# LONGHORN ARMY AMMUNITION PLANT

# KARNACK, TEXAS

# ADMINISTRATIVE RECORD

# VOLUME 1 of 1

## 1976

**Bate Stamp Numbers**
**000001 - 000032**

*Prepared for:*

**Department of the Army**
**Longhorn Army Ammunition Plant**
**Marshall, Texas 75671-1059**

**1995**

*VOLUME 1 of 1*

*1976*

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|---|---|---|
| **A.** | **Title:** | **Final Report - AEHA Water Quality Special Study No. 24-0586-77** |
| | **Group(s):** | **2 (Partial), 4** |
| | **Site(s):** | **LHAAP-18 & LHAAP-24 Burning Ground / Washout Pond & Evaporation Pond**<br>**LHAAP-35 Process Wastewater Sumps - Various**<br>**LHAAP-36 Explosive Waste Pads** |
| | **Location:** | **Longhorn Army Ammunition Plant, Marshall, Texas** |
| | **Agency:** | **U.S. Army Environmental Hygiene Agency, Aberdeen Proving Ground** |
| | **Author(s):** | **U.S. Army Environmental Hygiene Agency, Aberdeen Proving Ground** |
| | **Recipient:** | **Commander, USA Material Development And Readiness Command** |
| | **Date:** | **August 2 - 10, 1976** |
| | **Bate Stamp:** | **000001 - 000032** |

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WATER QUALITY SPECIAL STUDY NO. 24-0586-77
LONGHORN ARMY AMMUNITION PLANT
MARSHALL, TEXAS
2 - 10 AUGUST 1976

SERVING THE ARMY IN ITS HEALTH AND ENVIRONMENT PROGRAM

SENTINEL of HEALTH

US ARMY
ENVIRONMENTAL HYGIENE AGENCY
ABERDEEN PROVING GROUND, MD 21010

DEPARTMENT OF THE ARMY
U. S. ARMY ENVIRONMENTAL HYGIENE AGENCY
ABERDEEN PROVING GROUND, MARYLAND 21010

HSE-EW/WP

23 AUG 1977

WATER QUALITY SPECIAL STUDY NO. 24-0586-77
LONGHORN ARMY AMMUNITION PLANT
MARSHALL, TEXAS
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ABSTRACT

A water quality engineering study was conducted 2-10 August 1976 to characterize wastes in both the industrial waste sumps and the industrial waste pond to ascertain if the supernatant could be discharged directly to the surface drainage or would require treatment. The concentrations of barium, lead, total nitrogen and solids, the lack of mixing and the continuing chemical activity of the supernatant preclude its discharge to surface drainage. Findings, conclusions and recommendations cover operations at sumps and equipment cleanup areas. The analytical results and the visual review of surface water drainage throughout the installation indicate that present liquid waste management practices have no adverse effects upon the aquatic biota.

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DEPARTMENT OF THE ARMY
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1. AUTHORITY.

a. AR 40-5, Health and Environment, 25 September 1974.

b. AR 200-1, Environmental Protection and Enhancement, 7 December 1973 with two changes.

c. Letter, DRSAR-ISE, US Army Armament Command, 18 February 1976, subject: USAEHA Mission Services FY 77, ARMCOM Environmental Engineering Requirements.

2. REFERENCE. USAEHA Water Quality Engineering Special Study No. 24-014-72/73, Longhorn Army Ammunition Plant, Marshall, Texas, 3-19 April 1972 (8 December 1972).

3. PURPOSE.

a. This study was conducted at the request of ARMCOM (now ARRCOM) (Authority 1c). As consideration is being given to the discharge of the settled supernatant from an industrial waste evaporation basin to the surface drainage, the characterization of the waste is essential to determine extent of treatment required to meet NPDES permit requirements.

b. Specific objectives developed during the entrance interview and tour of operations were:

(1) Characterization of liquid and settled sludge in the industrial waste pond.

(2) Characterization of liquid and settled sludges in sumps associated with manufacturing operations which are collected and discharged to the industrial waste pond.

(3) Review of water consumption.

c. Limitation. A previous study performed 3-19 April 1972 (reference 2) provided comprehensive coverage of waste discharges from the water treatment plant, sanitary sewage treatment plant, power plant, and laundry. As the recommendations drawn upon the findings made in this previous report are being augmented under MCA projects, repetition of past coverage was not deemed pertinent or necessary. Coverage of this study may be considered a supplement to areas not covered in reference 2.

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4. GENERAL.

a. Acknowledgements. The excellent cooperation received from both US Government and Thiokol Chemical Company personnel was appreciated during this study.

b. Personnel Contacted.

LTC Paul L. Greenberg, Commanding Officer
MAJ Charles R. Carson, Executive Officer
Mr. Don Maley, Chief Engineer, US Army
Mr. Robbie L. Wilson, Operations Review Officer, US Army
Mr. David T. Rayner, Facilities Design Supervisor, Thiokol Chemical Company
Mr. Herman Krackenberger, Quality Assurance Supervisor, Thiokol Chemical Company
Mr. C. N. Ford, Transportation, Thiokol Chemical Company
Mr. Max Morgan, Chemist, Thiokol Chemical Company

c. Abbreviations and Definitions. A glossary of technical terms and units, along with other appropriate abbreviations, is available in Appendix A. Abbreviations and units in this report are included therein.

d. Background.

(1) General. LAAP is GOCO installation under the jurisdiction of ARRCOM. Thiokol Chemical Corporation is the contractor operator of the plant. The installation's primary missions are the load, assembly and pack of pyrotechnic signals and the loading of rocket motors.

(2) Geography and Receiving Streams. LAAP is located 16 miles northeast of Marshall, Texas, on the southwest shore of Caddo Lake, a shallow lake with a surface area of approximately 40,000 acres (16,200 ha). LAAP's 8,523 acres (3452 ha) are drained toward Caddo Lake by three major streams (see Figure). The southern part of the installation is drained by Harrison Bayou, which originates off the installation and flows in a northeasterly direction. Discharges to this bayou consist of storm runoff. The northern and central areas of the installation are drained by two unnamed bayous. These will be referred to in this report as Northern and Central Bayou, respectively. Central Bayou originates on the installation as two branches flowing through the magazine area in a northeasterly direction, combining before draining into Caddo Lake. Discharges to the bayou consist of storm runoff and thus the bayou flows intermittently. Northern Bayou also originates on the installation initially flowing in an easterly and then northeasterly direction. Upon completion of MCA projects, presently under construction, this bayou will receive the plant's major discharges. These include once through cooling waters and the discharge from the sanitary sewage treatment plant.

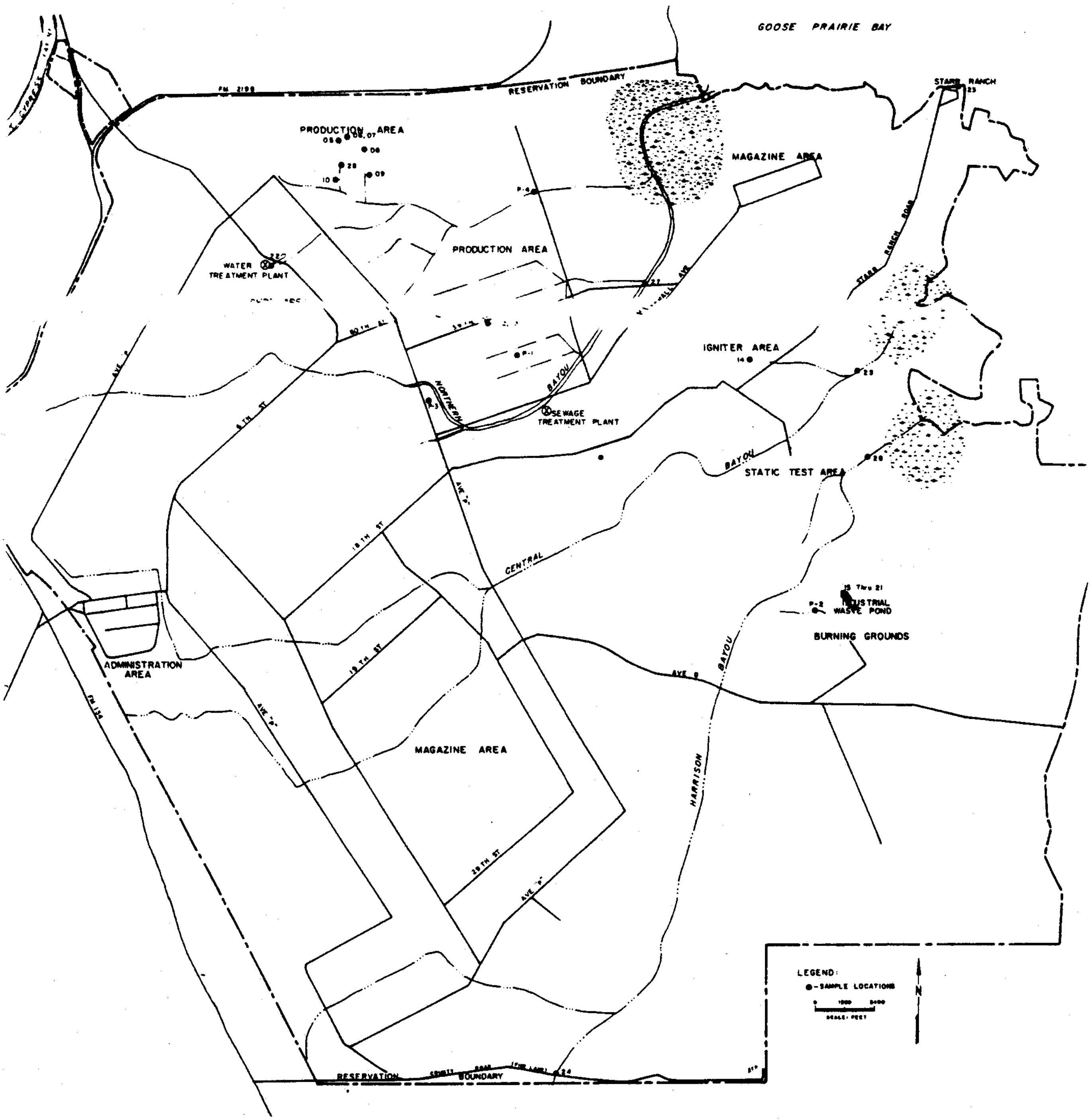


FIGURE. MAP OF SAMPLING POINTS - LONGHORN ARMY AMMUNITION PLANT, TX.

(3) Terrestrial Vegetation. Terrestrial vegetation includes deciduous and coniferous trees in wooded areas and lush dense grass elsewhere.

(4) Soils. Soils may be characterized as consolidated mixtures of sand, silt, and clay with very low permeability as demonstrated by tests performed on soils at LAAP. Grain size distribution was 46 to 48 percent sand, 35 to 36 percent silt, and 16 to 19 percent clay. On two samples the permeability ranged between 6 X $10^{-5}$ and 1 X $10^{-6}$ cm/sec. These quaternary deposits ranged from 5.0 ft to 25.0 ft in depth. The low permeability of the soils was further demonstrated by the ponding of waters from cooling water discharges, ponding of dried up streams, and the existence of Caddo Lake. While the general region is reported to serve as the region of surface water recharging to the Cypress Aquifer through the outcropping of more permeable soils, no such areas were encountered on the installation.

(5) Population. The predicted population of LAAP at mobilization levels of operation is 4779. The present population level is 679 persons. As no housing is provided on the installation, population levels represent the work force. The septic tank fields serve approximately 12 percent of the working force and the sanitary sewage treatment plant serves the balance.

(6) Plant Operation: The plant's operations fluctuate directly with the demand for pyrotechnic ammunition and rocket motors. At the time of the study, the plant was basically operating on a one shift, 8-hour workday, 5-day workweek schedule. Certain operations, however, utilize partial night shifts to maintain necessary support and production continuity.

e. Industrial Waste Sumps. Since most production operations consist of component assembly, rather than manufacturing, only small volumes of production related wastewaters are generated, primarily by housekeeping practices. These wastewaters are considered contaminated by explosives or illuminants and are discharged to sumps, where particulates are allowed to settle out. These sumps are pumped out into tank trucks periodically, and transported to an evaporating pond located at the explosive burning grounds. There are approximately 150 sumps.

f. Industrial Waste Pond. An industrial waste pond is used to contain solids and liquid wastes from the industrial waste sumps. Liquid and solid wastes from the rocket motor washout facility immediately to the north are also discharged to this pond. The pond is approximately 300 ft X 300 ft X 14 ft deep (91.44 m X 91.44 m X 4.27 m) covering two acres (0.81 ha).

g. Water Supply and Treatment.

(1) Source. LAAP obtains its water from the Black Cypress Bayou (see Figure) which connects Lake of the Pines with Caddo Lake. The raw water is pumped from the bayou through a screened intake into a 2.8 MG (10,598 $m^3$)

capacity storage tank located adjacent to the WTP. The large pumping capacity [2- 7,800 gpm (29.52 $m^3$ per second), 1- 2,000 gpm (7.57 $m^3$ per minute)] was originally installed to meet the requirements for TNT manufacture. LAAP no longer manufactures TNT and all the related facilities have been moved from the installation. Flow measurements are determined by timing pump operation.

(2) Potable Water Treatment. From the 2.8 MG (10,598 $m^3$) tank, the raw water flows by gravity through a mixing chamber (where lime, alum, and chlorine are added) into one of two upflow clarifiers, which are used alternately. The water then flows through rapid sand filters into the 375,000 gallon (1419 $m^3$) capacity clear well, where it is pumped into the distribution system. Sodium hexametaphosphate is added manually at the sand filters for corrosion control. After filtration, the water is chlorinated to maintain a 0.5 mg/l total chlorine residual in the system, and lime is added for pH control. The plant has a 2.3 MGD (8,706 $^3$ per day) capacity. Flow measurements are computed by timing pump operations. The potable water source supplies drinking, fire, cooling and wash down waters.

(3) Fire water. Fire water is raw water pumped from the 2.8 MG (10,598 $m^3$) tank. Flow measurements are computed by difference of raw and treated waters. This water serves as the principal source for fire and cooling.

h. Precipitation. The average annual rainfall is 45 in (114.3 cm), the mean annual lake evaporation is 54 in (137.2 cm) and the average annual runoff is 15 in (38.1 cm).

5. PROCEDURES.

a. Sampling. Grab sampling was used exclusively. The fact that wastes in the sumps and pond represented collections over long periods, from a week to years, negated the requirement for time or flow composited sampling. Liquids were dipped from the top 12 in (30.48 cm). At the industrial waste pond three grab samples were collected along the diagonal and combined to form a single composite sample. Three composite samples were collected in this manner. Sediments were collected using a 1-1/2 in (3.81 cm) diameter plastic pipe which was inserted into the bottom sediments and withdrawn as with a pipette.

b. Sampling Points. The locations of sample points are indicated on the figure of the map of the installation. The sample number, type and description of the location are provided in Table 1, Appendix B.

c. Handling of Samples. Samples were divided and preserved by USAEHA personnel in accordance with the following schedule:

(1) Metals were preserved with 1.5 to 2.0 ml nitric acid per 8 oz (237 ml) bottle resulting in pH 2 or less.

(2) Nutrients and TOC were preserved with 0.2 ml sulfuric acid per 8 oz (237 ml) bottle.

(3) Phenols were preserved with phosphoric acid and copper sulfate to pH 3.0 or less.

(4) General analyses samples were not preserved.

(5) Oil and grease were preserved with 1 ml sulfuric acid resulting in pH 2 or less.

Samples were packed by USAEHA personnel for shipment to USAEHA for analysis. LAAP personnel handled shipment of samples.

d. Analyses. The parameters for analysis were chosen from a review of compounds used in the manufacture of military pyrotechnics, installation purchase orders, USEPA NPDES permits and key plant personnel assessments. The analyses were performed at the USAEHA by Agency personnel in accordance with the precedures indicated in Table 2, Appendix B.

6. FINDINGS.

a. General. No aluminum, cobalt, titanium, tungsten or zirconium were found in detectable amounts in any liquid wastes, streams or raw water. The pH of liquid samples changed for many samples between the time they were collected and the time of analysis at this Agency as noted in Table 3, Appendix B. A change in more than one pH unit indicates a lack of chemical stability of the waste and is so noted in the table.

b. Industrial Waste Sumps.

(1) Analytical Results. The analytical results for the liquid supernatants from the sumps at production buildings are provided in Table 4, Appendix B, with a summary of high, low and average values provided in Table 5, Appendix B. The analytical results for sediments are provided in Table 6, Appendix B. While the range in parameters for the 10 sumps sampled is broad with concentrations frequently below the detectable limit, in every instance there are one or more parameters which preclude the free discharge to surface drainage. The sediments are rich in all parameters tested with the exception of mercury for which all analyses were below the detectable limit. While the concentration is relatively high in the supernatant for sample 10, none was found in the sediment.

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(2) Observations.

(a) General. At the time of the study the installation was experiencing mechanical problems with the pump on the tank truck used to collect supernatant liquids and sediments from the sumps. Within a week the pump was repaired and routine pumping recommenced. If a problem exists with the present routine, it lies in the coverage of inactive areas where slow leaks and storm runoff fill up the sumps. The installation does not maintain a list of all sumps nor records on inspection or dates each is pumped. The findings at sumps illustrates the need for extending the present routine of pumping sumps at active production sites to inspection of inactive sites and all sites after a rainfall.

(b) SP 05. The covered sump was full. Mosquito larvae were observed living in the supernatant. The sediment collected from the sump could not be safely shipped to the Agency because it was producing gas. Within a few hours the plastic cube container containing the sample had expanded to a point of bursting. Hydrochloric acid was added to a portion of the sample to drive the reaction to completion requiring twice the volume of acid to the volume of sludge. As time did not permit treatment of the entire sample, the sample was discarded. The covers to the sump did not have a vent to allow the discharge of gases generated from the reaction of waste ingredients.

(c) SP 06. The covered sump was full. A skim of oil was observed on the sediment sample.

(d) SP 07. The covered sump was full. No oil was observed.

(e) SP 08. The sump had no cover and was nearly empty. No sediment was found. While the sump was nearly empty the analyses indicated a strong industrial waste.

(f) SP 09. The sump had no cover, was almost empty and contained no solids. The COD, barium and chromium concentrations were appreciable.

(g) SP 10. The sump had no cover and was almost empty. Both the supernatant and sediment were strong industrial wastes. The magnesium content was the highest of any sump sediment analyzed.

(h) SP 11. The covered sump was full. Some oil and grease were observed on the surface. A frog was observed living in the sump. A trichlor odor was noticed while collecting samples.

(i) SP 12. The sump was either overflowing from waste discharges or surface drainage was flooding the sump. The sediment had an organic decay odor. The wood cover was covered with sod. Minnows were observed living in pooled water. With a pH 6.0 and a relatively weak wastewater, the waters might be expected to support life. However, the change in pH during shipment of the sample indicates that the sump wastes are not stable.

(j) SP 13. As the wood cover was jammed from swelling caused in part by a heavy layer of vegetation, it was not possible to remove it. Consequently no samples were collected.

(k) SP 14. The sump had no cover and was half full of a 50-50 mixture of supernatant and sediment. While the supernatant did not carry the normal array of metals and was relatively stable, it did contain high concentrations of COD, $NO_2/NO_3$-N and barium. The sediment sample collected could not be shipped for the same reason as sample 05, [see paragraph 6b(2)(b)].

(ℓ) SP P-1. The uncovered sump was full. The effluent bypass pipe was plugged preventing the 12 inch (30.5 cm) head of supernatant from discharging to the surface drainage. Outside of TDS and low pH the supernatant was relatively weak. The sludge was a bright red with a low solids content.

(3) Ditches. Ditches were inspected downstream of all sumps. In all cases lush vegetative growth of a wide variety of plants grew in and along them. Where ditches carried water, a variety of algae, plants, fish and invertebrate insect life were prevalent.

c. Drainage.

(1) Burning Ground. Drainage from the burning ground was collected from stagnant pools along the main drainage ditch to ascertain the extent of potential pollution from this area. The analytical results provided in Table 7, Appendix B, indicate a barium concentration as the only parameter of potential concern. As barium would be diluted in general runoff to well below 1.0 mg/l which is a recognized standard for the States of Illinois and Virginia, (no Texas Standard), there is no indication of a problem area.

(2) Pot Cleanup Area. Several cleanup areas were observed where pots and vessels, used in conveying and mixing various substances, are cleaned by flushing in open areas. The flushings are then discharged directly to surface drainage ditches. The analytical results for sample 28, Table 7, Appendix B, collected from one operating location indicate a very acid waste with high TSS. While the COD is not high, 60 mg/l, the theoretical COD based upon the TOC value is only 15. The difference between measured and computed values can be inorganic oxygen demand. However, the source or cause of the difference is not apparent from the analysis. As there is little difference in the source of these discharges from those collected in the industrial sumps, the array of parameters during cleaning operations and likely their concentrations would be very similar. As such, these discharges do constitute an industrial waste which should be collected and contained in a sump and similarly disposed of.

d. Industrial Waste Pond.

(1) Supernatant.

(a) The analytical results for the industrial waste pond supernatant are provided in Table 8, Appendix B. The supernatant has three characteristics which prevent its discharge to surface drainage--high concentrations of substances, lack of mixing and continuing chemical activity.

(b) The concentrations of TS and TDS are high as are total nitrogen, chloride, strontium and barium. The average TOC correlates very closely with COD, 46.3 mg/l for a theoretical COD based on TOC as against 45 mg/l for measured COD. This indicates there is no inorganic oxygen demand. While the average lead concentration (0.09 mg/l) is within the range of established State water quality standards, 0.05 mg/l for Virginia and 0.1 mg/l for Illinois (Texas has no standard), the single high value (0.27 mg/l) would be reason to prevent discharge to surface streams.

(c) While the concentrations of most parameters are well within a 10 percent analytical variation, the ranges of iron, lead, tin and zinc indicate that complete mixing is not accomplished and as a result chemical reactions with bottom sediments can be expected. It would be difficult if not impossible to say where stabilization of supernatant occurs such that the supernatant could be safely drawn off.

(d) There is a complex array of chemical reactions occurring among supernatant parameters which result in precipitation of some parameters and between the supernatant and sediments which solubilize others. The concentration of zinc in sump supernatant samples ranged between 0.112 and 2.12 mg/l, while in the pond supernatant, the range fell to between 0.036 and 0.067 mg/l. Similar reductions are seen for chromium, iron, manganese and silicon. The observed gaseous erruptions in the vicinity of the truck dumping station can be attributed to hydrogen from the reaction of magnesium metal with a slightly acid supernatant. The generation of hydrogen, associated with the storage of moist magnesium, is a recognized hazard by Thiokol Chemical Corporation personnel. The lack of chemical stability is further demonstrated with a drop in pH from 6.5 to 4.1 during storage and transport of the supernatant samples (see Table 3, Appendix B).

(e) The lack of normal plant and animal life in the pond attests to the toxicity of the wastes. No plant life was observed in the pond. While turtles were observed swimming in the pond, the carcasses of two turtles were found at the edge of the pond. Turtles are extremely mobile and their occurrence in such a limited environment can not be construed as a lack of toxicity. They can and apparently do survive in such ponds primarily because they breathe air and do not ingest large quantities of the pond contents relative to their body weight.

(2) Sediments. The analytical results of industrial waste pond sediments are provided in Table 9, Appendix B. The variations in parameter concentrations are much greater than with the pond supernatant. The point G18 which was furthest from the influent point has the lowest concentrations of parameters and percent solids. In general, the higher concentration of parameters occurs in the vicinity of the influent. The increase in solids from 2.75 percent for sump sediments to 12.05 percent for pond sediments indicates that sediments are being concentrated in the pond.

(3) Evaporation. The need for considering discharge of the supernatant is appreciated for the net evaporation is only 9 in per year. The gross evaporation of 54 in less 45 in per year rainfall leaves only 9 in evaporation.

e. Receiving Waters.

(1) General. The characteristics of receiving waters are presented in Table 10, Appendix B, along with controls from Caddo Lake and the raw and treated tap water. The raw water drawn from Black Cypress Bayou, when treated, increases in TS and TDS from the addition of lime and alum. Comparisons of raw and treated waters analyzed under the drinking water surveillance program indicated that there was no change in water characteristics other than slight increases in TD, TDS, calcium and sulfates in the treated waters.

(2) North Bayou. The increases in parameters in the North Bayou over the treated water supply are slight and are traceable to discharges of boiler blowdown, water softening operations, water treatment plant sludge and filter backwashes and sewage treatment plant effluent. Completion of projects presently under construction to improve the treatment of these waste waters will bring the concentrations of parameters down to a point which will make the waters in the North Bayou indiscernible from the control waters. At the present time the concentrations of metals are generally below those of Harrison Bayou as it flows onto the installation. The abundant diverse plant life along the bayou and the fish observed in pooled streches attest to the quality of North Bayou waters.

(3) Central Bayou. The quality of water discharging to Caddo Lake is as good or better than the controls. This bayou drains the area where extensive use is made of septic tanks with filter beds for the treatment of sanitary sewage. The pH stability and low metals confirm observations that no industrial wastes are being discharged to this ditch.

(4) Harrison Bayou. With the exception of conductivity, TS, TDS, COD, TP, chloride, iron and silicon, the quality of the waters in Harrison Bayou is as good or better as they leave the installation than when they enter it. A comparison of sample 26 with the controls indicates no significant or adverse effects from the drainage from the burning ground area. An abundant variety of animal and plant life prevails everywhere along this bayou.

f. Water Consumption. Water production is measured by timing pump operations. The flow meters provided were designed to measure the quantities used in support of TNT production, something in the order of 30 MGD. The present consumption rate lies below the minimum measurable limits of the meters. The average daily recorded water pumped is:

| | |
|---|---|
| Fire Water | 99 TGD |
| Potable | 504 TGD |
| Total Daily | 603 TGD |

Applying average loading factors the accountable water usage is as follows:

Government and Thiokol Personnel

| | |
|---|---|
| 679 workers X 30 gpcd/1000 = | 20.4 TGD |

Construction Workers

| | |
|---|---|
| 49 workers X 30 gpcd/1000 = | 1.5 TGD |
| Steam $\frac{\text{2,980 gallons per month}}{\text{30 days per month (1000)}}$ = | 9.3 TGD |

Boiler Plant Blowdowns

| | |
|---|---|
| 300 GPH X 12 Hours/1000 = | 3.6 TGD |

Backwash to Filters at Water Treatment Plant

| | |
|---|---|
| $\frac{\text{650,000 gallons per month}}{\text{30 days per month (1000)}}$ = | 21.7 TGD |
| Production Wash Down to Sumps = | 10 TGD |
| Total Accountable Water Used = | 156.5 TGD |

The unaccountable water is by difference:

| | |
|---|---|
| Pumped | 603 TGD |
| Accountable | 156 TGD |
| Unaccountable | 447 TGD |

The sanitary sewage averaged 40 TGD according to the plant operator. Assuming 70 percent of water pumped reaches the plant, the water consumed for personnel, shops and power house blowdown should approach 40 TGD/0.70 or 57.1 TGD. The estimated sum of personnel use (21.9 TGD) and the boiler plant blowdown (3.6 TGD) is 25.5 TGD which indicates a higher percapita usage than assumed or unidentified uses. While water used for compressor cooling, air conditioning, car washing, wash down, cafeterias, and leaks is not included, it is difficult to imagine values which would account for 447 TGD. The lack of flow meters throughout the system prevents any accurate estimation or control of uses or losses.

7. CONCLUSIONS.

a. The present sump pumping program does not include periodic inspection of inactive sites or inspection of all sites after a rainfall.

b. Accessibility to sumps is limited by poor maintenance of covers.

c. The covers to sumps are not designed to prevent the collection of hydrogen or other gases produced by the chemical reaction of sump contents.

d. Ditches and receiving streams have not been damaged by any possible inadvertant sump overflow or drainage from pot cleaning or burning ground activity [see paragraph 6b(3) and 6e].

e. The high concentrations of barium, total nitrogen, lead and total solids render the quality of the industrial waste pond supernatant unsatisfactory for discharge to streams.

f. The contents of the pond are chemically active with no apparant point where waste supernatant is sufficiently stabilized to permit discharge to streams.

g. The Industrial Waste Pond functions to precipitate suspended and dissolved solids and concentrate sediments from sump wastes.

h. Waste discharges from pot and vessel cleaning operations are not collected, contained or treated as sump wastes.

i. The lack of a wide diversity of biological life in the Industrial Waste Pond is indicative of the toxicity of its contents.

j. There is no indication the waters of the North, Central or Harrison Bayous are or have been adversely affected by production activities.

k. No operable flow measurement equipment is provided on treated or fire water lines.

l. Water consumption is higher than can be justified by rough estimates.

8. RECOMMENDATIONS.

a. Treat Industrial Waste Pond supernatant to remove waste parameters before discharing to the streams, see paragraph 6d.

b. Extend sump pumping program to periodic inspection and pumping of inactive sites and all sites after rainfall [see paragraph 6b(2)(d)].

c. Improve maintenance of sumps and sump covers [see paragraph 6b(2)(j)].

d. Design all sump covers to prevent the collection of hydrogen or other gases [see paragraph 6b(2)(b)].

e. Collect, contain and treat wastes discharged from pot and vessel cleaning operations [see paragraph 6c(2)].

f. Install adequate flow measurement equipment on treated and fire water lines to control and identify consumption, see paragraph 6f.

9. CONSULTATION AND ASSISTANCE.

a. This Agency will provide further consultation and assistance in the implementation of the recommendations made in this report upon request. Requests for such assistance should be directed through appropriate channels to Commander, USA Health Services Command, ATTN: HSPA-H, Ft Sam Houston, TX 78234, in accordance with paragraph 1-5, AR 40-5.

b. Technical consultation can be obtained informally by contacting the Chief, Water Quality Engineering Division (AUTOVON 584-3845/3554).

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## APPENDIX A

## ABBREVIATIONS AND DEFINITIONS

| | |
|---|---|
| Al | aluminum |
| ARMCOM | US Army Armament Command |
| ARRCOM | US Army Armament Materiel Readiness Command (This organization was formerly known as ARMCOM) |
| B | boron |
| Ba | barium |
| Ca | calcium |
| $CaCO_3$ | calcium carbonate |
| Cd | cadmium |
| Cl | chloride |
| cm | centimeter |
| cm/sec | centimeters per second |
| COD | chemical oxygen demand |
| Co | cobalt |
| Cr | chromium |
| Cu | copper |
| F | fluoride |
| ft | feet |
| Fe | iron |
| GOCO | government owned contractor operated |
| GPD | gallons per day |
| gpcd | gallons per capita per day |
| GPH | gallons per hour |
| gpm | gallons per minute |
| H | hydrogen |
| h | hours |
| ha | hectares |
| Hg | mercury |
| $HNO_3$ | nitric acid |
| $H_2SO_4$ | sulfuric acid |
| in | inches |
| K | potassium |
| kg | kilogram |
| km | kilometer |
| LAAP | Longhorn Army Ammunition Plant |
| m | meter |
| $m^3$ | cubic meters |
| Mg | magnesium |
| MG | million gallons |
| MGD | million gallons per day |
| mg/l | milligrams per liter |
| ml | milliliter |

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| | |
|---|---|
| Mn | manganese |
| Mo | Molybdenum |
| N | nitrogen |
| Na | sodium |
| ND | Not detectable |
| $NH_3$-N | ammonia nitrogen |
| $NO_2/NO_3$-N | nitrite and nitrate nitrogen |
| NPDES | National Pollutant Discharge Elimination System |
| O | oxygen |
| $O_2$ | oxygen gas |
| P | phosphorus |
| Pb | lead |
| pH | Negative logarithm (base 10) of hydrogen ion ($H^+$) concentration |
| ppm | parts per million parts by weight |
| S | sulfur |
| Sb | tin |
| Si | silicon |
| $SiO_2$ | silicate |
| $SO_4$ | sulfate |
| SP | sample point |
| Sr | strontium |
| STP | sewage treatment plant |
| TDS | total dissolved solids |
| TGD | thousand gallons per day |
| TKN | total Kjeldahl nitrogen expressed as N |
| TOC | total organic carbon |
| TP | total phosphorus |
| TS | total solids |
| TSS | total suspended solids |
| Ti | titanium |
| µmho/cm | micromhos per centimeter |
| USAEHA | US Army Environmental Hygiene Agency |
| W | tungsten |
| WTP | Water Treatment Plant |
| Zn | zinc |
| Zr | zirconium |

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APPENDIX B

Laboratory analyses as presented in Tables 4 and 6 through 10 were performed by personnel of the Environmental Chemistry Division of USAEHA.

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APPENDIX B

TABLE 1. DESCRIPTION OF SAMPLES AND SAMPLE POINT LOCATIONS

| Sample No. | Type Liquid | Type Sediment | Location |
|---|---|---|---|
| 05 | X | | Sump, Bldg P-1 |
| 06 | X | | Sump, Bldg P-3 (w/air cleaner device) |
| 07 | X | | Sump, Bldg P-3 |
| 08 | X | | Sump, Bldg P-11 (w/air cleaner device) |
| 09 | X | | Sump, Bldg B-10 |
| 10 | X | | Sump, Bldg B-7 |
| 11 | X | | Sump, Bldg 45-E, West Sump |
| 12 | X | | Sump, Bldg 45-E, Central Sump |
| 13 | X | | Sump, Bldg 45-E, East Sump |
| 14 | X | | Sump, Bldg 34-Y, Igniter Area |
| 15 | X | | Industrial Waste Pond, Composite of 3 grab samples |
| 16 | X | | Industrial Waste Pond, Composite of 3 grab samples |
| 17 | X | | Industrial Waste Pond, Composite of 3 grab samples |
| 22 | X | | Raw Water, Tap from Water Treatment Plant |
| 23 | X | | Caddo Lake @ Starr Ranch, background |
| 24 | X | | Harrison Bayou at county road off Rt 134 |
| 25 | X | | Central Bayou, east of Igniter Area |
| 26 | X | | Harrison Bayou, east of Static Test Area |
| 27 | X | | North of Bayou at 59th Street |
| 28 | X | | Ditch Sample adjacent to pot-cleanup across from Bldg B-11 |
| P-1 | X | | Sump, Bldg 33G |
| P-2 | X | | Stagnant Stream below burning ground area |
| P-3 | X | | Cold water tap at Quality Assurance Lab |
| P-4 | X | | Stream to North Bayou at Karnack Road |
| G05 | | X | Same location as 05 |
| G06 | | X | Same location as 06 |
| G07 | | X | Same location as 07 |
| G08 | | X | Same location as 08 |
| G09 | | X | Same location as 09 |
| G10 | | X | Same location as 10 |
| G11 | | X | Same location as 11 |
| G12 | | X | Same location as 12 |
| G14 | | X | Same location as 14 |
| G18 | | X | Industrial Waste Pond |
| G19 | | X | Industrial Waste Pond |
| G20 | | X | Industrial Waste Pond |
| G21 | | X | Industrial Waste Pond |
| GP-1 | | X | Same location as P-1 |

TABLE 2. ANALYTICAL PROCEDURES

| Parameter | Symbol | Expressed As | Units | Detection Limit | Procedure |
|---|---|---|---|---|---|
| pH | pH | | Units 0-14 | | Standard Methods[1], 144 A. Glass Electrode Method pg 276 (Tape for Field Measurements) |
| Acidity | | $CaCO_3$ | mg/l | | Standard Methods[1], 101, Acidity, pg 50 |
| Alkalinity | | $CaCO_3$ | mg/l | | Standard Methods[1], 102, Alkalinity, pg 52 |
| Total Organic Carbon | TOC | C | mg/l | 1.0 | Standard Methods[1], 138A Combustion-Infrared Method (Tentative), page 257. Samples were acidified and homogenized prior to analysis. |
| Ammonia | $NH_3$-N | N | mg/l | .03 | (a) Concentration Range 0.03-1.0 mg/l; Selective ion Electrode Method, Orion Research[2], Instruction Manual, Ammonia Electrode Model 95-10, 1972.<br>(b) Concentration Range 1.0-100 mg/l; Preliminary Separation by Microdiffusion[3] and Selective Ion Electrode Determination, Orion Research Institution Manual, Ammonia Electrode Model 95-10, 1972.[2] |
| Nitrite/Nitrate | $NO_2/NO_3$-N | N | mg/l | .04 | Technicon Auto Analyzer[4], Industrial Method 33-69W, preceded by sample treatment with Aluminum Hydroxide Suspension, as in Standard Methods, pg 235. |
| Total kjeldahl Nitrogen | TKN | N | mg/l | .10 | Technicon Auto Analyzer[4], Industrial Method 29-69A. Samples were acidified and homogenized prior to analyses. |
| Total Solids | TS | Solids | mg/l | | Data obtained by summing values obtained from Standard Methods[1], 224c, Total Suspended Matter, pg 537; and Standard Methods[1], 224E, Dissolved Matter, pg 539 |
| Total Dissolved Solids | TDS | Solids | mg/l | | Standard Methods[1], 224E, Dissolved Matter, pg 539. Evaporated filtrate from Standard Methods,[1] 224C, Total Suspended Matter, pg 537. Filtrate of samples with nitrobody contamination was oven dried over sand to prevent possible explosion. Samples with high dissolved solids content were dried at 180°C as in Standard Methods[1], 148, Residue, pg 286-288. |
| Total Suspended Solids | TSS | Solids | mg/l | 3 | Standard Methods[1], 224C, Total Suspended Matter, 103-105°C, pg 537 |
| Oil and Grease | Oil and Grease | | mg/l | 10 | Standard Methods[1], 137, Oil and Grease, pg 254 for relatively clean samples, Standard Methods[1], 209A, Soxhlet Extraction Method, pg 409 for samples with grass material contamination. |
| Total Phosphorus | TP | P | mg/l | | Technicon Auto Analyzer[4], Industrial Method 94-70W, preceded by sample digestion as in Standard Methods, 223 C, Preliminary Digestion Steps for Total Phosphorus III, pg 526. |
| Sulfate | $SO_4$ | $SO_4$ | mg/l | | Standard Methods[1], 156 C, Turbidimetric Method pg 334 |
| Chloride | Cl | Cl | mg/l | | Standard Methods[1], 112 B, Mercuric Nitrate Method, pg 96. Used Hach diphenylcarbazone indicator-buffer powder pillows. |
| Fluoride | F | F | mg/l | | Technicon Augo-Analyzer[4], Industrial Method 129-71W/Preliminary |

see footnotes 1 2 3 4 on page B-4



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TABLE 2. ANALYTICAL PROCEDURES (Continued)

| Parameter | Symbol | Expressed As | Units | Detection Limit | Procedure |
|---|---|---|---|---|---|
| Chemical Oxygen Demand | COD | $O_2$ | mg/l | 5 | Standard Methods[1], 220 Oxygen Demand (Chemical) pg. 495 |
| Conductivity | | G | µmho/cm | | Standard Methods[1], 154, Specific Conductance, pg 323 |
| Volatile Suspended Solids | VSS | Solids | mg/l | | Standard Methods[1], 224 D, Volatile and Fixed Suspened Matter, pg 538 |
| Phenols | | | mg/l | .01 | Technicon Auto-Analyzer[4], Industrial Method 27-71W/Preliminary |
| Boron | B | B | mg/l | .05 | Automated Fluorometric Method for Determination of Boron in Waters, Detergents and Sewage Effluents[5], Water Research, Vol 6, pg 1475. |
| Aluminum | Al | Al | mg/l | 1.0 | |
| Barium | Ba | Ba | | .3 | |
| Calcium | Ca | Ca | | .1 | |
| Cadmium | Cd | Cd | | .005 | |
| Cobalt | Co | Co | | .2 | |
| Copper | Cu | Cu | | .025 | "Methods for Chemical Analysis of Water and Wastes, 1971[6] Metals (Atomic Absorption Methods) pg H3, Preliminary Treatment of Samples, Para 4.1.3 pg 88. |
| Chromium | Cr | Cr | | .025 | |
| Iron | Fe | Fe | | .1 | |
| Mercury | Hg | Hg | | .0002 | |
| Potassium | K | K | | .5 | |
| Magnesium | Mg | Mg | | .5 | |
| Manganese | Mn | Mn | | .03 | |
| Molybdenum | Mo | Mo | | .5 | |
| Lead | Pb | Pb | | .1 | |
| Tin | Sb | Sb | | .5 | |
| Silicon | Si | $SiO_2$ | | 2.0 | |
| Strontium | Sr | Sr | | .1 | |
| Titanium | Ti | Ti | | 1.0 | |
| Tungsten | W | W | | 10 | |
| Zinc | Zn | Zn | | .015 | |
| Zirconium | Zr | Zr | | 10 | |

[1]APHA, AWWA, WPCF, Standard Methods for the Examination of Water and Wastewater, 13th edition, 1971, American Public Health Association, New York, NY, 1971
[2]Orion Research Incorporated, Cambridge, Mass
[3]USAEHA, Environmental Chemistry Division, "Ammonia Determination by a Micro-Diffusion Method", Aberdeen Proving Ground, MD
[4]Technicon Corporation, "Technicon Auto-Analyzer Methodology," Industrial Methods, Technicon Instruments Corporation, Tarrytown, NY
[5]Canada Centre for Inland Waters, Dept of the Environment, Water Quality Division, "Automated Fluorometric Method for Determination of Boron in Waters, Detergents and Sewage Effluents", Water Research, Vol 6, pg 1475
[6]EPA, "Methods for Chemical Analysis of Water and Wastes, 1971," Environmental Protection Agency, National Environmental Research Center, Analytical Quality Control Laboratory, Cincinnati, Ohio 45268

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TABLE 3. STABILITY OF LIQUID SAMPLES AS INDICATED BY CHANGES IN pH.

| Sample No. | pH Tape At Sample Point | pH Meter at Agency | Stability High | Stability Low |
|---|---|---|---|---|
| 05 | 6.5 | 3.8 | | X |
| 06 | 5.5 | 7.0 | | X |
| 07 | 6.0 | 6.8 | X | |
| 08 | 7.0 | 7.1 | X | |
| 09 | 7.0 | 4.4 | | X |
| 10 | 8.0 | 9.6 | | X |
| 11 | 6.0 | 2.7 | | X |
| 12 | 6.0 | 3.9 | | X |
| 14 | 8.0 | 7.1 | X | |
| 15 | 6.5 | 4.0 | | X |
| 16 | 6.5 | 4.1 | | X |
| 17 | 6.5 | 4.1 | | X |
| 22 | 6.4 | 6.5 | X | |
| 23 | | 6.7 | | |
| 24 | 6.2 | 6.9 | X | |
| 25 | 6.0 | 6.6 | X | |
| 26 | 6.0 | 3.1 | | X |
| 27 | 6.0 | 3.3 | | X |
| 28 | 6.0 | 2.6 | | X |
| P-1 | 3.0 | 2.5 | X | |
| P-2 | 7.0 | 6.8 | X | |
| P-3 | | 6.8 | | |
| P-4 | 6.0 | 6.3 | X | |

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TABLE 4. ANALYTICAL RESULTS FOR INDUSTRIAL WASTE SUMP SUPERNATANTS

| Parameter | Sump Samples* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | P-1 |
| pH | 3.8 | 7.0 | 6.8 | 7.1 | 4.4 | 9.6 | 2.7 | 3.9 | | 7.1 | 2.5 |
| Alkalinity | 2 | 4.3 | 37 | 358 | 0 | 198 | 0 | 2 | | 189 | 0 |
| Acidity | 22 | 12 | 12 | 28 | 17 | 0 | 147 | 36 | | 16 | 287 |
| Conductivity | 333 | 278 | 4440 | 999 | 244 | 6882 | 1221 | 366 | | 1221 | 2220 |
| TS | 369 | 1987 | 4849 | 1133 | 241 | 11962 | 157 | 219 | | 1135 | 684 |
| TDS | 356 | 1981 | 4843 | 1055 | 227 | 5950 | 133 | 191 | | 1119 | 666 |
| TSS | 13 | 6 | 6 | 76 | 14 | 6012 | 24 | 28 | | 16 | 18 |
| VSS | 4 | 1 | 3 | 54 | 13 | 1707 | 16 | 19 | | 6 | 10 |
| COD | 29 | 23 | 20 | 166 | 121 | 4158 | 59 | 51 | | 358 | 41 |
| TOC | 6 | 6 | 9 | 121 | 13 | 76 | 6 | 7 | | 109 | 11 |
| Oil & Grease | | | | 12.6 | 30.6 | 83.7 | | | | | |
| Phenols | .01 | .48 | .40 | .06 | .01 | .50 | ND | ND | | .14 | .11 |
| $NH_3$-N | .88 | .10 | .25 | .08 | .11 | 11.3 | ND | .10 | | 21 | .15 |
| TKN | 1.3 | 3.0 | 3.0 | 4.3 | 1.2 | 19.5 | 0.55 | 0.31 | | 32 | 1.1 |
| $NO_2/NO_3$-N | .10 | 290 | 490 | ND | 1.3 | 920 | ND | ND | | 83 | ND |
| TP | ND | ND | .05 | ND | .09 | .23 | ND | 1.4 | | .06 | ND |
| Cl | 260 | 29 | 28 | 30 | 65 | 825 | 170 | 50 | | 500 | 285 |
| F | ND | ND | .11 | ND | ND | ND | ND | ND | | ND | ND |
| $SO_4$ | 34 | ND | 2 | 12 | 12 | 280 | 10 | 80 | | 1 | 115 |
| Al | ND | ND | ND | ND | ND | ND | ND | ND | | ND | ND |
| B | .08 | ND | ND | .09 | .05 | ND | ND | ND | | ND | ND |
| Ba | 2.77 | 458 | 993 | 7.34 | 8.23 | 436 | 1.97 | .33 | | 93 | ND |
| Ca | 15.3 | 16.9 | 16.5 | 20.9 | 4.4 | 13.1 | 13.3 | 19.6 | | 5.6 | 69.4 |
| Cd | .005 | .018 | .029 | .010 | .011 | .021 | .010 | .006 | | .008 | .017 |
| Co | ND | ND | ND | ND | ND | ND | ND | ND | | ND | ND |
| Cu | .027 | ND | .048 | .029 | ND | .060 | .028 | ND | | ND | ND |
| Cr | ND | ND | ND | .034 | 1.143 | ND | ND | ND | | ND | ND |
| Fe | .24 | ND | .30 | 1.31 | .49 | 2.16 | .33 | .68 | | ND | 12.1 |
| Hg | .00038 | ND | .00045 | ND | ND | .18 | ND | .0005 | | ND | ND |
| K | 3.96 | 69.4 | 85.8 | 293 | 2.60 | 8.39 | 0.90 | 3.30 | | 5.79 | 3.79 |
| Mg | 12.49 | 1.89 | 3.15 | 2.40 | 7.42 | 165.7 | 1.35 | 2.17 | | 14.74 | 3.13 |
| Mo | ND | ND | ND | ND | ND | ND | ND | ND | | ND | ND |
| Mn | ND | .042 | .077 | 3.76 | ND | .075 | .032 | .244 | | ND | .619 |
| Na | | | | | | | | | | | |
| Pb | ND | ND | .12 | 1.41 | ND | ND | ND | ND | | ND | .26 |
| Sb | ND | ND | .94 | .58 | ND | ND | ND | ND | | ND | ND |
| Si | 9.6 | 14.4 | 10.9 | 14.1 | 2.6 | 23.8 | 5.3 | 13.9 | | 2.8 | 12.0 |
| Sr | .210 | 224 | 660 | .318 | .106 | 1.113 | ND | .115 | | 160 | .355 |
| Ti | ND | ND | ND | ND | ND | ND | ND | ND | | ND | ND |
| W | ND | ND | ND | ND | ND | ND | ND | ND | | ND | ND |
| Zn | .224 | .767 | .376 | .332 | .246 | .614 | .118 | .639 | | .112 | 2.12 |
| Zr | ND | ND | ND | ND | ND | ND | ND | ND | | ND | ND |

* All values expressed in mg/l except pH in units and conductivity in µmho/cm

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TABLE 5. SUMMARY OF RESULTS FOR INDUSTRIAL WASTE SUMP SUPERNATANTS

| Parameter* | High | Low | Average |
|---|---|---|---|
| pH | 9.6 | 2.5 | |
| Alkalinity | 358 | 0 | 83 |
| Acidity | 147 | 0 | 58 |
| Conductivity | 6882 | 278 | 1820 |
| TS | 11962 | 157 | 2274 |
| TDS | 5950 | 133 | 1652 |
| TSS | 6012 | 6 | 621 |
| VSS | 1707 | 1 | 183 |
| COD | 4158 | 20 | 503 |
| TOC | 121 | 6 | 36 |
| Oil & Grease | 83.7 | | |
| Phenols | .50 | ND | .17 |
| $NH_3$-N | 21 | ND | 3.40 |
| TKN | 32 | 1.1 | 6.53 |
| $NO_2/NO_3$-N | 920 | ND | 178 |
| TP | 1.4 | ND | .18 |
| Cl | 825 | 28 | 224 |
| F | .11 | ND | .01 |
| $SO_4$ | 280 | ND | 55 |
| Al | ND | ND | ND |
| B | .09 | ND | .02 |
| Ba | 458 | ND | 200 |
| Ca | 69.4 | 5.6 | 19.5 |
| Cd | .029 | .005 | .014 |
| Co | ND | ND | ND |
| Cu | .060 | ND | .192 |
| Cr | 1.143 | ND | .118 |
| Fe | 12.1 | ND | 1.76 |
| Hg | .18 | ND | .0181 |
| K | 293 | .90 | 47.7 |
| Mg | 165.7 | 1.35 | 21.44 |
| Mo | ND | ND | ND |
| Mn | 3.76 | ND | .485 |
| Na | | | |
| Pb | 1.41 | ND | .18 |
| Sb | .94 | ND | .15 |
| Si | 23.8 | 2.6 | 10.9 |
| Sr | 660 | ND | 104.6 |
| Ti | ND | ND | ND |
| W | ND | ND | ND |
| Zn | 2.12 | .112 | .555 |
| Zr | ND | ND | ND |

* All values expressed in mg/l except pH in units and conductivity in µmho/cm.

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TABLE 6. ANALYTICAL RESULTS FOR INDUSTRIAL WASTE SUMP SEDIMENTS

| Parameter | | Sump Samples | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | G05 | G06' | G07 | G08 | G09 | G10 | G11 | G12 | G14 | GP1 | High | Low | Average |
| Moisture | Percent | | 99.7 | 91.8 | | | 97.8 | 98.2 | 96.5 | | 99.5 | 99.7 | 91.8 | 97.25 |
| Solids | Percent | | .3 | 8.2 | | | 2.2 | 1.8 | 3.5 | | 0.5 | 8.2 | .3 | 2.75 |
| Volatile Solids After Drying | Percent | | 24 | 12 | | | 28 | 44 | 39 | | 42 | 44 | 12 | 31.5 |
| TP | mg/kg | | 555 | 964 | | | 188 | 200 | 2750 | | 990 | 2750 | 188 | 94.1 |
| Ca | mg/kg | | | 1151 | | | 1440 | 6998 | 7050 | | 3950 | 7050 | 1151 | 4118 |
| Cd | mg/kg | | | 11.4 | | | 4.3 | 14.2 | 82.7 | | 21.8 | 82.7 | 4.3 | 26.9 |
| Cu | mg/kg | | | 415 | | | 27 | 121 | 385 | | 440 | 440 | 27 | 278 |
| Fe | mg/kg | | | 268 | | | 36 | 277 | 550 | | 375 | 550 | 36 | 301 |
| Hg | mg/kg | | | ND | | | ND | ND | ND | | ND | ND | ND | ND |
| K | mg/kg | | | 1131 | | | 81 | 2592 | 1250 | | 162 | 2592 | 81 | 1043 |
| Mg | mg/kg | | | 725 | | | 99250 | 9072 | 2750 | | 5250 | 99250 | 725 | 23409 |
| Mn | mg/kg | | | 1.9 | | | 1.4 | 2.7 | 28.6 | | 2.2 | 28.6 | 1.4 | 7.4 |
| Pb | mg/kg | | | 466 | | | 26 | 1016 | 2270 | | 945 | 2270 | 26 | 945 |
| Sb | mg/kg | | | 108 | | | ND | 27 | 34 | | 48 | 108 | ND | 43 |
| Sr | mg/kg | | | 2401 | | | 98 | 7 | 5 | | ND | 2401 | 5 | 502 |
| Zn | mg/kg | | | 875 | | | 682 | 596 | 3600 | | 965 | 3600 | 596 | 1344 |



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TABLE 7. DRAINAGE FROM BURNING GROUND AND POT CLEANUP AREA

| Parameter* | Sample P-2 Burning Ground | Sample 28 Pot Cleanup Area |
|---|---|---|
| pH | 7.5 | 2.6 |
| Alkalinity as $CaCO_3$ | 111 | 0 |
| Acidity as $CaCO_3$ | 11 | 176 |
| Conductivity | 366 | 1332 |
| TS | 284 | 368 |
| TDS | 268 | 84 |
| TSS | 16 | 284 |
| VSS | 14 | 232 |
| COD | 26 | 60 |
| TOC | 10 | 6 |
| Oil & Grease | | |
| Phenols | | ND |
| $NH_3$-N | .06 | ND |
| TKN | .40 | .67 |
| $NO_2/NO_3$-N | .49 | ND |
| TP | ND | .18 |
| Cl | 30 | 165 |
| F | .16 | ND |
| $SO_4$ | 34 | 8 |
| Al | ND | ND |
| B | .12 | ND |
| Ba | 1.87 | .88 |
| Ca | 13.0 | 1.9 |
| Cd | ND | .006 |
| Co | ND | ND |
| Cu | ND | ND |
| Cr | .026 | ND |
| Fe | 1.06 | 1.46 |
| Hg | .00023 | ND |
| K | 5.74 | .90 |
| Mg | 23.0 | .76 |
| Mo | ND | ND |
| Mn | .032 | .077 |
| Pb | ND | ND |
| Sb | ND | ND |
| Si | 8.0 | 2.6 |
| Sr | .890 | ND |
| Ti | ND | ND |
| W | ND | ND |
| Zn | .149 | .255 |
| Zr | ND | ND |

* All values expressed in mg/l except pH in units and conductivity in µmho/cm.

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TABLE 8. ANALYTICAL RESULTS OF INDUSTRIAL WASTE POND SUPERNATANTS

| Parameter* | Sample 15 | Sample 16 | Sample 17 | Average |
|---|---|---|---|---|
| pH | 4.0 | 4.1 | 4.1 | 4.1 |
| Alkalinity | 5 | 6 | 5 | 5 |
| Acidity | 17 | 19 | 20 | 19 |
| Conductivity | 2886 | 2997 | 2886 | 2923 |
| TS | 2738 | 2724 | 2738 | 2733 |
| TDS | 2728 | 2710 | 2696 | 2711 |
| TSS | 10 | 14 | 42 | 22 |
| VSS | 10 | 10 | 11 | 10 |
| COD | 49 | 41 | 45 | 45 |
| TOC | 15 | 19 | 20 | 18 |
| Oil & Grease | 1.3 | ND | 1.8 | 1.0 |
| Phenols | .20 | .22 | .22 | .22 |
| $NH_3$-N | 6.5 | 6.4 | 6.2 | 6.4 |
| TKN | 7.9 | 8.2 | 7.9 | 8.0 |
| $NO_2/NO_3$-N | 2.6 | 1.9 | 1.9 | 2.1 |
| TP | .09 | .08 | .08 | .08 |
| Cl | 775 | 890 | 785 | 817 |
| F | .11 | .11 | .11 | .11 |
| $SO_4$ | 20 | 20 | 30 | 23 |
| Al | ND | ND | ND | ND |
| B | .19 | .30 | .18 | .22 |
| Ba | 20.7 | 19.5 | 20.3 | 20.2 |
| Ca | 17.4 | 16.7 | 16.8 | 17.0 |
| Cd | .010 | .010 | .012 | .011 |
| Co | ND | ND | ND | ND |
| Cu | .031 | .032 | ND | .021 |
| Cr | ND | ND | ND | ND |
| Fe | .36 | .77 | .40 | .51 |
| Hg | .0002 | ND | .00023 | .00014 |
| K | 20.1 | 21.1 | 22.1 | 21.1 |
| Mg | 142.6 | 137.4 | 140.7 | 140.2 |
| Mo | ND | ND | ND | ND |
| Mn | .145 | .149 | .144 | .145 |
| Pb | ND | .27 | ND | .09 |
| Sb | ND | .78 | ND | .26 |
| Si | ND | ND | ND | ND |
| Sr | 4.49 | 4.45 | 4.58 | 4.51 |
| Ti | ND | ND | ND | ND |
| W | ND | ND | ND | ND |
| Zn | .036 | .035 | .067 | .046 |
| Zr | ND | ND | ND | ND |

* All values expressed in mg/l except pH in units and conductivity in µmho/cm.

TABLE 9. LYTICAL RESULTS OF INDUSTRIAL WASTE POND SEDIMENTS

| Parameter | Units | G-18 | G-19 | Sample<br>G-20 | G-21 | High | Low | Average |
|---|---|---|---|---|---|---|---|---|
| Moisture | Percent | 96.4 | 90.9 | 95.9 | 68.6 | 96.4 | 68.6 | 87.95 |
| Solids | Percent | 3.6 | 9.1 | 4.1 | 31.4 | 31.4 | 3.6 | 12.05 |
| Volatile Solids after drying | Percent | 10 | 18 | 34 | 15 | 34 | 10 | 19.25 |
| TP | mg/kg | 291 | 212 | 562 | 1607 | 1607 | 212 | 668 |
| Ca | mg/kg | 150 | 250 | 1709 | 457 | 1709 | 150 | 642 |
| Cd | mg/kg | 2.0 | 2.4 | 17.8 | 8.8 | 17.8 | 2.0 | 7.8 |
| Cu | mg/kg | 250 | 411 | 990 | 3650 | 3650 | 250 | 1325 |
| Fe | mg/kg | 373 | 475 | 450 | 150 | 475 | 150 | 362 |
| Hg | mg/kg | ND | ND | ND | ND | ND | ND | ND |
| K | mg/kg | 3153 | 3506 | 3392 | 1042 | 3506 | 1042 | 2773 |
| Mg | mg/kg | 3253 | 4007 | 12062 | 122757 | 122757 | 3253 | 35520 |
| Mn | mg/kg | 1.0 | 1.4 | 28.3 | 14.4 | 28.3 | 1.0 | 11.3 |
| Pb | mg/kg | 156 | 239 | 1593 | 1149 | 1593 | 156 | 784 |
| Sb | mg/kg | 32 | 36 | 65 | 40 | 65 | 32 | 43 |
| Sr | mg/kg | ND | ND | 37 | 19 | 37 | ND | 14 |
| Zn | mg/kg | 168 | 213 | 1442 | 1845 | 1845 | 168 | 917 |



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TABLE 10. CHARACTERIZATION OF RECEIVING WATERS

| Parameter | North Bayou 27 | North Bayou P-4 | Central Bayou 25 | Harrison Bayou 24 | Harrison Bayou 26 | Caddo Lake 23 | Raw Water 22 | Tap Water P-3 | High | Low | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|
| pH | 3.3 | 6.3 | 6.6 | 6.9 | 3.1 | 6.7 | 6.5 | 6.8 | | | |
| Alkalinity | 0 | 12 | 32 | 49 | 0 | 30 | 20 | 22 | 49 | 0 | 11 |
| Acidity $CaCO_3$ | 41 | 9 | 12 | 11 | 69 | 9 | 15 | 10 | 69 | 9 | 33 |
| Conductivity | 710 | 155 | 322 | 233 | 699 | 122 | 133 | 211 | 710 | 155 | 472 |
| TS | 294 | 166 | 272 | 174 | 262 | 112 | 122 | 196 | 294 | 174 | 254 |
| TDS | 266 | 159 | 252 | 139 | 230 | 104 | 116 | 183 | 266 | 159 | 227 |
| TSS | 26 | 29 | 20 | 35 | 32 | 8 | 6 | 13 | 32 | 20 | 27 |
| VSS | 10 | 27 | 14 | 35 | 12 | 7 | 6 | 6 | 27 | 10 | 16 |
| COD | 25 | 32 | 42 | 28 | 46 | 22 | 21 | 12 | 46 | 25 | 37 |
| TOC | 10 | 10 | 14 | 13 | 15 | 8 | 10 | | 15 | 10 | 12 |
| Oil & Grease | | | | 4.9 | | | | | | | 4.9 |
| Phenols | ND | | ND | | ND | | | | ND | ND | ND |
| $NH_3$-N | .19 | .06 | ND | .11 | ND | .13 | .08 | | .19 | ND | .06 |
| TKN | .57 | .50 | .42 | .78 | .78 | .47 | .42 | .11 | .78 | .42 | .57 |
| $NO_2/NO_3$-N | .52 | ND | ND | ND | ND | ND | ND | ND | .52 | ND | .13 |
| TP | .67 | .14 | ND | ND | .17 | ND | ND | .92 | .67 | ND | .24 |
| Cl | 125 | 35 | 50 | 29 | 120 | 21 | 30 | 25 | 125 | 35 | 82 |
| F | .11 | ND | .12 | ND | ND | ND | ND | ND | .12 | ND | .06 |
| $SO_4$ | 60 | 30 | 26 | 32 | 15 | 6 | 19 | 42 | 60 | 15 | 33 |
| S | | | | | | | | | | | |
| Al | ND | ND | ND | ND | ND | ND | ND | | ND | ND | ND |
| B | .12 | ND | .05 | ND | ND | ND | ND | ND | .12 | ND | .04 |
| Ba | .38 | .88 | .12 | .74 | .40 | .21 | .44 | | .88 | .12 | .44 |
| Ca | 18.5 | 10.1 | ND | 16.2 | 10.7 | 6.9 | 5.9 | | 18.5 | ND | 9.8 |
| Cd | .006 | ND | ND | .006 | .006 | .005 | .009 | | .006 | ND | .003 |
| Co | ND | ND | ND | ND | ND | ND | ND | | ND | ND | ND |
| Cu | | ND | ND | ND | ND | ND | ND | | ND | ND | ND |
| Cr | ND | ND | ND | ND | ND | ND | ND | | ND | ND | ND |
| Fe | .75 | 2.21 | ND | 2.12 | 4.60 | .40 | 2.30 | | 4.60 | ND | 1.89 |
| Hg | .00065 | ND | ND | ND | ND | ND | ND | | .00065 | ND | .00016 |
| K | 4.25 | 2.51 | ND | 3.57 | 3.86 | 1.90 | 3.55 | | 4.25 | ND | 2.66 |
| Mg | 4.43 | 2.79 | .11 | 9.48 | 5.46 | 1.84 | 2.58 | | 5.46 | .11 | 3.20 |
| Mo | ND | ND | ND | ND | ND | ND | ND | | ND | ND | ND |
| Mn | .079 | .229 | ND | 1.26 | 1.13 | ND | .149 | | .229 | ND | .358 |
| Na | | | | | | | | | | | |
| Pb | ND | ND | ND | ND | ND | ND | ND | | ND | ND | ND |
| Sb | ND | ND | ND | ND | ND | ND | ND | | ND | ND | ND |
| Si | 16.1 | 13.5 | 12.0 | 7.5 | 9.2 | 3.2 | 13.9 | | 16.1 | 9.2 | 12.7 |
| Sr | .209 | .410 | .462 | .361 | .179 | ND | .122 | | .482 | .179 | .320 |
| Ti | ND | ND | ND | ND | ND | ND | ND | | ND | ND | ND |
| W | ND | ND | ND | ND | ND | ND | ND | | ND | ND | ND |
| Zn | .257 | .482 | ND | .332 | .173 | ND | .091 | | .482 | ND | .228 |
| Zr | ND | ND | ND | ND | ND | ND | ND | | ND | ND | ND |

All values expressed in mg/ℓ except pH in units and conductivity in μmhos/cm.



000032