TEXAS WATER COMMISSION

Report LD-0864

INVESTIGATION OF GROUND-WATER CONTAMINATION BY COTTON SEED DELINTING ACID WASTE, TERRY COUNTY, TEXAS

By

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TABLE OF CONTENTS

TABLES

TABLE OF CONTENTS (Cont'd.)

Page

ILLUSTRATIONS

Figures

Plates

Follows

INVESTIGATION OF GROUND-WATER CONTAMINATION BY COTTON SEED DELINTING ACID WASTE, TERRY COUNTY, TEXAS

INTRODUCTION

This investigation was conducted at the request of the Texas Water Pollution Control Board as the result of a complaint by Mr. W. D. Clark, Brownfield, Texas. Mr. Clark had stated in a letter to the Texas Water Pollution Control Board, dated December 31, 1963, that the Brownfield Seed and Delinting Company was disposing of acid in unlined pits and that he was concerned about the possibility of contamination in his nearby water wells.

A field investigation of the complaint was conducted during the period April 6 to April 10, 1964. During the investigation, water samples were collected and water levels were measured in selected water wells in the area, samples of the disposal fluid were collected, and the operations and disposal methods of the delinting company were observed. A second investigation was conducted on May 11 and 12, 1964, to obtain additional water well data and to make a reconnaissance of acid delinting operations in the general Southern High Plains area.

Location

The area of investigation lies one mile south of Brownfield, Terry County, Texas near State Highway 137 (see Figure 1). Terry County is located in the southern part of the Southern High Plains of Texas.

Geography and Economy

The topography of Terry County is relatively flat with playa lakes, sand dunes, and small stream valleys forming minor features of relief. Surface drainage-ways trend southeast; however, most of the annual rainfall of approximately 18 inches per year is absorbed by the characteristically sandy soils which allow a limited amount of runoff.

The economy of the area is based primarily on agriculture. Cotton is the predominant crop being sprinkler irrigated with ground water. Oil production in the county also contributes to the economy.

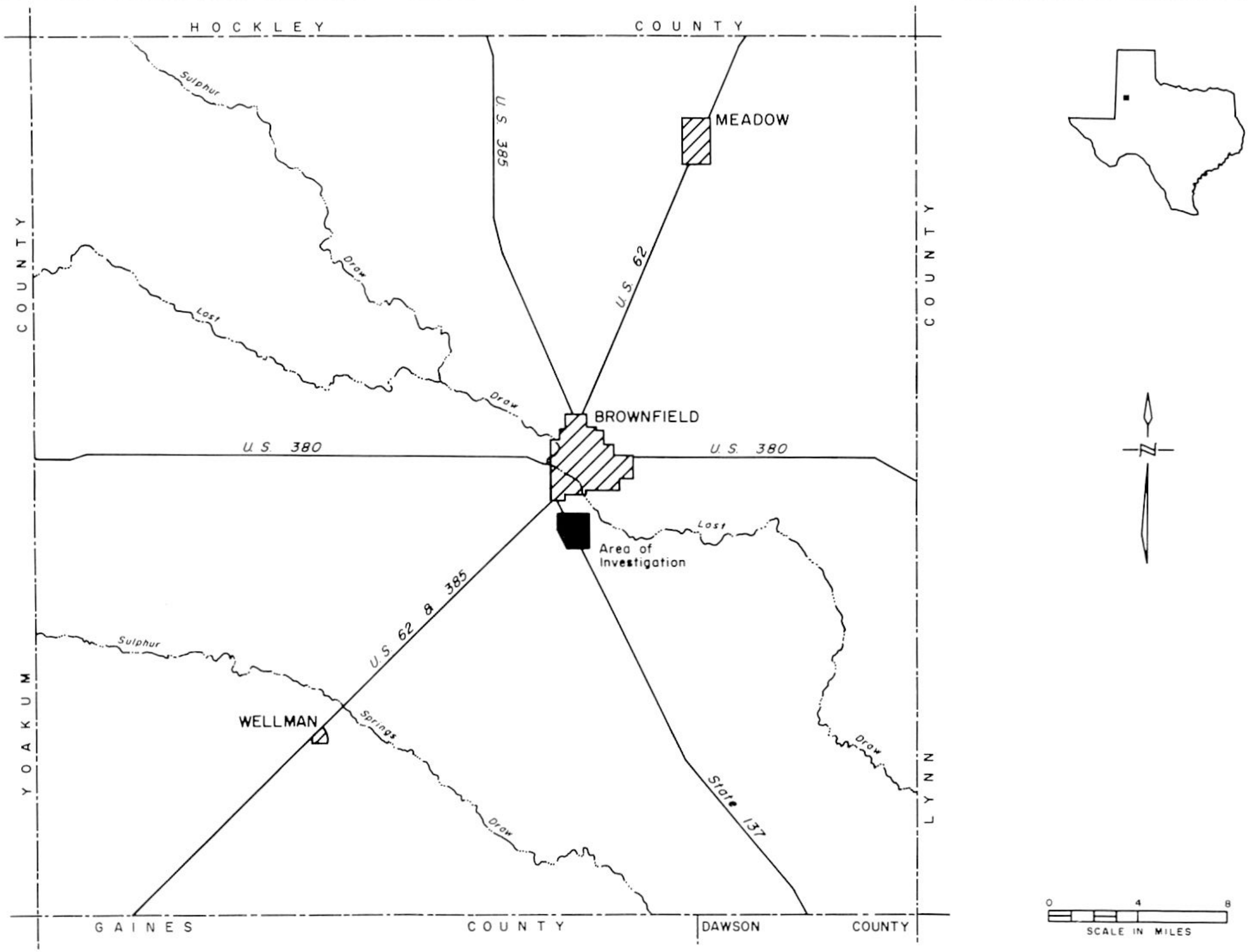


Figure 1
INDEX MAP SHOWING LOCATION OF AREA OF INVESTIGATION
Texas Water Commission

178

Previous Investigations

Apparently there have been no previous investigations in the area concerning acid disposal operations. General ground-water investigations have been conducted in this area by Cromack (1944), Cronin (1961) and Rayner (Mount and others, 1963).

Acknowledgements

Appreciation is expressed to all who contributed information and assistance in the preparation of this report. Managers and representatives of several delinting plants on the High Plains provided data concerning the operation of delinting plants. City officials of Brownfield provided information on the city water wells. The landowners and tenants furnished information on local wells. The writer is also grateful to Doctors M. E. Bloodworth, J. P. Wells, C. D. Welch and Messrs. H. J. Walker and D. E. Longenecker, all of the Texas Agricultural Extension Service, Texas A & M University, for useful information which they provided. Mr. W. B. Wardlow, Chief Chemist for the Texas State Department of Health, assisted in the interpretation of chemical analyses.

This report was prepared under the immediate supervision of S. C. Burnitt, Head, Subsurface Disposal Section, and L. G. McMillion, Director, Ground Water Division.

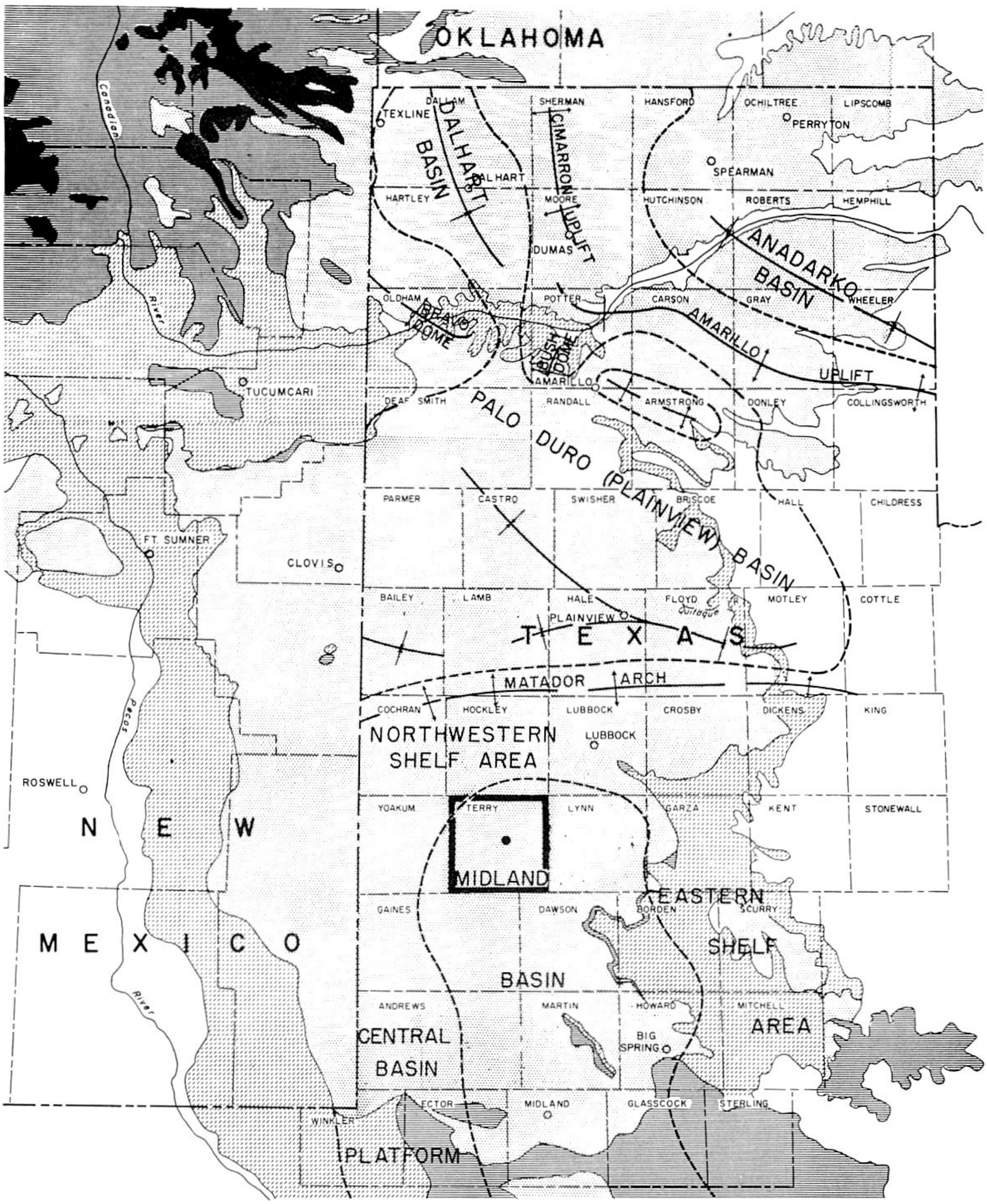
GENERAL GEOLOGY

The surface material in the area of investigation consists mainly of a sandy soil profile ranging in thickness from about 2 to 7 feet.

The Ogallala Formation of Pliocene Age lies beneath the surface material. The deposits composing the formation are of continental origin and represent a broad alluvial plain resulting from regional coalescence of braided stream systems which flowed eastward from uplifted mountains to the west. The extent of the Ogallala Formation is illustrated in Figure 2, a geologic map of the High Plains of Texas and adjacent areas.

The formation consists primarily of beds and lenses of clay, silt, sand and gravel, irregularly cemented with calcium carbonate. The basal part of the formation is commonly made up of medium to coarse-grained, chert-bearing quartz sand and gravel which may locally grade both laterally and vertically into clay and silt. The basal coarse-grained material generally grades upward into alternating layers of silt, clay, and fine-grained sand in which interspersed caliche nodules are common.

Calcium carbonate is the predominant type of cement in the Ogallala Formation. Although the sands are generally loosely cemented, carbonate cements are present throughout the formation. The cemented zone, typical of the stratigraphic top of the formation, is commonly referred to as "caliche" or "caprock". The sand and silt in the "caliche" zone generally contains abundant streaks and



(Adapted from Cronin, 1961, p.11)

From geologic map of United States, U. S. Geological Survey, 1932

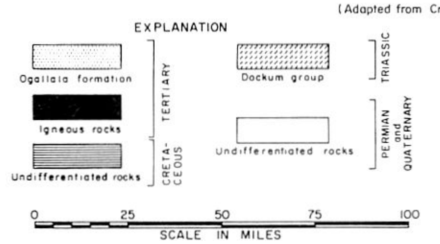


Figure 2

Geologic Map of the High Plains of Texas and Adjacent Areas Showing Major Structural Features and Location of Area of Investigation

Texas Water Commission

178

nodules of caliche, and in most places is loosely to solidly cemented with calcium carbonate and secondary silica. The "caliche" zone is generally considered to be related to periods of soil formation and the leaching action of downward-percolating rainfall.

The thickness of the Ogallala Formation in the area of investigation ranges from about 130 to 160 feet. The "caliche" zone in this area is about 20 to 30 feet thick.

The basal sand and gravel beds of the Ogallala Formation lie in contact with yellow and blue clay of the Comanche Series of Cretaceous Age. The Cretaceous section is about 150 feet thick, consisting mainly of clay, shale, limestone and 20 to 30 feet of sand and sandstone which occurs near the base. Water wells in the area of investigation do not penetrate the Cretaceous; however, there are several water wells in Terry County producing from Cretaceous rocks.

The Triassic "redbeds," which are several hundred feet thick, lie beneath the Cretaceous rocks.

OCCURRENCE, MOVEMENT, QUALITY AND DEVELOPMENT OF GROUND WATER

The Ogallala Formation is the principal aquifer in Terry County, and it supplies most of the water used for irrigation, public-supply, industrial, domestic, and stock-watering purposes.

Ground water in the Ogallala Formation generally occurs under water-table conditions. However, local artesian conditions may exist where the water is confined beneath lenticular beds of clay. In the study area relatively impermeable clay and shale beds of Cretaceous Age form the lower boundary of the aquifer.

The source of ground water in the Ogallala Formation in Terry County is precipitation that falls on the land surface and the ground water that moves into the area from counties to the north and west.

The slope of the water table in the area of investigation is shown on Plate 1 by contour lines which represent the altitude of the water table. The depth to water below land surface was measured in selected wells, and the elevations of well sites were determined with a Paulin altimeter (Table 1). The water table occurs at a depth of about 100 to 110 feet below land surface and slopes to the southeast at the rate of about 18 feet per mile. The normal direction of ground-water movement is to the southeast; however, pumping water wells cause depression cones in the water-table surface which locally modify the normal direction of ground-water movement. For example, the elevation of the water table in well 1 (a city of Brownfield municipal well) was 3,213 feet above sea level when measured on May 12, 1964. This elevation of the water table is about 15 feet below the expected elevation at this location as suggested by water levels in other wells nearby. It is presumed that the well had probably stopped pumping shortly before the measurement was made and the static water level had not recovered from the pumping level. Situations such as this may cause temporary reversals in the direction of ground-water movement.

The velocity of ground-water movement can be calculated by the formula

where $v = \frac{P\,I}{p}$

- v= velocity, in feet per day
- P= coefficient of permeability, in cubic feet per day per square foot
- I= hydraulic gradient, in feet per foot
- p= effective porosity, expressed as a ratio of the volume of all pore space to the total bulk volume of a segment of rock.

An average value of 400 gpd/foot^2 (gallons per day per square foot) is commonly accepted by many ground-water hydrologists for the average coefficient of permeability of the Ogallala Formation in the Southern High Plains.

Assuming an average coefficient of permeability of 400 gpd/foot^2, an average porosity of 30 percent, and utilizing the determined value of 18 feet per mile as the average hydraulic gradient, the calculated average velocity of ground-water movement in the area of the Brownfield Seed and Delinting plant is 0.6 feet per day or 7.2 inches per day. This calculation is based on a regional hydraulic gradient and does not account for the influence of pumping wells in the area.

Water in the Ogallala Formation is generally suitable for practically all purposes. It is characteristically low in sodium and chloride ions, with sulfate commonly slightly exceeding chloride. The water is generally high in bicarbonate content and comparatively high in calcium and magnesium concentrations, which cause hardness. Chemical analyses of 15 samples obtained during the investigation are given in Table 3. Wells 1, 3 and 4 (Plate 1), located in the northern and eastern parts of the area of present study are owned by the City of Brownfield and are used for public supply. Chemical analyses of water samples from these wells (Table 3) are probably representative samples of the quality of the natural ground water in the area of investigation.

Most of the water wells in the area of investigation were drilled with cable tool rigs during the late 1950's and early 1960's. The wells are completed with steel casing set to total depth and generally slotted at the water-bearing interval. Perforations are normally made in the casing by cutting vertical staggered slots. The size of hole drilled and casing used is determined by the intended yield of the well. Casing 16 inches in diameter is used in most irrigation wells equipped with turbine pumps, and casing 6 to 8 inches in diameter is commonly used in small capacity wells equipped with submersible pumps.

WASTE PRODUCTION AND DISPOSAL FROM SEED-DELINTING OPERATIONS

Process of Waste Production

In the High Plains, one of the most common methods used for the removal of lint from cotton seed is by the use of liquid sulfuric acid. The purpose of the operation is to remove the lint from the seed so that it can be handled with greater ease in the planting operation. The acid treatment also shortens the germination period of the seed.

The lint removal operation consists of applying approximately 93% by weight sulfuric acid (H_2SO_4) to cotton seed, washing the acid and dissolved lint from the seed with water and drying and sacking the seed.

Most of the business done by delinting plants on the High Plains is custom work for local farmers. The seed is brought to the plant by truck or trailer, unloaded in a dump, and elevated to a hopper. The seed moves down an inclined conveyor with the aid of several revolving cylinders equipped with fingers. The sulfuric acid is applied to the seed by means of 6 or 8 overhanging 1/8 or 1/2 inch open pipes. The amount of acid applied is regulated according to the lint condition of the seed. The revolving fingers mix the acid with the seed as it moves down the conveyor. Fresh water is then applied from several rows of overhanging open pipes as the seed is moved down the incline. The amount of water used to wash the acid and dissolved lint from the seed is regulated according to the condition of the seed. Seeds are occasionally tested to see if sufficient water is being used to wash away all of the acid. After the seed is cleaned it is conveyed to a gas dryer and moved over a shaker where inferior seeds are culled. The processed seed is then sacked for return to the owner.

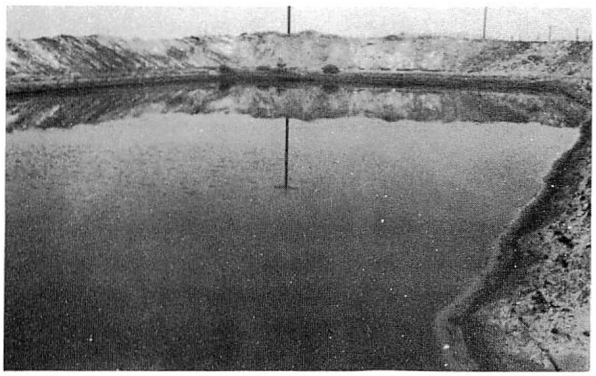
The Brownfield Seed and Delinting Company operates at full capacity generally during the months of October through January. Seed is processed periodically throughout the remainder of the year with estimated days of operation averaging approximately one day per week. The manager of the Brownfield Seed and Delinting Company estimated that about 300 tons of sulfuric acid is used to process 1,000 tons of seed per year at this plant.

During the initial field investigation of May 11 and 12, 1964, a reconnaissance of similar operations in the Southern High Plains disclosed that a minimum of 24 cotton seed delinting plants using liquid sulfuric acid are presently operating in the Southern High Plains of Texas. The waste from these plants is being discharged into unlined surface pits and playa lakes on the surface of the Ogallala Formation. These delinting plants were constructed during the years 1958 to 1963, with the exception of one plant which was operating in 1956. The delinting process and the amount of acid used annually in each of these 24 plants was determined to be similar to the operation at the Brownfield plant.

Waste Disposal

Waste from the seed delinting operation at the Brownfield Seed and Delinting Company has been discharged into unlined surface pits since September, 1958. There are three pits at the location whose dimensions are about 320 by 75 feet, 90 by 90 feet, and 93 by 36 feet respectively. These pits are shown in Figure 3. The pits were bottomed in the "caliche" zone of the Ogallala Formation. A sketch of the disposal system is shown in Figure 4. The plant waste flows from the delinting machine to the larger of the pits through a 4 inch underground steel pipe at an estimated rate of 120 gallons per minute

Brownfield Seed and Delinting Company site showing delinting building, acid storage tank, water well (arrow), and waste pit. View is south.



View of Brownfield Seed and Delinting Company's east disposal pit; looking east-northeast.

View of Brownfield Seed and Delinting Company's disposal pits; looking east.

Figure 3
Waste Discharge Pits at the Brownfield Seed and Delinting Company

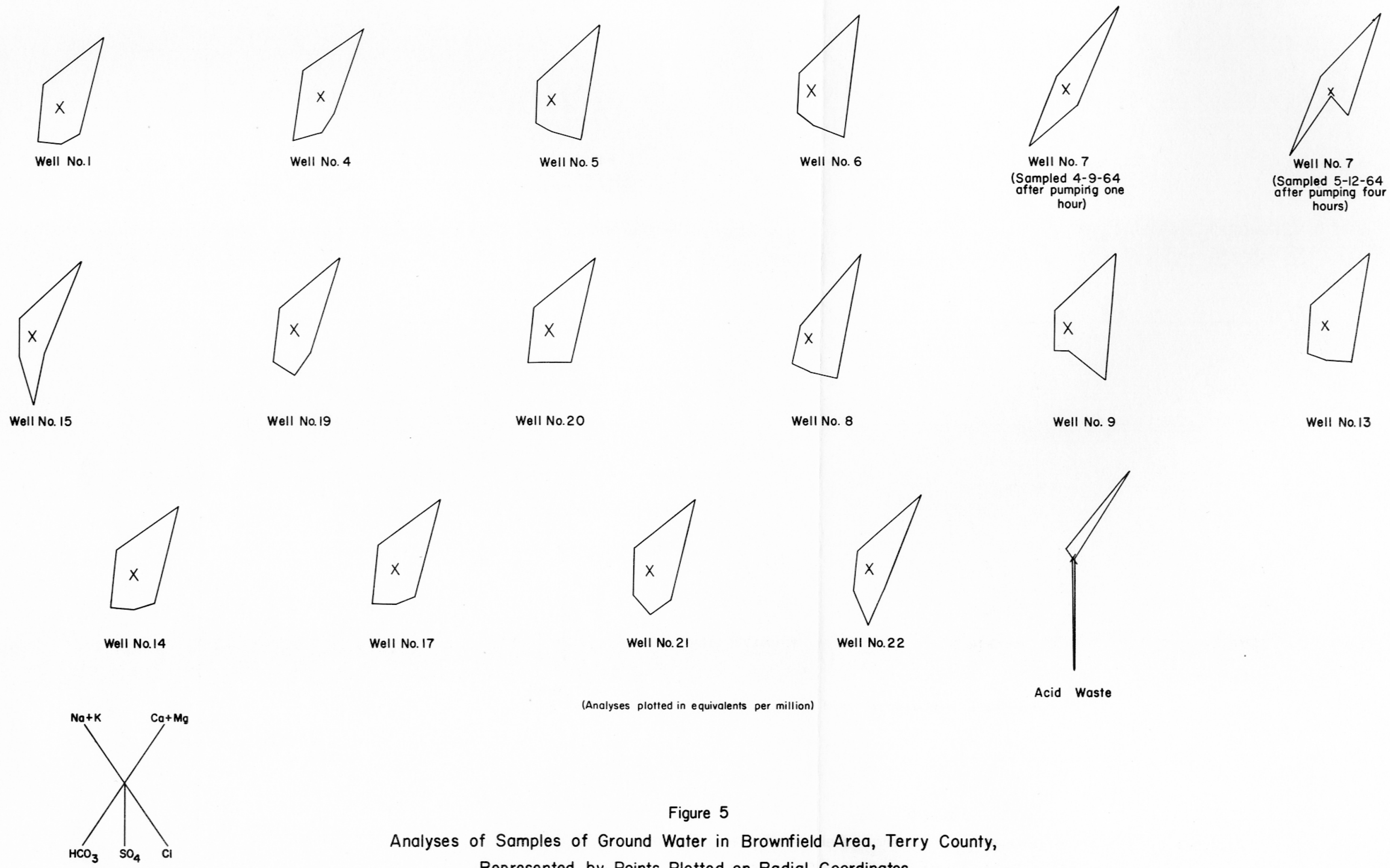


Figure 5

Analyses of Samples of Ground Water in Brownfield Area, Terry County, Represented by Points Plotted on Radial Coordinates

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For location of samples, see Plate I

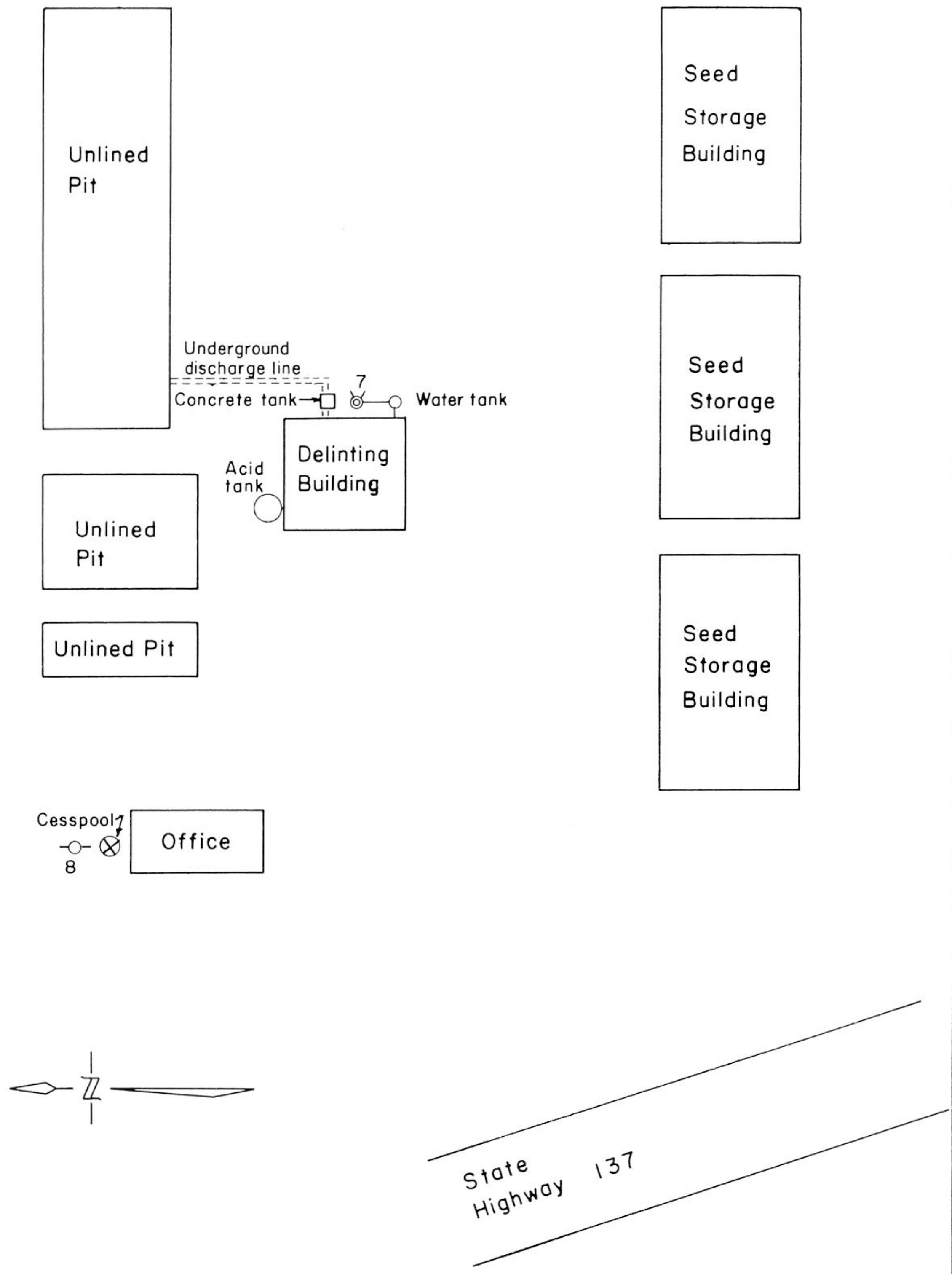

Figure 4

Sketch Map Showing Acid Waste Disposal System at the Brownfield Seed and Delinting Company Site

Texas Water Commission

178

during the delinting operation. The waste consists of dilute sulfuric acid (see Table 3 for chemical analyses); however, dissolved lint and cotton seed culls are also discharged into the pit along with the liquid waste.

The fluid content of a part of the acid waste which is not lost from the pit by seepage is probably evaporated; however, the surface area of the pits limits the amount of fluid dissipated by evaporation. The pits are approximately 6 feet deep and have a total surface area of about 35,450 square feet or 0.8 acre. The estimated total volume of waste discharged into these pits each year is about 3,600,000 gallons. Porterfield (in Burnitt and others, 1963) has prepared a hydrologic study of the potential effect of solar evaporation in the High Plains of Texas based on minimal historical conditions. In this study, it was assumed that the fluid surface of the evaporation pits are entirely free of evaporation retardants, or stagnation due to microorganisms, both of which may reduce the rate of evaporation significantly. It was also assumed that no seepage loss occurs and that the fluid at the evaporated surface is of the same mineral concentration as that of the input fluid.

By using the data and pit design criteria developed by Porterfield, it is calculated that in the waste production and disposal operations at the Brownfield Seed and Delinting Company a lined pit 6 feet deep and having a minimum surface area of approximately 2.5 acres would be needed to accomodate the current volume of fluid waste production. This would strongly suggest, therefore, that less than one-third of the acid solution placed in the unlined pits is being evaporated each year, while over two-thirds is lost from the pits by seepage into the subsurface.

GENERAL DISCUSSION OF CHEMICAL MECHANICS OF CONTAMINATION

The principal effect of acid contaminants entering a body of natural water is a disturbance of the natural carbonate-bicarbonate-carbon dioxide equilibrium and a significant addition of the primary anion comprising the acid, which in the case of sulfuric acid is the sulfate ion. The addition of a sulfuric acid contaminant to natural water would be expected to produce a reaction similar to the titration method of determining alkalinity in laboratory analytical analyses. Excess hydrogen ions (H^+) are supplied by the acid. Carbonate ions (CO_3^{--}) in solution in the natural water each take up one of the introduced hydrogen ions to become bicarbonate (HCO_3^-). As the process continues, the amount of unchanged carbonate decreases until the carbonate ions are ultimately nearly all changed over (Hem, 1959). At this point, a further small addition of acid produces a significant reduction in the pH or acidity of the solution.

Thus, the introduction of a dilute sulfuric acid waste solution directly into the natural ground water of the Ogallala Formation would be expected to result in a mixture exhibiting significant increases in bicarbonate (HCO_3^-) and sulfate (SO_4^{--}).

The material comprising a ground-water aquifer may have a very significant effect upon the chemical character of the contaminant, particularly as it percolates through the unsaturated part of the aquifer prior to reaching the water table. For example, the calcareous subsoils, caliche beds and nodules, and calcareous clays and cements characteristic of the Ogallala Formation furnish large amounts of readily soluble calcium and magnesium for reaction with the acid waste. The reaction between downward percolating sulfuric acid and calcium carbonate results in the formation of gypsum and free carbon dioxide as illustrated by the general equation below.

$$H_2SO_4 + H_2O + CaCO_3 \longrightarrow CaSO_4 \cdot 2\,H_2O + CO_2\uparrow$$

Calcium carbonate ($CaCO_3$) in the formation may also combine with the excess hydrogen ions supplied by the acid and be converted to calcium bicarbonate ($CaHCO_3$).

From the above discussion, the series of chemical reactions which might be expected in the process of seepage of an acid waste solution through the Ogallala Formation would be as follows:

(1) The acid would react initially with calcium (and magnesium) carbonate in the formation to form gypsum and free carbon dioxide.

(2) The leaching effect of the acid may result in an increase in permeability of the subsurface material and allow later solution of additional material. This in turn may allow additional ions (such as chloride) combined with other ions in the rock material to be transported into the ground water.

(3) A large part of the high concentration of sulfate ions in the acid, which is available for contamination, would remain in the unsaturated material of the formation as gypsum.

(4) Excess hydrogen ions, supplied by the acid, and free carbon dioxide (see previous equation) would combine to form carbonic acid (H_2CO_3) which ultimately enters the ground water.

(5) Until chemical equilibrium was established in the unsaturated part of the formation, the contaminated ground water would be characterized by an increase in the bicarbonate content, an increase in calcium and magnesium (particularly magnesium due to its greater solubility than calcium), a slight lowering of the pH, and a noticeable but not greatly significant increase in sulfate.

(6) Upon the establishment of equilibrium in the formation after prolonged seepage, reactions would diminish and the acid would percolate unaltered to the water table, thus producing contaminated ground water high in bicarbonate, very high in sulfate, and with a low pH. Soluble gypsum formed during the early stages of seepage would also be re-dissolved and carried into the ground water.

SUMMARY OF INVESTIGATION

During the present investigation, water samples were collected from 15 wells present in the area of the delinting plant. The chemical analyses of these samples are given in Table 3 and the variation in the chemical character of the samples is graphically illustrated in Figure 5 by means of pattern diagrams.

It is readily apparent by study of the analyses that well 7, the industrial well owned by Brownfield Seed and Delinting Company, has been effected by the acid waste. The first sample from the well was taken on April 9, after approximately 1 hour of continuous pumping. The well had previously been idle for approximately one month. The analysis exhibits unnatural concentrations of sulfate, bicarbonate, calcium, and magnesium; magnesium, which is more soluble than calcium, shows a larger proportional increase than calcium. The pH of the water was also significantly low (6.8). Because of the unstability of bicarbonate, it is also probable that some CO_2 was lost from the sample prior to analysis. It is also probable that the pH in the water when sampled was lower than the value obtained when the sample was analyzed.

The second sample, taken from the well on May 12 after 4 hours of pumping at an estimated rate of 120 gallons per minute, exhibited a similar unnatural bicarbonate content and an apparent increase in calcium and magnesium. However, the concentration of sulfate (only 46 ppm) is significantly lower than in the first sample, and apparently lower than the sulfate content of the natural ground water in the area.

It is possible that the contaminant is concentrated on the upper surface of the ground water in the area of the pit, possible as the result of the development of a ground water "mound" or elevation of the water table beneath the pits, and that a layering effect has developed in the contaminated ground water beneath the pit. This could result in variations in the character of the water samples obtained at different times of pumping due to the gradual fluctuations in the "pumping level" of the water table.

As previously described, an evaluation of the potential effect of evaporation as related to the volume of acid waste handled by the pits strongly indicates that much of the waste seeps into the aquifer. The chemical analyses indicate that it has penetrated the water table and moved into the area of influence of well 7. It is also possible that the liquid waste has a significant horizontal component of movement through the unsaturated part of the aquifer and has migrated down the well bore of well 7, which is located near the pits.

It was reported by representatives of the Brownfield Seed and Delinting Company that during the year 1960 or 1961 a leak developed in the waste discharge system leading to the pit. As the waste leaves the delinting building through the four inch underground pipe, it enters a small cement tank about 2 feet wide, 3 feet long, and 3 feet deep. This tank is located about 10 or 15 feet north of well 7 (see Figure 4). The leak developed in a corner of this tank, which reportedly allowed the acid waste to channel over to the well bore and enter directly into the well. Contamination was detected by the "bad smell" of the water. After the leak in the tank was corrected, it was necessary to pull the pump for repairs due to the corrosive action of the acid.

It was also reported that during the operating season the surface of the large disposal pit sometimes reaches a level which is above the opening of the discharge pipe. The discharge pipe was layed in a ditch from the delinting building to the pit, and covered with soil. Cement fill was not used in laying the pipe; therefore, when the pit is full it would be possible for the acid waste to flow through the loose fill material outside the discharge pipe and reach the well bore.

The analyses of well 8, also owned by Brownfield Seed and Delinting Company and located immediately west of the waste pits (see Figure 4), strongly suggest this well is also effected by the acid disposal operations. The abnormal bicarbonate content, lowered pH, and generally higher concentrations of the dissolved ions are probably the result of entrance of the acid waste into the ground water. An unlined cesspool, reportedly 30 feet deep, is also located about 20 feet south of well 8 and represents a possible source of mineral contaminants. In addition, treated city sewage effluent is used for irrigation by sprinkler system in a field immediately north of well 8. A cesspool, reportedly 10 feet deep, is also located about 40 feet north of well 9. This cesspool is periodically pumped out and the water used to irrigate a small garden approximately 100 feet north of well 9. However, none of the samples show abnormal nitrate concentrations which would be suggestive of sewage pollution.

Most household detergents contain the anionic surface-active agent alkyl benzene sulfonate (ABS). As ABS is not found in natural substances, its presence in water is evidence of contamination by sewage or other man-made wastes. ABS determinations of the samples from wells 8 and 9 indicated less than 0.2 ppm ABS. This is the lower limit which can be determined in routine laboratory analysis; therefore, it only indicates that concentrations of ABS in excess of 0.2 ppm are not present.

Arsenic content was determined in the water from wells 5, 6, 7, 8, 9, 15, and 19 (see Table 3). The maximum amount of arsenic reported was 0.12 ppm in wells 7 and 19. The least amount reported was 0.06 ppm in wells 6 and 8. According to 1962 drinking water standards of the U. S. Public Health Service, water containing an excess of 0.05 ppm constitutes grounds for rejection of water for municipal supply. There are no historical water quality records concerning the arsenic content of the ground water in this area;therefore, it is not known if the arsenic content of the water sampled is similar to the natural concentrations.

Arsenic could be present on the cotton seed that passes through the delinting process, due to the widespread use of arsenic-bearing defoliation chemicals and insecticides. Unfortunately, the arsenic content of the waste was not analyzed so this possible source of arsenic cannot be fully evaluated.

Samples from well 5 and 6 owned by Mr. W. D. Clark and located about 460 feet south of the east end of the large disposal pit, indicate no evidence of contamination as of May 11, 1964, although the calcium and magnesium content of the samples appear slightly higher than that of samples from other wells in the area. Contaminants reaching the water table beneath the disposal pit, and moving southeast at the rate of 0.6 feet per day, theoretically should reach well 6 in approximately 2 years. Since pit disposal started in September of 1958, or 5 years and 8 months ago as of May, 1964, contaminants have had sufficient time to reach wells 5 and 6. However, as pointed out previously, pumping wells in the area may have altered the direction and rate of ground-water movement. Furthermore, variations in permeability within the aquifer may have a significant effect on the path which the contaminant may follow.

Several of the samples collected from wells in the area exhibited relatively high proportions of sulfate; for example in samples from wells

15 and 22, the ratio of sulfate to chloride, based on equivalents per million, is approximately 3:1 and 2-1/2:1 respectively. A more thorough study, including a program of test drilling and water sampling, would be necessary to determine whether or not these samples represent natural conditions. The distance of well 22 from the waste pits and the time involved since disposal operations began probably preclude any possibility of contamination of these wells from the acid disposal operations.

Analyses of the wells sampled during this investigation were plotted on the classification diagram shown in Figure 6. Most of the water samples fall within Class C3-S1 (high salinity-low sodium water) which indicates that salinity is within acceptable limits for porous soils and salt-tolerant plants and no predictable danger exists for the development of harmful levels of exchangeable sodium in the soil.

Wells 7 and 8, both of which are apparently affected by the acid waste, fall within class C4-S1 (very high salinity low sodium water) which indicates that the water can be used for irrigation only on very porous soils and very salt tolerant crops. The presence of arsenic in significant concentrations in the water from well 7 might preclude use of this water for domestic consumption. The increased hardness, due to the increase in concentrations of calcium and magnesium in the wells, also severely limits the use of the water for other beneficial purposes.

POSSIBLE BENEFICIAL USES OF SULFURIC ACID WASTE

Sulfuric acid wastes from delinting plants might possibly be utilized in agricultural processes with beneficial use to plant growth. The possibility of the occurrence of ground-water contamination would also be greatly minimized if the waste was spread out on the surface of the soil as irrigation water because more of the acid would have opportunity to react with free carbonates in the soil.

Correspondence with personnel associated with the Texas Agricultural Extension Service, Texas A & M University indicated that little experimental data is available concerning the effect of sulfuric acid on West Texas soils and the use of sulfuric acid as an agricultural aid. Benefits reported from the use of sulfuric acid on calcareous soils appear to be related to the acidifying affects, such as lowering the soil pH, rather than supplying sulfur as a plant nutrient. Reportedly, sulfuric acid has also been used as a soil amendment for control of excess exchangeable sodium.

Waste from the Dimmitt Seed and Delinting Company disposal pit at Dimmitt, Texas, was applied by flood irrigation on bermuda grass during January, 1964, with apparent good results. During the field investigation in May, 1964, this area was visited and a thin white deposit was observed on the irrigated soil, which is probably a gypsum deposit formed by the acid reacting with the calcareous soil.

The Littlefield Seed and Delinting Company at Littlefield, Texas, disposed of acid waste in a playa lake during the years 1961-1964. The waste was reportedly periodically pumped from the lake and used to irrigate cotton crops by means of a sprinkler system.

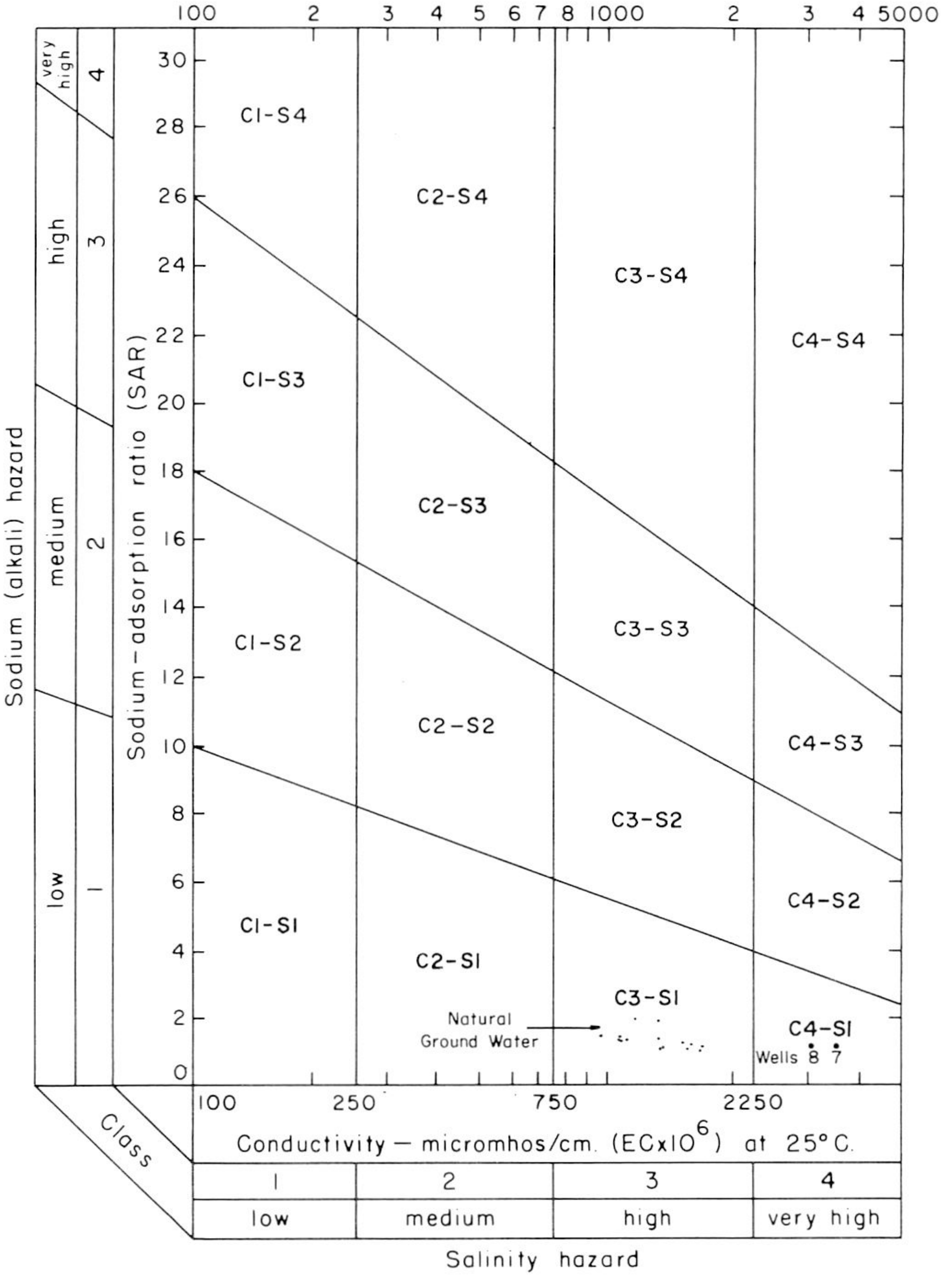

Figure 6

Diagram for the Classification of Irrigation Waters

(After United States Salinity Laboratory Staff, 1954, p. 80)

178

REGULATION OF WASTE DISPOSAL

Rules and regulations of the Texas Water Pollution Control Board require that permits for the disposal of industrial wastes and other wastes on the surface of the ground be filed with the Texas Water Pollution Control Board. According to records of the Texas Water Pollution Control Board, as of May, 1964 only one application for a permit to dispose of dilute sulfuric acid waste had been filed. This application was filed on February 18, 1963 by the Wellington Cotton Seed Delinting Company, located at Wellington, Collingsworth County, Texas.

SUMMARY OF CONCLUSIONS

The chemical character of the water from wells 5 and 6, owned by the complainant at whose request this investigation was made, does not appear to be significantly different from the quality of the natural ground water in the area as of May 11, 1964. The water from the two wells owned by the Brownfield Seed and Delinting Company (wells 7 and 8) are affected by the waste discharged from the delinting plant. The water from these two wells is still of usable quality for irrigation; however, the increased hardness and the presence of toxic arsenic ions (in well 7) might limit the use of this water for domestic purposes.

Calculations of the potential effect of evaporation in the area suggest that less than one-third of the sulfuric acid waste disposed in surface pits at the Brownfield Seed and Delinting Company is lost to evaporation. The major part of the waste is apparently lost by seepage into the subsurface.

A reconnaissance of the Southern High Plains of Texas disclosed that there are at least 24 sites where sulfuric acid waste is discharged into either surface pits or playa lakes.

Information obtained during the investigation was not conclusive as to the path taken by the waste as it moves from the pits to the water table. It may percolate vertically through the unsaturated zone until it reaches the water table or the waste may migrate laterally through the unsaturated beds for a short distance before it percolates downward to the water table. Both vertical and lateral movement probably takes place as the waste seeps from the pits.

The acid waste is apparently partly neutralized upon contact with the caliche and other carbonate-bearing sediments. However, after prolonged disposal it is doubtful that neutralization could continue without a fresh supply of carbonate material.

According to files of the Texas Water Pollution Control Board, there are no records of applications for surface discharge of sulfuric acid waste in the High Plains of Texas. The only application of this type on record is for a seed delinting company located in Collingsworth County.

RECOMMENDATIONS

1. All acid-delinting operations in the High Plains, as well as throughout the State, should file applications with the Texas Water Pollution Control Board for disposal permits if unlined pits are used in their operations. Each application should then be reviewed with respect to the effect of such disposal operation on the quality of ground-water resources in the area.

2. The present method of disposal of the acid wastes, as described in this report, at the Brownfield Seed and Delinting Company should be discontinued.

3. The water wells located within the area of this investigation should be regularly sampled for chemical analysis and the information collected during this study should be utilized as historical reference data.

SELECTED REFERENCES

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Table 1.-- Records of water wells in the area of investigation, Terry County, Texas

Method of lift and type of power: T, turbine; S, submersible; E, electric; Ng, natural gas; N, none

Use of Water: D, domestic; Irr, irrigation; P, public supply; Ind, industrial; S, stock-watering; N, none

Well No.	Owner	Driller	Date completed	Depth of well (ft.)	Casing: Diameter (in.)	Casing: Depth (ft.)	Water Bearing unit	Altitude of land surface	Water Level: Below land surface datum (ft.)	Water Level: Date of Measurement	Method of lift	Use of Water	Remarks
1	City of Brownfield	Skaggs Drilling Company	1961	163	16	163	Ogallala	3317.2	103.90	5-12-64	T,E	P	
2	Sarah Bullard	-	-	-	-	-	-	-	-	-	T,Ng	Irr	
3	City of Brownfield	-	1959	170	16	170	Ogallala	3316.5	98	7-10-61	T,E	P	
4	Do.	Skaggs Drilling Company	1961	165	16	165	do	3306	94.95	5-12-64	T,E	P	
5	W. D. Clark	Perry Bros.	1952	140	-	140	do	3319	99.70	4- 8-64	T,Ng	Irr	
6	Do.	-	-	136	-	136	do	3319	-	-	S,E	D,S	
7	Brownfield Seed and Delinting Co.	Ross	1958	144	16	144	do	3324	102.10	4- 8-64	T,E	Ind	
8	Do.	do	1963	-	-	-	do	-	-	-	S,E	D	
9	R. L. Key	-	1958	135	-	-	do	-	-	-	S,E	D	
10	W. H. Stallings	-	1963	175	16	175	do	3333	108.80	4- 8-64	T,Ng	Irr	
11	Do.	-	-	-	-	-	do	-	-	-	S,E	D	
12	Do.	-	-	-	-	-	do	-	-	-	T,Ng	Irr	
13	Ray Lackey	McConnel Well Service	1962	171	16	171	do	3326	104.68	4-8-64	T,Ng	Irr	
14	Do.	Perry Bros.	1956	170	6 5/8	170	do	-	-	-	S,E	D	
15	C. R. Warren, Jr.	-	1950	-	-	-	do	-	-	-	S,E	D	
16	Do.	Perry Bros.	-	-	-	-	do	-	-	-	S,E	Irr	
17	Arlin F. Daniel	Dick Perry	1960	169	6	169	do	-	-	-	S,E	D	
18	Don Thrash	-	-	-	-	-	do	-	-	-	T,E	Irr,S	
19	Melton Addison	-	-	-	-	-	do	-	-	-	T,Ng	Irr	
20	W. B. Tudor	-	-	-	-	-	do	-	-	-	N	N	abandoned
21	Phil Addison	J. W. Harris	1962	160	-	-	do	-	-	-	S,E	D	
22	Do.	-	-	160	-	-	do	-	-	-	T,E	Irr	
23	Z. McSherry	-	-	-	-	-	-	-	-	-	N	N	abandoned

Table 2 - Drillers' Logs of Wells

Well No. 1

Owner: City of Brownfield   Driller: John Hill

	Thickness (feet)	Depth (feet)
Surface	25	25
Clay, sandy and dry sand	40	65
Clay, sandy and rock ledges	55	120
Sand and gravel	43	163
Shale	2	165

Well No. 3

Owner: City of Brownfield   Driller: John Hill

	Thickness (feet)	Depth (feet)
Surface and caliche	20	20
Clay, sandy and dry sand	50	70
Clay, sandy	33	103
Rock	5	108
Clay, sandy	10	118
Sand and gravel, very little clay	37	155
Lime and shale	10	165

Table 3.--Chemical analyses of samples of ground water and acid waste.

(Analyses given are in parts per million except specific conductance, and pH.)

Well	Owner	Depth of well (ft.)	Date of collection	Silica (SiO_2)	Arsenic (As)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Total acidity as $CaCO_3$	ABS	Dissolved solids	Total hardness as $CaCO_3$	Specific conductance (micromhos at 25°C.)	pH
									Ground Water										
1	City of Brownfield	163	4- 8-64	51	--	73	65	69	268	200	133	4.0	4	--	--	710	455	1,160	7.7
4	do	165	do	60	--	56	54	68	287	160	72	4.2	5	--	--	600	363	988	7.8
* -	do	--	3-16-64	--	--	75	75	86	331	202	188	4.7	2	--	--	930	497	1,548	7.8
5	W. D. Clark	140	4- 7-64	56	--	100	101	81	253	232	259	4.0	5	--	--	940	670	1,610	7.6
5	do	140	5-11-64	56	0.09	97	100	83	253	259	265	3.9	5	--	--	990	650	1,650	7.5
6	do	136	4- 7-64	56	--	110	107	77	248	223	327	4.2	4	--	--	1,010	720	1,760	7.6
6	do	136	5-11-64	54	.06	116	101	75	250	230	315	4.0	7	--	--	1,030	710	1,740	7.6
7	Brownfield Seed & Delinting Co.	144	6-11-62	--	--	--	--	--	--	--	--	--	--	--	--	1,050	700	1,750	7.4
7	do	144	4- 9-64	60	--	104	463	138	1,590	469	281	3.3	< .4	222	--	2,160	2,160	3,550	6.8
7	do	144	5-12-64	56	.12	163	232	131	1,330	46	272	3.0	< .4	--	--	1,560	1,360	2,680	7.1
8	do	--	4- 8-64	54	--	208	249	104	570	520	550	5.4	7	--	--	1,930	1,540	3,080	7.0
8	do	--	5-12-64	51	.06	245	262	105	720	540	560	5.3	8	--	<0.2	2,130	1,690	3,300	6.9
9	R. L. Key	135	4- 8-64	58	--	98	107	75	229	159	328	4.0	4	--	--	930	690	1,650	7.6
9	do	135	5-11-64	56	.09	100	103	75	234	194	317	3.9	4	--	< .2	970	670	1,680	7.6
10	W. H. Stallings	175	4- 8-64	56	--	55	80	69	266	169	157	4.0	4	--	--	700	465	1,190	7.7
13	Ray Lackey	171	do	56	--	102	73	75	260	215	203	4.2	5	--	--	840	560	1,420	7.7
13	do	171	5-11-64	58	--	85	81	77	261	215	209	3.9	5	--	--	860	550	1,430	7.5
14	do	170	do	54	--	66	66	72	273	182	135	3.9	3	--	--	720	436	1,159	7.6
15	C. R. Warren, Jr.	--	4- 8-64	51	--	117	112	84	245	550	121	4.8	14	--	--	1,150	750	1,670	7.6
15	do	--	5-11-64	51	.08	117	117	90	244	540	142	4.2	8	--	--	1,190	770	1,730	7.5
17	Arlin F. Daniel	169	do	56	--	68	66	70	271	184	133	3.9	3	--	--	720	439	1,160	7.6
19	Melton Addison	--	4- 8-64	56	--	70	79	70	267	255	118	4.3	7	--	--	770	500	1,230	7.6
19	do	--	5-11-64	54	.12	75	77	72	270	261	119	4.0	5	--	--	800	500	1,250	7.7
21	Phil Addison	160	5-12-64	56	--	85	92	84	256	299	183	4.0	7	--	--	940	590	1,490	7.6
22	do	160	do	56	--	98	97	69	243	402	133	4.2	10	--	--	990	640	1,490	7.6

See footnote at end of table.

Table 3.--Chemical analyses of samples of ground water and acid waste--Continued

Well	Owner	Depth of well (ft.)	Date of collection	Silica (SiO_2)	Arsenic (As)	Cal-cium (Ca)	Magne-sium (Mg)	Sodium (Na)	Bicar-bonate (HCO_3)	Sul-fate (SO_4)	Chlo-ride (Cl)	Fluo-ride (F)	Ni-trate (NO_3)	Total acidity as $CaCO_3$	ABS	Dis-solved solids	Total hardness as $CaCO_3$	Specific conductance (micromhos at 25°C.)	pH
								Acid Waste											
Sample from earthen pit	Brownfield Seed & Delinting Co.	--	4- 9-64	--	--	352	449	144	--	45,600	289	--	--	54,500	--	--	2,720	422,280	0.2
Do.	do	--	do	--	--	320	449	142	--	43,200	284	--	--	52,500	--	--	2,640	414,120	.1
Do.	do	--	4- 8-64	--	--	288	371	166	--	48,000	340	--	--	67,500	--	--	2,240	541,008	.1
Do.	do	--	do	--	--	540	429	212	--	46,600	417	--	--	50,500	--	--	3,120	403,920	.2

* Composite sample of eleven wells owned by City of Brownfield.

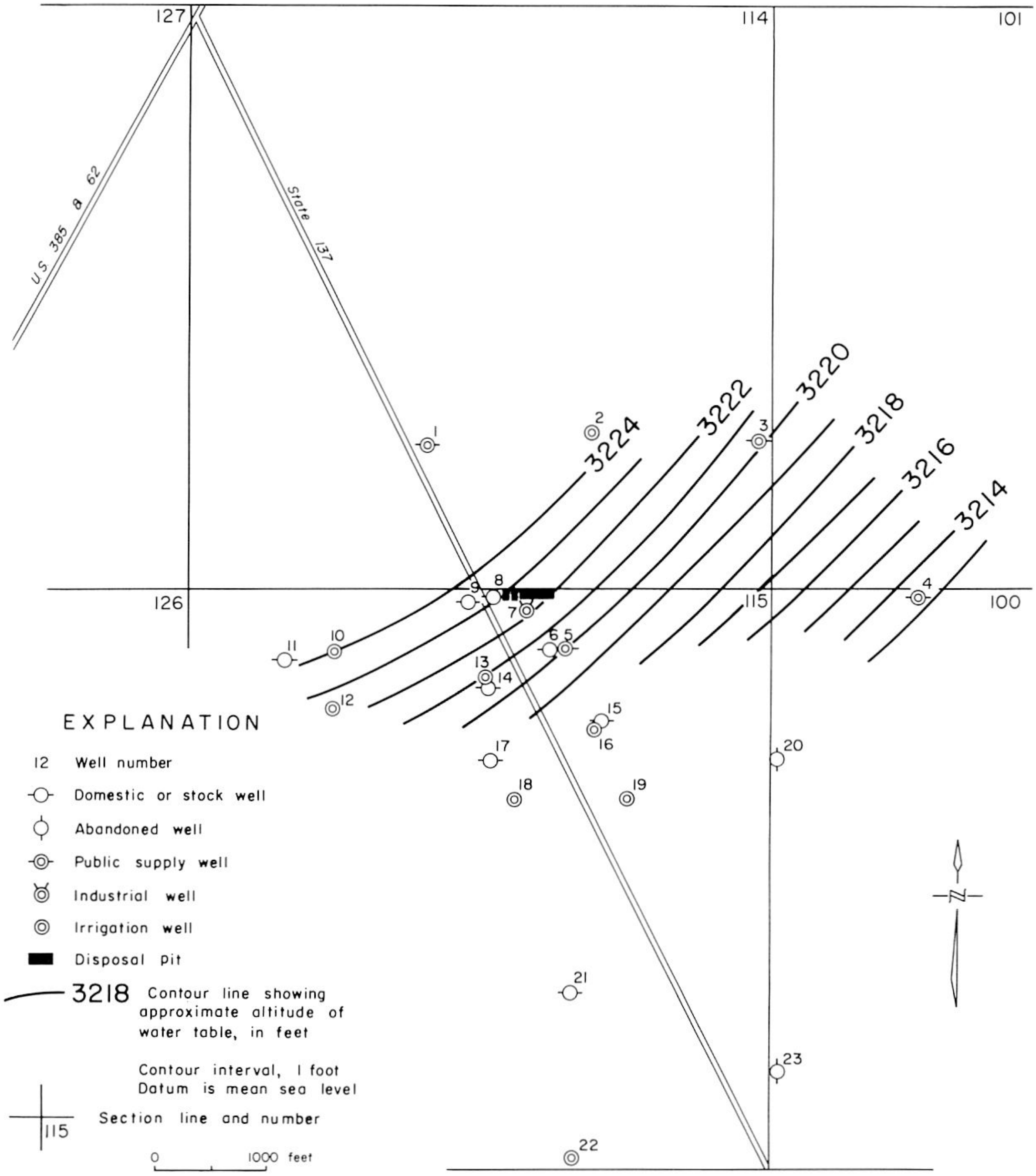

Plate I

Map Showing Location of Water Wells and Approximate Altitude of Water Table in the Area of Investigation South of Brownfield, Terry County, Texas

Texas Water Commission