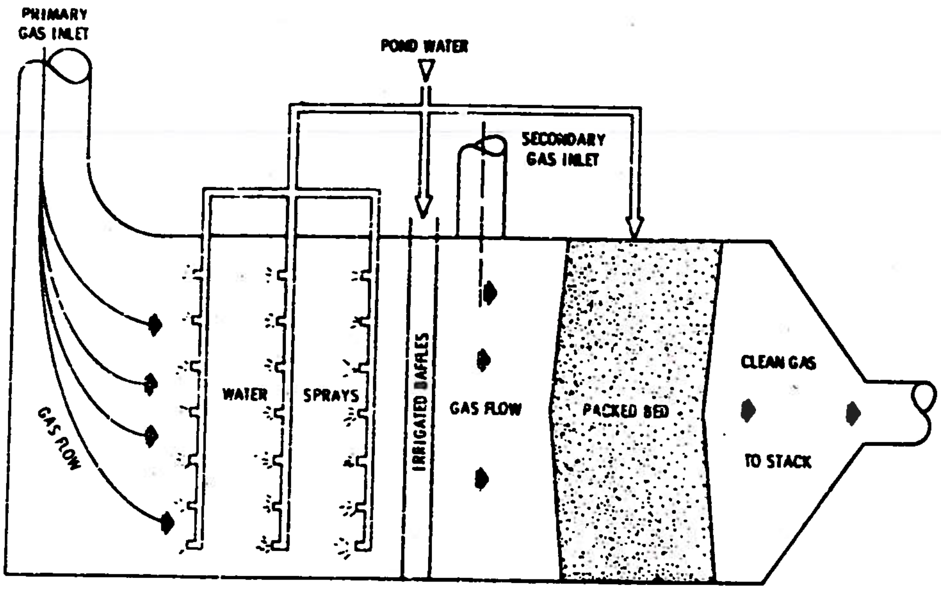

Figure 45. Spray-crossflow packed scrubber (31).

Important factors observed in efficiencies of control devices are composition and temperature of scrubbing water. Gypsum pond water contains 3,000 ppm to 10,000 ppm fluorine. The partial pressure of the hydrogen fluoride in the pond water makes efficient recovery of fluorides in the contaminated gas stream difficult (17, 64). The mass transfer process may even become inoperative at higher temperatures. To combat this effect, some industries use fresh water in the last stage of the scrubber to reduce gaseous fluorides to an acceptable level.

The temperature influence on scrubber outlet concentrations is depicted in Figure 46 (76).

c. Superphosphoric Acid Wet Scrubber--
As in WPPA plants, superphosphoric acid plants treat exhaust air with wet scrubbers to remove particulates and gaseous fluorine compounds. The type of wet scrubber used in this application, however, is different from the WPPA choice because of a lower gas flow rate. A water-induced venturi scrubber, shown in Figure 47, is the typical choice (31).

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(76) Specht, R. C., and R. R. Calaceto. Gaseous Fluoride Emissions from Stationary Sources. Chemical Engineering Progress, 63(5):7884, 1967.

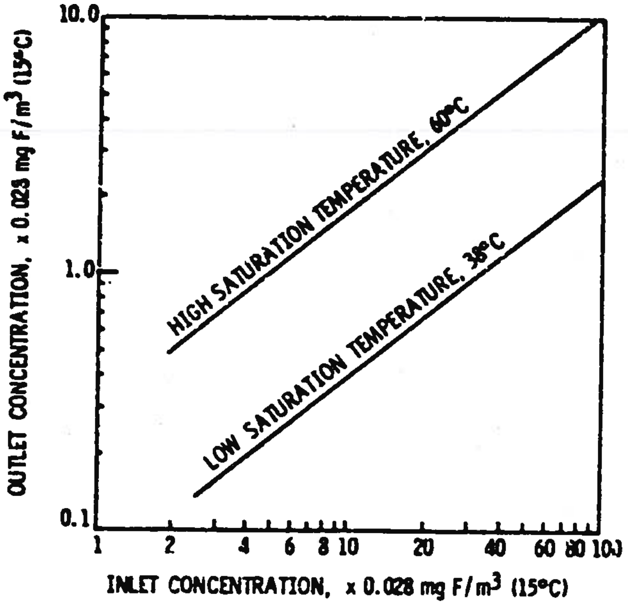

Figure 46. Inlet concentration versus outlet concentration at scrubber discharge temperatures for a cyclonic spray tower (76).

Reprinted from Chemical Engineering Progress by courtesy of the American Insititute of Chemical Engineers.

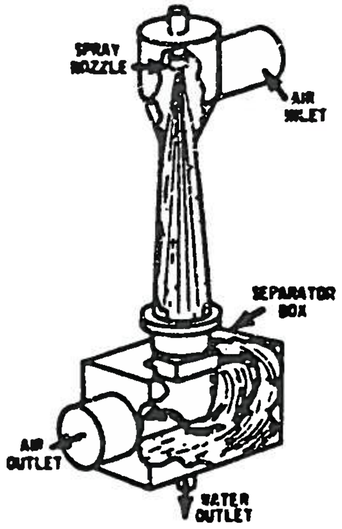

Figure 47. Water-induced venturi scrubber (31).

The gas stream to the scrubber is from a combination of sources: barometric condenser, hot well vents, and product cooler tank. The enclosed system is maintained at a slight negative pressure to induce inward leakage at openings in access ways and equipment, thus eliminating potential fugitive emissions. Scrubbers installed to handle the exhaust streams are of nominal capacity, about 4.2 m^3/s, regardless of plant size (77). Because of the low gas flow rate and availability of large amounts of gypsum pond water, scrubbing requirements for superphosphoric acid plants can be met with the venturi ejector without use of mechanically more complicated packed and conventional venturi scrubbers (31).

The water-induced venturi does not depend on gas flow for motive power. The ejector venturi uses a large liquid spray under high pressure to induce air flow through the throat section, where intimate gas-liquid contact occurs. This unit is followed by a gas-liquid separation chamber to prevent entrainment of the contaminated liquid droplets in the exhausted gas. Efficient separation is achieved by a cyclonic section, which also removes remaining particulates. An alternative is a packed or cyclonic-packed scrubber in the separator vessel.

Scrubber efficiency is increased with higher liquid-to-gas ratios and with increasing nozzle pressure. Plant data indicate that these installations are 99% to 99.8% efficient (31).

2. Normal Superphosphate and Triple Superphosphate

Superphosphate production and storage facilities utilize a variety of devices including wet scrubbers, cyclones, and baghouses to control emissions of particulates, fluorides, and combustion gases (31, 32).

Particulate emissions from ground rock unloading, storage, and transfer systems are controlled by baghouse collectors. Cloth filters have reported efficiencies of over 99.9% for particles smaller than 75-μm (Appendix B). Collected solids are recycled to the process.

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(77) Frazier, A. W., E. F. Dillard, and J. R. Lehr. Chemical Behavior of Fluorine in the Production of Wet Process Phosphoric Acid. Presented at the American Chemical Society Annual Meeting, Chicago, Illinois, August 24-29, 1975. 16 pp.

Emissions of silicon tetrafluoride, hydrogen fluoride, and particulate from the production area and curing buildings are controlled by scrubbing the offgases with recycled water. Wet scrubbing combines the ability to remove particulate by impaction on the surface of liquid droplets with the ability to absorb gaseous fluoride compounds into the liquid phase. Exhausts from the dryer, cooler, screens, mills, and curing building, where heavier loadings of particulate may be present, are sent first to a cyclone separator and then to a wet scrubber.

Gaseous silicon tetrafluoride in the presence of moisture reacts as follows:

$$3SiF_4 + 2H_2O \rightarrow SiO_2 + 2H_2SiF_6 \qquad (32)$$

The silica is present as a gelatinous mass of polymeric silica which has the tendency to plug scrubber packings. The use of conventional packed countercurrent scrubbers and other contacting devices with small gas passages for controlling silica is therefore limited. Scrubber types that can be used within this restriction are 1) spray tower, 2) cyclonic scrubbers, 3) venturi scrubbers, 4) impingement type scrubbers, 5) jet ejector scrubbers, and 6) spray-crossflow packed scrubbers.

Spray towers are not capable of the high efficiencies (greater than 95%) required for compliance with present regulations. They find use, however, as precontactors for fluorine removal at relatively high concentration levels (greater than 3,000 ppm).

Air pollution control techniques vary from plant to plant depending on particular plant designs. The effectiveness of abatement systems for the removal of fluoride and particulate varies from plant to plant depending on a number of factors. The effectiveness of fluorine abatement is determined by 1) inlet fluorine concentration, 2) outlet or saturated gas temperature, 3) composition and temperature of the scrubbing liquid, 4) scrubber type and transfer units, and 5) effectiveness of entrainment separation (16, 31). Control effectiveness is enhanced by increasing the number of scrubbing stages in series and by using fresh water scrub in the final stage. Reported efficiencies for fluoride control range from less than 90% to over 99% depending on inlet fluoride concentrations and the system employed. An efficiency of 98% for particulate control is achievable (31).

3. Ammonium Phosphate

Emission control technology applied to DAP production serves three purposes: recovery of ammonia, recovery of particulate MAP and DAP, and prevention of pollutant emissions of ammonia, fluorides, and particulates. Common practice in the industry is to combine emission points for emission control: reactor and ammoniator-granulator, dryer and cooler, and product sizing and material transfer. Reactor and ammoniator-granulator emissions are vented directly to a wet scrubber system, while emissions from remaining sources pass through cyclone collectors for product recovery and recycle before passing to a wet scrubber system.

The chemistry for ammonia recovery is identical to the process chemistry discussed earlier: Ammonia is scrubbed from offgases with excess phosphoric acid where it reacts to form ammonium phosphates which are retained in the scrubbing liquor. Silicon tetrafluoride, the primary gaseous fluoride emission species, is scrubbed from offgases according to reactions in Equations 33 and 34.

$$2HF + SiF_4 \rightleftarrows H_2SiF_6 \qquad (33)$$

$$3SiF_4 + 4H_2O \rightleftarrows Si(OH)_4 + 2H_2SiF_6 \qquad (34)$$

All ammoniation-granulation plants have some form of pollution control equipment, but a complete characterization of emission control practices of the industry is not available (5). Combined requirements for particulate collection and gas absorption for ammonia recovery and fluoride emission control permit application of a wide variety of scrubber types for DAP service. Devices applied to DAP emission control include

- Spray towers
- Venturi scrubbers
- Impingement scrubbers
- Spray-crossflow packed bed scrubbers

Spray towers provide the interphase contacting necessary for gas absorption by dispersing scrubbing liquid in the gas phase as a fine spray. Several types of spray towers are in general use. The simplest consists of an empty tower equipped with liquid spray nozzles at the top and a gas inlet at the bottom. Scrubbing liquor sprayed into the gas stream falls by gravity through the upward flowing contaminated gas. A disadvantage of this device is entrainment of scrubbing liquid aerosols into the exit gas stream.

Cyclonic spray towers eliminate excessive droplet entrainment by using centrifugal force to remove droplets. Figure 48 presents schematic diagrams of one- and two-stage cyclonic spray tower scrubbers. Gas enters the scrubber tangentially and scrubber liquor is directed parallel to gas flow, providing crossflow contacting of gas and liquid streams (11, 43).

Venturi scrubbers (Figure 49) are particularly well suited for streams with high solids or silicon tetrafluoride loadings because of their high solids handling capacity and self-cleaning characteristics. A venturi provides a high degree of gas-liquid mixing, but relatively short contact time and cocurrent flow

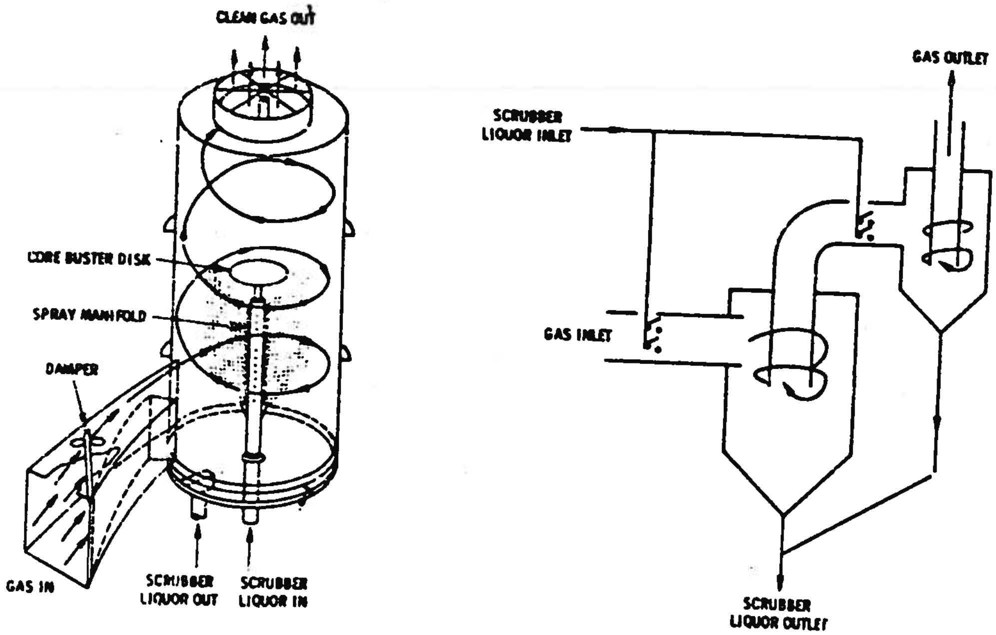

Figure 48. Cyclonic spray tower scrubbers (11, 45).

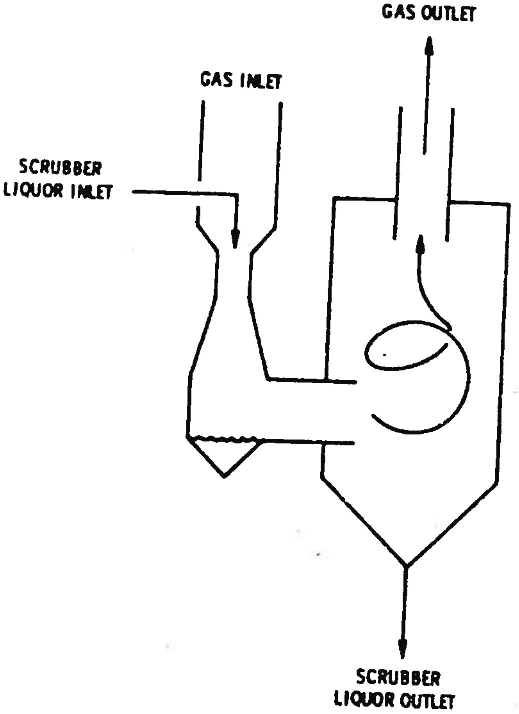

Figure 49. Venturi scrubber (11).

limit absorption capabilities. Scrubbing liquor is introduced at high velocity through a nozzle upstream of the venturi throat, and water velocity pulls flue gas through the venturi. Entrained scrubbing liquor requires a mist eliminator. The cyclone in Figure 49 is used to remove mists. In application to DAP emissions, venturi scrubbers are often used as the initial component of a multiple scrubber system (11).

Although impingement scrubbers are primarily particulate collection devices, they also possess some absorption capability. The Doyle scrubber pictured in Figure 50 is most commonly used by the fertilizer industry.

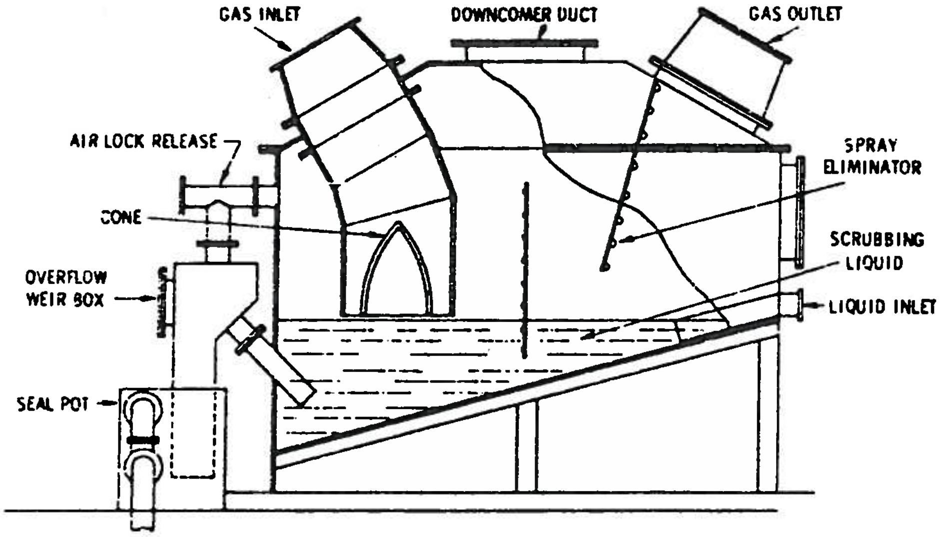

Figure 50. Doyle impingement scrubber (11).

Effluent gases are introduced into the scrubber as shown in Figure 50. The lower section of the inlet duct is equipped with an axially located core that causes an increase in gas stream velocity prior to its impingement on the scrubbing liquor surface. Effluent gases contact the pool of scrubbing liquid at a high velocity and undergo a reversal in direction. Solids impinge on the liquid surface and are retained, while absorption of gaseous fluorides is promoted by interphase mixing generated by impact. Solids handling capacity is high; however, absorption capability is very limited (11).

The spray-crossflow packed bed scrubber shown earlier in Figure 45 consists of two sections--a spray chamber and a packed bed--separated by a series of irrigated baffles. Both spray and packed sections are equippped with a gas inlet. Effluent streams with relatively high fluoride concentrations--particularly those rich in silicon tetrafluoride--are treated in the spray chamber before entering the packing. This preliminary scrubbing removes silicon tetrafluoride, thereby minimizing bed plugging. It also reduces packed stage loading and provides some solids handling capacity. Gases low in silicon tetrafluoride can be introduced directly to the packed section.

The spray section consists of a series of countercurrent spray manifolds with each pair of spray manifolds followed by a system of irrigated baffles. Irrigated baffles remove precipitated silica and prevent formation of scale in the spray chamber.

Packed beds of both cocurrent and crossflow design have been tried; crossflow design has proven to be more dependable. Crossflow design operates with the gas stream moving horizontally through the bed while scrubbing liquid flows vertically through the packing. Solids tend to deposit near the front of the bed where they can be washed off by a cleaning spray. The back portion of the bed is usually operated dry to provide mist elimination.

Spray-crossflow packed bed scrubbing is effective from a gas absorption standpoint, but it is less effective for collecting particulate; hence, it is used as a "tail gas" or secondary scrubber following a particulate scrubber. Packed scrubbers are seldom used as primary scrubbers due to their tendency to plug with gelatinous silicon or DAP (45).

Equipment commonly used for primary scrubbing includes venturis and cyclonic spray towers, while cyclonic spray towers, impingement scrubbers, and spray-crossflow packed bed scrubbers are used as secondary scrubbers (11, 43, 45). Primary scrubbers generally use 20% to 30% P_2O_5 phosphoric acid as scrubbing liquor principally to recover ammonia (45). Secondary scrubbers generally use gypsum pond water principally for fluoride control.

Throughout the industry, however, there are many combinations and variations. Some plants use reactor-feed concentration phosphoric acid (40% P_2O_5) in both primary and secondary scrubbers, and some use phosphoric acid near the dilute end of the 20% to 30% P_2O_5 range in only a single scrubber (31, 43). Existing plants are equipped with ammonia recovery scrubbers on the reactor, ammoniator-granulator, and dryer, and particulate controls on the dryer and cooler. Additional scrubbers for fluoride removal are common but not typical. Only 15% to 20% of installations contacted in an EPA survey were equipped with spray-crossflow packed bed scrubbers or their equivalent for fluoride removal (11).

Emission control efficiencies for DAP plant control equipment have been reported as:

Ammonia	94% to 99% (11, 45)
Particulates	75% to 99.8% (45, 71)
Fluorides	74% to 94% (11)

Fluoride emissions and the need for controlling them could be eliminated from DAP production if fluorides were removed from phosphoric acid raw material. As shown earlier in Table 16, furnace phosphoric acid has very little (less than 1 ppm) fluorine content, but essentially all ammonium phosphates are currently produced from WPPA. Furnace acid is not used primarily because it costs 29% more per metric ton of P_2O_5 to produce than WPPA (78).

Particulate collection efficiency of dry cyclones increases as gas flow rate increases. However, increasing exhaust gas flow rate also increases gas flow rate through the dryer. It has been reported that additional dust is emitted from the discharge end of the dryer when gas velocity exceeds 112 m/min (46). One way to increase gas velocity in the cyclone, but not in the dryer, is to install an open duct in the exhaust line between the cyclone and dryer and cooler discharge as shown in Figure 51. Gas velocity through the dryer and cooler can then be regulated by means of the damper.

H. BYPRODUCT RECOVERY

Fluorine compounds volatilized during production of phosphate fertilizer materials are being considered as a valuable resource for production of fluosilicates, fluorides, and hydrofluoric acid (63). Fluorine is recovered from gas effluent streams as a weak solution of fluosilicic acid by the following reaction sequence:

$$\text{Phosphate rock} + \text{acid} \longrightarrow HF \qquad (35)$$

$$4HF + SiO_2 \longrightarrow SiF_4 + H_2O \qquad (36)$$

$$3SiF_4 + 2H_2O \longrightarrow 2H_2SiF_6 + SiO_2 \qquad (37)$$

Calcium fluoride contained in the rock reacts with acid to form hydrogen fluoride. This hydrogen fluoride in turn reacts with silica present in the rock to form silicon tetrafluoride. Silicon tetrafluoride vapor dissolves readily in an aqueous scrubbing solution to form fluosilicic acid. Silica formed during absorption of silicon tetrafluoride is removed by filtration and the product is a solution of 17% to 25% fluosilicic acid (63). Systems recover the acid at concentrations of 25% or less, a constraint which results from a rapid increase in vapor pressure

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(78) Environmental Considerations of Selected Energy Conserving Manufacturing Process Options, Vol. 13, Phosphorus/Phosphoric Acid Industry Report. EPA-600/7-76-034m (PB 264 279), U.S. Environmental Protection Agency, Cincinnati, Ohio, December 1976. 96 pp.

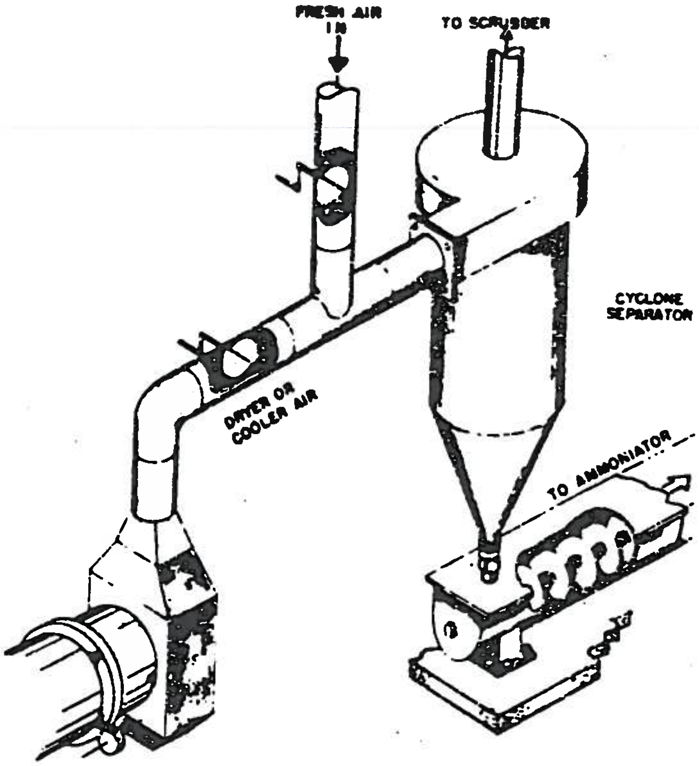

Figure 51. Cyclone gas velocity control (46).

at higher concentrations. The small amount of silica-containing liquid waste generated is normally consumed as a filler in fertilizer production.

A number of plants in the phosphate fertilizer industry are currently practicing recovery techniques. Approximately 60% of NSP plants recover fluorine as a weak solution of fluosilicic acid utilizing two-or three-stage wet scrubbing systems.

Between 10% and 20% of WPPA plants recover fluorine during evaporation-concentration of the phosphoric acid. Two systems available for fluosilicic acid recovery are inventions of the Swenson Evaporation Co. and Swift & Co. (22, 27). The Swenson system involves condensation of evaporator vapors and flash evaporation to produce an approximately 15% solution. In the Swift process, a weak solution of fluosilicic acid scrubs the fluoride-containing vapors from the evaporator and flows to a recirculation tank. Fluosilicic acid (about 18% to 20%) is bled from the tank, and water is added to the recycled solution to maintain the required concentration of acid for scrubbing.

An alternative method of fluorine recovery is removal of fluosilicate salts prior to concentration of the approximately 30% P_2O_5 acid. One procedure involves addition of sodium carbonate to the filtered solution of weak acid and subsequent precipitation of sodium fluosilicate.

Process modifications to recover fluoride byproducts reduce emissions from the WPPA scrubber and gypsum ponds by removing fluoride from process streams. The emission factor developed for the scrubber system at WPPA plants recovering fluoride byproducts was one-half the factor for plants not practicing recovery techniques.

SECTION 5

WATER EFFLUENTS

Because of the integrated nature of the phosphate fertilizer industry, considering the wastewater handling practices of the industry as a whole is necessary. Wastewater arising from different manufacturing operations are often combined for treatment at one location. The integrated character of the industry can be seen in Table 44. Over 70% of the plants produce only one type of phosphate fertilizer material, while 30% of all the plants consist of multiunit operations. However, more than 80% of phosphate fertilizer production occurs at multiunit plants.

TABLE 44. DESCRIPTION OF PHOSPHATE FERTILIZER COMPLEXES IN THE UNITED STATES BY UNIT OPERATIONS

Unit operations at plant site	Number of plants	Percent of total
WPPA	5	4.1
NSP	61	50.4
DAP	23	19.0
WPPA, SPA	3	2.5
WPPA, NSP	1	0.8
WPPA, TSP	2	1.7
WPPA, DAP	10	8.3
WPPA, TSP, DAP	6	5.0
WPPA, SPA, DAP	2	1.7
WPPA, NSP, TSP	1	0.8
NSP, TSP, DAP	1	0.8
WPPA, SPA, TSP, DAP	4	3.3
WPPA, NSP, TSP, DAP	2	1.7
Total	121	100

WPPA--wet process phosphoric acid.
SPA--superphosphoric acid.
NSP--normal superphosphate.
TSP--triple superphosphate (includes both granular and run-of-pile).
DAP--diammonium phosphate (some plants also make monoammonium phosphate).

The remainder of this section considers wasewater handling practices, gypsum pond characteristics, effects of lime treatment, and potential environmental effects of those plants that do discharge wastewaters.

A. SOURCES OF WASTEWATER

Two basic wastewater source types exist in a phosphate fertilizer plant--point and nonpoint. Point sources are those which originate as a definite wastewater stream from a particular process. Nonpoint sources originate from random leaks or from large areas within a plant. Point sources for each of the five basic processes are discussed first, below, followed by a general discussion of nonpoint sources for the entire plant.

1. Point Sources

Point sources of wastewater generated at phosphate fertilizer plants can be divided into three general classes:

- Contact process water
- Noncontact cooling water
- Steam condensate

Contact process wastewater refers to any water which, during manufacturing or processing, comes into direct contact with or results from production or use of any material, intermediate product, finished product, byproduct, or waste product.

a. Phosphoric Acid--
Sources of contact process wastewater from WPPA production include wet scrubber liquor, gypsum slurry water, and barometric condensers (Figure 52). Recycled gypsum pond water is used in the wet scrubber system to remove particulates, fluorides, and phosphates from the gas streams. This reservoir of contaminated process water also supplies the water requirements for transferring waste gypsum to a disposal area and for operation of barometric condensers. Acid sludge underflow, generated in acid clarification, contains substantial amounts of phosphate and is normally disposed of by blending into a dry fertilizer (usually TSP); it does not enter the pond system.

Once-through or recirculated noncontact cooling water is used to control the exothermic reaction when concentrated sulfuric acid is diluted. Cooling water may be either recirculated gypsum pond water or a separate nonprocess stream that is recycled or discharged. Significant quantities of steam are used in WPPA production. In many plants, the steam is used on a once-through basis. Uncontaminated steam condensate is discharged to the receiving waters without treatment. Contaminated steam condensate, such as that from barometric condensers and vacuum ejectors, is discharged to the gypsum pond.

Wastewater streams at phosphoric acid plants are contaminated to varying degrees by quantities of phosphoric acid, fluorides, sulfates, and gypsum.

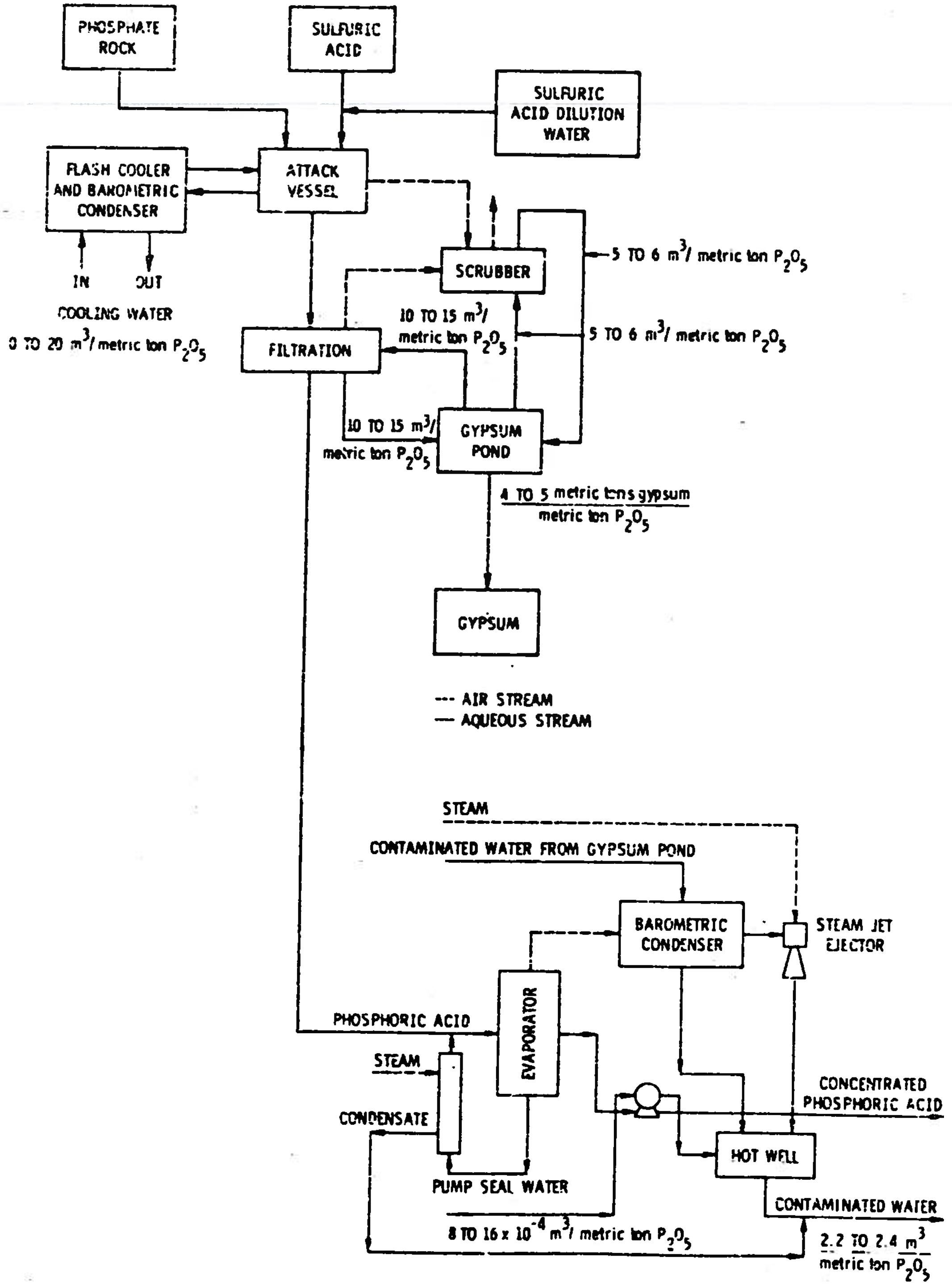

Figure 52. WPPA production (17).

b. Superphosphoric Acid--

Superphosphoric acid plants are located at fertilizer complexes producing WPPA. As a result, water usage requirements are supplied for the most part by the existing water recycle system. Process wastewater streams at superphosphoric acid plants come from the barometric condensers, steam jet ejectors, and wet scrubbers. These streams pick up quantities of phosphoric acid and fluorides and are returned to the gypsum pond for reuse at the phosphate fertilizer complex. Noncontaminated steam condensate may be segregated into a separate nonprocess water system and recycled or discharged.

c. Normal Superphosphate

The only process wastewater stream generated at NSP plants is the wet scrubber liquor used to reduce the level of fluoride gases and particulate matter evolved from the mixer, den, and conveyors (Figure 53). Scrubber liquor is discharged to a water containment or pond system and reused. Nearly two-thirds of the NSP plants presently practice fluorine recovery, thereby eliminating or greatly reducing the need for a pond. In this system, fluorine in the exhaust gas stream is recovered as a weak solution of fluosilicic acid. NSP plants recoverying fluosilicic acid consume the small amount of silica-containing liquid waste generated as a filler in fertilizer production and report no discharge of wastewater.

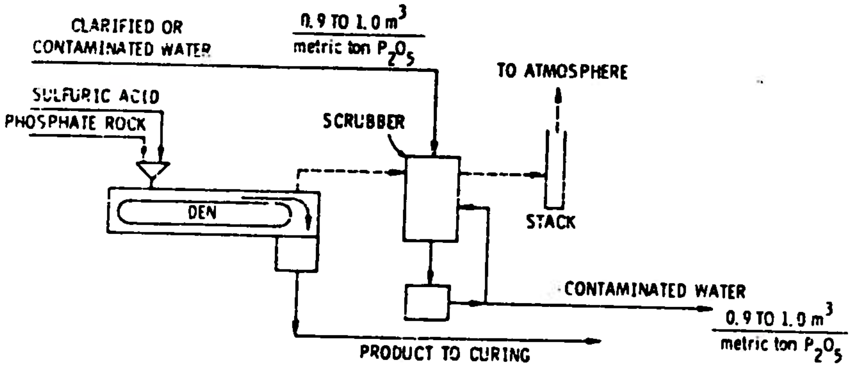

Figure 53. NSP production (17).

d. Triple Superphosphate

The wet scrubber liquor is the only process wastewater stream generated at TSP production units (Figures 54 and 55). Recycled gypsum pond water is used in the scrubber system to reduce the level of fluoride gases and particulate matter evolved during fertilizer production and storage.

e. Ammonium Phosphate--

At ammonium phosphate plants, substantial quantities of ammonia are volatilized from the acid neutralizer, ammoniator-granulator, and dryer. Process economics require that ammonia be recovered.

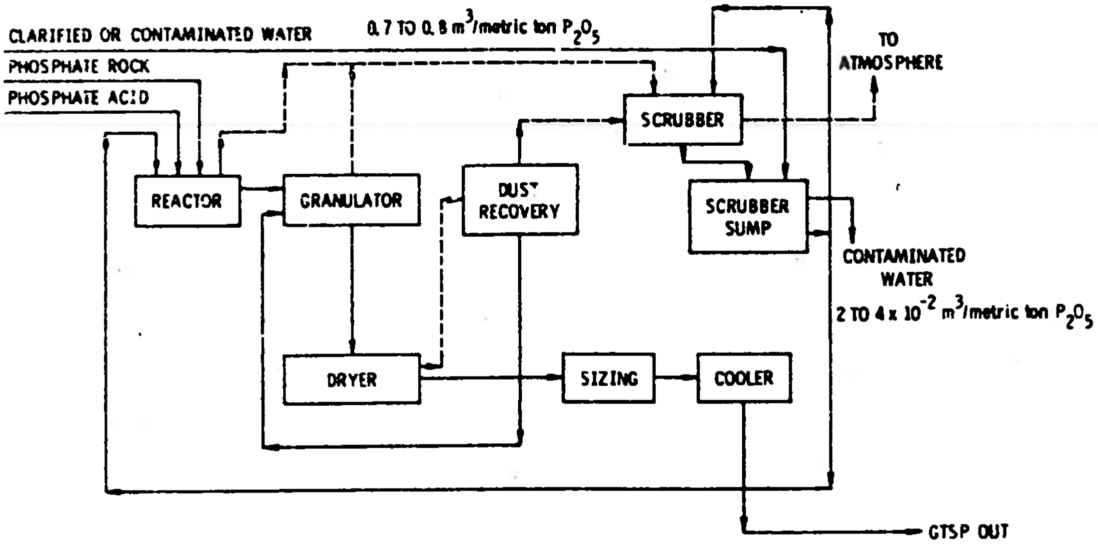

Figure 54. ROP-TSP production (17).

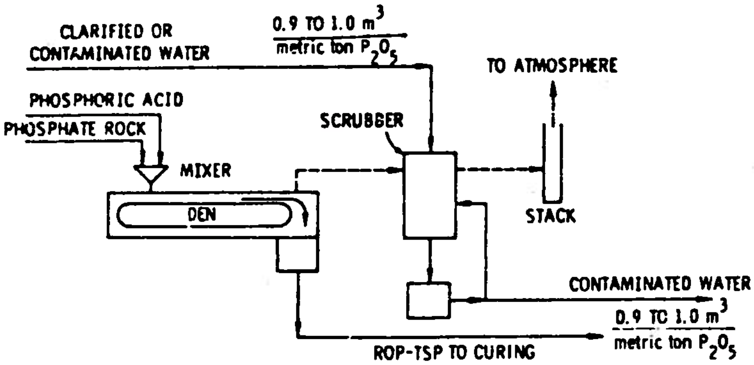

Figure 55. GTSP production (17).

Weak (28% P_2O_5) phosphoric acid is used as the scrubbing liquor and is recycled back to the ammoniator-granulator (Figure 56). Phosphoric acid scrub solution is consumed in the process and therefore results in no effluent. However, the phosphoric acid scrub solution contains a small percentage of fluoride (1% to 3%), and optimum scrubber operation for ammonia recovery results in stripping of some of the fluoride from the acid. Secondary wet scrubber systems are occasionally used to further remove fluorides, particulates, ammonia, and combustion products from the neutralizer, granulator, dryer, cooler, and screening operations. This secondary scrubber system uses water as a scrubber liquor and is therefore a wastewater source. Scrubber effluents are contained in a water recycle system.

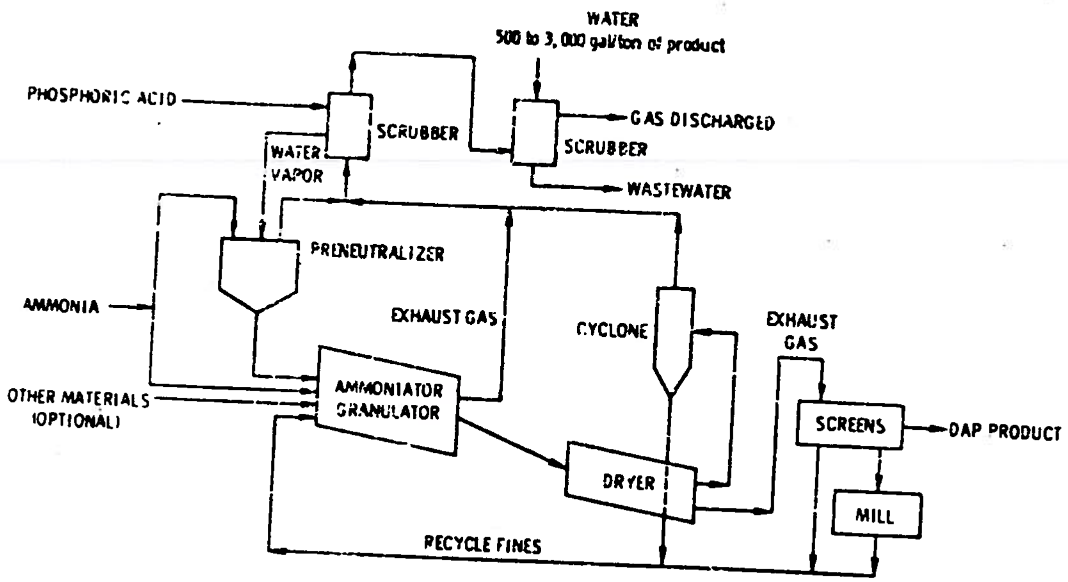

Figure 56. DAP production (4).

2. Nonpoint Sources

In phosphate fertilizer plants, various nonpoint sources can contribute to wastewater handling requirements.

a. Leaks and Spills--

In any plant, a certain number of valve and pump leaks as well as random spills can be expected. These leaks and spills are collected as part of the housekeeping procedure and, where possible, reintroduced directly to the process or contained in the contaminated water system. Spillage and leaks therefore do not normally represent a direct contamination of plant effluent streams that flow directly to natural drainage.

b. Runoff--

Rainfall runoff from a plant can collect quantities of contaminants from the ground and buildings at the production facility. Drainage from gypsum piles and mined-out areas at a phosphate fertilizer complex also may be a significant contributor to the overall water handling requirements of a plant. Runoff and drainage are collected and treated before discharge, if necessary, or sent to the contaminated water system for containment. Noncontaminated waters are kept segregated where possible and discharged without treatment.

c. Seepage--

The potential exists for chemical and radiological contamination of groundwaters as a result of seepage from gypsum stacks and large process water cooling ponds. Existing data is inconclusive and is insufficient to determine the possible extent of this contamination. The potential impacts due to seepage need to be determined on a site specific basis. Seepage can be reduced or prevented if it is a problem by lining ponds and underlaying gypsum piles with an impervious material.

3. Gypsum Pond

a. Gypsum Pond Characteristics--

The gypsum pond is an integral part of the wastewater treatment scheme at a typical phosphate fertilizer complex. The pond serves as a settling basin for gypsum (a byproduct of WPPA) and other waste solids, and it functions as a reservoir for recycling process water and cooling water. The size of the gypsum pond at a WPPA plant is approximately 2.23 x 10^{-3} km^2/metric ton P_2O_5/day (20). Gypsum ponds are located adjacent to the plant complex; they are, in many cases, abandoned phosphate rock mine pits.

Clarified gypsum pond water can be recycled for use in scrubbers and barometric condensers and for slurrying waste gypsum cake from the WPPA filtration process. With each recycle, the level of dissolved contaminants in the water increases. After 3 yr to 5 yr of recycle, impurities in pond waters approach equilibrium concentrations (20) which are a function of pH, temperature, and other chemical factors, and are maintained by volatilization and precipitation of impurities. Typical equilibrium concentrations are shown in Table 45 (17, 20).

TABLE 45. TYPICAL EQUILIBRIUM COMPOSITION OF GYPSUM POND WATER (17, 20)

Contaminant[a]	Concentration, g/m^3	Radioactivity, pCi/ℓ[b]
Phosphorus pentoxide	6,000 to 12,000	
Fluoride	3,000 to 10,000	
Sulfate	2,000 to 4,000	
Calcium	350 to 1,200	
Ammonia	0 to 100	
Nitrate	0 to 100	
Silica	1,600	
Aluminum	100 to 500	
Iron	70 to 300	
^{226}Ra		60 to 100

[a] The typical pH range is 1.0 to 1.8.

[b] Picocuries per liter; 1 picocurie equals 0.037 becquerel.

At pH less than 2, it is estimated that 80% of the phosphate present exists as phosphoric acid, the remaining 20% being the $H_2PO_4^-$ anion (20). The major equilibrium of fluoride componds as depicted in a model developed by Environmental Science and Engineering, Inc., is shown in Figure 57 (20). Data collected by remote sensing indicate that fluoride emissions from the gypsum pond

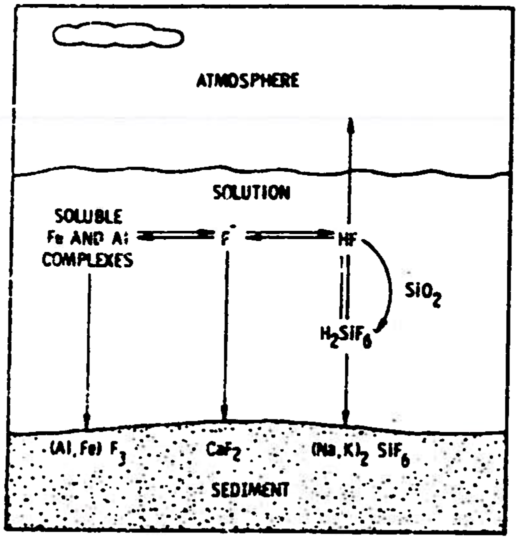

Figure 57. Major gypsum pond equilibrium (20).

consisted entirely of hydrogen fluoride. The silicon tetrafluoride concentration was below the detectable threshold of 0.5 ppb (66). In addition to predominant compounds, fluosilicic acid (H_2SiF_6) and hydrogen fluoride (HF), small amounts of fluoride will be present in the water as soluble and insoluble aluminum and iron complexes.

b. Seepage Control from Gypsum Piles--
Natural soil from the surrounding area provides the base for dikes surrounding gypsum ponds. Gypsum is used to increase the height of the dike. A drainage ditch surrounds the perimeter of the area to control contaminated water seepage through earth and gypsum.

Design of the ditch is dependent on area geology and impoundment water level. Figures 58 and 59 show examples of dike (64) and seepage ditch construction. Water effluent collected is pumped from a low collection point in the ditch back into the pond.

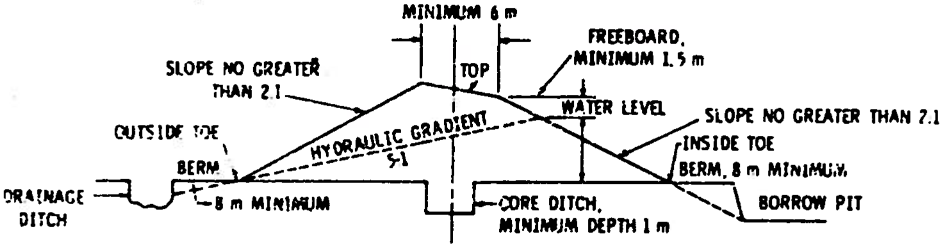

Figure 58. Recommended minimum cross section of dam (64).
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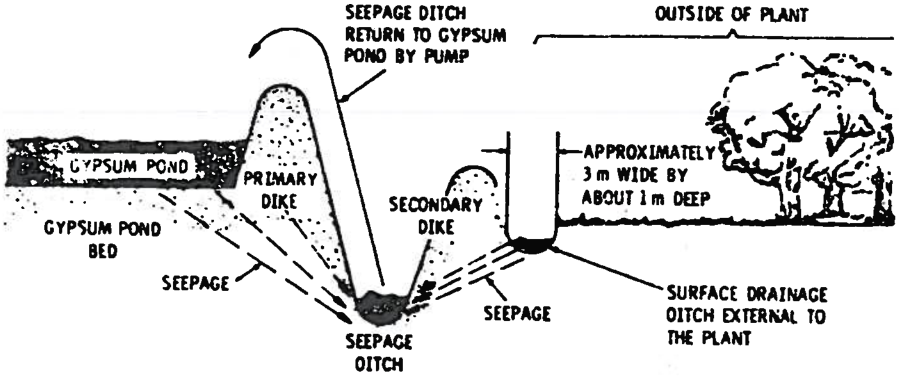

Figure 59. Gypsum pond water seepage control (17).

c. Lime Treatment of Gypsum Pond Effluents--
Double or triple lime treatment of gypsum pond effluents is the only wastewater control technology used by the phosphate fertilizer industry, and it is practiced at only those plants that still discharge effluents. A schematic diagram of a two-stage lime treatment plant is shown in Figure 60.

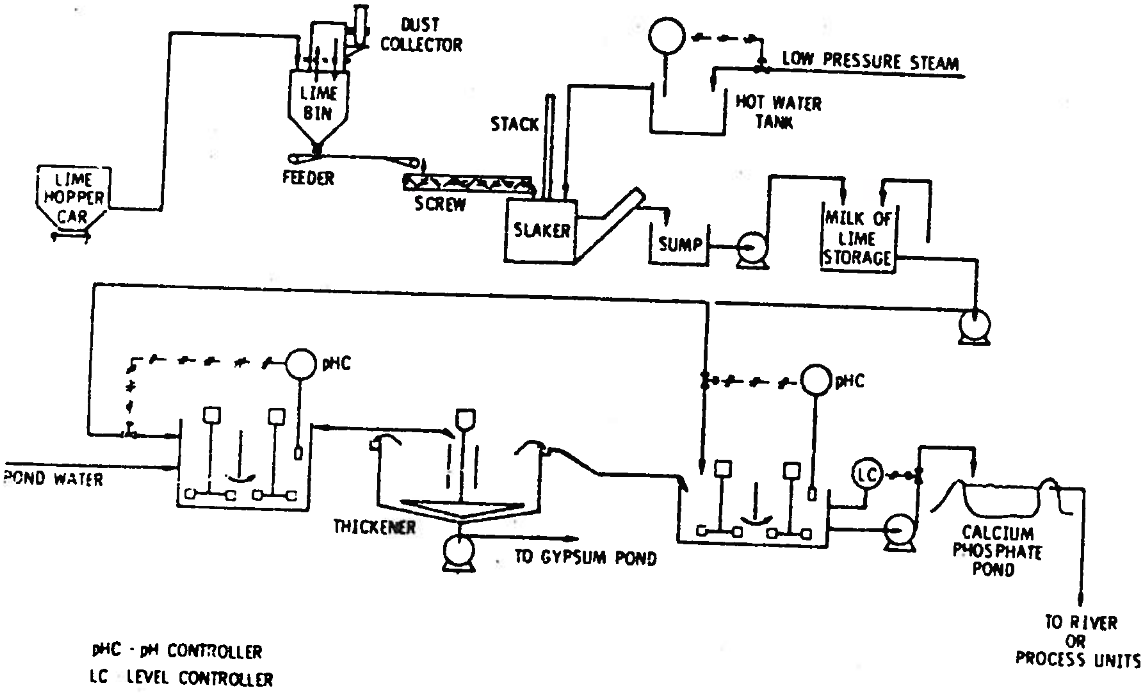

Figure 60. Two-stage lime treatment plant (17).

At least two stages of liming are required; the first treatment raises pH from less than 2 to about pH 3.5 to about pH 4.0 (20).

As pH increases, availability of fluoride ions increases, as illustrated in Figure 61 (20). Calcium fluoride (CaF_2) precipitates according to the following reaction (20):

$$Ca^{++} + 2F^{-} \longrightarrow CaF_2 \downarrow \qquad (38)$$

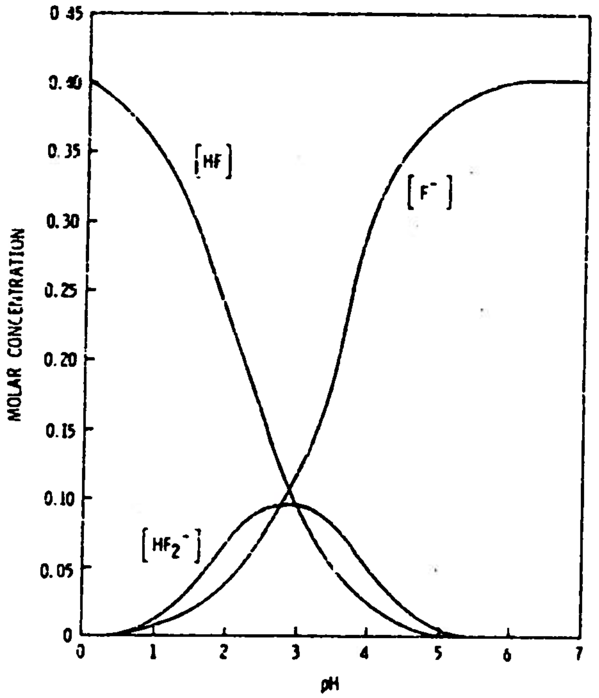

Figure 61. Species predominance diagram for 0.4 M hydrogen fluoride solution (20).

Another reaction also occurs, resulting in deposition of silica and calcium fluoride (20):

$$H_2SiF_6 + 3CaO + H_2O \longrightarrow 3CaF_2 + 2H_2O + SiO_2 \qquad (39)$$

The second stage of lime treatment raises pH to greater than 6.0, with calcium phosphates precipitating via the following reactions (20):

$$2H_3PO_4 + CaO + H_2O \longrightarrow Ca(H_2PO_4)_2 + 2H_2O \qquad (40)$$

$$Ca(H_2PO_4)_2 + CaO + H_2O \longrightarrow 2CaHPO_4 \downarrow + 2H_2O \qquad (41)$$

Additional calcium fluoride will also precipitate.

Results of neutralizing a sample of gypsum pond water to a pH of 5.1 are given in Table 46 (23).

TABLE 46. REACTION OF GYPSUM POND WATER WITH LIME (28)

Calcium carbonate added			Chemical composition of filtrate, g/m³			
kg/m³	Percent of theoretical[a]	pH of filtrate[b]	Phosphorus pentoxide	Calcium oxide	Sulfate	Fluoride
0[c]	0	1.8	2,000	1,400	2,760	2,900
6.0	50	3.2	1,650	1,200	2,500	1,000
9.0	75	3.4	1,410	1,100	2,300	70
12.0	100	4.8	590	1,100	2,600	20
13.2	110	5.1	580	1,100	2,700	20
15.0	125	5.1	580	1,100	2,600	30
18.0	150	5.1	580	1,100	2,600	30

[a] Calcium carbonate required to react with fluorine and phosphate.

[b] Measured with Beckman glass electrode pH meter, Model H-2.

[c] Original gypsum pond water.

Laboratory data for phosphorus and fluoride removal at pH values over 5 are presented in Table 47 (17).

TABLE 47. LABORATORY DATA FOR PHOSPHORUS AND FLUORIDE REMOVAL AT HIGHER pH (17)

pH	Phosphorus, g/m³		Fluoride, g/m³	
	Laboratory	Plant	Laboratory	Plant
5.5				
6.0		42		17
6.5		24		14
7.0	500	18	13	12.5
7.5	330	14	8.5	12.5
8.0	200	12	6.8	12.5
8.5	120	8	5.8	12.5
9.0	20	6	5.2	12.5
9.5	3	3	4.8	12.5
10.0	1.2	1.2	4.6	12.5

NOTE.—Blanks indicate data not available.

^{226}Ra is also precipitated by lime treatment with increasing pH as shown in Table 48.

TABLE 48. REMOVAL OF ^{226}Ra BY LIME TREATMENT (17)

pH	^{226}Ra, pCi/ℓ
2.0	91
1.5	65
4.0	7.6
8.0 to 8.5	0.04

"Double lime" treatment does not reduce nitrogen levels, although at high pH (greater than 9.0) significant ammonia loss to ambient air can occur (17). To date there is no proven means of economically removing ammonia nitrogen from aqueous solutions having low concentrations in the range of 20 to 60 g/m^3. The best control method is keeping the ammonia contaminant level low by preventing its entry into the main contaminated water system. This is accomplished to a great extent by scrubbing emissions from the ammonium phosphate production unit with a weak solution of phosphoric acid that is subsequently consumed in the process.

The main disadvantage of the liming operation for continual use is the high cost involved. Because the buffering capacity of the gypsum pond water is high at pH 1.0 to pH 3.0, large amounts of lime are required to raise the pH initially to 3.0 relative to the amount required to raise the pH from 3.0 to 6.0 (20). An additional disadvantage is the deposition of calcium fluoride on the lime particles, rendering them chemically inactive. The use of high intensity agitators is required to prevent this from happening.

An investigation was conducted specifically to evaluate the reduction in radionuclide levels in wastewaters by various lime treatment processes (14). In the initial treatment laboratory tests, process pond water was obtained from a Florida wet process facility, and four bases (quick lime, limestone, hydrated lime, and dolomite) were added to 4 ℓ of process water in different amounts to increase the pH. After vigorous agitation, the solutions were allowed to settle, and the resultant supernatant liquids were filtered and analyzed for their soluble ^{226}Ra concentrations. The results as presented in Table 49 show that in all treatment cases the soluble ^{226}Ra concentration was reduced by more than 99.7%, even though the final pH ranged from 4.0 to 8.0. This large reduction is attributed to the amount of readily available sulfate ions in the process water enabling large-scale coprecipitation of calcium-radium sulfate.

TABLE 49. LABORATORY PROCESS WATER TREATMENT STUDY (14)

Treatment	Amount of base added, g	Resultant pH	Dissolved ^{226}Ra, pCi/ℓ
Untreated process water	0	2.0	75.8[a]
Calcium oxide (quick lime)	70	7.9	0.15
Limestone rock	500	4.6	0.11
Slaked lime (hydrated lime)	50	8.0	0.07
Dolomite	500	4.0	0.16

[a] 6.7 pCi/ℓ undissolved.

Subsequently, field studies were conducted at several WPPA facilities to verify the effectiveness of lime treatment as observed in the laboratory (14). Results at four plants are presented in Table 50.

TABLE 53. EFFECT OF LIME TREATMENT ON RADIOACTIVITY REMOVAL FROM EFFLUENTS FROM A WPPA PLANT (14)

Sample	pH	Total ^{226}Ra, pCi/ℓ	Total uranium, pCi/ℓ			Total thorium, pCi/ℓ		
			^{234}U	^{235}U	^{238}U	^{228}Th	^{230}Th	^{232}Th
Plant A--Field Survey Number 1								
Untreated process water	2.0	82.3	1,086	48	1,045	2.5	70	4.5
Outfall (after double liming)	9.1	4.54	1.09	ND[a]	0.52	0.44	0.57	0.04
Plant A--Field Survey Number 2								
Untreated process water	1.9	55.6	411	24	394	3.4	101	3.2
Limed once	4.4	1.20	b	b	b	b	b	b
Prior to second liming	4.3	1.5	39.7	2.2	39.5	ND	0.52	ND
Outfall (after second liming)	7.1	1.8	16.8	0.98	15.8	0.32	0.71	0.11
Plant B--Field Survey Number 1								
Untreated process water	2	86.2	1,769	98.8	1,825	3.92	393	6.33
After first liming[c]	4.5	74.0	736	33.4	734	6.15	4.3	7.5
Prior to second liming	6	0.90	67.8	3.17	68.1	ND	1.32	ND
Outfall (after double liming)	8	0.45	0.26	ND	0.33	0.1	0.13	ND
Untreated nonprocess water	-[b]	1.39	0.28	ND	0.39	ND	ND	ND
Nonprocess water after liming	-[b]	2.6	0.96	ND	0.75	0.13	0.79	0.07
Nonprocess water outfall	-[b]	0.98	0.34	ND	0.42	ND	1.32	ND
Plant C--Field Survey Number 1								
Process water	1.9	55.2	676	35.1	661	0.86	8.6	4.1
Outfall (after single liming)	6.6	2.55	0.26	ND	0.28	ND	ND	ND

[a] None detected. [b] Not measured.

[c] These concentrations are high because of the large suspended solids load of 23.5 g/ℓ. The dissolved concentrations in picocuries per liter were 5.2 for ^{226}Ra, 12.8 for ^{234}U, 0.52 for ^{235}U, and 12.9 for ^{238}U.

Field survey number 1 at Plant A was conducted very early in the rainy season prior to the initiation of large-scale effluent treatment. Field survey number 2 was performed late in the rainy season after almost continuous lime treatment for over 2 mo. A comparison of process water from survey number 1 to survey number 2 shows a 32% decrease in ^{226}Ra concentration during the second survey. This is probably due to the combination of dilution of the process water by the influx of surface rain runoff and the removal of the radioactive material by treatment and discharge of approximately 10,000 cubic meters of water per day.

Results for every plant show that treatment with lime is highly efficient (greater than 94%) in removing ^{226}Ra from the discharged process water, in good agreement with removal efficiencies observed in the laboratory experiments. Lime treatment also proved to be extremely effective in removing uranium and ^{230}Th from treated process water, with removal efficiencies of at least 96% and 99%, respectively, in the four cases noted.

Therefore, although primarily designed for pH, phosphorus and fluoride control, not for removal of radionuclides in the effluent, treatment with lime was observed to be highly effective in removing ^{226}Ra, uranium, and thorium from the effluent discharge. These results are attributed to the following factors (14):

- Process water contains a large concentration of sulfate and phosphate ions to enable ready compound formation.

- Neutralization by an agent such as lime not only allows for the reduction of solubility of several compounds but provides an ample supply of calcium ions to enable the large-scale formation of calcium sulfate.

- The relative insolubility of radium sulfate makes it readily coprecipitate with calcium sulfate.

- Uranium and thorium probably precipitate along with calcium sulfate and other components through substitution for calcium in formed compounds.

- Settling provides the opportunity for the precipitated compounds to be removed from the effluent and not be discharged as suspended solids.

B. POTENTIAL ENVIRONMENTAL EFFECTS

1. Wastewater Disposal and Treatment Practices

Information about the extent of wastewater disposal and/or containment practices utilized by the phosphate fertilizer industry was obtained through industrial contacts. A summary of the wastewater handling practices is presented in Table 51. Contacts with over 70% of the plants in the industry revealed that nearly 75% have no discharge of process wastewater. Of the 15 plants that reported a discharge, 12 reported a discharge of treated process water only when necessitated by excessive rainfall. Several of these had not treated or discharged water for several years. In actual practice, discharge of contaminated process water from the recycle pond system is held to an absolute minimum due to the treatment cost involved.

Wastewater discharge practices have been restricted due to recently promulgated EPA regulations. Beginning July 1, 1977, and effective when each plant's wastewater discharge permits are subject to renewal, discharge of process wastewater pollutants to navigable waters is allowed only under the following conditions (79):

- Process wastewater impoundment facilities must be constructed to contain precipitation from the 10-yr, 24-hr rainfall event as established by the U.S. National Weather Service.

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(79) 40 CFR 418, Fertilizer Manufacturing Point Source Category, Subpart A--Phosphate Subcategory. Federal Register, 41(98): 20582-20585, 1976.

TABLE 51. WATER EFFLUENT DISPOSAL AND CONTAINMENT PRACTICES FOR THE PHOSPHATE FERTILIZER INDUSTRY

[percent of plants specified (number of plants)]

	Industry					
	Wet process phosphoric acid plants	Superphosphoric acid plants	Normal superphosphate plants	Triple superphosphate plants	Ammonium phosphate plants	Total phosphate fertilizer industry
Process water discharged continuously:						
Treated	7 (2)[a]	0 (0)	0 (0)[b]	7 (1)[a]	6 (2)[a]	3.1 (2)
Untreated	3 (1)[c]	0 (0)	0 (0)	0 (0)	0 (0)	1.5 (1)
Discharge of treated process water only when necessitated by excessive rainfall[d,e]	38 (11)[f]	44 (4)[f]	6 (2)	57 (8)[f]	38 (12)[f]	18.5 (12)
No discharge of process water reported	52 (15)	56 (5)	88 (27)	36 (5)	53 (17)	72.3 (47)
Insufficient information	0 (0)	0 (0)	6 (2)	0 (0)	3 (1)	4.6 (3)
Total	100 (29)	100 (9)	100 (31)	100 (14)	100 (32)	100 (65)
Pond system onsite for water containment and reuse:	90 (26)	89 (8)	36 (11)	100 (14)	84 (27)	
Continuous discharge from pond system	7 (2)[a]	0 (0)	0 (0)	7 (1)[a]	6 (2)[a]	
Discharge only when necessitated by periods of excessive rainfall	38 (11)	44 (4)	6 (2)	57 (8)	38 (12)	
No discharge from pond system reported	45 (13)	44 (4)	23 (7)	36 (5)	38 (12)	
Treat pond system with lime to precipitate fluorides and other contaminants	3 (1)	11 (1)	13 (4)	7 (1)	3 (1)	
Uncertain	0 (0)	0 (0)	6 (2)	0 (0)	3 (1)	
No pond system onsite	0 (0)	0 (0)	-[g]	0 (0)	3 (1)[h]	
Information regarding wastewater handling system incomplete	10 (3)	11 (1)	3 (1)	0 (0)	13 (4)	
Recover fluosilicic acid	28 (8)	0 (0)	61 (19)	0 (0)	0 (0)	
Number of plants contacted	29	9	51[i]	14	33[i]	
Number of plants in industry	36	9	66	16	48	
Percent of industry surveyed	81	100	77	88	69	

[a] Completion of proposed modifications to water recycle system in December 1977 at one plant will result in discharge of process wastewater only in event of excessive rainfall.

[b] One NSP plant that was found to discharge into a sewer system after neutralizing liquid wastes ceased production in 1975.

[c] One plant uses Mississippi River water on a once-through basis and discharges without treating (gypsum is impounded).

[d] Actual number may vary somewhat since some plants that report no discharge of process wastewater may in fact discharge in the event of an extremely rainy period.

[e] Many plants report no discharge of process wastewater necessary for 3 yr or more.

[f] One plant reported that excess water is double limed and sent to a mine for use and that no contaminated water will be allowed to enter navigable streams or public waters.

[g] Number of plants having no pond system onsite is uncertain, because NSP plants practicing fluorine recovery may still employ a small pond or reservoir.

[h] Ammonium phosphate production unit is located at a steel mill.

[i] Wastewater handling practices for those plants expected to close during 1976 or early 1977 were not included in survey.

- Process wastewater must be treated and discharged whenever the water level due to catastrophic precipitation events equals or exceeds the midpoint of the surge capacity.

- When such a discharge must occur, the pollutant concentrations must have 30-day average values of less than 35 g/m^3 of total phosphorus and 25 g/m^3 of fluoride.

2. Effluent Parameters

Wastewater from the manufacture of phosphate fertilizer materials originates from many point and nonpoint sources. The quantity and characteristics of a given plant effluent are dependent on the types of processes present at a complex, plant-to-plant variations in process design and operation, equipment age, level of maintenance, plant drainage and collection system, and wastewater treatment methods. As a result, it is difficult to define average effluent parameters that are truly representative of the industry as a whole. The approach taken in this study is to present available water discharge data for a representative number of the phosphate fertilizer complexes that report a discharge.

Justification for this approach is as follows:

- Thirteen of the fourteen ammonium phosphate plants that were found in the study to discharge wastewater are located at fertilizer complexes producing phosphoric acid. The one exception uses excess process water to irrigate pasture land. No other information is available concerning this plant. Another plant reporting a discharge of treated wastewater and not located at a phosphoric acid complex was expected to discontinue ammonium phosphate production in early 1977 and was not included in the survey results.

- All superphosphoric acid plants are located at complexes producing WPPA.

- Fifteen of the sixteen TSP plants are located at fertilizer complexes producing WPPA. The one exception was expected to close during calendar year 1976 or early 1977.

- The two NSP plants that reported a discharge of process water when necessitated by excessive rainfall are located at complexes producing phosphoric acid.

Available wastewater discharge data on file as of October 1976 at the Florida Department of Environmental Regulation in Winter Haven were collected and are presented in Table 52. Nonprocess water from a phosphate fertilizer plant may include any of the following: noncontact cooling water from the phosphoric acid

TABLE 52. WASTEWATER DISCHARGE DATA FOR PHOSPHATE FERTILIZER PLANTS

Plant code	Design production capacity, metric tons P_2O_5/day	Type of discharge	Reported treatment	pH, range (average)	Yearly average/daily maximum Flow rate, m^3/s	Fluoride, g/m^3	Total suspended solids, g/m^3	Phosphorus, g/m^3	Ammonia-nitrogen, g/m^3	^{226}Ra, pCi/ℓ	Date
A	1,900	Process (pond)	Double limed.	5.6/11.7 (8.8)	0.41/0.21	20.1/49.0	21.8/71.0	43.1/330.0	32.6/82	2.0/6.2	7/75 to 6/76
		Nonprocess:									
		1	–[a]	6.2/11.7 (9.2)	0.29/0.61	4.38/14.0	3.7/18.0	0.8/12.1			7/75 to 6/76
		2		2.4/9.0 (7.4)	0.018/0.031	9.3/175	19.3/128	46.3/780			7/75 to 12/75
B	1,270	Pond[b]	Neutralize discharge.[c]	3.5/10.5	2.0/	28.5/225	68/267	25/55	7.4/149		Date unknown[d]
C[e]	272	Nonprocess	Lime treat if necessary.	/7.1 (6.7)	0.36/0.91	5.0/56	10/15	15.3/18.9			5/75 to 4/76
					0.36/	1.8/	6.6/	11.2			6/77 to 5/78
D[e]	535	Nonprocess[f]	Lime treat if necessary.	/7.5 (6.6)	0.18/0.44	8.2/12.8	8.5/14.1	21.0/37.2			4/75 to 4/76
					0.28/	6.3/	4.3/	12.1/			
E	381	Process (pond)[g]	Double limed.	5.6/11.4	0.0013/	39.2/183	172/	52.9/	8.8/		1973
		Seepage (pond)		3.6/6.2	0.000020/	3,381/6,500	20.8/	39/			
		Nonprocess		5.5/10.2	0.027/	4.0/42.5	10/	4.9/	3.6/		
F	907	Nonprocess[h, i]	Allowed to settle before discharge.	/8.0 (5.4)	0.025/0.11	1.66/5.1	15.5/58	2.56/4.8			7/75 to 7/76
G	363	Process (pond)[j]	Neutralize and discharge.[k]	/10.54 (3.37)	0.45/0.69	8.4/27.0	21.9/215	15.3/128			6/75 to 5/76

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[a] Blanks indicate information not available. [b] All wastewater enters pond system. [c] New wastewater handling system now used. [d] Early 1970's.

[e] More recent effluent data supplied by plant personnel. [f] Zero discharge of process water from pond system practiced.

[g] Last discharge of process water occurred in 1975; as of October 1976 discharge of process water only during period of excessive rainfall.

[h] Discharge of pond water only in period of extreme rainfall. [i] No discharge of pond water required in previous 5-yr period.

[j] All water enters pond system. [k] Modifications to existing wastewater handling system completed December 1977. Will discharge from pond only during period of heavy rainfall after double limining in future.

production unit, cooling tower blowdown from an associated sulfuric acid plant, rainfall runoff, drainage from mined-out areas, washdown waters, and spills.

3. Source Severity

For water effluents source severity compares the concentration of a particular pollutant after discharge and dilution in the receiving body with an estimated allowable concentration denoted as the hazard factor. The concepts of hazard factor and severity are used as a basis for comparison of the relative impacts of a large number of source types. The hazard factors used in this evaluation may be changed as better health effects data becomes available.

In determining the source severity of a plant, the discharge quantity is compared to the receiving body flow rate times the hazard factor according to Equation 42.

$$S = \frac{V_D C_D}{V_R + V_D \; F} \tag{42}$$

where S = source severity for a particular pollutant

V_D = wastewater effluent flow rate, m^3/s

C_D = concentration of particular pollutant, g/m^3

V_R = volumetric flow rate of receiving body above plant discharge, m^3/s

F = hazard factor for particular pollutant, g/m^3

Hazard factors for individual pollutants are given in Table 53 (80-82).

A value of 1.00 g/m^3 was used for the ammonia-nitrogen present in the wastewater effluent because at a pH of 7 or lower, nearly 100% of the ammonia-nitrogen exists in the ionized form.

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(80) Quality Criteria for Water. EPA-440/9-76-023, U.S. Environmental Protection Agency, Washington, D.C., 1976. pp. 16-21.

(81) Manual of Treatment Techniques for Meeting the Interim Primary Drinking Water Regulations. EPA-600/8-77-005, U.S. Environmental Protection Agency, Cincinnati, Ohio, May 1977. 73 pp.

(82) Eimutis, E. C., J. L. Delaney, T. J. Hoogheem, S. R. Archer, J. C. Ochsner, W. R. McCurley, T. W. Hughes, and R. P. Quill. Source Assessment: Prioritization of Stationary Water Pollution Sources. EPA-600/2-77-107p, U.S. Environmental Protection Agency, Washington, D.C., December 1977. 119 pp.

TABLE 53. HAZARD FACTORS (80-82)

Effluent species	Hazard factor
	g/m³
Fluoride	0.19
Total suspended solids	25
Phosphate-phosphorus	0.10
Ammonia-nitrogen (ionized form)	1.00
	pCi/ℓ
^{226}Ra	5

Discharge data presented in Table 52 were used to calculate source severity values. Source severities for individual phosphate fertilizer complexes are presented in Table 54. Only one set of eight measurements for ^{226}Ra contamination in discharged process waters was available. The low severity determined for this case along with the information presented in Table 48 for radium precipitation with increasing pH suggest that the severity due to this contaminant will remain extremely low in effluent streams treated with lime to remove fluorides and phosphates. Source severities for fluoride, phosphorus, and to a lesser degree ammonia-nitrogen are in a number of cases greater than 1.0. This is due to the low flow rate (1 m³/s to 6 m³/s) of the receiving bodies (83). By comparison, the mean flow rate of the Ohio River at Greenup, Kentucky, is 3,210 m³/s (84).

In addition to the effects from normal wastewater discharge, there is a potential danger from dike failure around a gypsum pond. Such failures have occurred in the past and have resulted in large fish kills when untreated pond waters were discharged directly into surface streams. Dikes are now constructed to prevent this from happening; thus, there is no way to evaluate the chances of future dike failures.

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(83) Water Resources Data for Florida, Water Year 1975. Volume 3--West-Central Florida Surface Water, Ground Water, Quality of Water. USGS-WRD-FL-75-3 (PB 259 493), U.S. Department of Commerce, Tallahassee, Florida, July 1976. 1249 pp.

(84) Water Resources Data for Kentucky, Water Year 1975. USGS-WDR-KY-75-1 (PB 251 853), U.S. Department of Commerce, Louisville, Kentucky, January 1976. 348 pp.

TABLE 54. SOURCE SEVERITIES FOR WASTEWATER DISCHARGES AT INDIVIDUAL PHOSPHATE FERTILIZER COMPLEXES

Plant code	Receiving body	Type of discharge	Mean flow rate of receiving body,[a] m³/s (82)	Source severities[b]				
				Fluoride	Total suspended solids	Phosphorus	Ammonia-nitrogen	Radium
A	North Prong, Alafia River	Process (pond)	2.97	1.43	0.012	5.82	0.44	0.007
		Nonprocess		2.3	0.018	3.2	-[c]	-
		Combined		3.59	0.028	8.44	-	-
B	North Prong, Alafia River	Pond[d]	2.97	11.6	0.20	19.3	0.57	-
C	Peace River	Nonprocess[e]	1.02	6.86	0.10	39.9	-	-
				2.47	0.069	..	-	-
D	Peace River	Nonprocess[e]	1.02	6.47	0.051	31.5	-	-
				7.14	0.037	26.1	-	-
E	North Prong, Alafia River	Process (pond)	2.97	0.089	0.0030	0.227	0.0038	-
		Seepage (pond)		0.12	0.0000058	0.00273	-	-
		Nonprocess		0.19	0.0036	0.44	0.32	-
		Combined		0.40	0.0065	0.67	0.36	-
F	Skinned Sappling Creek to Alafia River	Nonprocess	6.14[g]	0.035[g]	0.0025[g]	0.102[g]	-	-
G	Thirty Mile Creek to North Prong, Alafia River	Process Pond	2.97[i]	5.75[i]	0.11[i]	19.9[i]	-	-

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[a] Mean of daily averages for the 1975 water year (October 1974 to September 1975).

[b] Average discharge rates and contaminant levels used in severity calculations.

[c] Dashes indicate that information not reported or that insufficient information was available to perform calculation.

[d] All wastewater enters pond system.

[e] Zero discharge of process water from pond system practiced.

[f] Discharge of process water from pond system only in event of extreme rainfall period.

[g] Based on information available for the Alafia River since flow data for Skinned Sappling Creek are not reported.

[h] All water enters pond system.

[i] Based on information available for the North Prong of the Alafia River since flow data for Thirty Mile Creek are not reported.

SECTION 6

SOLID RESIDUE

A. SOURCES OF SOLID RESIDUE

Solid residue wastes are generated at phosphate fertilizer plants in the form of sludges and other slurries. These suspensions are sent to the gypsum pond or other settling basin where solids settle. The settled mass is either left in the pond, dredged for use in extending the dike, or recovered as a resource.

There are three sources of solid residue in the phosphate fertilizer industry:

- Gypsum from the filtration of wet process phosphoric acid.
- WPPA sludge.
- Wet scrubber liquor.

Gypsum ($CaSO_4 \cdot 2H_2O$), a byproduct in WPPA manufacture, is formed by reaction of phosphate rock with aqueous sulfuric acid:

$$Ca_3(PO_4)_2 + 3H_2SO_4 + 6H_2O \rightleftarrows 2H_3PO_4 + 3(CaSO_4 \cdot 2H_2O) \qquad (43)$$

Reactant slurry flows from the acidulator to the filtration unit, where phosphoric acid is drawn off by vacuum filtration, leaving gypsum cake on the filter. Cake is washed with weak phosphoric acid to recover its residual acid and then rinsed from the filter screens with recycled pond water. Gypsum slurry flows to the gypsum pond for solids settling. In areas where land stability or availability prevents the use of ponds, gypsum cake from the filters is transported by conveyor to gypsum piles.

The quantity of gypsum produced in a WPPA plant ranges from 4.6 to 5.2 metric tons of gypsum/metric ton P_2O_5 produced (24, 64). As a rule of thumb, approximately 1,360 m^3 of gypsum will be accumulated yearly per metric ton of P_2O_5 produced per day (24).

A second source of solid residue is phosphoric acid from which impurity-bearing minerals settle out in the clarifier to form acid sludges. Phosphate rock salts which contribute to acid sludge formation include fluorine, iron, aluminum, silicon, sodium, and potassium salts. Table 55 shows an analysis of solids collected at various stages of WPPA acid production (22).

TABLE 55. ANALYSIS OF SOLIDS FROM WPPA (22)

Reprinted from Phosphoric Acid, Volume I, A. V. Slack, editor, p. 694, by courtesy of Marcel Dekker, Inc.

	Analysis, weight percent						
Solids from	Phosphorus pentoxide	Calcium	Sulfate	Aluminum	Iron	Fluorine	Silica
32% P_2O_5 acid (feed to evaporators)	1.[illegible]	14.8	38.9	0.3	0.2	19.9	10.3
54% P_2O_5 acid from evaporators	6.8	12.9	29.0	5.1	0.3	22.0	5.3
54% P_2O_5 acid from storage	38.9	3.3	4.7	1.5	9.6	12.9	6.1

Fluosilicates, fluorides, silica, cryolite [(Na or K)$_3$AlF$_6$], sulfates, unreacted phosphate rock, and various other combinations of impurities as complex salts have been identified in acid sludge (22).

Acid sludge is separated from acid in the clarification process. Separated solids can be either dried and used as a fertilizer or sent to the gypsum pond. Effluent from the clarification process ranges from 0.7 m^3 to 3.2 m^3/metric ton P_2O_5 (17).

The third source of solid residue wastes is wet scrubber liquor. Wet scrubbers are used throughout the phosphate fertilizer industry to remove particulates and fluorides from exhaust gas streams. Recycled gypsum pond water is used as scrubbing solution. After passing through the wet scrubber, solution is recycled back to the gypsum pond for solids settling.

At ammonium phosphate plants, for example, scrubber liquor going to the gypsum pond contains about 10 g of solid residue per kilogram of P_2O_5. This solid residue (20) is primarily silicon hydroxide ($Si[OH]_4$). The solids value is calculated on the basis of a filtered-to-concentrated phosphoric acid ratio of 1:1, assuming that all the fluorine from the acid goes to the exhaust gas stream as silicon tetrafluoride and that 85% of silicon tetrafluoride is collected in the scrubbing system. These solids will be deposited in the gypsum pond.

Although solid residue values for wet scrubber systems at other phosphate fertilizer operations do not exist, they should be similar to those for ammonium phosphate plants.

B. POTENTIAL ENVIRONMENTAL EFFECTS

Approximately 99% of solid residue wastes generated at phosphate fertilizer plants are stored in ponds, stacked in piles, or stored in mining pits at the plant site. The remaining 1% is sold as a raw material for various products.

Rainfall drainage from gypsum piles is collected in a ditch and recycled to the gypsum pond. Therefore, under normal conditions there will be no adverse environmental effect due to solid residues. The only concern due to these wastes is the large amount of land area required to store gypsum and the unsightly appearance of 30-m piles of gypsum.

To date, there are no data with which to evaluate potential effects on groundwater due to leaching from gypsum piles. Since gypsum wastes contain mainly calcium sulfate and lesser quantities of phosphates and fluorides, any potential adverse effect should be minimal.

There are no data available to estimate air emissions from gypsum piles due to wind erosion. However, this effect is minimal; layers of clay are applied to the surface of the gypsum for added strength when the material is used for dikes. Also, gypsum is listed as a nuisance dust with a corresponding inhalation TLV of 10 mg/m^3 of air (70).

C. CONTROL TECHNOLOGY

1. Disposal Practices

Waste gypsum produced in a WPPA plant ranges from 4.6 to 5.2 metric tons gypsum per metric ton of P_2O_5 produced (24, 64). Approximately 1,360 m^3 of gypsum will be accumulated yearly per metric ton of P_2O_5 produced per day so that at least 2,230 m^2 of land area per daily metric ton P_2O_5 should be reserved for gypsum disposal.

In the United States and other locations, three disposal practices are currently used: 1) gypsum ponds and piles, 2) abandoned mine pits, and 3) sea disposal. In the United States, more than 90% of the plants use gypsum ponds to collect slurry. Initially, two or more areas are converted to lagoons by means of low dikes provided with proper outfalls for potential effluent discharge. As one area becomes filled, the gypsum stream is diverted to the second area, and the first section is allowed to dry out sufficiently to support mechanical equipment. The dike is then increased in height using deposited gypsum as raw material, and the procedure is repeated. Existing gypsum piles range in height from 30 m to 36 m (17, 24).

In western states where poor land stability or availability prevents using gypsum ponds, gypsum cake from the vacuum filters is transported by conveyor to gypsum piles.

The second disposal technique is practiced primarily in Florida. Instead of constructing gypsum ponds, abandoned phosphate rock surface mines are used as gypsum ponds and for other solid residue disposal. The only potential environmental hazard from this disposal technique is possible leaching of fluorides, phosphates, and 226 Ra into groundwater systems. The potential for such leaching to occur is presently unknown.

A third disposal technique, used by less than 2% of phosphate fertilizer plants in the United States but more widely used throughout Europe, is practiced at plants located in coastal areas. After removal from the vacuum filters, gypsum is slurried with about a tenfold quantity of seawater or cooling water. It is then pumped into the ocean, or, in a few cases, discharged into major rivers (64).

Seawater is a better solvent for gypsum than freshwater. Solubility of gypsum in seawater is about 3,500 g/m^3 as compared to about 2,300 g/m^3 in fresh water. The solids content of the gypsum slurry is below 5%, low enough for quick dispersion and dissolution in ocean water (64).

2. Resource Recovery

Several approaches have been taken in seeking commercial uses for waste gypsum and its associated solid residues. In 1975, approximately 30 x 10^6 metric tons of gypsum waste were generated by the phosphate fertilizer industry (85). Of this total, about 90 x 10^3 metric tons were applied to calcium-deficient soil in the southern states for peanut growing. Gypsum was also used for improvement of alkali soils in California and for land reclamation in coastal areas.

Because gypsum waste, often referred to as phosphogypsum (86), contains varying quantitites of phosphoric acid, it also serves as a light fertilizer.

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(85) Personal communication with John Sweeney, U.S. Bureau of Mines, Tallahassee, Florida, 26 September 1977.

(86) Murakami, K. By-product Recovery, As Raw Material for Plaster and Cement - Japanese Practice. In: Phosphoric Acid, Volume I, A. V. Slack, ed. Marcel Dekker, Inc., New York, New York, 1968. pp. 519-523.

Waste gypsum has been used for wallboard. In the United States, however, the dihydrate process for phosphoric acid production produces a gypsum waste high in phosphoric acid which results in poor quality wallboard. Also, there is some concern about possible low-level radiation effects from wallboard made of uranium- and radium-containing gypsum wastes.

In Europe and Japan where the hemihydrate process is more commonly used, the resulting gypsum waste is purer, containing less phosphoric acid and uranium. More of this gypsum waste is used for wallboard. In England, where only the standard dihydrate process is used, special purification methods make the byproduct suitable for wallboard. This purification step is more economically feasible in England than in the United States because natural (and purer) gypsum is not as abundant in England as it is in the United States (27).

Another possible use for gypsum is in cement and other road toppings. However, the phosphoric acid and other phosphates retard setting and lower the strength of the hardened body. Fluorine compounds reduce setting time and lower the concrete strength, but these effects are small compared to the effects of phosphate contamination (86). In Florida, there are further concerns over public exposure to low-level radiation from road surfaces containing gypsum wastes or from road base material containing phosphate rock mining overburden.

Gypsum can be reacted with ammonia and carbon dioxide to form ammonium sulfate and calcium carbonate. This is an old and well-known practice applied to natural gypsum, but there has been relatively little application to waste gypsum. Only a few plants in India, Japan, and Europe use this technology (27).

Another potential resource recovery method is treating waste gypsum with silica at high temperatures to produce sulfuric acid. Furthermore, the additional product of calcium silicate could be used for cement. Although the method is technically feasible, the high water content of gypsum, the corrosive effect of fluorides, and the adverse effect of P_2O_5 content on cement quality are all major drawbacks. Moreover, due to the price and availability of sulfur in the United States, this technology is not yet economically feasible (27).

While several potential resource recovery methods are technically feasible, less than 1% of the gypsum waste in the United States is utilized because its recovery is not economically feasible and its disposal does not pose an environmental hazard. The remaining quantity is stored in piles near the plants.

SECTION 7

GROWTH AND NATURE OF THE INDUSTRY

A. PRESENT TECHNOLOGY

The recent trend in WPPA manufacture has been toward larger capacity, enclosed producing units with closer control of operating variables. Single, multicompartment tanks have replaced the earlier multiple tank systems and increased capacities from the older design capabilities of 180 to 270 metric tons P_2O_5 per day. Today a modern plant can produce 450 to 1,100 metric tons P_2O_5 daily (17). Improved engineering design and materials of construction have decreased capital and operating costs per unit capacity and have improved overall operating efficiency in WPPA manufacture. Recent production rates for WPPA are shown in Figure 62.

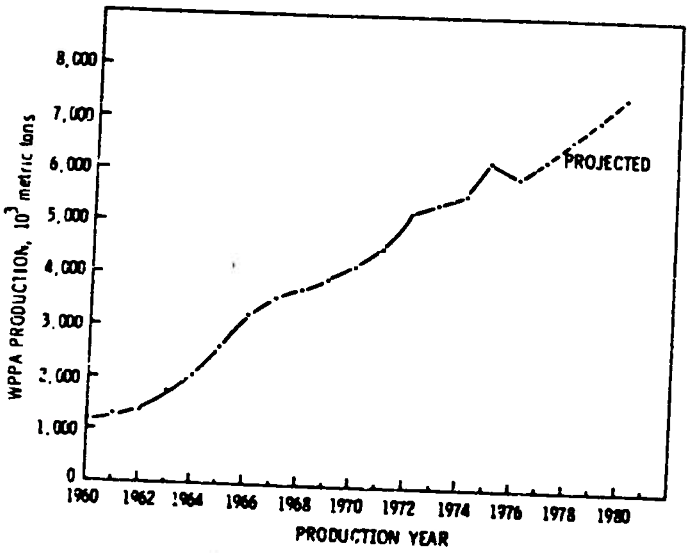

Figure 62. WPPA production trend (3).

NSP was, for many years, the major agricultural source of phosphate nutrient. In 1947 NSP accounted for over 90% of the total domestic supply. Since the mid 1950's, however, the popularity of NSP has undergone a sharp decline, and only in the past few years has the rate of decline started to moderate. Production