Miscellaneous Paper EL-93-10
July 1993

US Army Corps
of Engineers
Waterways Experiment
Station

Agricultural Uses of Yazoo River Dredged Material

Report 1
Cotton Production on Dredged Material in a Thick-Layer Confined Disposal Facility

by *Richard A. Price, Paul R. Schroeder*
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Report 1 of a series

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Prepared for U.S. Army Engineer District, Vicksburg
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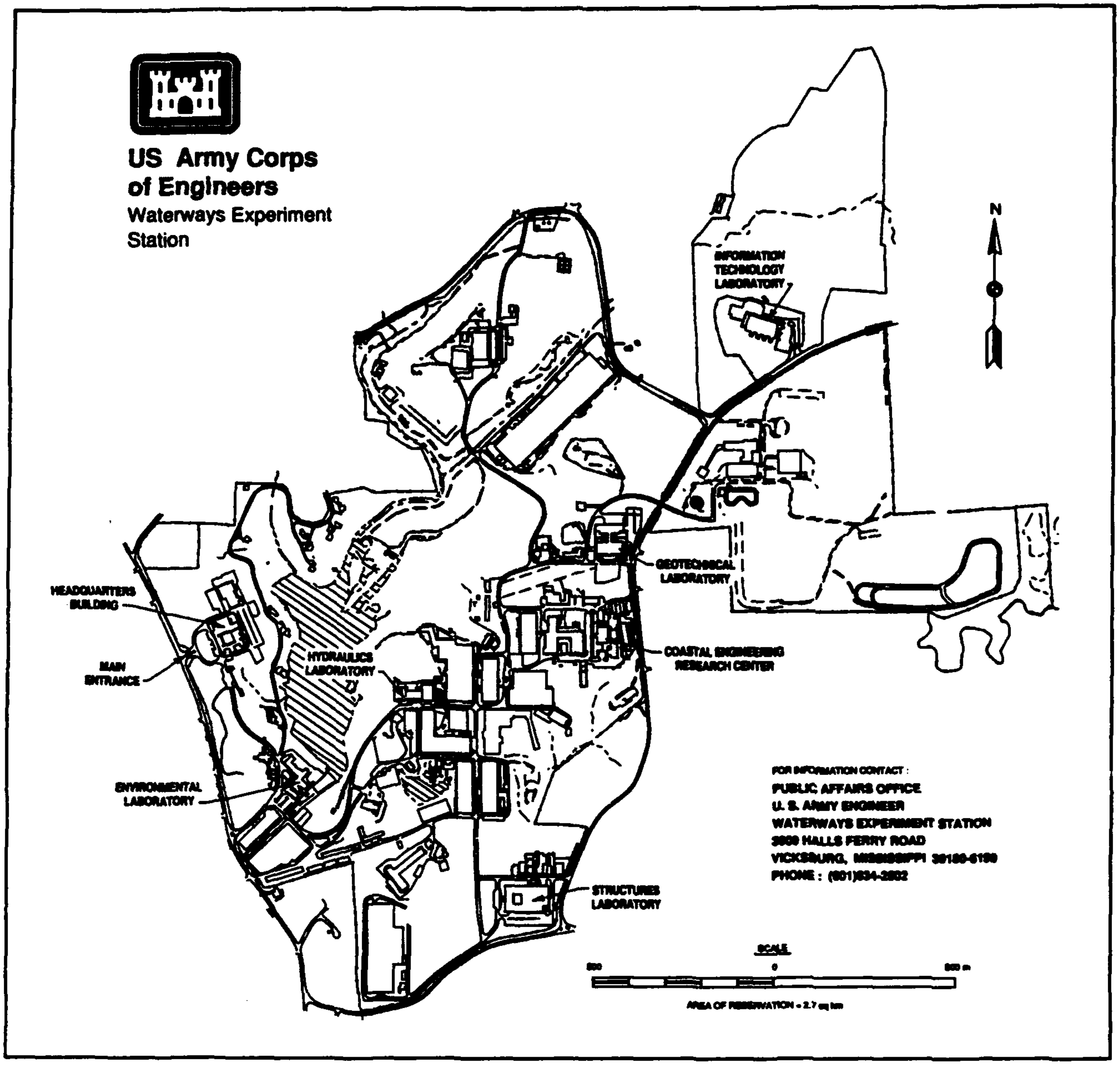

Waterways Experiment Station Cataloging-in-Publication Data

Agricultural uses of Yazoo River dredged material. Report 1, Cotton production on dredged material in a thick-layer confined disposal facility / by Richard A. Price ... [et al.] ; prepared for U.S. Army Engineer District, Vicksburg.

60 p. : ill. ; 28 cm. — (Miscellaneous paper ; EL-93-10)

Includes bibliographical references.

1. Reclamation of land — Mississippi. 2. Dredging spoil — Mississippi — Yazoo River — Environmental aspects. 3. Cotton growing. I. Price, Richard A. II. United States. Army. Corps of Engineers. Vicksburg District. III. U.S. Army Engineer Waterways Experiment Station. IV. Title: Cotton production on dredged material in a thick-layer confined disposal facility. V. Series: Miscellaneous paper (U.S. Army Engineer Waterways Experiment Station) ; EL-93-10.

TA7 W34m no.EL-93-10

Contents

Preface

The study reported herein was conducted by the Fate and Effects Branch (FEB), Environmental Processes and Effects Division (EPED), Environmental Laboratory (EL), of the U.S. Army Engineer Waterways Experiment Station (WES). The study was conducted for and sponsored by the U.S. Army Engineer District, Vicksburg.

The study was conducted by Dr. Bobby L. Folsom, Jr., Principal Investigator, Mr. Richard A. Price, FEB, and Dr. Paul R. Schroeder, Engineering Applications Branch, (EAB), Environmental Engineering Division (EED). Technical assistance in conduct of field sampling and laboratory tests was provided by Ms. Donna Garrett, Ms. Brenda Allen, and Mr. Keith Fessel, FEB. Assistance was provided by Ms. Elizabeth Tominey and Ms. Erica Seals, FEB, in the preparation of tables and figures. This report was written by Mr. Price under the direct supervision of Dr. Charles R. Lee, Team Leader, Contaminant Assessment and Monitoring Team, EPED.

The study was conducted under the direct supervision of Dr. Folsom, Team Leader, Plant Bioassay Team, Dr. Lloyd R. Saunders, Chief, FEB, Mr. Donald L. Robey, Chief, EPED, and Dr. John Harrison, Director, EL.

At the time of publication of this report, Dr. Robert W. Whalin was Director of WES. COL Leonard G. Hassell, EN, was Commander.

This report should be cited as follows:

> Price, R. A., Schroeder, P. R., Banks, L. E., Sanders, J. G., and Johnson, D. R. (1993). "Agricultural Uses of Dredged Material; Report 1, Cotton Production on Yazoo River Dredged Material in a Thick-Layer Confined Disposal Facility," Miscellaneous Paper EL-93-10, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Conversion Factors, SI to Non-SI Units of Measurement

SI units of measurement used in this report can be converted to non-SI units as follows:

Multiply	By	To Obtain
centimeters	0.3937	inches
meters	3.281	feet
kilometers	0.6214	miles
liters	0.2642	gallons
hectares	2.471	acres
kilograms/hectare	0.8922	pounds/acre
bales/hectare	2.471	bales/acre

1 Introduction

Background

Channel improvement and levee construction in and along the Yazoo River drainage basin were authorized by the U.S. Congress to alleviate flooding of residential areas, towns, and farmland in that part of the state of Mississippi known as "The Delta," a fertile area lying between the Mississippi and Yazoo Rivers. The work was tasked to the U.S. Army Engineer District, Vicksburg. Much of the work was completed on the lower portion of the Yazoo River during the 1970's. Hydraulic dredging operations placed dredged material in large (approximately 12 ha), deep (approximately 4.5 m), confined disposal facilities (CDFs) constructed near the Yazoo River channel. Most of the CDFs were not filled to capacity with dredged material and were designed to be used years later to contain additional dredged material resulting from future maintenance dredging operations. Many of the CDFs were constructed on privately owned land, and use of the land by the Corps of Engineers was generally under a right-of-way purchase. Although landowners retained title to the land on which CDFs were constructed, reuse of the land for agricultural purposes or to account for crop reduction acreage was eliminated.

The Problem

Many of the previous CDFs were constructed on what is considered some of the most productive cotton land in the delta area. A few farmers had tried, with little success, to produce a profitable crop on CDFs that were sufficiently filled. Farm equipment often became mired to their axles while attempting to till the dredged material. Many of the landowners made no attempt to utilize the CDFs after witnessing some of the difficulties encountered by neighboring landowners. Since the CDFs were allowed to become fallow, willow trees and assorted weeds became established and water was generally ponded on the lower end of most CDFs. The Corps began having difficulty in acquiring additional easements from landowners along the upper portion of the Yazoo River. The landowners referred to the CDFs as "spoil pits" and did not want them placed on their land.

A study to provide for a dredged material disposal alternative that would enhance agricultural utilization was begun by the Vicksburg District. The U.S. Army Engineer Waterways Experiment Station (WES), Environmental Laboratory was asked to assist the Vicksburg District in support of this initiative. If such an initiative could successfully result in productive cotton land, then landowners would be more willing to allow placement of dredged material on their land and consequently would provide disposal sites for future dredging projects.

Objectives

This study was divided into two phases. Phase I concentrated on dredged material in an old, thick-layer CDF. Phase II will be conducted on a newly constructed, thin-layer CDF on marginal cotton land. The objectives of phase I were to (a) determine response of cotton to Yazoo River dredged material as a growth medium and (b) to produce a substantial cotton crop on a representative deep-layer CDF. The objectives of phase II are to determine dredged material and disposal site soil mixes possible in a thin-layer CDF and cotton response to those mixes. This report will focus only on phase I.

2 Site Selection, Evaluation, and Preparation

Site Selection and Evaluation

In selecting an existing thick-layer CDF, investigators desired to have one located in an agricultural area in cotton production and which had received minimal disturbance. The selected CDF (4A) was located in an area adjacent to the Yazoo River levee about 9.7 km north of Yazoo City, MS, and was surrounded by productive cotton land (Figure 1). Water was ponded on the lower portion of CDF 4A (Figure 2), and the middle and upper portions of the CDF were colonized by small trees and assorted weeds (Figure 3). The upper portion of the CDF had previously been cleared of trees, and a windrow from the clearing operation remained on the CDF. Other than the windrow, which was also colonized with weeds, there was no indication of disturbance on the site. Preliminary core sampling indicated that ponded water on the lower portion of the CDF was affecting moisture content and subsurface drainage on the middle and upper portions of the CDF. It was necessary to remove the excess water from the site prior to any use of heavy equipment on the CDF.

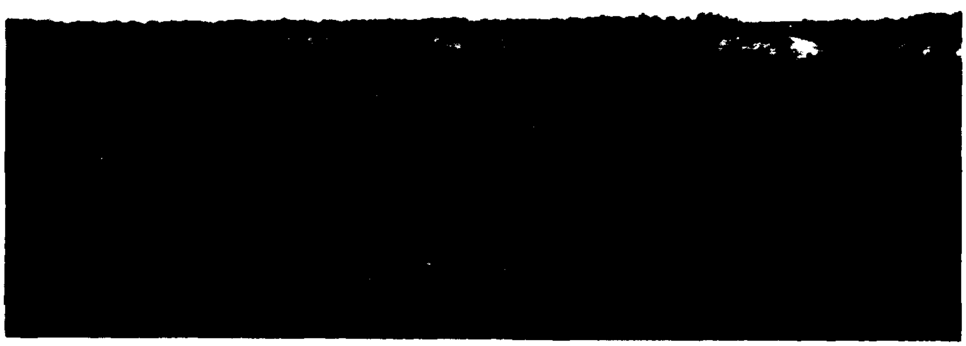

Figure 1. CDF 4A surrounded by cotton fields

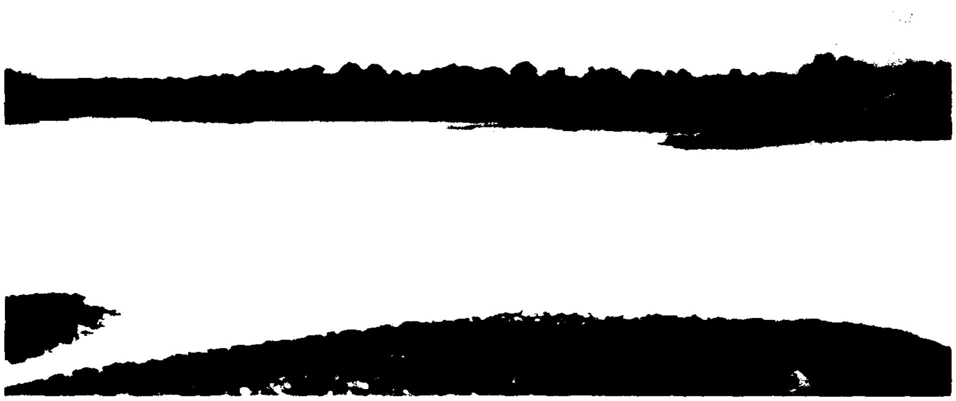

Figure 2. Water ponded on the lower end of CDF 4A

Figure 3. Assorted weeds and trees on the upper portion of CDF 4A

Site Drainage and Preparation

Corps personnel breached the levee at the lower portion of the CDF (Figure 4), thereby allowing trapped water to escape. Once most of the water had drained and desiccation started, a backhoe was used to dig a series of ditches (Figure 5) to provide a conduit for additional water removal during storm events and additional drying of the lower end of the CDF. Tractor-driven rotary mowers were used to cut down the weeds and smaller trees. A bulldozer was then used to remove trees that were not removed by mowing and to roughly level the middle and upper portions of the site.

Figure 4. Breaching the dike on the lower end of CDF 4A

Figure 5. Digging drainage trenches in the lower end of CDF 4A

Results and Discussion

Three months after water was removed, CDF 4A provided limited support of heavy equipment. Sheets of plywood had to be placed for additional support for the backhoe to accomplish ditching. Core samples taken after surface water removal indicated areas within the lower portion of the CDF were only 1 to 1.2 m above the original soil surface layer. Where the original soil surface had been removed for levee construction, the dredged material was as thick as 2.7 m in the lower portion of the CDF. The ditches provided for good drainage of the CDF, except for a few sink areas in the lower end of the CDF where the elevation was below that of the drainage ditch outside of the CDF.

3 Site Characterization

Methods and Materials

Sampling grids

The CDF was divided into 30.5- by 30.5-m grids using a 91-m tape and laser transit (Hewlett-Packard Model 3810B). The grids were marked with wire flagging and labeled as shown in Figure 6. This grid system provided an easy method of accurately sampling the entire CDF.

Core samples

Core samples were collected from the center of each grid, rows A-H, down to a depth of 46 cm with a hand-operated soil auger having a bucket diameter of 7 cm. Samples from each core were collected at 0- to 15-, 15- to 30-, and 30- to 45-cm depths. Soil cores in grids I-Z were initially collected to a depth of 45 cm and later to a depth of 1.5 m in 30-cm increments. Additional samples were collected from the I-M and N-Z grid areas to a depth of 30 cm. Samples were placed in wax-lined soil collection bags and transported to the WES for physical and chemical analyses.

Core samples were also collected, for comparative purposes, from the cotton field just north of CDF 4A and from a productive cotton field near Egypt, MS, the site of phase II testing.

Particle size analysis

Particle size analyses of core samples were accomplished using the method of Day (1956) as modified by Patrick (1958). Particle size was characterized according to content of sand (>50 μm), silt (<50 μm and >2 μm) and clay (<2 μm).

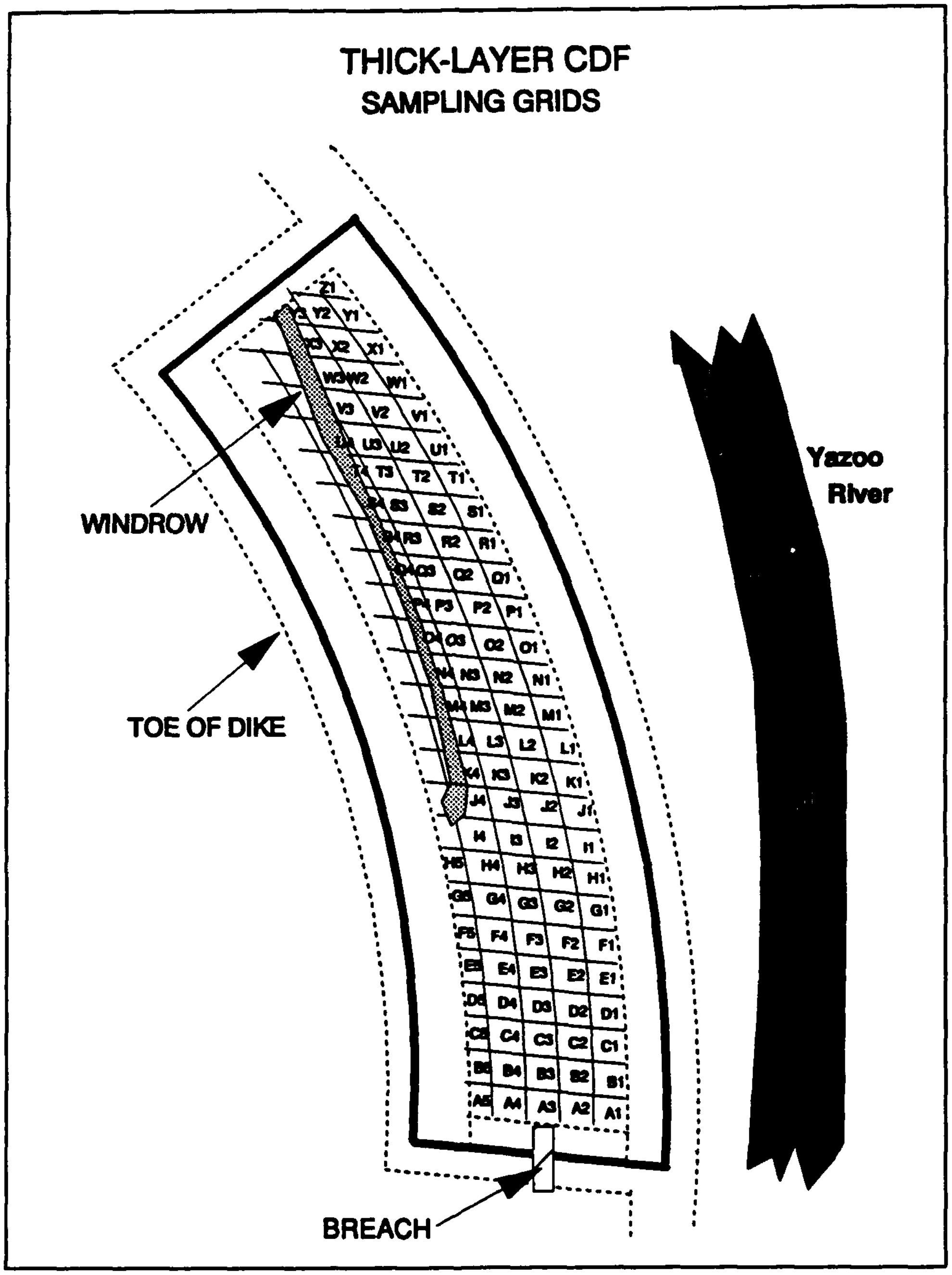

Figure 6. Sampling grids on CDF

Determination of pH

To determine pH, 10 g oven dry weight (ODW to nearest 0.001 g) of dredged material was weighed into a tall 50-ml Pyrex glass beaker, and 20 ml of distilled water was added. The mixture was stirred with a polyethylene rod until all particles were saturated. Then, the mixture was stirred with a magnetic stirrer for 1 min every 15 min for 45 min. After 45 min, the pH electrode was placed into the solution above the surface of the dredged material and the pH was read on a pH meter (Folsom, Lee, Bates 1981).

Organic matter

Organic matter (OM) was determined by weight loss on ignition at 550 °C in accordance with procedure No. 209E of the American Public Health Association (1976). A 5-g subsample (ODW) was weighed to the nearest 0.001 g and dried at 105 ± 2 °C until constant weight (48 hr). A 5-g sample of the oven-dried sediment was weighed to the nearest 0.001 g and combusted at 550 ± 5 °C for 24 hr in a muffle furnace. The sample was allowed to cool to room temperature in a moisture desiccator and then reweighed to the nearest 0.001 g. Weight loss on ignition was calculated and reported as percent OM using the following formula:

$$\%\,OM = \frac{\text{weight oven-dry sample} - \text{weight combusted sample}}{\text{weight oven-dry sample}} \times 100$$

Sample digestion and heavy metals analysis

Heavy metal concentrations were determined on composite dredged material samples and on National Bureau of Standards Reference Material (NBS) 1646. A 1-g (ODW) (weighed to the nearest 0.001 g) sample was placed into a 120-ml Teflon PFA vessel, and 10 ml of concentrated nitric acid was added. A cap was placed on the vessel and sealed at 16.3 joules of torque. Vessels containing the dredged material composites, one NBS 1646 standard, and one acid blank were placed in a digestion turntable and venting tubes were attached. The turntable was placed in a MDS-81-D microwave digestion unit (CEM Corporation, Matthews, NC), set into 360-deg rotation, and heated at 600 watts (W) for 2 min 30 sec and then at 480 W for 10 min. After cooling to room temperature, each vessel was hand-vented to release pressure and then uncapped. After uncapping, 5 ml of 30 percent hydrogen peroxide was added to each vessel and allowed to effervesce. When the effervescence stopped, each solution was quantitatively filtered through a Whatman No. 41 filter and diluted with distilled water to 100 ml. The resultant acid digest was analyzed by inductively coupled plasma emission spectrometry (ICP) or direct-current plasma emission spectrometry (DCP). Mercury was determined by cold-vapor atomic absorption spectrometry (CVAAS).

Agricultural analysis

Agricultural analysis, normally conducted for agricultural soils, was conducted on dredged material samples collected from each grid in rows I-Z at the 0- to 30-cm depth in 1988 and from composited samples collected at the 0- to 30-cm depth in 1990. The analysis included pH, cation exchange capacity, exchangeable bases, avilable phosphorus, organic matter, base saturation and fertilizer recommendations and was performed by Pettiet Agricultural Services in Leland, MS. The methods used for each test are listed in Appendix A.

Results and Discussion

Particle size distribution

The results of the particle size analysis for each grid are provided in Appendix B. Particle size distribution of the 0- to 45-cm depth across the site is presented in Figure 7. Based on particle size distribution, CDF 4A was divided into three sections: A-H, I-M, and N-Z. Grids A-H consisted largely of clay, I-M consisted largely of silt, and N-Z consisted largely of sand. Table 1 is a comparison of mean particle size and texture classification for each section with those of two productive cotton fields at Egypt and Yazoo City, MS. The calculated mean of the A-H grids resulted in a soil classification of silty clay. Grids A-H had a mean sand content of only 2 percent while the clay and silt made up 50.1 and 47.9 percent, respectively. The high clay content results in a poorly drained material not considered ideal for cotton production without extensive efforts to increase drainage. Since waterlogging is the most common restriction to cotton production (Monroe 1987), grids A-H were eliminated as a medium for cotton growth in this study.

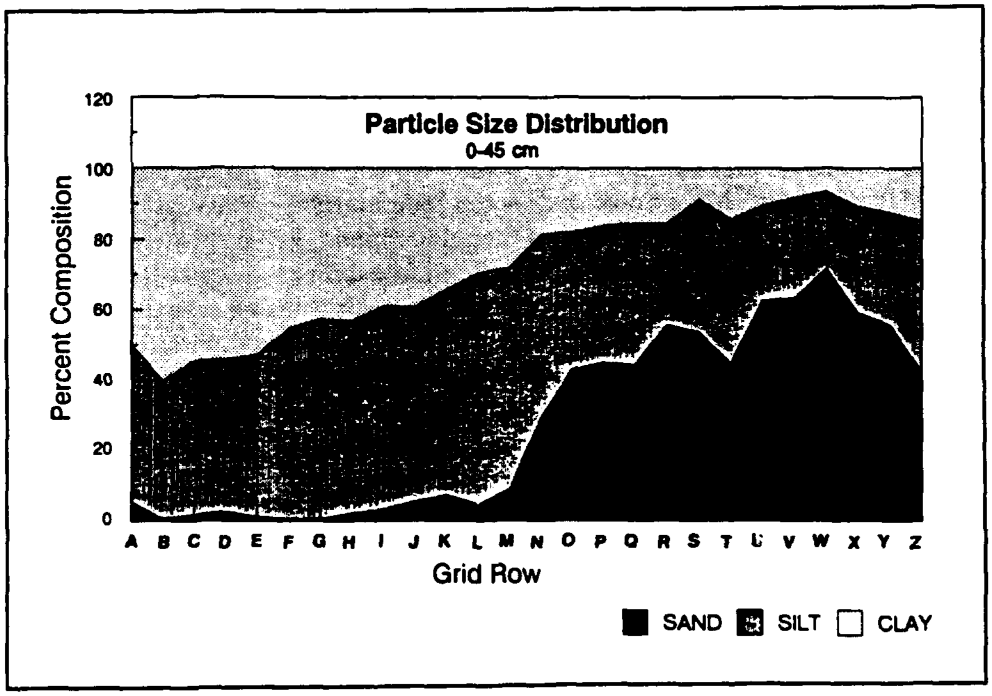

Figure 7. Particle size distribution in CDF 4A, 0-45 cm

Table 1
Comparison of Particle Size Characteristics of Composites from CDF 4A and from Productive Cotton Fields

Parameter	CDF4A Grids			Cotton Field	
	A-H	I-M	N-Z	Yazoo City, MS	Egypt, MS
Sand (%)	2.0	5.5	51.3	27.5	13.5
Silt (%)	47.9	60.5	35.3	52.5	57.4
Clay (%)	50.1	34.0	13.4	20.0	29.1
Classification	Silty clay	Silty clay loam	Loam	Silt loam	Silty clay loam

The mean particle size distributions for grids I-M and N-Z are shown to be very similar to those of the two cotton field soils. Although the mean particle size distribution in the I-M grids exhibits half the sand content and slightly higher silt and clay contents compared with the Egypt, MS, cotton field, the soil classification was the same. The particle size distribution in the Yazoo City cotton field has higher sand and less silt and clay contents than the Egypt, MS, field. Sand content is higher and silt and clay contents are lower in the N-Z grids than both the I-M grids and the Yazoo City field. With respect to textural classes, the fineness of the materials would fall in the order of I-M grids > Egypt field > Yazoo City field > N-Z grids. Table 2 provides a better understanding of the basic texture of these soils and the importance of particle size distribution of the CDF 4A dredged material and area cotton fields. Both the N-Z grids and Yazoo City field have a medium texture while the I-M grids and Egypt field have a moderately fine texture. One must recall the fact that CDF 4A was not designed for agricultural use and no attempt was made to evenly apply and mix the Yazoo River dredged material during disposal. However, in phase II of this project, the dredged material will be disposed into a CDF and mixed in such a manner as to provide the most benificial medium for cotton production that is economically feasible. With that in mind, if one calculates the entire sampling grid area (A-Z) a particle size distribution of 23.8 percent sand, 44.8 percent silt, and 31.4 percent clay or a clay loam textural class is obtained. This calculation probably underestimates the silt and sand contents, since core samples were not collected from the entire depth of dredged material to the original soil surface, and a medium textured classification would be a better estimate. However, either a medium or moderately fine texture puts Yazoo River dredged material within the range of suitable agricultural soils for cotton production in the Mississippi Delta area.

Table 2
General Terms Used to Describe Soil Texture in Relation to Basic Soil Textural Class Names[1]

General Terms		
Common Names	**Texture**	**Basic Soil Textural Class Names**
Sandy soils	Coarse	Sandy Loamy sands
Loamy soils	Moderately coarse	Sandy loam Fine sandy loam
	Medium	Very fine sandy loam Loam Silt loam Silt
	Moderately fine	Clay loam Sandy clay loam Silty clay loam
Clayey soils	Fine	Silty clay Clay

[1] Brady (1974)

Particle size distribution was also determined on the 0- to 150-cm core samples taken in 30-cm increments from each grid (I-Z). Mean particle size distribution of each grid row is presented by depth in Figures 8-12. These figures indicate some variability with depth in the distribution of sand, silt, and clay as was evident during core sample collection, where stratified layers of sand, silt, clay, or organic matter were identified. However, general distribution of clay decreased from the I to M grids while the sand content increased from the N to Y grids. Overall distribution of sand in the 120- to 150-cm depth is decreased, replaced by higher silt content.

Analysis of the mean of particle size distribution by depth over the entire I-Z grid area indicated little variabilty with depth, except for sand and silt in the 120- to 150-cm depth, Table 3. Mean particle size distribution of the 0- to 150-cm depth for the I-Z grids was 20.4 percent sand, 59.2 percent silt, and 20.2 percent clay, yielding a silt loam classification, the same classification as the Yazoo City cotton field. Consequently, these data suggest that the Yazoo River dredged material has the physical characteristics that when equally distributed and mixed will have the same physical properties as those of productive area cotton fields. In other words, although it is not the intention to return existing CDFs along the Yazoo River to agricultural use, future CDF construction and Yazoo River dredged material disposal have the potential of improving marginal farmland into land more conducive to cotton production.

Table 3
Mean Particle Size Distribution by Depth

Depth, cm	% Clay	% Silt	% Sand
0-30	18.3	51.2	30.6
30-60	19.4	52.6	27.9
60-90	20.3	52.6	27.2
90-120	20.3	52.8	26.9
120-150	20.3	59.2	20.4

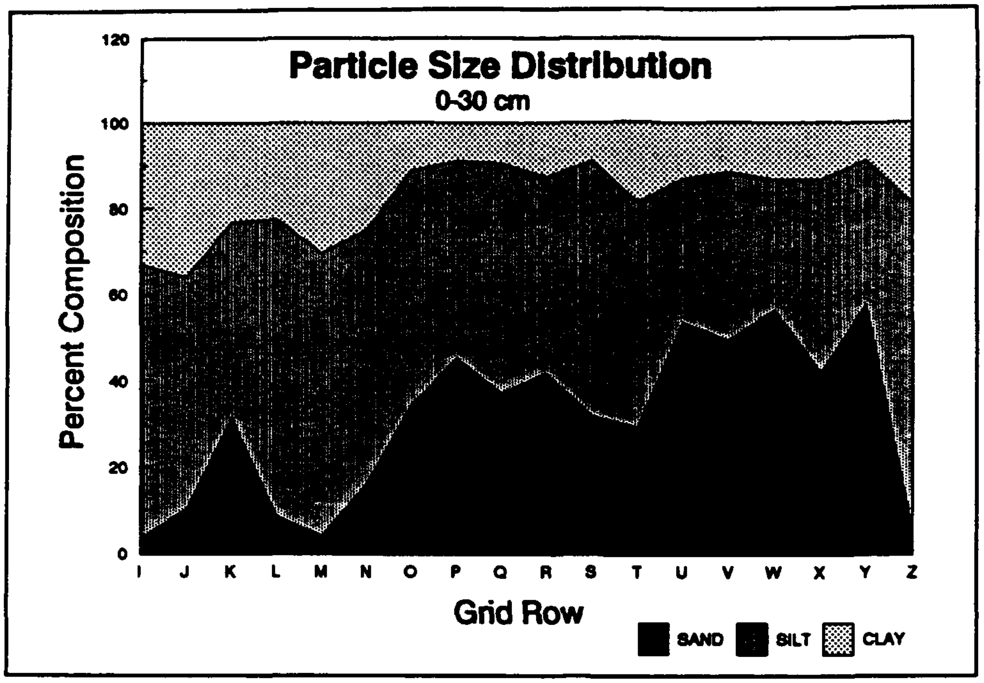

Figure 8. Particle size distribution in I-Z grids, 0-30 cm

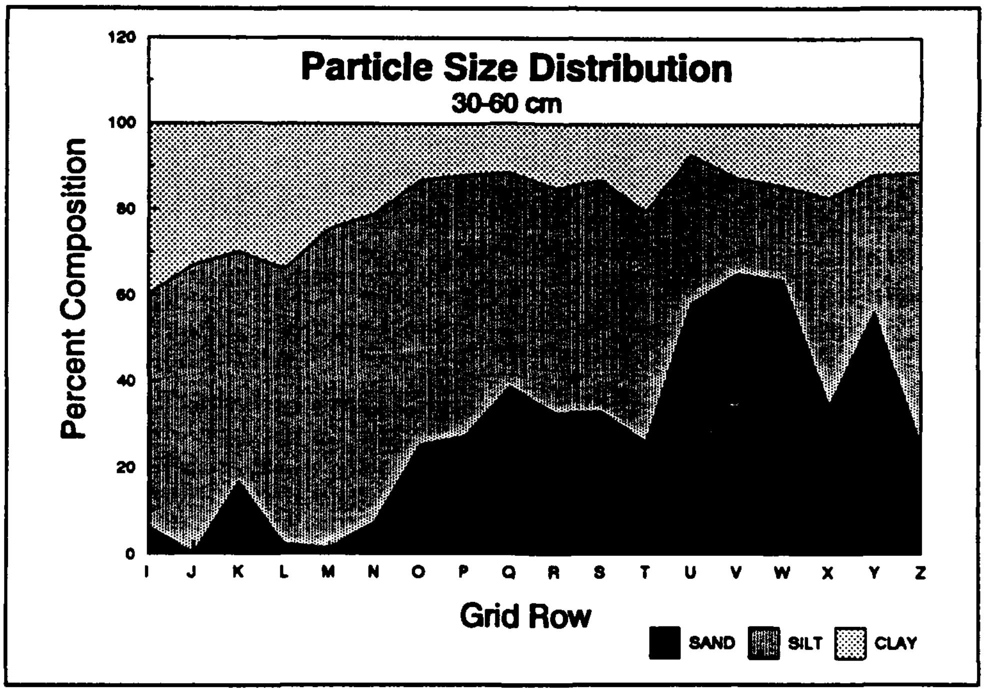

Figure 9. Particle size distribution in I-Z grids, 30-60 cm

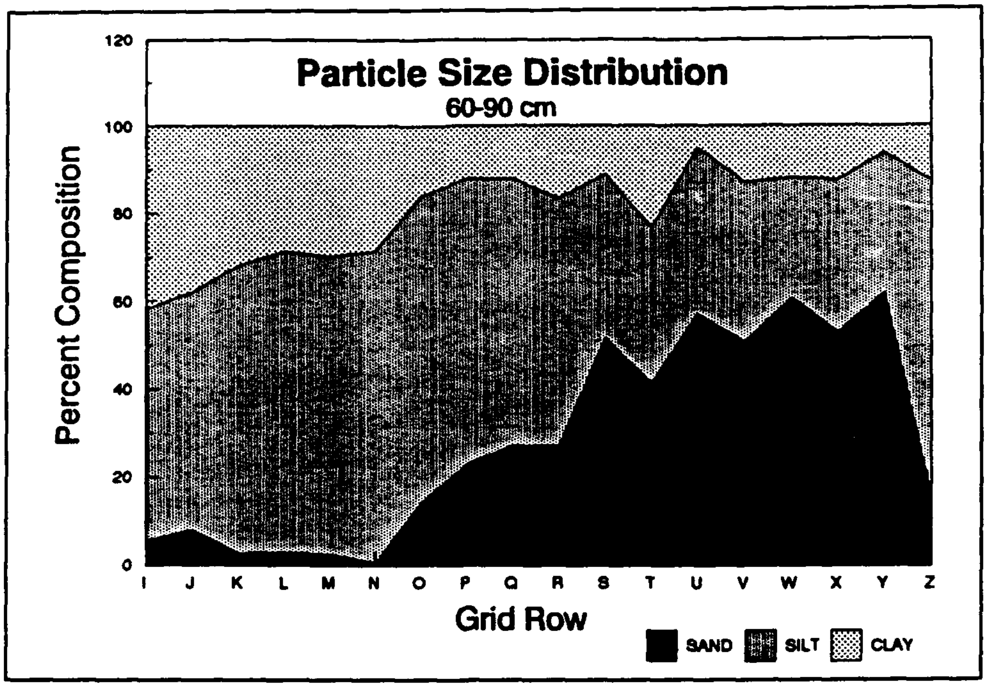

Figure 10. Particle size distribution in I-Z grids, 60-90 cm

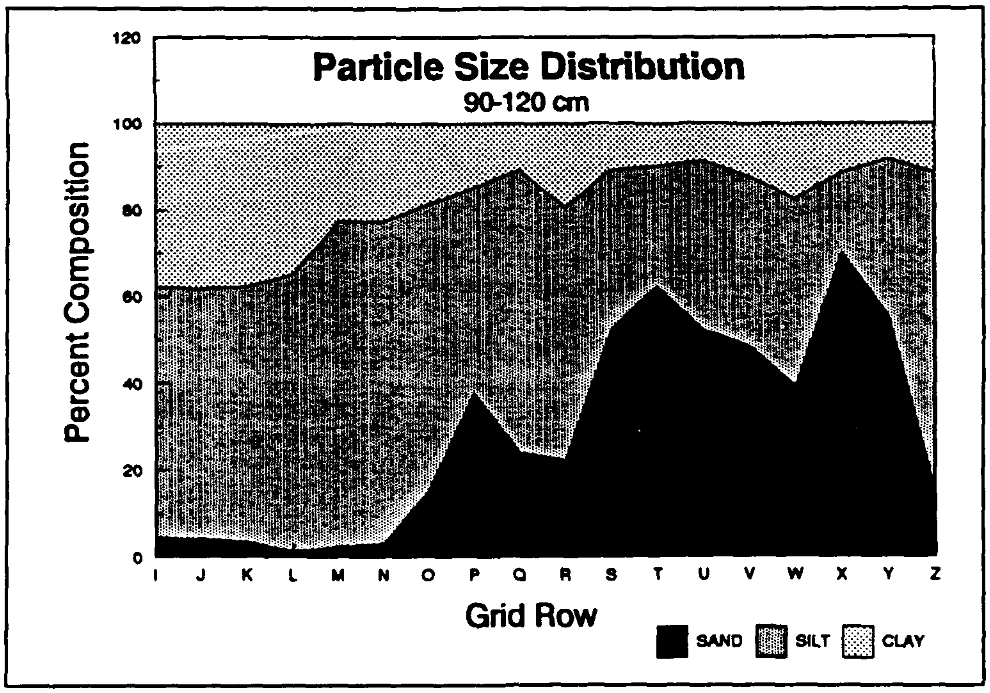

Figure 11. Particle size distribution in I-Z grids, 90-120 cm

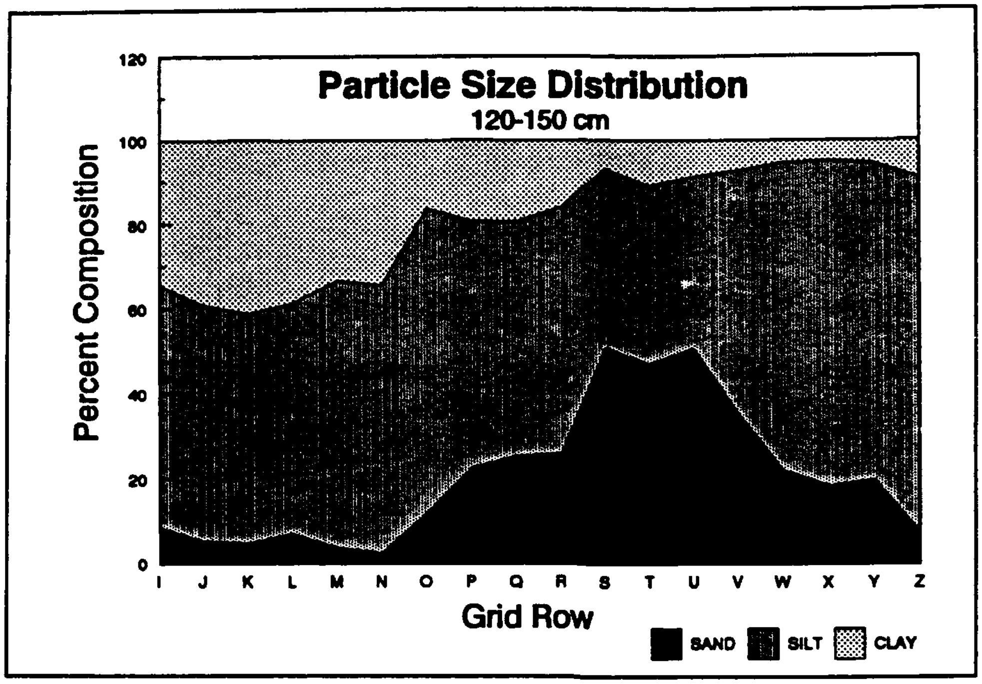

Figure 12. Particle size distribution in I-Z grids, 120-150 cm

Fertility

Mean fertility levels of the I-M and N-Z composites and the productive cotton field near Egypt, MS, are presented in Table 4. Agricultural analysis indicated that mean nutrient levels in the I-M and N-Z grids were very similar to nutrient levels in the Egypt, MS, cotton field. The Egypt field has been under cotton production for many years and soil nutrient levels have been managed for efficient cotton production. Organic matter content in the N-Z grids was considerably lower than the Egypt cotton field. Adequate organic matter is important for desirable physical and chemical properties of soils and optimum growth of higher plants. The concentration of

Table 4
Comparison of Fertility Characteristics of Dredged Material Composites and a Productive Cotton Field

Parameter	Grids I-M	Grids N-Z	Cotton Field, Egypt, MS
pH	5.8	6.0	6.2
Phosphorus, mg/kg	35	38	37
Potassium, mg/kg)	124	97	131
Magnesium, mg/kg	579	300	286
Calcium, mg/kg	2021	1106	2198
Organic matter, %	0.72	0.37	0.96

organic matter in the soil is also important in the selection of application rates of herbicides and fertilizers. However, increasing organic matter content is easily accomplished with organic amendments or green manuring (incorporation of a green cover crop), and the low organic matter in the N-Z grids was not considered a significant problem in the course of this study.

pH

A soil pH of 6.0 to 6.5 is considered desirable for vigorous plant growth and the suppression of certain diseases (Blasingame 1983). Although the agricultural analysis indicated some pH values in the I-Z grids were below 6.0, these were not low enough to justify liming. However, pH values outside of desirable ranges, while not requiring immediate corrective action, do require yearly monitoring, since liming may be necessary in subsequent years.

The pH values (Appendix B) determined at the WES by the method described previously (Folsom, Lee, and Bates 1981) were found to be lower than values reported by Pettiet Agricultural Services. Samples analyzed by Pettiet Agricultural Services were obtained from the 0- to 45-cm sample collection in 1988 prior to site disturbance and from 0- to 30-cm samples collected in 1990. Samples analyzed at the WES were obtained from the 0- to 30-cm reach of the 0- to 150-cm core samples collected in 1989 after leveling and tillage of the site. Somewhat lower pH values might be expected after tillage due to better aeration and oxidation of the dredged material. Composites for the I-M and N-Z grids were prepared and sent to Pettiet Agricultural Services for analysis to compare with values obtained at the WES. Results are shown in Table 5. The 1988 Pettiet pH values differ from the WES values by 1.3 and 1.0 for the I-M and N-Z, respectively. The 1990 Pettiet values differed by 0.9 and 1.0. After inquiry, it was discovered that pH values at Pettiet Agricultural Services were adjusted by 0.9 to correlate with the percent base saturation. Most agricultural laboratories adjust pH values to correlate with the percent base saturation for a more accurate determination of lime needs. Taking the 0.9 adjustment into account, the WES pH values are almost perfectly in agreement with the Pettiet pH values.

Table 5
Comparison of Laboratory pH Results

	Pettiet Ag Services		WES
Composite	1988	1990	1989
I-M	5.83	5.62	4.50
N-Z	6.01	5.97	5.00

Although the pH values were not considered optimum for cotton growth, liming to raise the pH was not considered economically feasible since only a small amount of lime would be necessary. However, lime would probably be necessary after the first year of cotton production and yearly monitoring of the pH is suggested.

Heavy metals analysis

Yazoo River dredged material was not believed to contain contaminants at levels of concern. However, selected heavy metals concentrations were determined to assess any potential problems with uptake by cotton plants. Total mean concentrations in composites of grids I-M and N-Z were compared to various criteria concerning heavy metal content in surface soils (Table 6). Concentrations of lead, zinc, and copper were well below allowable limits for application to surface soils and below recommended soil concentrations. Concentration of cadmium was below the 2.5 mg/kg soil concentration for plant uptake and therefore was not a concern for uptake by cotton plants. Elevated levels of cadmium in Yazoo River dredged material are not surprising due to the historical use of phosphate fertilizers in the Yazoo River drainage basin. Phosphorus fertilizers are known as important sources of cadmium as an impurity (Kabata-Pendias and Pendias, 1984). Cadmium concentrations in urban gardens in the United States may range from 0.02 to 13.6 mg/kg on a dry weight basis (Chaney 1980). Although the total cadmium concentrations in the I-M and N-Z composites are below the recommended limitations, uptake and bioaccumulation of cadmium by some agricultural food and forage crops may be of concern. Further study should be conducted to address potential bioaccumulation of cadmium by food or forage plants growing in Yazoo River dredged material. Likewise, crop rotation of food and forage crops with cotton would require further study to evaluate potential cadmium uptake by rotational crops. In addition, should cotton land created with Yazoo River dredged material be converted into other agricultural use, further study of plant uptake of cadmium by the proposed crops or plants should be conducted. A regulated limitation for soil cadmium in the Netherlands is 1.0 mg/kg for agricultural crops that are consumed by humans or by animals that will eventially be consumed by humans (Lee et al. 1991).

Table 6
Metal Concentrations in Soils (mg/kg)

Parameter	Composite		Maximum Application[1]	Recommended Limitations[2]	
	I-M	N-Z			
Arsenic	9	10	—	—	
Cadmium	1.1	0.9	2.5	2.5 (ph 5.5)	(EPA 1979)
Copper	17	8.5	125	125	(Logan and Chaney 1983)
Lead	17	10	500[3]	500	(EPA 1977)
Zinc	70	35	250	250	(Logan and Chaney 1983)

[1] Maximum recommended application of municipal sludge-applied metals to medium-textured cropland soils to prevent phytotoxicity of crops or crops that might have adverse human or animal consumption health effects. EPA, US Department of Agriculture, USFDA (1981)
[2] Recommended limitations on potentially toxic constituents in surface (0-15 cm) soils.
[3] Maximum allowable lead content in soil for human exposure as related to direct soil ingestion in the United Kingdom and in the United States.

4 Greenhouse Study

Methods and Materials

Dredged material collection

Dredged material was collected from CDF 4A to conduct the greenhouse portion of the study. Material was collected with a shovel from each grid to a depth of 30 cm and placed in 19-L buckets. Five buckets of dredged material were collected from each grid. Samples were collected and composited from each bucket of the five buckets to supply a sample from each grid for agricultural analysis. The material in the buckets was separately placed in two dump trucks by section (I-M and N-Z) for preparation of two composites. The material was transported to the WES and dumped in two separate piles in an open-end hangar building. The material was turned and mixed daily until completely air dried. Samples were collected from each of the two composites for final physical and chemical analysis.

Table 7
Fertilizer Treatments, mg/kg, in Phase I Greenhouse Test

Treatment	N	P	K
Control	0	0	0
N1P0K0	50	0	0
N2P0K0	75	0	0
N1P1K0	50	30	0
N2P1K0	75	30	0
N1P0K1	50	0	30
N2P0K1	75	0	30
N1P1K1	50	30	30
N2P1K1	75	30	30
N3P2K2	150	60	60

Preparation for cotton plant bioassay

Air-dried amounts equivalent to 13.2 kg oven-dried weight of each composite of grids I-M and N-Z were placed into polyethylene mixing trays. Fertilizer additions were prepared by mixing reagent grade chemicals into 1.5 L of distilled water. Reagent grade NH_4NO_3, Na_2HPO_4, and KCL were used for nitrogen (N), phosphorus (P), and potassium (K), respectively. The fertilizer treatment solutions were added to the dredged material and thoroughly mixed. The fertilized dredged material was then placed in a 19.9-L greenhouse container containing a layer of sand and foam. Fertilizer treatments are listed in Table 7 and were prepared in replicates of four for each dredged material composite.

Greenhouse operation and growing techniques

Five cotton (*Gossypium hirsutum* L. var. DPL 50) seeds were planted in each pot and allowed to germinate. After reaching a height of 8 cm, seedlings were thinned to the most vigorous three and upon reaching 15 cm, were thinned to the most vigorous two. The replicates, randomly placed on tables in the greenhouse, were subjected to a controlled environment. Day length of 16 hr was maintained by using light fixtures whose face was 130 cm from the top of the greenhouse container. The 130-cm height allows maximum potential plant growth to occur without damage from the heat produced. Lights are arranged in a pattern of alternating high pressure sodium lamps and high pressure multivapor halide lamps. Alternating lamps provide an even photosynthetic active radiation (PAR) distribution pattern of 1200 μEinsteins/m^2/sec. The temperature of the greenhouse was maintained at 32.2 ± 2 °C maximum during the day and 21.1 ± 2 °C minimum at night to simulate a summer environment. Relative humidity was maintained as close to 100 percent as possible, but never less than 50 percent. Soil/sediment moisture content was maintained between 30 and 60 MPa (field capacity is 30 MPa) by adding reverse osmosis (RO) water as necessary. Soil moisture tensiometers, placed in each container, were monitored daily and water was added when tensiometers read greater than 60 MPa. RO water was added to the surface of the dredged material to fill the container and allowed to infiltrate downward. Additional water was added, if necessary, to bring the moisture content to field capacity.

Plant growth and observation

Plants were visually monitored throughout the growth period for indications of disease, nutrient deficiency, and insect infestations. Height of plants was measured twice during the growth period and recorded (Appendix C). Plants from each container were measured and an average for each treatment was determined.

Insect control

Whiteflies and aphids were identified on the plants and were controlled with periodic applications of Diazonon and Orthene at the manufacturer's labeled recommendations.

Harvest and yield determination

After 116 days, watering was discontinued to allow drying of the plants, thereby facilitating boll opening. After 130 days, most bolls were open (Figure 13) and the seed lint from each container was harvested and placed in paper bags. The bags were placed in a forage dryer at 70 °C for 48 hr before weighing to determine the oven-dry weight of seed lint in grams/container. An estimate in bales/ha yield was determined by the following calculation:

$$\frac{\text{bales}}{\text{ha}} = \frac{\text{grams seed lint/pot} \times 135{,}905 \text{ plants/ha} \times 38\% \text{ lint/seed lint}}{1{,}000 \text{ g/kg} \times 2 \text{ plants/cont} \times 217.7 \text{ kg/bale}}$$

$$\frac{\text{bales}}{\text{ha}} = \text{grams seed lint/pot} \times 0.1186$$

where

Seed lint = lint fibers plus seed
Average cotton plant population/ha = 135,905
Lint weight = about 38 percent of total seed lint weight
Standard weight of cotton bale = 217.7 kg

Figure 13. Harvesting cotton in greenhouse after 130 days of growth

Results and Discussion

Appearance and growth

Seedling emergence and initial growth appeared normal in both the I-M and N-Z composites. An ice storm, 1 month after planting, caused power failure in the greenhouse for 4 days and temperatures fell to 6 °C before emergency heaters were supplied. Slight damage from the low temperatures was observed on some leaves, but growth resumed normally when temperatures were regulated. Vegetative growth response to treatments varied between composites. Cotton did not respond well to the higher rates of N during initial stages of growth and higher vegetative yields were obtained with the N1 rates (Table 8). Initial response of cotton, grown in the I-M composite, to increasing N was not significantly different, but final vegetative growth was greater with the higher N rates. Normally, in a field situation, N applied at high rates is split into two applications rather than a single application, as occurred in the greenhouse study. Splitting the N application prevents possible damage to the crop as well as reduces loss by leaching, surface runoff, and/or volatilization before the plant can utilize it. Some loss of N may have occurred in the N-Z due to higher sand composition and fewer adsorption sites. Plants in the N-Z composite may have initially incurred some inhibiting effects in the high N treatments and the 4 days of cold temperatures may have limited response to N in both composites.

Table 8
Cotton Plant Growth Response to Treatments

	Plant Height, cm			
	February		April	
Treatment	I-M	N-Z	I-M	N-Z
Control	40.1A[1]	27.3CD	52.6D	35.3C
N1P0K0	37.7A	32.8BC	60.3BCD	53.9AB
N2P0K0	41.5A	33.8B	62.5ABCD	49.5AB
N1P1K0	43.5A	37.8AB	63.1ABCD	56.7A
N2P1K0	42.2A	36.7AB	67.5ABC	53.7AB
N1P0K1	39.6A	37.2AB	60.9BCD	52.3AB
N2P0K1	40.4A	37.1AB	69.8AB	51.8AB
N1P1K1	42.4A	42.2A	57.4CD	54.7AB
N2P1K1	41.9A	34.9B	66.3ABC	48.3B
N3P2K2	41.3A	22.2D	73.2A	56.1AB

[1] Means in a column with the same letter are not significantly different by Waller-Duncan K-ratio T test.

Vegetative response to P and K additions was not readily determined, but appeared to be highly variable between treatments. The available P levels of 35 and 38 mg/kg in I-M and N-Z composites, respectively, are above the 7.5 mg/kg (16.8 kg/ha) in soils considered well supplied with available P (Jones 1979). Excessive P fertilization may, in fact, reduce N absorption and micronutrient uptake by plants (Anderson 1977), but the effects of P on N absorption were not determined using plant tissue analysis in this test. Exchangeable K concentrations in the I-M composite were above the 60-100 mg/kg levels reported by Hearn (1981) as the minimum critical level below which deficiency is likely to occur. The 97 mg/kg exchangeable K concentration in the N-Z composite is barely within the critical level range; however, treatments with K additions did not significantly improve vegetative appearance. Again, the 4 days of cold temperatures may have limited response to both P and K additions. The cotton plants were observed daily for indications of disease, pests, and nutrient deficiency. No diseases were noted; however, symptoms indicative of boron and sulfur deficiency were observed, but were not severe enough to verify. Whiteflies (SI ssp) and aphids were detected and controlled with applications of Diazanon and Orthene.

Total lint yields

Average yield of seed lint in grams/pot is presented in Table 9. Overall, the I-M composite produced higher yields than the N-Z composite for each treatment except N1P1K1. Yields increased in the I-M composite as N rate increased with the N3P2K2 treatment producing statistically higher yields than the other treatments. Affects of P and K on lint yield were variable in both composites. N rate had a variable affect on lint yield in the N-Z composite. Although the N2P1K0 treatment produced the highest yield, it was not statistically different than the N1P1K1 and N3P2K2 treatments. This indicates that excessive N in the N-Z composite had no beneficial effect on lint yield. To estimate ginned lint yield on a kg/ha basis, grams seed lint/pot is multiplied by 25.8, assuming 135,905 plants/ha and 38 percent ginning percentage. Appendix C, Table C2, lists the seed lint yield for each treatment in grids I-M and N-Z.

Table 9
Comparison of Seed Lint Yields, g/pot, Between Treatments and Composites

Treatment	I-M Yield	N-ZYield
Control	13.6E[1]	0.8E
N1P0K0	23.1D+[2]	14.9BC+
N2P0K0	30.1B	16.8BC
N1P1K0	23.5CB	11.8D
N2P1K0	25.7CB	20.3A
N1P0K1	23.1CD+	14.2CD+
N2P0K1	24.7CB	14.8BC
N1P1K1	17.7ED+	17.4AB+
N2P1K1	30.1B	16.5BC
N3P2K2	50.9A	17.3AB

[1] Means in a column with the same letter are not significantly different by Waller-Duncan K-ratio T test.
[2] Means in a row with a + are not significantly different by t-test at alpha = 0.05.

Yield of estimated ginned lint is presented in Figure 14. The average yield of the I-M and N-Z composites with a fertilizer rate of N2P0K0 would be 594 kg/ha or 2.7 bales/ha. Most cotton research in the greenhouse is conducted to assess response to herbicides and determine disease and pest resistance. Lint yield response to fertilizers is usually conducted in the field. For a greenhouse cotton plant bioassay to accurately predict lint yields under field conditions, extensive greenhouse testing and field verification would be required. However, to provide some perspective to the relevance of greenhouse lint yields to field conditions, some assumptions were made to express the results on a kg/ha basis. Greater rooting volume was expected to contribute to higher lint yields on the CDF than in the greenhouse, using equivalent fertilizer applications.

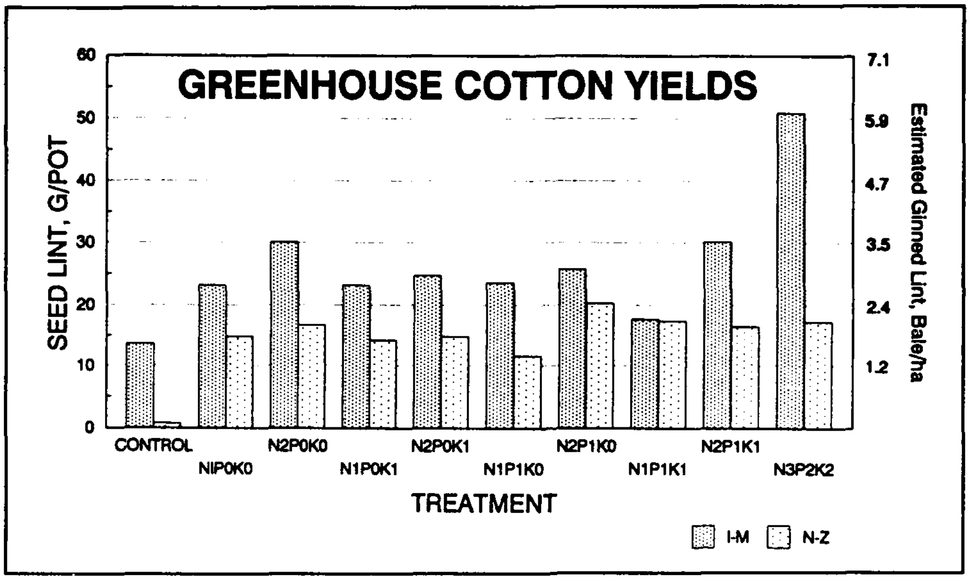

Figure 14. Estimated yields in bales/ha from the greenhouse test

5 Field Test

Methods and Materials

Site preparation production methods

The entire I-Z grids of the CDF field site were prepared for planting cotton. A bulldozer was used to fill in depressions and roughly level the site (Figure 15). The site was then disked with a tractor-drawn disk and two passes were made with a chisel plow. However, due to unfavorable weather conditions, local farmers fell behind in planting their crops and it became impossible to locate a farmer willing to give up valuable time to plant CDF 4A. As a result, the CDF was not planted in 1989.

Figure 15. Bulldozer used to roughly level the test area

The following year, the landowner agreed to provide all necessary equipment, materials, and labor to produce a cotton crop on CDF 4A. Preparation began by leveling the site with a land plane. Soil preparation and planting methods were the same as those in surrounding cotton fields, except that rows were not hipped prior to planting. Preplant herbicides were incorporated and the site was planted with Delta Pine and Land DPL-20 cotton on 10 May 1990. A pre-emergent herbicide was applied immediately after planting to eliminate existing weeds. The cotton was cultivated twice and post-emergent herbicides were applied. Insects were controlled with applications of insecticide as necessary. Nitrogen fertilizer was applied at the rate of 79 kg/ha preplant and 79 kg/ha side dress.

Harvest and yield determination

At the end of October, two strips (eight rows) totaling an area equal to 0.4047 ha (1 acre) were marked on the site. A mechanical cotton picker was used to harvest the cotton from the two strips. The harvested seed lint was placed in a cart and transported to a cotton gin for processing. The processed lint was weighed to determine the total lint yield in kg/ha.

Results and Discussion

After leveling the site with a bulldozer in April 1989, significant rainfall inhibited area farmers' ability to plant and obtain a successful stand of cotton in fields surrounding the CDF. The landowner was scheduled to plant cotton on the CDF during the 1989 growing season, however, due to circumstances beyond his and the investigators' control, cotton planting was not possible. Another farmer was contracted to disk and chisel plow the site in late May 1989. Since the site had not been land leveled, depressions were still present on the site and the farmer's tractor became mired in a wet spot on one occasion. The dredged material did break up easily and was very workable with farm implements. The tilled site is shown in Figure 16.

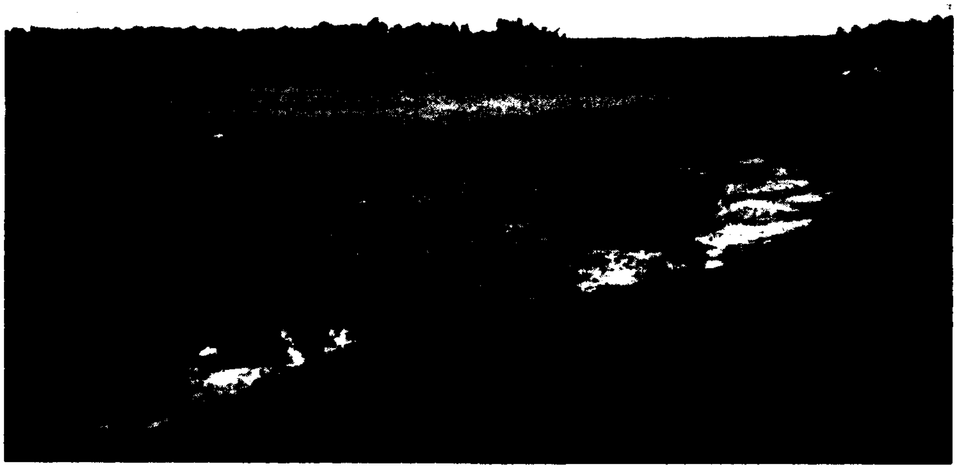

Figure 16. Test area (I-Z grids) after tillage in May 1989

For the 1990 growing season, CDF 4A was land leveled and prepared for planting by the landowner. Cotton was planted on 10 May 1990 and is shown in the early stages of growth in Figure 17. The cotton appeared very healthy except in depressions on the upper portion of the site (Figure 18) where excessive water inhibited plant growth. Cotton was chest high at maturity in the middle portion of the test site (Figure 19). The 0.4-ha (1-acre) harvested sample yielded 352 kg of ginned lint or 1.6 bales, shown at harvest in Figure 20. For comparison, the average yield on CDF 4A equates to 870 kg/ha. Although yield was not determined by grid row, the N-Q grids appeared to have some of the higher lint yields. The predominantly silt and clay I-M grids did have excessive water at times due to slower drainage. This slightly inhibited growth during periods of frequent rainfall, but was probably of more benefit during extended periods of no rainfall. The lint yield in the I-M grids did not appear to be much less than the N-Q grids. The lowest yields appeared to be in the sandier S-Z grids where drainage was excessive in some areas and depressions held water for extended periods in other areas. The response to particle size distribution in the field demonstration was similar to the response in the greenhouse as demonstrated by the reduced yield in the sandier material.

Figure 17. Cotton in early stage of growth on CDF 4A

Figure 18. Cotton growth inhibited by waterlogging in depressions

Figure 19. Cotton near maturity in the N-Q grid row area

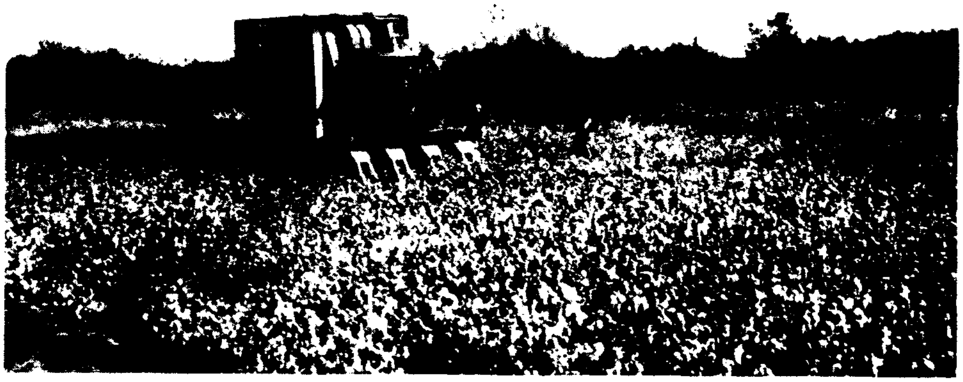

Figure 20. Cotton at harvest on CDF 4A

Cotton yield estimates from Yazoo and surrounding counties are compared with the yield from CDF 4A in Table 10. The average ginned lint yield for Yazoo County cotton fields in 1990 was 954 kg/ha (Knight and McWilliams 1992). Yields from additional counties bordering Yazoo County and the Yazoo River are also presented. The average yield from CDF 4A was slightly lower than average yields from surrounding counties except for Leflore County. This indicates that the yield from CDF 4A was considered a substantial yield for the area production year. This is significant since many of the area cotton fields are more extensively managed for fertility and are irrigated.

Table 10
Comparison of CDF 4A Yield with Yields of Yazoo and Surrounding Counties[1]

	County					
	Yazoo	Holmes	Humphreys	Leflore	Warren	CDF 4A
Yield, kg/ha	954	957	969	858	919	870

[1] County yield estimates (Knight and McWilliams 1992).

6 Conclusions

This study demonstrated that Yazoo River dredged material is a soil medium capable of producing substantial cotton lint yields. The greenhouse study indicated that cotton growing in Yazoo River dredged material responds well to added N fertilizer and additions of P and K were not necessary for initial production of cotton. The yield response to particle size distribution in the field demonstration was similar to the response in the greenhouse. Lint yield in the field was higher than lint yield in the greenhouse under comparable fertilizer treatments. The use of greenhouse bioassays for predicting lint yields under field conditions will require further research to develop a prediction coefficient. However, greenhouse bioassays were shown to be a valuable tool for evaluating yield response of cotton to various growing mediums and amendments. Future plant bioassays for cotton response to dredged material should include a known productive cotton soil as a reference for comparisons.

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Appendix A
Laboratory Methods for Agricultural Soil Analysis

The following laboratory tests were conducted by Pettiet Agricultural Services, Soil and Plant Testing Laboratory, Leland, MS.

Test for	Test Methods
pH	Glass pH electrode measure of a 1:2 soil-to-water mixture.
Lime	Glass pH electrode measure of a 1:2 soil-to-buffer mixture using the Mississippi State University (p-nitrophenol) lime solution.
P, K, Ca, & Mg	Using the Mehlich 3 extract[1] (0.2N CH_3COOH; 0.25 NH_4NO_3; 0.015N NH_4F; 0.013N HNO_3; 0.01M EDTA). Phosphorus was determined colorimetrically; potassium by atomic emission; calcium and magnesium by atomic absorption analyses.
CEC & % base saturation	Calculated by summation of the base nutrients and acidity shown by the lime test.
Organic matter	Using modified Debolt version of the Wakley-Black method (0.5M matter $NA_2Cr_2O_7$ and 11.5N H_2SO_4 digestion mixture).[2] Reduced chromium was determined by colorimetric methods.

[1] Mehlich (1984). "Mehlich 3 Soil Test Extractant," *Comm. Soil Sci. and Plant Anal.*, 15(12), 1406-1416.
[2] American Society of Agronomy, Inc. (1965). "Organic Matter Methods. Methods of Soil Analyses, Vol. 2, Chemical and Microbiological Properties," Agronomy Monograph Series No. 9, 1372-1375.

Appendix B
Physical and Chemical Data of Dredged Material

Table B1
Particle Size Distribution in Grids A-H
(0- to 15-, 15- to 30-,
and 30- to 45-cm depths)

Obs	Row	Grid	Depth	%Clay	%Silt	%Sand
1	1	1	15	20.0	52.5	27.5
2	A	3	45	55.0	42.5	2.5
3	A	3	15	52.5	47.5	0.0
4	A	4	15	42.5	52.5	5.0
5	A	2	30	62.5	37.5	0.0
6	A	3	30	72.5	27.5	0.0
7	A	4	45	52.5	47.5	0.0
8	A	1	30	32.5	55.0	12.5
9	A	2	15	40.0	47.5	12.5
10	A	1	45	27.5	55.0	17.5
11	A	2	45	57.5	40.0	2.5
12	A	5	15	52.5	45.0	2.5
13	A	5	45	57.5	40.0	2.5
14	A	1	15	35.0	47.5	17.5
15	A	5	30	60.0	40.0	0.0
16	A	4	30	47.5	45.0	7.5
17	B	1	45	62.5	35.0	2.5
18	B	3	30	60.0	40.0	0.0
19	B	4	45	70.0	30.0	0.0
20	B	2	15	62.5	37.5	0.0
21	B	5	15	65.0	35.0	0.0
22	B	1	15	65.0	35.0	0.0
23	B	3	45	55.0	45.0	0.0
24	B	5	45	62.5	37.5	0.0
25	B	4	15	55.0	45.0	0.0
26	B	4	30	65.0	35.0	0.0
27	B	2	45	67.5	32.5	0.0
28	B	1	45	52.5	47.5	0.0
29	B	2	30	60.0	40.0	0.0
30	B	5	30	60.0	37.5	2.5
31	B	3	15	50.0	47.5	2.5
32	B	1	30	50.0	50.0	0.0
33	C	3	45	55.0	45.0	0.0
34	C	5	15	60.0	40.0	0.0
35	C	1	45	65.0	35.0	0.0
36	C	3	15	55.0	45.0	0.0
37	C	4	30	57.5	42.5	0.0
38	C	1	15	37.5	57.5	5.0
39	C	4	15	57.5	42.5	0.0
40	C	2	15	55.0	45.0	0.0
41	C	5	45	57.5	40.0	2.5
42	C	3	30	50.0	47.5	2.5
43	C	5	30	57.5	40.0	2.5
44	C	1	30	37.5	55.0	7.5
45	C	2	45	52.5	45.0	2.5

(Continued)

(Sheet 1 of 3)

Table B1 (Continued)

Obs	Row	Grid	Depth	%Clay	%Silt	%Sand
46	C	4	45	55.0	42.5	2.5
47	C	2	30	65.0	35.0	0.0
48	D	4	45	55.0	42.5	2.5
49	D	2	30	42.5	45.0	12.5
50	D	2	15	60.0	40.0	0.0
51	D	4	15	62.5	37.5	0.0
52	D	1	30	60.0	35.0	5.0
53	D	1	15	60.0	37.5	2.5
54	D	5	15	62.5	37.5	0.0
55	D	3	15	57.5	42.5	0.0
56	D	5	30	60.0	40.0	0.0
57	D	1	45	60.0	40.0	0.0
58	D	5	45	50.0	47.5	2.5
59	D	3	30	47.5	52.5	0.0
60	D	2	45	30.0	57.5	12.5
61	D	3	45	47.5	50.0	2.5
62	D	4	30	57.5	42.5	0.0
63	E	3	30	47.5	52.5	0.0
64	E	5	30	47.5	50.0	2.5
65	E	5	15	47.5	42.5	10.0
66	E	2	30	57.5	40.0	2.5
67	E	4	45	45.0	55.0	0.0
68	E	5	45	62.5	37.5	0.0
69	E	3	45	60.0	40.0	0.0
70	E	2	45	60.0	40.0	0.0
71	E	1	15	57.5	42.5	0.0
72	E	4	30	50.0	50.0	0.0
73	E	4	15	50.0	50.0	0.0
74	E	3	15	50.0	50.0	0.0
75	E	1	30	57.5	42.5	0.0
76	E	2	15	47.5	52.5	0.0
77	F	1	45	47.5	50.0	2.5
78	F	3	15	45.0	55.0	0.0
79	F	2	30	52.5	47.5	0.0
80	F	4	15	42.5	57.5	0.0
81	F	5	45	47.5	52.5	0.0
82	F	1	30	52.5	45.0	2.5
83	F	1	15	45.0	55.0	0.0
84	F	5	30	47.5	50.0	2.5
85	F	4	45	45.0	55.0	0.0
86	F	3	30	40.0	60.0	0.0
87	F	2	45	42.5	57.5	0.0
88	F	5	15	50.0	50.0	0.0
89	F	2	15	47.5	52.5	0.0
90	F	3	45	37.5	62.5	0.0
91	F	4	30	37.5	62.5	0.0
92	G	5	45	40.0	60.0	0.0
93	G	2	30	37.5	62.5	0.0

(Continued)

(Sheet 2 of 3)

Table B1 (Concluded)

Obs	Row	Grid	Depth	%Clay	%Silt	%Sand
94	G	4	45	40.0	55.0	5.0
95	G	1	45	42.5	57.5	0.0
96	G	5	30	42.5	55.0	2.5
97	G	1	15	40.0	60.0	0.0
98	G	1	30	40.0	60.0	0.0
99	G	4	30	37.5	62.5	0.0
100	G	2	45	52.5	47.5	0.0
101	G	4	15	45.0	55.0	0.0
102	G	2	15	45.0	55.0	0.0
103	G	3	45	45.0	55.0	0.0
104	G	3	30	50.0	50.0	0.0
105	G	3	30	40.0	60.0	0.0
106	G	5	15	47.5	52.5	0.0
107	G	3	15	40.0	60.0	0.0
108	H	1	15	42.5	57.5	0.0
109	H	3	15	40.0	57.5	2.5
110	H	2	15	40.0	57.5	2.5
111	H	3	45	45.0	47.5	7.5
112	H	4	15	45.0	55.0	0.0
113	H	5	15	55.0	45.0	0.0
114	H	5	45	45.0	55.0	0.0
115	H	4	30	35.0	65.0	0.0
116	H	3	30	37.5	62.5	0.0
117	H	5	30	50.0	47.5	2.5
118	H	2	45	45.0	55.0	0.0
119	H	4	45	32.5	55.0	12.5
120	H	1	30	45.0	55.0	0.0
121	H	2	30	42.5	57.5	0.0
122	H	1	45	47.5	47.5	5.0

(Sheet 3 of 3)

Table B2
Particle Size Distribution in Grids I-Z
(0- to 45-cm depth)

Obs	Row	Grid	%Sand	%Silt	%Clay
1	I	1	7.50	51.250	41.250
2	I	2	5.00	53.750	41.250
3	I	3	0.00	61.250	38.750
4	I	4	1.25	63.750	35.000
5	J	1	22.50	47.500	30.000
6	J	2	0.00	56.875	43.125
7	J	3	0.00	59.375	40.625
8	J	4	0.00	56.875	43.125
9	K	1	27.50	46.250	26.250
10	K	2	1.25	59.375	39.375
11	K	3	0.00	64.375	35.625
12	K	4	1.25	63.750	35.000
13	L	1	6.25	67.500	26.250
14	L	2	5.00	66.250	28.750
15	L	3	6.25	63.750	30.000
16	L	4	1.25	65.000	33.750
17	M	1	8.75	62.600	28.750
18	M	2	13.75	60.000	26.250
19	M	3	10.00	61.250	28.750
20	M	4	3.75	67.500	28.700
21	N	1	7.50	67.500	25.000
22	N	2	52.50	32.500	15.000
23	N	3	40.00	40.000	20.000
24	N	4	17.50	67.500	15.000
25	O	1	2.50	70.000	27.500
26	O	2	62.50	22.500	15.000
27	O	3	32.50	50.000	17.500
28	O	4	75.00	12.500	12.500
29	P	1	5.00	75.000	20.000
30	P	2	50.00	37.500	12.500
31	P	3	62.50	20.000	17.500
32	P	4	62.50	22.500	15.000
33	Q	1	32.50	50.000	17.500
34	Q	2	65.00	20.000	15.000
35	Q	3	42.50	42.500	15.000
36	Q	4	37.50	47.500	15.000
37	R	1	47.50	40.000	12.500
38	R	2	62.50	17.500	20.000
39	R	3	57.50	30.000	12.500
40	R	4	55.00	27.500	17.500
41	S	1	45.00	42.500	12.500
42	S	2	55.00	40.000	5.000
43	S	3	50.00	40.000	10.000
44	S	4	65.00	27.500	7.500
45	T	1	52.50	40.000	7.500
46	T	2	55.00	20.000	25.000
47	T	3	22.50	60.000	17.500

(Continued)

Table B2 (Concluded)

Obs	Row	Grid	%Sand	%Silt	%Clay
48	T	4	50.00	42.500	7.500
49	U	1	52.50	27.500	20.000
50	U	2	42.50	47.500	10.000
51	U	3	70.00	22.500	7.500
52	U	4	85.00	10.000	5.000
53	V	1	67.50	25.000	7.500
54	V	2	80.00	12.500	7.500
55	V	3	42.50	47.500	10.000
56	W	1	60.00	32.500	7.500
57	W	2	80.0	15.0	5.0
58	W	3	75.0	17.5	7.5
59	X	1	42.5	37.5	20.0
60	X	2	70.0	25.0	5.0
61	X	3	65.0	27.5	7.5
62	Y	1	75.0	17.5	7.5
63	Y	2	52.5	40.0	7.5
64	Y	3	40.0	37.5	22.5
65	Z	1	42.5	42.5	15.0

Table B3
Agricultural Analysis of Grids I-Z
(0- to 45-cm samples)

Grid	pH	TA	P	K	Mg	Ca	OM	CEC	Lime
I1	5.4	7.5	56	324	1322	4620	0.89	25	2
I2	5.98	4.4	64	345	1524	5330	0.68	24.5	0
I3	5.36	7.5	65	282	1138	4080	1	22.8	2
I4	5.84	4.9	61	335	1387	4750	1.06	23	0
J1	5.42	6.2	65	246	969	3520	0.8	19.4	1.5
J2	5.66	5.8	69	277	1249	4340	0.93	22.2	0
J3	5.47	6.3	75	285	1100	3890	0.72	21	1.5
J4	6.03	4.8	61	313	1386	4720	0.91	22.8	0
K1	5.83	3.9	74	178	942	3350	0.55	16.4	0
K2	5.78	5.2	70	299	1236	4320	0.86	21.5	0
K3	5.59	5.1	66	220	1056	3690	0.82	19	0
K4	5.73	4.6	67	280	1161	4170	0.79	20.2	0
L1	5.72	3.7	74	187	933	3270	0.56	16	0
L2	5.99	3.2	79	221	1143	3920	0.63	18	0
L3	5.96	3.7	83	215	1208	4260	0.92	19.7	0
L4	5.86	4	80	236	1214	4160	0.58	19.8	0
M1	5.96	3.2	79	195	1001	3490	0.59	16.3	0
M2	6.49	2.2	73	135	996	3440	0.29	15.1	0
M3	6.3	2.9	78	189	1124	3770	0.35	17.3	0
M4	6.22	3.1	68	189	1076	3730	0.43	17.2	0
N1	5.92	3	74	251	841	2960	0.34	14.2	0
N2	5.36	2.9	98	183	370	1620	0.14	8.7	1
N3	6.14	2.5	77	239	684	2570	0.83	12.1	0
N4	6.03	1.8	57	154	502	1840	0.3	8.7	0
O1	5.97	2.8	63	259	838	2970	0.51	14	0
O2	5.73	2	72	164	394	1590	0.21	7.8	0
O3	5.72	2.6	67	175	463	1820	0.52	9.3	0
O4	5.67	2.7	87	191	406	1390	0.24	8.1	0
P1	5.69	2.8	64	152	567	2060	0.24	10.5	0
P2	5.95	2.2	69	139	477	1720	0.24	8.7	0
P3	5.91	2.7	94	215	487	1730	0.64	9.3	0
P4	5.85	2.2	81	125	492	1750	0.15	8.8	0
Q1	6.07	1.9	66	134	545	1930	0.15	9.2	0
Q2	5.93	2.2	82	119	487	1740	0.17	8.7	0
Q3	6.32	1.7	70	181	500	1790	0.4	8.5	0
Q4	5.86	2.2	67	126	450	1760	0.16	8.6	0
R1	6.83	1.2	59	229	994	3330	0.22	14	0
R2	6.65	1.5	56	282	712	2540	0.63	11.2	0
R3	6.02	2.3	59	149	496	1890	0.46	9.3	0
R4	5.75	3.5	95	149	541	2320	0.24	11.7	0
S1	6.33	1.9	69	140	540	2010	0.24	9.4	0
S2	6.4	2	69	142	539	2010	0.3	9.5	0
S3	6.83	1.3	82	198	707	2530	0.31	10.8	0
S4	6.49	1.2	61	178	597	2220	0.9	9.5	0
T1	6.35	1.4	70	143	596	2010	0.17	9.1	0
T2	6.85	1.3	80	463	1269	4680	0.4	18.9	0
T3	6.28	2.2	62	271	855	3350	0.67	14.5	0
T4	6.26	2.3	78	164	567	2060	0.21	10	0

(Continued)

Table B3 (Concluded)

Grid	pH	TA	P	K	Mg	Ca	OM	CEC	Lime
U1	6.23	2.3	66	324	942	3810	0.28	16.2	0
U2	6.32	1.6	54	198	672	2360	0.31	10.6	0
U3	5.78	2.6	86	171	478	1780	0.27	9.3	0
U4	5.99	2	87	130	380	1420	0.21	7.3	0
V1	5.64	3	74	119	434	1700	0.2	9.2	0
V2	5.75	2.8	81	145	442	1640	0.24	8.9	0
V3	5.55	3.2	67	137	486	1840	0.44	10	0
W1	5.69	2.4	73	139	452	1690	0.24	8.7	0
W2	5.71	2.4	77	124	400	1460	0.3	7.9	0
W3	5.76	2	85	163	385	1500	0.24	7.6	0
X1	5.83	3.7	72	242	879	3090	0.39	15.4	0
X2	5.55	2.7	109	351	392	1390	0.4	8.3	1
X3	5.89	2.5	87	190	567	2170	0.21	10.5	0
Y1	5.85	3	82	148	502	2120	0.38	10.6	0
Y2	5.84	2.9	77	215	624	2240	0.43	11.4	0
Y3	6.13	4	95	292	1152	4150	0.34	19.5	0
Z1	5.82	4.2	86	328	851	2970	1.62	15.6	0

Table B4
Particle Size Distribution in Grids I-Z
(0- to 30-, 30- to 60-, 60- to 90-,
90- to 120-, and 120- to 150-cm depths)

Obs	Row	Grid	Depth	%Clay	%Silt	%Sand
1	I	1	30	23.4131	62.4350	14.1519
2	I	1	60	24.3465	53.8186	21.8350
3	I	1	90	21.6616	61.1621	17.1764
4	I	1	120	28.4827	64.7333	6.7840
5	I	1	150	28.6309	65.0703	6.2988
6	I	2	30	42.5080	57.4920	0.0000
7	I	2	60	44.5876	52.0188	3.3936
8	I	2	90	40.6504	55.0747	4.2748
9	I	2	120	39.8301	58.4174	1.7525
10	I	2	150	37.1649	58.4019	4.4332
11	I	3	30	39.4425	60.5575	0.0000
12	I	3	60	44.5726	55.4274	0.0000
13	I	3	90	46.6916	53.3084	0.0000
14	I	3	120	31.1850	59.7713	9.0437
15	I	3	150	23.2678	54.2916	22.4405
16	I	4	30	25.7865	74.2135	0.0000
17	I	4	60	45.7636	54.2364	0.0000
18	I	4	90	58.0297	41.9703	0.0000
19	I	4	120	51.6726	48.3274	0.0000
20	I	4	150	48.4001	51.0890	0.5109
21	J	1	30	36.5344	44.3633	19.1023
22	J	1	30	23.2138	43.8483	32.9378
23	J	1	90	21.8285	48.7930	29.3785
24	J	1	120	24.3340	61.4754	14.1906
25	J	1	150	27.0828	61.9035	11.0137
26	J	2	30	39.2259	60.1464	0.6276
27	J	2	60	36.7358	62.9756	0.2886
28	J	2	90	37.7211	59.8335	2.4454
29	J	2	120	35.3774	62.8931	1.7296
30	J	2	150	32.3583	59.5392	8.1025
31	J	3	30	38.9307	61.0693	0.0000
32	J	3	60	27.2727	72.7273	0.0000
33	J	3	90	60.2732	39.7268	0.0000
34	J	3	120	48.9936	51.0064	0.0000
35	J	3	150	48.2057	50.8838	0.9106
90	J	4	30	42.1607	57.8393	0.0000
37	J	4	60	35.1379	64.8621	0.0000
38	J	4	90	32.0349	67.9651	0.0000
39	J	4	120	43.9765	56.0235	0.0000
40	J	4	150	48.8513	50.1716	0.9770
41	K	1	30	10.1010	7.5758	82.3232
42	K	1	60	12.5408	27.5897	59.8696
43	K	1	90	30.0183	60.0365	9.9452
44	K	1	120	27.0619	59.2784	13.6598
45	K	1	150	27.2374	59.6628	13.0999
46	K	2	30	15.1362	42.8860	41.9778
47	K	2	60	33.8014	59.8024	6.3963

(Continued)

(Sheet 1 of 7)

Table B4 (Continued)

Obs	Row	Grid	Depth	%Clay	%Silt	%Sand
48	K	2	90	37.9879	62.0121	0.0000
49	K	2	120	35.2021	64.7979	0.0000
50	K	2	150	35.0285	62.2730	2.6985
51	K	3	30	33.9958	66.0042	0.0000
52	K	3	60	38.0677	61.9323	0.0000
53	K	3	90	24.5415	74.9160	0.5425
54	K	3	120	52.6458	47.3542	0.0000
55	K	3	150	52.6458	45.8963	1.4579
56	K	4	30	33.5917	64.5995	1.8088
57	K	4	60	35.4052	64.5948	0.0000
58	K	4	90	35.0649	64.9351	0.0000
59	K	4	120	35.3403	64.6597	0.0000
60	K	4	150	49.7446	48.4001	1.8553
61	L	1	60	35.3311	57.5766	7.0924
62	L	1	90	30.0811	60.1622	9.7567
63	L	1	120	29.8391	64.8677	5.2932
64	L	1	150	24.4153	51.4007	24.1840
65	L	2	30	17.8389	68.8073	13.3537
66	L	2	60	32.2165	67.0103	0.7732
67	L	2	90	29.6239	69.5518	0.8243
68	L	2	120	27.3794	72.6206	0.0000
69	L	2	150	21.7725	74.2828	3.9447
70	L	3	30	28.6235	70.2576	1.1189
71	L	3	60	41.0487	58.9513	0.0000
72	L	3	90	29.9401	70.0599	0.0000
73	L	3	120	40.8217	59.1783	0.0000
74	L	3	150	58.4716	41.5284	0.0000
75	L	4	30	17.9257	71.7029	10.3713
76	L	4	60	26.9923	71.9794	1.0283
77	L	4	90	24.3091	74.2068	1.4841
78	L	4	120	40.4700	59.5300	0.0000
79	L	4	150	49.6245	50.3755	0.0000
80	L	I	30	25.7003	64.2508	10.0488
81	M	1	30	36.4868	63.5132	0.0000
82	M	1	60	24.5415	74.9160	0.5425
83	M	1	90	32.6883	60.1464	7.1653
84	M	1	120	29.9323	62.4675	7.6002
85	M	1	150	27.2515	59.6937	13.0548
86	M	2	30	33.6091	59.4623	6.9286
87	M	2	60	24.4530	72.0721	3.4749
88	M	2	90	29.3293	70.6707	0.0000
89	M	2	120	21.8678	77.1803	0.9519
90	M	2	150	21.8621	77.1605	0.9774
91	M	3	30	25.4582	66.1914	8.3503
92	M	3	60	24.7203	75.2797	0.0000
93	M	3	120	21.8565	77.1407	1.0028
94	M	3	150	46.2718	53.7282	0.0000
95	M	4	30	25.9134	72.5577	1.5289

(Continued)

(Sheet 2 of 7)

Table B4 (Continued)

Obs	Rpw	Grid	Depth	%Clay	%Silt	%Sand
96	M	4	60	24.2656	74.0741	1.6603
97	M	4	90	27.0062	72.9938	0.0000
98	M	4	120	16.5100	83.4900	0.0000
99	M	4	150	37.3808	61.8716	0.7476
100	N	1	30	10.5988	34.4462	54.9550
101	N	1	60	29.7234	70.2766	0.0000
102	N	1	90	48.1771	51.8229	0.0000
103	N	1	120	27.1599	62.0797	10.7605
104	N	1	150	28.3213	61.7920	9.8867
105	N	2	30	44.6650	52.1092	3.2258
106	N	2	60	11.4040	60.8211	27.7750
107	N	2	90	19.1424	79.1220	1.7356
108	N	2	120	20.4971	76.8640	2.6390
109	N	2	150	21.5027	78.4215	0.0759
110	N	3	30	23.0120	71.5929	5.3950
111	N	3	60	19.1718	79.2434	1.5849
112	N	3	90	27.2021	72.7979	0.0000
113	N	3	120	27.2232	72.5953	0.1815
114	N	3	150	55.3157	44.6843	0.0000
115	N	4	30	21.8285	77.0416	1.1299
116	N	4	60	24.3777	75.6223	0.0000
117	N	4	90	19.3299	80.6701	0.0000
118	N	4	120	16.5352	81.4042	2.0605
119	N	4	120	21.3568	78.6432	0.0000
120	N	4	150	32.4929	67.5071	0.0000
121	O	1	30	16.5647	79.0010	4.4343
122	O	1	60	13.7983	82.7898	3.4119
123	O	1	90	22.8021	77.1979	0.0000
124	O	1	120	35.4238	62.9756	1.6006
125	O	1	150	27.0688	59.2936	13.6375
126	O	2	30	13.8854	60.5908	25.5239
127	O	2	60	21.4918	73.3249	5.1833
128	O	2	90	18.9970	75.9878	5.0152
129	O	2	120	11.3852	80.3213	8.3835
130	O	2	150	16.2378	79.9400	3.8221
131	O	3	30	6.3468	55.8517	37.8015
132	O	3	60	8.7456	69.9650	21.2894
133	O	3	90	12.6263	75.7576	11.6162
134	O	3	150	12.5094	85.0638	2.4268
135	O	3	150	13.9736	81.3008	4.7256
136	O	4	30	7.8839	22.0751	70.0410
137	O	4	60	8.8563	20.2429	70.9008
138	O	4	90	10.0075	50.0375	39.9550
139	O	4	120	8.7653	55.0964	36.1382
140	O	4	150	11.3464	52.9501	35.7035
141	P	1	30	13.8644	80.6655	5.4701
142	P	1	60	13.9665	81.2595	4.7740
143	P	1	90	21.4809	78.3422	0.1769

(Continued)

(Sheet 3 of 7)

Table B4 (Continued)

Obs	Row	Grid	Depth	%Clay	%Silt	%Sand
144	P	1	120	35.0376	38.9307	26.0317
145	P	1	150	39.0625	60.9375	0.0000
146	P	2	30	6.3131	45.4545	48.2323
147	P	2	60	13.9029	78.3620	7.7351
148	P	2	90	8.8473	83.4176	7.7351
149	P	2	120	11.3407	83.1653	5.4940
150	P	2	150	12.4969	82.4794	5.0237
151	P	3	30	6.2081	37.2486	56.5433
152	P	3	60	10.0629	55.3459	34.5912
153	P	3	90	10.0528	50.2639	39.6833
154	P	3	120	6.2500	27.5000	66.2500
155	P	3	150	12.5723	42.7458	44.6819
156	P	4	30	8.8496	20.2276	70.9229
157	P	4	60	9.9676	27.4109	62.6215
158	P	4	90	7.5719	47.9556	44.4725
159	P	4	120	6.2438	39.9600	53.7962
160	P	4	150	12.4782	47.4170	40.1048
161	Q	1	30	8.7873	82.8521	8.3605
162	Q	1	60	10.0654	83.0398	6.8948
163	Q	1	90	12.6550	87.3450	0.0000
164	Q	1	120	19.0018	80.9982	0.0000
165	Q	1	150	41.8629	58.1371	0.0000
166	Q	2	30	8.7719	32.5815	58.6466
167	Q	2	60	11.2108	22.4215	66.3677
168	Q	2	90	9.9133	49.5663	40.5204
169	Q	2	120	6.2531	57.5288	36.2181
170	Q	2	150	7.4832	59.8653	32.6515
171	Q	3	30	8.7173	52.3039	38.9788
172	Q	3	60	11.3236	45.2944	43.3820
173	Q	3	90	15.3257	45.9770	38.6973
174	Q	3	120	6.3420	63.4196	30.2385
175	Q	3	150	17.8072	45.7899	36.4030
176	Q	4	30	11.3436	45.3743	43.2821
177	Q	4	60	12.8074	48.6680	38.5246
178	Q	4	90	10.0150	60.0901	29.8948
179	Q	4	120	11.4562	58.5540	29.9898
180	Q	4	150	10.0528	57.8035	32.1438
181	R	1	30	8.8161	57.9345	33.2494
182	R	1	60	10.9436	68.0934	20.9630
183	R	1	90	10.0326	80.2608	9.7065
184	R	1	120	12.6422	75.8534	11.5044
185	R	1	150	25.5558	51.1117	23.3325
186	R	2	30	18.9012	25.2016	55.8972
187	R	2	60	22.0093	54.3760	23.6147
188	R	2	90	33.9603	54.8589	11.1808
189	R	2	120	30.6513	56.1941	13.1545
190	R	2	150	10.4493	83.5946	5.9561
191	R	3	30	6.1214	53.8688	40.0098

(Continued)

(Sheet 4 of 7)

Table B4 (Continued)

Obs	Row	Grid	Depth	%Clay	%Silt	%Sand
192	R	3	60	11.3350	45.3401	43.3249
193	R	3	90	7.4914	38.5274	53.9812
194	R	3	120	15.1592	42.9510	41.8898
195	R	3	150	10.1549	40.6194	49.2257
196	R	4	30	16.5479	45.8248	37.6273
197	R	4	60	16.5017	40.6194	42.8789
198	R	4	90	14.1753	51.5464	34.2784
199	R	4	150	10.1755	53.4215	36.4030
200	R	4	150	23.0888	61.5700	15.3412
201	S	1	30	6.2877	60.3622	33.3501
202	S	1	60	8.8161	52.8967	38.2872
203	S	1	90	10.0908	63.0676	26.8416
204	S	1	120	7.5700	47.9435	44.4865
205	S	1	150	5.0239	55.2625	39.7136
206	S	2	30	13.8994	48.0162	38.0844
207	S	2	60	24.6178	51.8269	23.5553
208	S	2	90	18.1441	36.2882	45.5677
209	S	2	120	25.8665	46.5598	27.5737
210	S	2	150	10.1626	40.6504	49.1870
211	S	3	30	6.2814	57.7889	35.9296
212	S	3	60	7.5586	75.5858	16.8556
213	S	3	90	8.3913	21.5776	70.0312
214	S	3	120	7.5019	37.5094	54.9887
215	S	3	150	4.9826	29.8954	65.1221
216	S	4	30	8.8697	70.9579	20.1723
217	S	4	60	11.2528	35.0088	53.7384
218	S	4	90	7.4590	27.3496	65.1914
219	S	4	120	2.5013	15.0075	82.4912
220	S	4	150	7.5113	42.5638	49.9249
221	T	1	30	29.8159	46.6684	23.5157
222	T	1	60	38.4717	47.7580	13.7702
223	T	1	90	41.6089	32.3625	26.0287
224	T	1	150	12.6968	48.2478	39.0554
225	T	2	30	6.3052	45.3972	48.2976
226	T	2	60	11.3179	35.2113	53.4708
227	T	2	90	20.3200	22.8600	56.8199
228	T	2	120	13.7226	12.4750	73.8024
229	T	2	150	9.9552	19.9104	70.1344
230	T	3	30	19.2604	64.2013	16.5383
231	T	3	60	11.2641	77.5970	11.1389
232	T	3	90	7.6084	50.7228	41.6688
233	T	3	120	6.2893	42.7673	50.9434
234	T	3	150	10.0326	57.6875	32.2799
235	U	1	30	11.5296	58.9290	29.5414
236	U	1	60	10.0985	47.9677	41.9339
237	U	1	90	5.0454	63.0676	31.8870
238	U	1	120	8.7478	62.4844	28.7678
239	U	1	150	8.6207	54.1872	37.1921

(Continued)

(Sheet 5 of 7)

Table B4 (Continued)

Obs	Row	Grid	Depth	%Clay	%Silt	%Sand
240	U	1	150	11.2080	59.7758	29.0162
241	U	2	30	16.3934	27.7427	55.8638
242	U	2	60	13.9276	48.1134	37.9590
243	U	2	90	6.2861	42.7458	50.9681
244	U	2	120	8.8206	35.2823	55.8972
245	U	2	150	6.2205	7.4645	86.3150
246	U	3	30	11.3550	12.6167	76.0283
247	U	3	60	2.5272	20.2173	77.2555
248	U	3	60	2.4963	22.4663	75.0374
249	U	3	90	3.7764	7.5529	88.6707
250	U	3	120	8.4931	19.4128	72.0942
251	V	1	30	11.3065	27.6382	61.0553
252	V	1	60	5.0289	27.6590	67.3120
253	V	1	90	3.7641	27.6035	68.6324
254	V	1	120	5.9298	28.4630	65.6072
255	V	1	150	6.2578	27.5344	66.2078
256	V	1	150	6.1973	93.8027	0.0000
257	V	2	30	13.8087	35.1494	51.0419
258	V	2	60	21.0240	24.7341	54.2419
259	V	2	90	25.7400	51.4801	22.7799
260	V	2	120	24.6305	49.2611	26.1084
261	V	2	150	13.9100	27.8199	58.2701
262	V	3	30	5.0607	20.2429	74.6964
263	V	3	30	15.8924	53.7897	30.3178
264	V	3	30	11.3407	57.9637	30.6956
265	V	3	60	11.1940	14.9254	73.8806
266	V	3	90	8.7984	30.1659	61.0357
267	V	3	120	6.2267	39.8506	53.9228
268	V	3	150	6.3243	40.4756	53.2001
269	V	3	150	3.7566	96.2434	0.0000
270	W	1	30	16.5690	43.3342	40.0969
271	W	1	60	34.4740	38.3044	27.2217
272	W	1	90	28.3600	49.3218	22.3181
273	W	1	120	16.7655	64.4828	18.7516
274	W	1	150	3.7509	96.2491	0.0000
275	W	2	30	18.4957	24.6609	56.8434
276	W	2	60	6.2925	17.6189	76.0886
277	W	2	90	3.7323	12.4409	83.8268
278	W	2	120	8.5262	17.0524	74.4214
279	W	2	150	3.7129	96.2871	0.0000
280	W	3	30	4.9975	22.4888	72.5137
281	W	3	60	2.5151	10.0604	87.4245
282	W	3	90	6.2235	27.3836	66.3928
283	W	3	90	8.7829	20.0753	71.1418
284	W	3	120	26.9093	48.6930	24.3977
285	W	3	150	8.7719	25.0627	66.1654
286	X	1	30	16.0217	44.3678	39.6105
287	X	1	60	24.5415	46.4996	28.9589

(Continued)

(Sheet 6 of 7)

Table B4 (Concluded)

Obs	Row	Grid	Depth	%Clay	%Silt	%Sand
288	X	1	90	23.2558	48.9596	27.7846
289	X	1	120	11.3493	22.6986	65.9521
290	X	1	150	6.3084	20.1867	73.5049
291	X	1	150	6.2578	93.7422	0.0000
292	X	2	30	13.4245	51.2570	35.3185
293	X	2	60	11.3436	27.7288	60.9277
294	X	2	90	8.7282	37.4065	53.8653
295	X	2	120	5.0531	22.7388	72.2082
296	X	2	150	3.7594	96.2406	0.0000
297	X	3	30	10.1600	38.1001	51.7399
298	X	3	60	15.8382	70.6628	13.4990
299	X	3	90	5.0251	17.5879	77.3869
300	X	3	120	18.1378	9.6735	72.1886
301	X	3	150	3.7230	96.2770	0.0000
302	Y	1	60	10.1574	43.1691	46.6734
303	Y	1	90	5.7991	44.0733	50.1276
304	Y	1	120	8.0552	43.7284	48.2163
305	Y	1	120	6.2877	40.2414	53.4708
306	Y	1	150	6.1989	34.7136	59.0875
307	Y	2	30	7.4386	34.7136	57.8478
308	Y	2	60	13.8018	20.0753	66.1230
309	Y	2	90	5.9751	26.2906	67.7342
310	Y	2	120	8.4623	29.0135	62.5242
311	Y	2	150	6.2735	93.7265	0.0000
312	Y	3	60	11.3780	32.8698	55.7522
313	Y	3	90	6.2909	25.1636	68.5455
314	Y	3	120	6.3243	30.3567	63.3190
315	Y	3	120	11.4011	38.0035	50.5954
316	Y	3	150	3.7566	96.2434	0.0000
317	Y	I	30	10.2599	31.9197	57.8203
318	Z	1	30	18.8537	75.4148	5.7315
319	Z	1	60	11.3751	63.1951	25.4297
320	Z	1	90	12.7033	71.1382	16.1585
321	Z	1	120	11.3751	73.3064	15.3185
322	Z	1	150	8.8630	83.5655	7.5715

(Sheet 7 of 7)

Table B5
WES pH Data for I-Z Grids, 1989
(0- to 30-cm depth)

Obs	Row	Grid	pH
1	I	1	4.16
2	I	2	4.16
3	I	3	4.12
4	I	4	4.76
5	J	1	3.89
6	J	2	4.12
7	J	3	3.87
8	J	4	3.85
9	K	1	4.54
10	K	2	4.42
11	K	3	4.25
12	K	4	4.25
13	L	1	4.71
14	L	2	5.54
15	L	3	5.54
16	L	4	3.98
17	M	1	4.60
18	M	2	4.98
19	M	3	4.80
20	M	4	4.89
21	N	1	4.87
22	N	2	4.54
23	N	3	4.96
24	N	4	4.74
25	O	1	4.79
26	O	2	4.92
27	O	3	4.72
28	O	4	5.18
29	P	1	4.73
30	P	2	4.69
31	P	3	5.00
32	P	4	4.62
33	Q	1	5.56
34	Q	2	4.54
35	Q	3	4.98
36	Q	4	4.92
37	R	1	6.15
38	R	2	5.10
39	R	3	5.05
40	R	4	4.82
41	S	1	4.86
42	S	2	4.72
43	S	3	5.93
44	S	4	5.51
45	T	1	4.93
46	T	2	5.23
47	T	3	5.42

(Continued)

Table B5 (Concluded)

Obs	Row	Grid	pH
48	U	1	5.09
49	U	2	5.80
50	U	3	4.73
51	V	1	4.54
52	V	2	4.95
53	V	3	4.94
54	W	1	4.84
55	W	2	4.61
56	W	3	5.18
57	X	1	4.76
58	X	2	4.81
59	X	3	5.64
60	Y	1	4.73
61	Y	2	4.86
62	Z	1	4.88

Appendix C
Growth and Yield Data for Cotton Bioassay

Table C1
Average Seedling Height, centimeters/pot

Obs	Treat	Grid	Height Feb	Height Apr
1	P0K0N0	IM	39.25	50.40
2	P0K0N0	IM	40.85	52.25
3	P0K0N0	IM	41.20	56.25
4	P0K0N0	IM	39.20	51.30
5	P0K0N0	NZ	25.90	35.85
6	P0K0N0	NZ	23.50	35.20
7	P0K0N0	NZ	28.75	33.90
8	P0K0N0	NZ	30.90	36.25
9	P0K0N1	IM	30.75	51.20
10	P0K0N1	IM	46.05	63.35
11	P0K0N1	IM	40.85	69.35
12	P0K0N1	IM	33.05	57.10
13	P0K0N1	NZ	36.35	52.10
14	P0K0N1	NZ	34.95	54.90
15	P0K0N1	NZ	27.75	49.45
16	P0K0N1	NZ	32.30	59.05
17	P0K0N2	IM	42.05	67.65
18	P0K0N2	IM	38.00	61.10
19	P0K0N2	IM	47.85	64.05
20	P0K0N2	IM	38.00	57.00
21	P0K0N2	NZ	34.50	56.80
22	P0K0N2	NZ	39.20	48.35
23	P0K0N2	NZ	31.00	42.20
24	P0K0N2	NZ	30.45	50.75
25	P0K1N1	IM	30.30	71.65
26	P0K1N1	IM	43.75	59.00
27	P0K1N1	IM	41.95	55.90
28	P0K1N1	IM	42.20	56.95
29	P0K1N1	NZ	36.75	53.95
30	P0K1N1	NZ	38.10	49.40
31	P0K1N1	NZ	39.60	51.50
32	P0K1N1	NZ	34.25	54.00
33	P0K1N2	IM	45.50	65.65
34	P0K1N2	IM	45.20	73.30
35	P0K1N2	IM	40.65	60.25
36	P0K1N2	IM	30.05	79.95
37	P0K1N2	NZ	35.60	59.35
38	P0K1N2	NZ	39.95	52.35
39	P0K1N2	NZ	36.95	48.70
40	P0K1N2	NZ	35.95	46.75
41	P1K0N1	IM	44.90	66.25
42	P1K0N1	IM	40.35	52.45
43	P1K0N1	IM	44.70	60.35
44	P1K0N1	IM	44.05	73.35
45	P1K0N1	NZ	34.90	50.30
46	P1K0N1	NZ	39.45	70.80

(Continued)

Table C1 (Concluded)

Obs	Treat	Grid	Height Feb	Height Apr
47	P1K0N1	NZ	41.40	54.25
48	P1K0N1	NZ	35.35	51.55
49	P1K0N2	IM	43.65	66.85
50	P1K0N2	IM	38.30	60.30
51	P1K0N2	IM	39.60	71.30
52	P1K0N2	IM	47.15	71.65
53	P1K0N2	NZ	24.85	51.45
54	P1K0N2	NZ	45.30	57.45
55	P1K0N2	NZ	37.65	50.00
56	P1K0N2	NZ	39.15	55.80
57	P1K1N1	IM	47.35	58.50
58	P1K1N1	IM	44.90	61.65
59	P1K1N1	IM	40.50	54.55
60	P1K1N1	IM	36.75	54.90
61	P1K1N1	NZ	41.85	48.70
62	P1K1N1	NZ	43.65	56.55
63	P1K1N1	NZ	37.95	49.40
64	P1K1N1	NZ	45.20	63.95
65	P1K1N2	IM	42.45	71.15
66	P1K1N2	IM	31.75	54.60
67	P1K1N2	IM	50.10	74.50
68	P1K1N2	IM	43.20	64.75
69	P1K1N2	NZ	38.80	47.70
70	P1K1N2	NZ	36.50	48.35
71	P1K1N2	NZ	33.00	43.95
72	P1K1N2	NZ	31.30	53.00
73	P2K2N3	IM	32.65	61.90
74	P2K2N3	IM	43.00	69.35
75	P2K2N3	IM	45.20	85.80
76	P2K2N3	IM	44.30	75.90
77	P2K2N3	NZ	22.50	66.15
78	P2K2N3	NZ	24.35	59.20
79	P2K2N3	NZ	25.50	50.05
80	P2K2N3	NZ	16.30	49.10

Table C2
Greenhouse Seed Lint Yield

Obs	Treatmt	Grid	Yield g/pot	Yield kg/ha
1	CONTROL	IM	15.55	401.19
2	CONTROL	IM	13.35	344.43
3	CONTROL	IM	12.75	328.95
4	CONTROL	IM	12.85	331.53
5	CONTROL	NZ	0.00	0.00
6	CONTROL	NZ	1.75	45.15
7	CONTROL	NZ	1.35	34.83
8	CONTROL	NZ	0.00	0.00
9	P0K0N1	IM	16.05	414.09
10	P0K0N1	IM	34.65	893.97
11	P0K0N1	IM	17.65	455.37
12	P0K0N1	IM	24.05	620.49
13	P0K0N1	NZ	11.15	287.67
14	P0K0N1	NZ	15.45	398.61
15	P0K0N1	NZ	14.95	385.71
16	P0K0N1	NZ	17.85	460.53
17	P0K0N2	IM	24.45	630.81
18	P0K0N2	IM	26.75	690.15
19	P0K0N2	IM	39.35	1015.23
20	P0K0N2	IM	29.65	764.97
21	P0K0N2	NZ	17.95	463.11
22	P0K0N2	NZ	18.05	465.69
23	P0K0N2	NZ	11.95	308.31
24	P0K0N2	NZ	19.05	491.49
25	P0K1N1	IM	34.35	886.23
26	P0K1N1	IM	26.65	687.57
27	P0K1N1	IM	17.55	452.79
28	P0K1N1	IM	13.95	359.91
29	P0K1N1	NZ	9.05	233.49
30	P0K1N1	NZ	16.55	426.99
31	P0K1N1	NZ	15.15	390.87
32	P0K1N1	NZ	16.05	414.09
33	P0K1N2	IM	25.85	666.93
34	P0K1N2	IM	28.15	726.27
35	P0K1N2	IM	20.95	540.51
36	P0K1N2	IM	23.75	612.75
37	P0K1N2	NZ	17.25	445.05
38	P0K1N2	NZ	10.45	269.61
39	P0K1N2	NZ	16.65	429.57
40	P0K1N2	NZ	14.95	385.71
41	P1K0N1	IM	26.95	695.31
42	P1K0N1	IM	19.25	496.65
43	P1K0N1	IM	23.55	607.59
44	P1K0N1	IM	24.45	630.81
45	P1K0N1	NZ	10.85	279.93
46	P1K0N1	NZ	12.35	318.63
47	P1K0N1	NZ	13.25	341.85
48	P1K0N1	NZ	10.25	264.45

(Continued)

Table C2 (Concluded)

Obs	Treatmt	Grid	Yield g/pot	Yield kg/ha
49	P1K0N2	IM	26.05	672.09
50	P1K0N2	IM	26.65	687.57
51	P1K0N2	IM	26.65	687.57
52	P1K0N2	IM	23.55	607.59
53	P1K0N2	NZ	21.75	561.15
54	P1K0N2	NZ	19.25	496.65
55	P1K0N2	NZ	18.35	473.43
56	P1K0N2	NZ	21.65	558.57
57	P1K1N1	IM	18.55	478.59
58	P1K1N1	IM	15.95	411.51
59	P1K1N1	IM	20.55	530.19
60	P1K1N1	IM	15.65	403.77
61	P1K1N1	NZ	18.95	488.91
62	P1K1N1	NZ	17.85	460.53
63	P1K1N1	NZ	15.65	403.77
64	P1K1N1	NZ	17.05	439.89
65	P1K1N2	IM	32.75	844.95
66	P1K1N2	IM	25.05	646.29
67	P1K1N2	IM	30.35	783.03
68	P1K1N2	IM	32.35	834.63
69	P1K1N2	NZ	16.85	434.73
70	P1K1N2	NZ	17.05	439.89
71	P1K1N2	NZ	15.65	403.77
72	P1K1N2	NZ	16.55	426.99
73	P2K2N3	IM	46.65	1203.57
74	P2K2N3	IM	50.15	1293.87
75	P2K2N3	IM	57.55	1484.79
76	P2K2N3	IM	49.25	1270.65
77	P2K2N3	NZ	14.75	380.55
78	P2K2N3	NZ	19.55	504.39
79	P2K2N3	NZ	16.15	416.67
80	P2K2N3	NZ	18.65	481.17

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
July 1993

3. REPORT TYPE AND DATES COVERED
Report 1 of a series

4. TITLE AND SUBTITLE
Agricultural Uses of Yazoo River Dredged Material; Report 1, Cotton Production on Dredged Material in a Thick-Layer Confined Disposal Facility

5. FUNDING NUMBERS

6. AUTHOR(S)
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7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199;
U.S. Army Engineer District, Vicksburg, 2101 N. Frontage Road, Vicksburg, MS 39180-5191

8. PERFORMING ORGANIZATION REPORT NUMBER
Miscellaneous Paper EL-93-10

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Engineer District, Vicksburg
2101 N. Frontage Road
Vicksburg, MS 39180-5191

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
Available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

The use of Yazoo River dredged material for improving farmland considered marginal for cotton (*Gossypium hirsutum* L.) production was studied as an alternative to thick-layer confinement methods. The thick-layer confinement methods were not well received by landowners along the Yazoo River because of the loss of productive farmland by placement of confined disposal facilities (CDF) and lack of agricultural benefit. Disposal of Yazoo River dredged material in a shallow layer on marginal farmland not only provides for a means of dredged material disposal, but also improves marginal farmland making it more conducive to cotton production. Before the shallow-layer disposal concept was attempted, cotton response to Yazoo River dredged material was first studied on an existing thick-layer CDF.

Dredged material was collected from an existing thick-layer CDF, and the entire CDF was characterized physically and chemically. Based on particle size analysis, the CDF was divided into three sections characterized as clay, silty clay loam, and loam. The clay section, which made up one third of the CDF, was not suitable for cotton production due to high moisture-holding capacity of the excess clay. Cotton

(Continued)

14. SUBJECT TERMS
Agriculture — Dredged material
Cotton — Thick-layer disposal

15. NUMBER OF PAGES
60

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED		

13. (Concluded).

was grown in an environmentally controlled greenhouse on dredged material collected from the silty clay loam and loam sections under various fertilizer treatments. Lint yields were equivalent to 351.5 and 20.0 kg ha^{-1} with no fertilizer added to the silty clay loam and loam, respectively. Yields of 775.3 and 432.2 kg ha^{-1} on the silty clay loam and loam, respectively, were obtained with an N rate of 168 kg ha^{-1}. Lint yields were generally higher in the silty clay loam than the loam. Response to phosphorus and potassium additions was not as evident as response to additions of nitrogen and varied between the two test materials and nitrogen rates. Only nitrogen additions were determined necessary for substantial cotton production on Yazoo River dredged material, as tested.

Cotton was then planted on the CDF using normal agricultural practices, and nitrogen fertilizer was applied at 78 kg ha^{-1} preplant and 78 kg ha^{-1} sidedress actual nitrogen. A 0.4-ha (1-acre) test strip was harvested by normal mechanical means to determine the total lint yield. The deep-layer CDF produced an average yield of 870 kg ha^{-1} of ginned lint or about 1.6 bales per acre. This yield was considered equivalent to average yields obtained in the area for that growing season. This indicates Yazoo River dredged material can provide a beneficial medium for cotton production.