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CALCASIEU RIVER AND PASS DREDGED MATERIAL SEDIMENTATION STUDY

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Final Report

by

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1 Introduction

Background

As part of the Army Corps of Engineers mission to maintain navigable waterways of the US, an issue that must be addressed is the proper handling and storage/disposal/reuse of dredged material. One option for the storage of dredged material is the use of a confined disposal facility (CDF). A CDF is a diked area where dredged material is placed, either by mechanical methods of dredging or by hydraulic dredging. The conceptual design of the CDF requires an evaluation of the properties and settling behavior of the dredged material to be placed therein. This evaluation will provide information necessary to estimate storage requirements needed for the placement of dredged material along the Calcasieu River and Pass located in Lake Charles. Louisiana

Purpose

The purpose of this report is to document and present the results of the laboratory tests performed to measure sedimentation properties of the dredged material from the Calcasieu River and Pass located at Lake Charles, LA. Also presented will be the correlation between turbidity and total suspended solids (TSS).

Objectives

The overall objective was to support the U.S. Army Corps of Engineers, New Orleans District in their mission to dredge the Calcasieu River and Pass and to provide storage of the resulting dredged material. To fulfill this objective, settling tests were run to determine the settling behavior of the Calcasieu River and Pass sediments when they are hydraulically dredged. This will aid the District in managing the CDFs to meet their requirements. Also in support of the overall objective, data was collected on the turbidity and TSS concentrations in the water column during the settling column tests. This facilitated the development of a correlation curve for turbidity and TSS that a contractor and/or inspector can use to quickly *estimate* TSS by *measuring* turbidity. Turbidity is a much more easily and quickly measured parameter than TSS because turbidity is measured with a commercially available meter, while TSS has to be measured in a laboratory using ovens, analytical balances, filtration apparatus, and etc. Also, capacities of current CDFs along the Calcasieu River and Pass from mile 5-36 were evaluated to determine the volume of the CDFs for the placement of the dredged material. The volume calculations were based on the safe dike elevation calculations made for the disposal areas.

2 Column Settling Test Procedures

Physical Characteristics

Historical MVN test data on soil samples previously retrieved from the bottom of the Calcasieu River channel were reviewed for the purpose of determining appropriate locations for additional sampling in support of the Scope of Work.

Previous sampling was conducted by several dredging contracts during the 1990's from the river mouth (approximate mile 0) north to the Lake Charles area (approximate river mile 36), including an ERDC study (Calcasieu River Sediment Removal Study TN-EL-94-9 by Roy Wade) and the 1961 New Orleans District Design Memorandum.

One major purpose for identifying additional sampling locations was to optimize the evaluation of the future post-dredged material. The material behavior will be determined by conducting column settling tests for each sampled material.

The general trend for material classification in the channel bottom (surficial deposits) from the mouth up to Lake Charles is observed as follows:

Bar channel: Silty to Highly Plastic Clay (generally fat clay, CH)
Mile 0 to Mile 6: Silty Clay to Low Plasticity Silt (generally silt, ML)
Mile 6 to Mile 9: Silty Clay (CL) to Low Plasticity Silt (generally silt, ML)
Mile 9 to Mile 11: Silty Clay (CL)
Mile 11 to Mile 13: Silty Clay (CL) to Highly Plastic Clay (generally fat clay,CH)
Mile 13 to Mile 22: generally silt, ML, with some sandy silt SM and silty clay CL
Mile 22 to Mile 30: generally fat clay, CH
Mile 30 to Mile 36: sands and clays

It was recommended that sediment with a high percentage of clay be sampled to represent worst-case settling behavior. As a very general observation, there are three areas along the river channel bottom which have the highest probability of containing fat clay (CH) sediments:

-Nearshore below the river mouth
-Mile 11 to 13
-Mile 22 to 30

Since the study area begins at river mile 4, obtaining nearshore sediments to model upland CDF sites was not considered necessary unless those sediments will be dredged and placed in future CDF sites above mile 4.

Surficial sediment sampling along the channel bottom was recommended to be conducted within river miles 11 to 13 and river miles 22 to 30. Sampling locations based on previous soil test results were suggested as follows:

Mile 11 to 13:

State Plane Coordinates (NAD 83)	GPS Coordinates
X= 2645340, Y= 525286	29 55 44.89312, 93 20 22.86931
X= 2646119, Y= 531242	29 56 43.97991, 93 20 15.20108
X= 2645722, Y= 531280	29 56 44.28727, 93 20 19.72067
X= 2646113, Y= 533248	29 57 03.83401, 93 20 15.66811
X= 2645908, Y= 533266	29 57 03.97667, 93 20 18.00171

Mile 22 to 30:

State Plane Coordinates (NAD 83)	GPS Coordinates
X= 2650740, Y= 583019	30 05 17.25525, 93 19 32.91513
X= 2650761, Y= 585003	30 05 36.89585, 93 19 33.06881
X= 2650972, Y= 585030	30 05 37.19940, 93 19 30.67250
X= 2651146, Y= 585048	30 05 37.40749, 93 19 28.69555
X= 2652590, Y= 585443	30 05 41.56518, 93 19 12.33755
X= 2650500, Y= 585775	30 05 44.49192, 93 19 36.19244
X= 2654095, Y= 586800	30 05 55.25432, 93 18 55.47425
X= 2653820, Y= 587067	30 05 57.84990, 93 18 58.65713
X= 2663271, Y= 622263	30 11 47.81335, 93 17 17.91267

It was recommended that four (4) of the above sites be selected as sampling locations either at or near the coordinates within 200 feet of the channel centerline. At each selected location enough sample material was collected to fill four (4) five-gallon buckets, plus four (4) five-gallon buckets of river water. The four buckets of sediment will be tested for material properties (water content, gradation and classification, organic ash content, specific gravity, and atterberg limits). The four buckets will then be homogeneously mixed and tested to determine the anticipated future post-dredging settling behavior.

The physical characteristics of the dredged material are important in the design of a CDF and starting the column settling tests. Four sediment samples were used to evaluate the physical characteristics of the lower (mi. 5-14) and middle (mi. 14-24) reaches of Calcasieu River and Pass sediment (Table 1). The remaining portion of this sample was used for the settling column tests. Eustis Engineering performed the settling column tests on the 4 samples with the ERDC Environmental Lab performing a duplicate settling column test on sample A. Prior column testing and physical analysis was performed on three sections of the upper reach (mi. 33-36, mi. 30-33 and mi. 23-30, respectively) as reported by Wade (1994). Descriptions of geotechnical and engineering testing are presented below. Based on the Unified Soil Classification System, the Calcasieu sediments were classified as a CH for all four samples tested.

Specific Gravity. Specific gravity (SG) of the particulates in the sediment was measured using the procedures given in the Laboratory Soils Testing Engineering Manual (USACE 1970). The specific gravities of the four Calcasieu River sediments were 2.76, 2.70, 2.675, and 2.69 for samples A, B, C, and D, respectively.

Table 1 Sediment Physical Characteristics				
Characteristic	**Sample A**	**Sample B**	**Sample C**	**Sample D**
Specific Gravity	2.76/2.73*	2.70/2.72*	2.74/2.675*	2.74/2.69*
In Situ Solids Concentration				
Water content	298**	169**	281**	244**
Void ratio	8.2	4.6		
Atterberg Limits				
Liquid limit	105	132	104	75
Plastic limit	30	29	29	24
Plasticity index	75	103	75	51
Grain-Size Distribution				
Percent gravel	0.0	0.0	0.0	0.0
Percent sand	0.6	6.3	8.3	13.7
Percent silt/clay	99.4	93.7	91.7	86.3
Classification	CH	CH	CH	CH

* Data from Eustis Engineering

** Water content was performed on samples from buckets

Water Content. The in situ water content (W) of fine-grained sediment samples is also an important parameter evaluating settling behavior and the volumetric changes occurring following dredging and disposal. It should be noted that the water content in this appendix is identical to the geotechnical engineering water content. Since the water content is defined as the ratio of weight of water to weight of solids expressed as percent, it can exceed 100 percent. The procedures are given in the Laboratory Soils Testing Engineering Manual (USACE 1970). Using the specific gravity and water content, the void ratio (e) and solids concentration (S) can be expressed as follows:

$$e = \frac{W * SG}{100}$$

$$S = \frac{1000 * SG}{1 + e}$$

Grain-size Distribution. Grain-size distributions were determined on the samples using standard sieve and hydrometer analyses as outlined in the Laboratory Soils Testing Engineer Manual (USACE 1970). The resulting gradation curves are shown in Figures 1-4. The samples ranged from 86.3 to 99.4% fines.

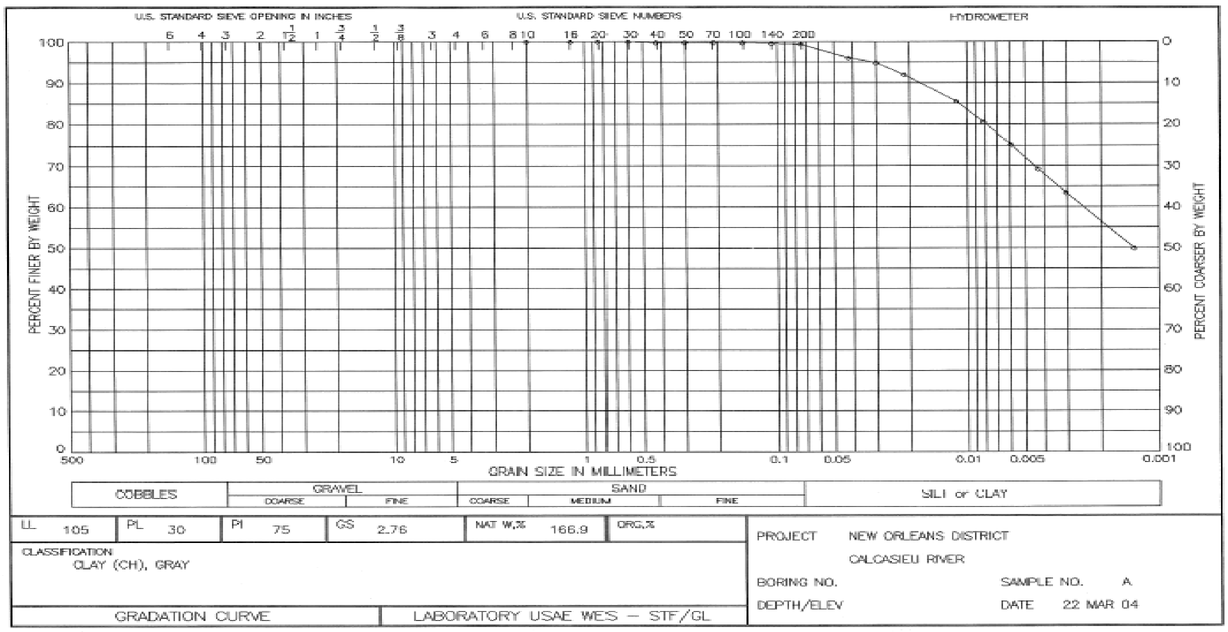

Figure 1. Gradation curve for Sample A of the Calcasieu River and Pass

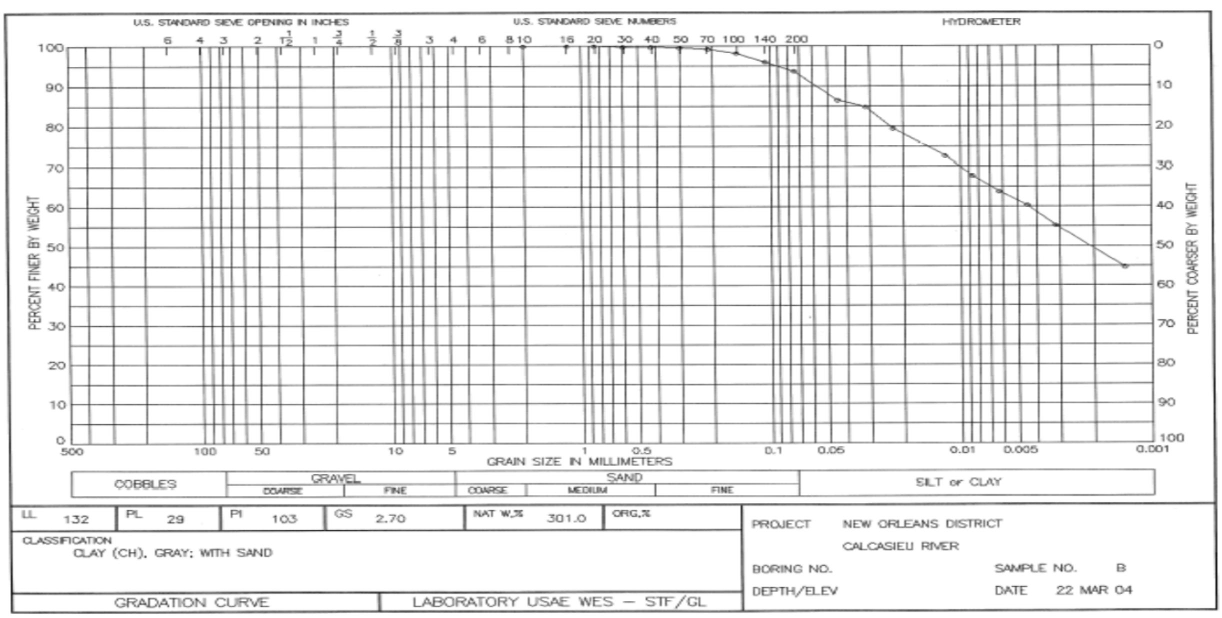

Figure 2. Gradation curve for Sample B of the Calcasieu River and Pass

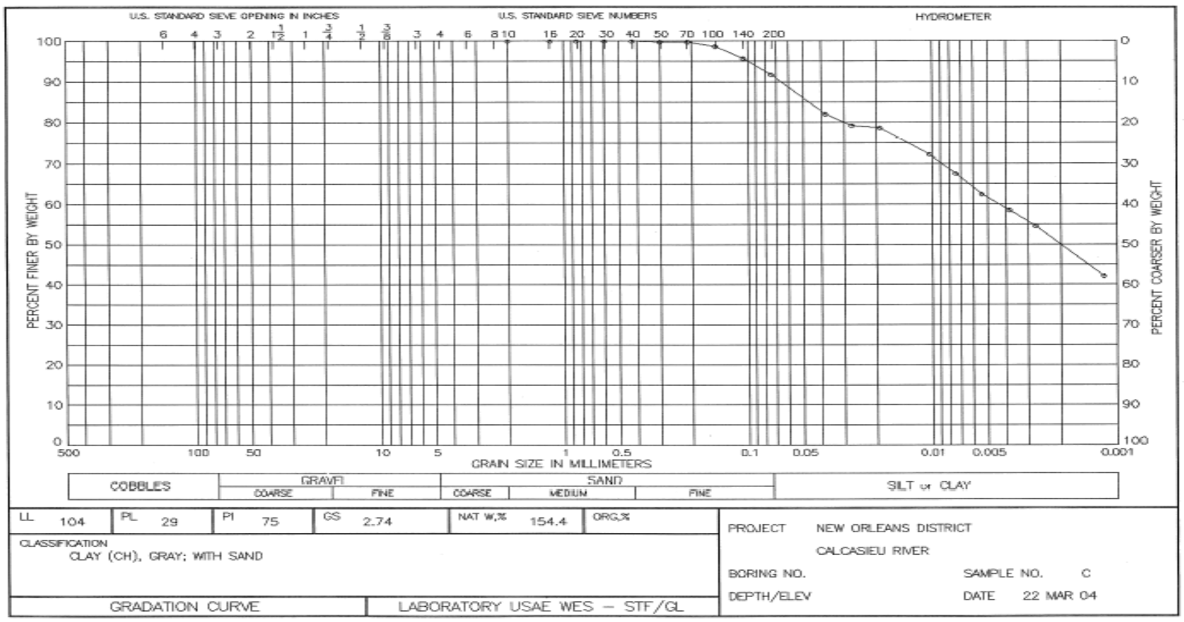

Figure 3. Gradation curve for Sample C of the Calcasieu River and Pass

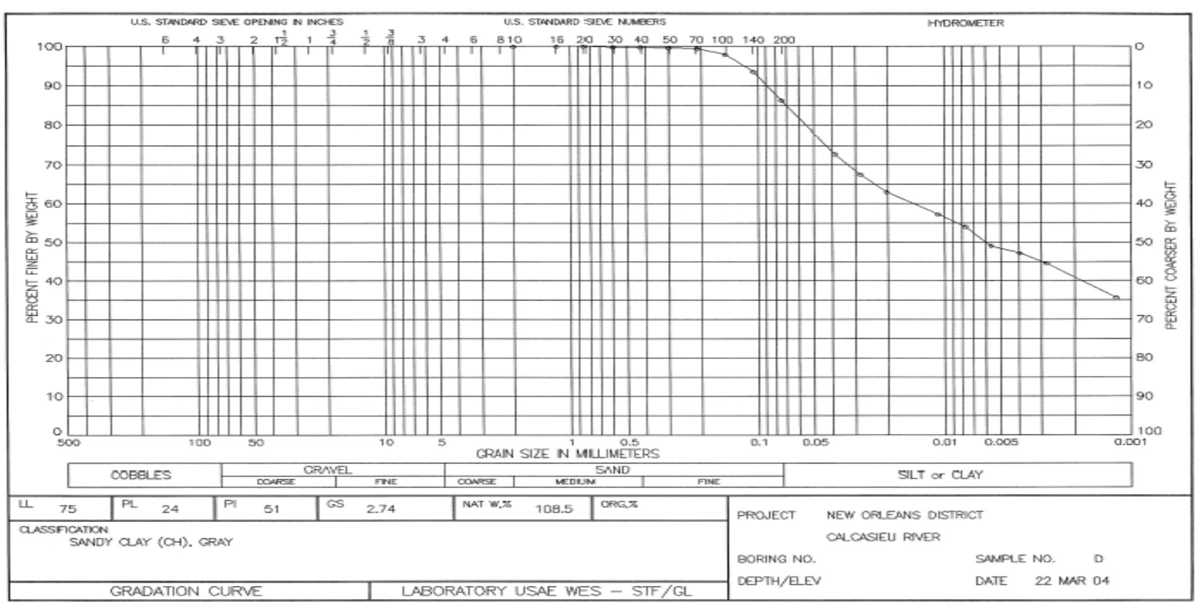

Figure 4. Gradation curve for Sample D of the Calcasieu River and Pass

Plasticity. The Liquid Limit (LL) and Plastic Limit (PL) were determined for composite sediment samples using standard soils testing procedures as outlined in the Laboratory Soils Testing Engineer Manual (USACE 1970). The plasticity index (PI) was then computed; PI = LL – PL.

Unified Soil Classification System (USCS) Classification. Visual classifications and classifications using results of the grain-size distribution and plasticity tests were determined using the USCS as outlined in the Laboratory Soils Testing Engineer Manual (USACE 1970).

Settling Column Test Experimental Procedures

The settling column test procedures described by Palermo, Montgomery, and Poindexter (1978), U.S. Army Corps of Engineers (USACE, 1987), and Palermo and Thackston (1988) provided the approach used to run the laboratory tests for determining the sedimentation properties of the Calcasieu River and Pass, samples A, B, C, and D, dredged material.

Settling tests

The column settling tests involved mixing sediment and site water to simulate the concentration of a dredged material slurry, placing the material in a settling column, and observing the different types of settling behavior. Conducting a single settling test for the composite samples collects all three types of settling data (zone, compression, and flocculent settling data). The general procedures are described below.

Laboratory Procedures

Slurry preparation

A target slurry concentration is used to simulate the solids concentration anticipated during production by a hydraulic dredge. Usually, target slurry concentrations selected for settling tests are dependent on the grain size distribution of the sample estimated by %fines plus 3 times the % coarse fraction. Solids concentrations were determined for the column settling tests by taking samples from the discharge pipe of a dredge performing work on the Calcasieu River just before the column settling tests were run. The average solids concentration measured from the dredge was 126 g/L.

After completely mixing the slurry, the mixing intensity was decreased to allow the majority of the coarse-grained material to settle in the mixing chamber while keeping the fine-grained material in suspension. While slowly mixing, the fine-grained slurry was transferred from the 130-liter mixing chamber to an 8-in. diameter, 6-ft tall column with ports at 0.5-ft intervals starting near the 6.0-ft height (Figure 5). Immediately after loading the column with the slurry, samples were extracted from the sampling ports at 1.0-ft intervals throughout the column. The average of the total solids samples collected from the column was used as the solid concentration for the column settling test. The total solids concentrations for the slurry (representing the fine-grained fraction of the original slurry) that was transferred into the columns are given in Table 2. The average total solids concentration was determined to be 127.65 g/L, 125.46 g/L, 127.98 g/l, and 113.12g/L for samples A, B, C, and D, respectively. The sample A tested by the Environmental Lab had an average suspended solids concentration of 135.4 g/L. A photo of the settling test of the Calcasieu sediments is shown in Figure 6.

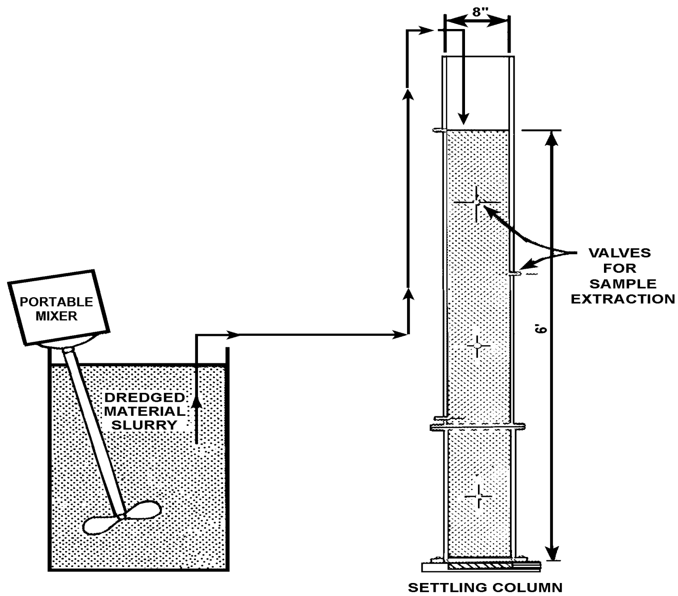

Figure 5. Schematic of settling column

Table 2. Total Solids Concentration of Column Slurry Sample

Port Height, (ft)	Sample A (g/L)	Sample B (g/L)	Sample C (g/L)	Sample D (g/L)
1.0	127.4/131.9*	125.9	126.2	122.2
2.0	126.4/136.5*	124.5	129.3	122.5
3.0	127.2/136.6*	128.4	129.5	113.3
4.0	128.1/136.8*	123.1	130.0	112.8
5.0	129.5/136.8*	124.0	127.0	109.2
6.0	127.3/133.6*	126.9	125.9	98.7
Average	127.65/135.4*	125.46	127.98	113.12

* Denotes samples collected by Environmental Laboratory

Figure 6. Calcasieu settling column test

Zone settling test

The zone settling test consists of recording the fall of the liquid-solids interface with time after placing the slurry in a sedimentation column. These data are plotted as height of the interface versus time. The slope of the curve in the constant velocity settling zone is the zone settling velocity, which is a function of the initial slurry concentration. The zone settling velocity is used in the design process to determine the minimum ponded area required for a given flow rate.

The zone settling test was performed concurrently with the compression settling test on the same slurry in the same column. Zone settling typically occurs during the first 12 hours of a dredged material settling test and compression settling occurs after the first 24 hours of the test. The height of the interface was read periodically during the first 12 hours with sufficient frequency to define the zone settling velocity. From the plot of the interface height (ft) versus time (hr), the zone settling velocity was determined.

Compression settling test

The compression settling test must be run to obtain data for estimating the volume required for initial storage of the dredged material. Following the zone-settling test (the first 12 hours immediately after the column was loaded with the slurry), the height of the interface was measured at approximately daily intervals for the next 15 days. The interface height, the initial height of the slurry, and the initial solids concentration of the slurry in the column are used to estimate the concentration of settled solids below the interface as a function of time as required in the compression settling analysis.

Flocculent settling test

The flocculent settling test consists of measuring the concentration of suspended solids above the liquid-solids interface at various depths and time intervals in a settling column. Normally, an interface forms near the top of the settling column during the first day of the test; therefore, sedimentation of the material below the interface is described as zone settling. The flocculent test procedure is performed only for that portion of the water column above the interface. Samples of the supernatant were extracted from each sampling port above the liquid-solid interface at different time intervals and the suspended solids concentrations were determined.

The flocculent settling test was performed concurrently with the zone and compression settling tests on the same slurry in the same column. Therefore, the initial slurry concentrations for the flocculent, zone, and compression settling tests were the same. Samples of the supernatant, if available, were extracted with a syringe at fixed ports located every 0,5 feet above the bottom of the column. Supernatant samples were collected at approximately 2, 4, 7, 12, 24, 48, 72, 96, 168, 264, and 360 hours after loading the slurry. Samples were taken at all ports above the supernatant-settled solids interface where supernatant was available. Suspended solids concentrations were then determined on the supernatant samples by Standard Method 2540D (APHA-AWWA-WPCF 1989). Turbidity of the supernatants were measured using a Hach Digital model 2100 turbidimeter and determined by Standard Method 2130B (APHA-AWWA-WPCF 1989). Substantial reductions of suspended solids are expected to occur during the early part of the test, but reductions should lessen at longer retention time (USACE 1987).

3 Data Analysis and Results for Column Settling Test

The behavior of the Calcasieu sediment at slurry concentrations equal to that expected for inflow to a CDF is governed by zone settling processes. The sediments exhibited a clear interface between settled material and clarified supernatant.

The settling test data were analyzed using the Automated Dredging and Disposal Alternative Management Systems (ADDAMS) (Schroeder and Palermo 1995) which is a family of computer programs developed at ERDC to assist in planning designing, and operating dredging and dredged material disposal projects. The SETTLE module of ADDAMS was used for the settling test data (Hayes and Schroeder 1992).

Data adjustment

Column settling tests were performed by Eustis on four sediment samples (A, B, C, D) from the Calcasieu River. A replicate of Sample A was also tested at ERDC. Upon examination of the Eustis data, it was discovered that the column settling tests were not performed exactly according to the column testing procedure guidance. At each sample interval, samples were taken from both above and below the sediment-water interface for Total Suspended Solids (TSS) and Total Solids (TS) analyses, respectively. The procedure guidance calls for only sampling below the interface for TS at the beginning of the test, and from that point on, sampling only above the interface for TSS.

Sampling below the interface throughout the test caused the measurements of the interface height over time to be lower than they should have been. Other effects could also have occurred, such as disturbance of the column, which may affect the settling rate, although there is no way to know these effects. The interface height measurements by Eustis include height reduction due to settling of the solids and sampling. To develop settling curves, the interface height as a function only of compression settling is needed. To account for the effect on the interface height, a series of calculations were performed to estimate what the interface height should have been in the absence of sampling. The calculations used to correct the interface height are based on the mass lost during each sampling event.

In theory, if sampling below the interface does not occur, the mass (M) of solids in the column remains constant. The mass (M) is equal to the solids concentration (C) times volume (V) below the solids interface, or since the column area is constant, we can simplify using the interface height (H) rather than volume; so M = CH. The following definitions will be used to develop the equations for estimating the theoretical interface height without sampling.

M_o -original mass
M_i -actual mass (after sampling) at time i
C_o -original solids concentration (average TS from initial TS sampling)
$\overline{C}_i$ -average solids concentration at time i, (average TS from TS sampling at time i)
C_i -solids concentration at time i (calculated based on mass at time i)
H_o -original height (slurry height at start of test, after initial TS sampling)
H_i -actual height at time i, (recorded interface height)
ΔH_i -height differential at time i due to sampling
H_{oi}' -theoretical original height if had started with mass M_i
H_i' -theoretical height at time I if had not sampled
M_o' -original mass if had started with the actual mass at time i, = M_i
M_i' -theoretical mass at time i, = M_o

The original mass of solids in the column can be calculated as

$$M_o = H_o C_o$$

Without sampling, mass is constant, $M_o = M_i$. However, since sampling occurred, a portion of the solids mass was removed at each sampling event, and $M_o \neq M_i$. M_i can be calculated as the original mass minus the cumulative mass lost:

$$M_i = H_o C_o - \sum_i^n \Delta H_i \overline{C_i}$$

Then, the theoretical original height, if had started with mass M_i, can be calculated as:

$$H_{oi}^{'} = \frac{M_i}{C_o}$$

Then, mass at time i is equal to the theoretical original mass ($M_i = M_o'$), which is equal to the original solids concentration times theoretical original height:

$$M_i = H_i C_i = H_{oi}^{'} C_o = M_o^{'}$$

Or, solving for the concentration at time i,

$$C_i = \frac{H_{oi}^{'} C_o}{H_i}$$

Then, the theoretical mass (had sampling not occurred) at time i, M_i' should equal the concentration at time i times the theoretical height at time i, and should equal the original mass ($M_o = M_i'$):

$$M_o = H_o C_o = H_i' C_i = M_i'$$

Rearranging, to solve for the theoretical height at time i:

$$H_i' = \frac{H_o C_o}{C_i}$$

This series of equations was used to adjust the data from Eustis to estimate the interface height had sampling below the interface not occurred. The computed values of H_i' from each column settling test were used to develop the compression settling curves.

Compression Settling Tests

For the compression tests, the initial slurry concentration and height, and height of the interface versus time were entered into SETTLE (Appendix A) for each of the 4 samples tested. The SETTLE program uses the initial slurry concentrations of 127.65 g/l, 135.4 (EL sample A) 125.46, 127.98, 113.12, and height of 6.85 ft, 6.24 ft (EL sample A), 6.46 ft, 6.61 ft, and 6.39 ft for samples A, B, C, and D, respectively, to determine the solids concentration at a given time. A plot was generated showing the relationship between solids concentration (g/L) and retention time (days) and is presented in Figure 7 for all the samples tested, including the results from prior testing of the three sections of the upper reach (Wade 1994). Appendix A shows the compression settling curves for each individual sample. SETTLE also generated a regression equation for the resulting power curve relating solids concentration to time. The composite sample regression equation may be used to determine the solid concentration at any given time. The regression coefficients are presented in Table 3. The regression equation used was:

$$C = aT^b$$

where:

C = settled solids concentration, g/L
T = time, days
a,b = regression coefficients

Zone Settling Tests

Zone settling velocity for the Calcasieu River sediment sample was determined to be 0.195 ft/hr, 0.175 ft/hr (EL sample A), 0.153 ft/hr, 0.172 ft/hr, and 0.131 ft/hr for samples A, B, C, and D, respectively, for the zone settling test. The height of the interface and their corresponding elapsed time from the start of the test when the height was measured were entered (Appendix B) and plotted in the SETTLE program to determine the zone settling velocity. Figure 8 presents the zone settling curves for all samples tested. Appendix B presents the zone settling curves for each individual sample. When the zone settling curve departs from a linear relationship, compression settling begins. The transition from zone to compression settling occurred between 10 and 12 hours (Appendix B). The zone settling velocity is adjacent to the plot of the zone settling data.

Table 3. Compression Settling Regression Coefficients					
Coefficient	**Sample A**	**Sample A (EL)**	**Sample B**	**Sample C**	**Sample D**
a	174	198	179	221	231
b	0.083	0.105	0.092	0.118	0.186

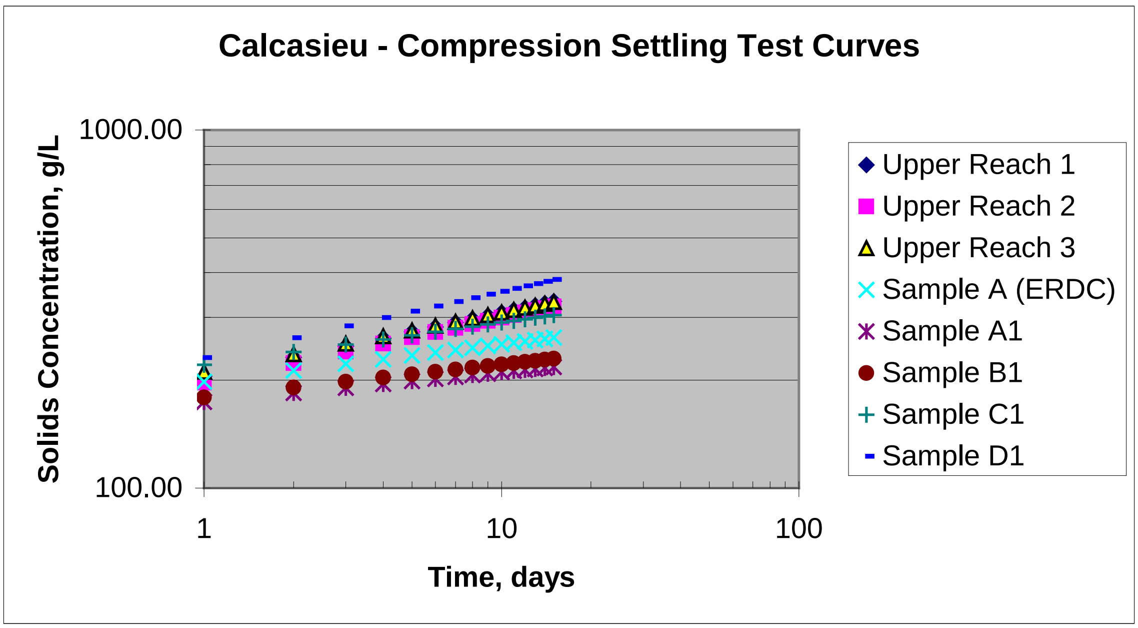

Figure 7. Compression settling curves for all samples.

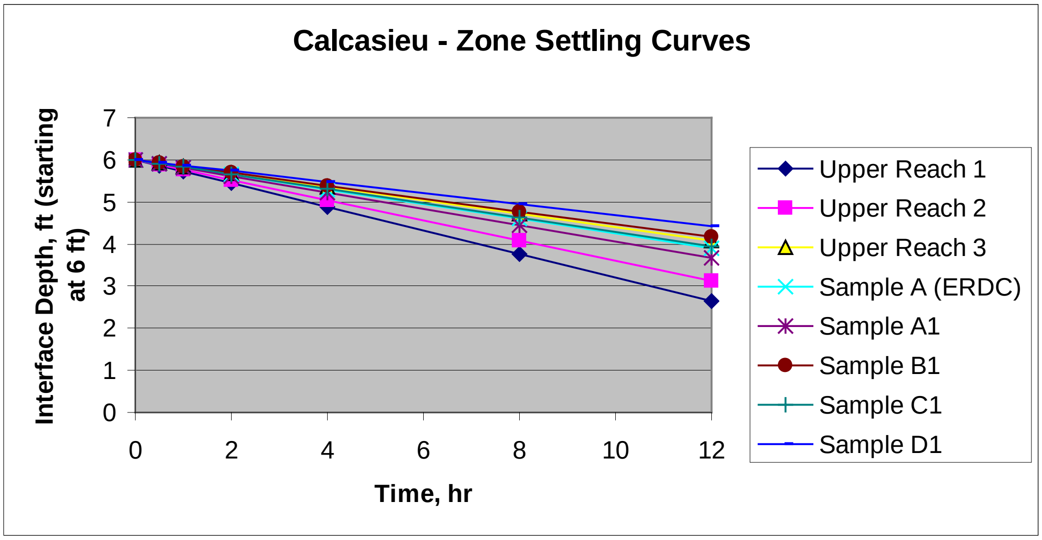

Figure 8. Zone settling curves for all samples, assuming initial slurry height of 6.0 feet

Flocculent Settling Tests

An extension of the flocculent settling test is presented in USACE (1987). Palermo (1985) analyzed the effects of several possible assumptions regarding the magnitude of the value to be used as the initial concentration in the laboratory test and showed that all gave essentially the same final result. Therefore, it was recommended that, for simplicity, the concentration in the first sample taken at the highest sampling port be used as the initial concentration. SETTLE generates two curves based on the settle data presented in Appendix C. The plot generated by SETTLE is the concentration profile curve (Appendix C). The concentration profile curve, which plots the depth below the surface (ft) versus percent of initial concentration, shows that the suspended solids concentrations decrease with time and increase at deeper ponding depths (1, 2, and 3 ft) at the weir. The actual depth of withdrawal is a function of the flow rate and the weir length; the depth is shallower for lower flow rates and longer weir lengths. The supernatant suspended solids curves derived from the concentration profile curves compare the effects of retention time on the supernatant suspended solids concentration at 1-, 2-, and 3-ft ponding depths. Figure 9 shows that increasing the retention time beyond 24 hr for 1, 2, or 3 ft of ponding depth provide little additional improvement in supernatant suspended solids concentration. Actual field suspended solids will be somewhat greater because of resuspension by wind and wave action. Based on field experience, a re-suspension factor is estimated to range from 1.5 to 2.5 depending on ponding depth and surface area (Shields, Schroeder, and Thackson 1987) (Table 4).

Table 4 Recommended Re-suspension Factors For Various Ponding Areas and Depths		
	Anticipated Average Ponded Depth	
Anticipated Ponded Area	**Less than 2 ft**	**2 ft or Greater**
Less than 100 acres	2.0	1.5
Greater than 100 acres	2.5	2.0

Turbidity

Samples of the supernatant from the flocculent settling test were split to measure turbidity of corresponding TSS concentration (Appendix D). TSS is commonly used as an indicator of the overall performance of CDFs, both for solids retention and for most other contaminants, which are strongly associated with the solid particles by adsorption or ion exchange. Turbidity, being much more easily measured than TSS, may be used instead of TSS during routine operational monitoring if approved by the regulatory agency.

The figures presented in Appendix D show the correlation curves between TSS and turbidity for the Calcasieu River sediment. The field inspector and others can measure the turbidity of the effluent with a turbidity meter and estimate a TSS concentration from the curve. Samples for TSS measurement can be collected less frequently for compliance monitoring and to field verify the correlation for laboratory samples.

Slope Stability and Stress Deformation Analysis.

A preliminary estimate of safe containment dike elevation (rotational stability analysis) was performed using GeoSlope’s Sigma/W and Slope/W packages. This preliminary estimate was performed for comparison purposes and to provide an early idea (phase I) of the storage capacity. For this estimate, the supporting data (foundation borings and soil properties) were taken from the 1961 New Orleans District Design Memorandum, in particular from Plate 23’s Retention Dike Shear Stability Analysis.

For a 10 ft-elevation (measured from the bottom to top of dike), the slope stability analysis results were similar to those for the 10 ft dike on Plate 23, with a safety factor around 1.4. Since the analyses fairly agree for a 10 ft dike, the same soil properties were used for analyzing the stability of higher dikes.

An 11 ft dike elevation filled to its top was found to have a minimum slope stability factor of safety of 1.2, and a 12 ft dike filled to its top has a minimum slope stability factor of safety of 1.0. If actual dike elevations reported to be 16 ft tall contain dredged material filled to the dike top, the factor of safety is less than one, and the dikes would be highly unstable.

Taking the fill elevation behind the dike into account, Figure 9 shows that a fill elevation between 8 ft and 11 ft yields safety factors approaching unity as the fill elevation is increased. With an 11 ft dike filled to capacity (no freeboard), the factor of safety against rotational failure is 1.2.

After construction of an 11 ft dike, finite element analysis indicated that initial deformation (immediate settlement) would be approximately 1 ft. An initial 11 ft-high dike would in effect become a

10 ft-high dike.

Based on the preliminary analyses for slope stability and initial stress deformation, it is recommended that the retention dikes be built no higher than 11 ft in elevation, with freeboard for 10 ft dredged material fill elevation. The factor of safety against slope failure should be between 1.2 and 1.3.

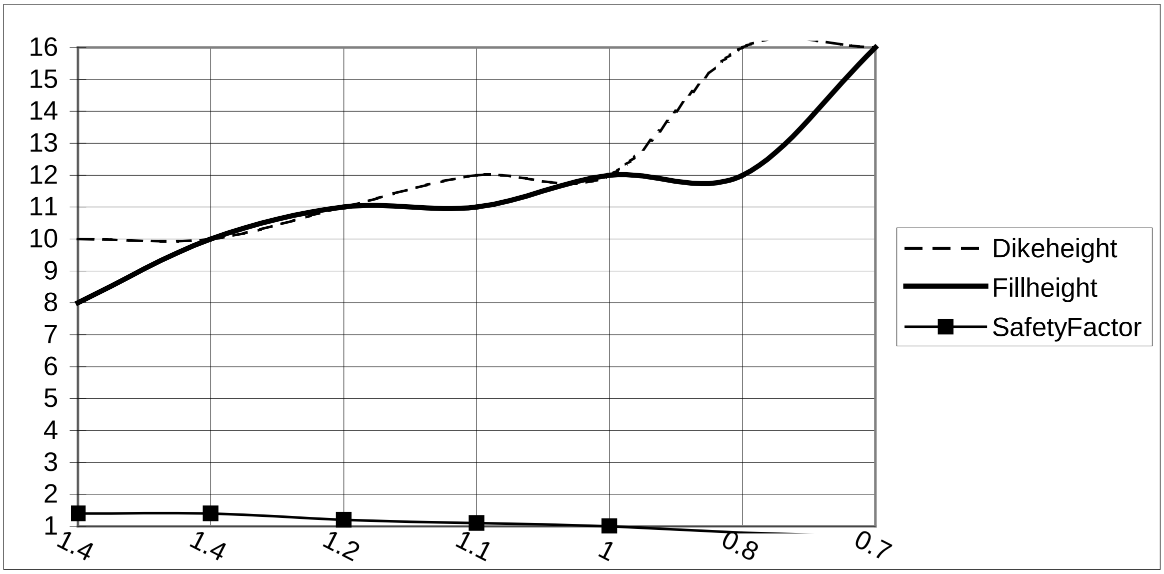

Figure 9. Fill elevation Versus safety factor for dike elevations

Alternatives for allowing higher dike elevations such as soil modification or reinforcement were not explored in this report. Higher dike elevations should be possible using such techniques, based on past projects in Mobile District, Norfolk District, and others.

4 CDF Volumes

Based on the data from the column settling tests, the CDF capacities were calculated for varying fill elevations and volumes. A lidar survey of the disposal areas was provided by the New Orleans District that provided data on the dike elevation of each CDF and the volume at varying fill elevations. The CDFs were grouped into three groups that represent the three reaches of the Calcasieu River that were studied for this phase of the DMMP. The upper reach incorporated CDFs 1 through 12B, the middle reach consisted of CDFs 13 through E, and the lower reach consisted of CDFs H, M, and N. Appendix E presents the lidar survey that was used for calculating the fill elevations.

The data for the column settling test for the upper reach, mile 24 to 36, was obtained from the study performed by Wade in 1994. The upper reach for the Wade report was divided in to three sub-reaches due to differences in the geotechnical characteristics of the sediments found in the upper reach. The three sub-reaches were identified as Reach 1, mile 33-36, Reach 2, mile 30-33, and Reach 3, Mile 24-30. The in-situ volume of material to be dredged from Reaches 1, 2, and 3 are 1.52 million yd^3, 1.73 million yd^3, and 3.25 million yd^3, respectively, for a total of 6.5 million cubic yards. Based on these volumes the SETTLE model computes the storage area needed for the material but does not include ponding within the CDF or freeboard. SETTLE models were run using two different dredge sizes, 27 inch and 30 inch. Using the settling column data, geotechnical data, and dredge size, Reach 1 requires a storage capacity of 2,180,950 yd^3 for the 27 inch dredge and 2,250,217 yd^3 for the 30 inch dredge. Reach 2 requires 1,519,669 yd^3 for the 27 inch dredge and 1,563,445 yd^3 dredge. Reach 3 requires 3,744,171 yd^3 for the 27 inch dredge and 3,852,476 yd^3 for the 30 inch dredge. The total volume requirement for the upper reach of the Calcasieu River is 7,444,790 yd^3 for a 27 inch dredge and 7,666,138 yd^3 for a 30 inch dredge.

Based on the Lidar surveys of disposal areas 1-12B, volumes were calculated at three different fill elevations. These elevations were 10 feet, 12 feet, and 14 feet. This was assuming a 2- foot freeboard within the disposal area so the dikes would be 2 feet higher than the fill elevations. Ponded area was not considered for this evaluation but should be added to assure adequate effluent quality and settling of the material within the CDF. At the 10- foot fill elevation, the volume of the present CDFs is 3,751,821 yd^3. The 12-foot fill elevation had a volume of 4,412,484 yd^3 and the 14-foot fill elevation had a volume of 4,537,518 yd^3. With the information provided on the safe dike elevation of 11 feet, with a safety factor of 1.2, it is not recommended going above this elevation for the dikes unless measures are taken to reinforce the dikes to prevent failure. The 10-foot fill elevation calculations were performed assuming a 12- foot elevation dike with a safety factor of 1.0.

The middle reach of the river, mile 14-24, has 4,500,000 yd^3 of in-situ material to be removed from the channel. The storage area needed for this material using a 27 inch and 30 inch dredge varies from between 4.5 and 9.6 million cubic yards. The large variance of volume needed for the material is due to the fact that the samples collected for the column settling tests had a wide range of moisture content. The moisture content of samples A, B, C, and D ranged from approximately 170% to almost 300%. Since these were grab samples and not cores taken from the channel these results could be misleading and not reflect what is actually present in the channel. Due to this, a range of moisture contents were input into the SETTLE model to predict the volume needed for storage of the dredged material. Using the 10- foot, 12- foot, and 14- foot fill elevations for the disposal areas used for the middle reach, the volumes that are currently available are 1,277,765 yd^3, 1,810,167 yd^3, and 2,520,037 yd^3, respectively.

The lower reach of the river, mile 5-14, has approximately 4 million cubic yards of in-situ material to be dredged from the river. Using calculations for a 27 and 30 inch dredge, the storage capacity needed for the lower reach CDFs ranges between 4 and 9 million cubic yards. Like the middle reach, the samples collected varied in moisture content so different moisture contents were entered into SETTLE in order to obtain a range of the storage volume needed to hold the 4 million cubic yards of in-situ material. The CDFs on the lower reach of the river do not presently have dike elevations over 10 feet. Site H has a dike elevation of 10 feet, site M has an elevation of 6 feet, and site N has a dike elevation of 8 feet in the front and 6 feet in the back. Due to these dike elevations there is only a capacity of 567,896 yd^3 for the placement of dredged material in the lower reach. Depending on the scheduling of the dredging to be performed on the Calcasieu River, disposal areas E and D could be used for some of the dredging done for the lower reach. Table 5 shows that depending on the dike elevation, this would increase the lower reach storage capacity to approximately 1 million cubic yards based on the 10 foot dike elevation. It should be noted that if these areas are used for the lower reach then the capacity for the middle reach will be decreased for the storage of the dredged material from that reach.

The total amount of sediment to be dredged for the Calcasieu River between miles 5 and 36 is 15 million cubic yards of in-situ material. Depending on the dredge size used, 27 or 30 inches, the total storage area needed to dispose of this material is between 16 and 26.5 million cubic yards. The range of the storage area needed is due to the fact that water contents used for the model runs were 100%, 150%, 200%, 250%, and 300% due to the fact that the samples collected and those previously done by Wade in 1994 varied from around 100% to close to 300%. Table 5 presents the current capacities for each CDF used for the placement of dredged material from miles 5-36 along the Calcasieu River. Table 8 presents the storage capacity for each CDF at the 10 foot, 12 foot, and 14 foot fill elevation along with the total volume of material to be dredged.

Table 5. Storage capacity of current CDFs using varying fill elevations

Disposal Area	Current capacity fill up to 10'	Current capacity fill up to 10'	Current capacity fill up to 12'	Current capacity fill up to 12'	Current capacity fill up to 14'	Current capacity fill up to 14'	In Situ dredge volume	Capacity needed for 30" dredge
1	150,041		292,014		292,014			
2	48,400		153,267		278,301			
3 (Clooney Island)	194,407		509,815		509,815			
4	171,014		171,014		171,014			
5	192,794		291,208		291,208			
6	Out		Out		Out			
7	772,790		772,790		772,790			
8	909,924		909,924		909,924			
9	0		0		0			
10	204,894		204,894		204,894			
11	197,634		197,634		197,634			
12A	258,134		258,134		258,134			
12B	651,789	3,751,821	651,789	4,412,484	651,789	4,537,518	6,500,000	7,666,138
13 (Choupique Island)	379,135		379,135		379,135			
15	422,695		422,695		422,695			
16N	0		0		0			
16S	Out		Out		Out			
17	0		0		0			
22	0		145,201		145,201			
23	0		24,200		161,334			
D	121,000		484,002		1,056,737			
E	354,935	1,277,765	354,935	1,810,167	354,935	2,520,037	4,500,000	4.5 to 9.8 MCY
H	164,561		164,561		164,561			
M	403,335		403,335		403,335			
N	0	567,896	0	567,896	0	567,896	4,000,000	4.0 to 9.0 MCY
Total	5,597,482	5,597,482	6,790,547	6,790,547	7,625,450	7,625,450	15,000,000	16.2 to 26.5 MCY

5 Conclusions

Conclusions

Based on the result of the settling tests, consolidation tests, and turbidity measurements, it is concluded that:

a. Dredged material from the Calcasieu River and Pass is predominantly fine grain material in the middle and lower reaches accounting for approximately 90 % of the material. The upper reach of the study area averages approximately 40 % sand and 60 % fines.

b. The Calcasieu River sediment exhibited zone settling. The zone settling velocity was 0.195 ft/hr, 0.175 ft/hr (EL sample A), 0.153 ft/hr, 0.172 ft/hr, and 0.131 ft/hr for samples A, B, C, and D, respectively.

c. The curves developed for the correlation between TSS and turbidity for the 4 samples had varying R^2 values ranging from0.4611 to 0.9636. It is suggested that the curve developed by ERDC be used for determining the correlation between TSS and turbidity. It should be noted that this is a rough approximation and should be used for no other reason than to estimate TSS.

d. A slope stability analysis was performed to approximate the safe dike elevation that could be used for the disposal areas. The analysis was performed using data supplied by the New Orleans District in a 1961 memorandum. The safe dike elevation was determined to be 11 feet with a safety factor of 1.2. A dike elevation of 12 feet gives a safety factor of 1.0. It is recommended that dikes not be built above the 11 foot elevation unless measures are taken to strengthen the foundation materials so as to reduce the chance of dike failure.

e. Water contents varied greatly for the samples collected from sites A, B, C, and D. Due to this, and the fact that the upper reach samples previously collected by Wade, 1994 were lower, a range of water contents were used in running the SETTLE model. This resulted in a range of estimated dredged material storage requirements in the middle and lower reaches. More accurate estimates could be achieved if representative water contents were available for the in-situ material to be dredged in each reach.

f. The total volume of material to be dredged from the Calcasieu River and Pass in the short term is 15,000,000 yd^3. The upper reach has a total of 6.5MCY, the middle reach has a total of 4.5 MCY, and the lower reach has a total of 4.0 MCY.

g. Depending on the size dredge used for the removal of the material, 27 or 30 inch, the upper reach requires a storage volume of 7.5 to 7.75 MCY. The middle reach requires a storage area between 4.5 and 9.8 MCY. The lower reach requires a storage volume of between 4.0 and 9.0 MCY. The total area needed for storage between miles 5 and 36 is between 16.0 and 26.5 MCY.

h. Three fill elevations were used to determine the present storage capacities of the CDFs along the Calcasieu River. The 10-foot fill elevation has a storage capacity of approximately 5.6 MCY, the 12-foot fill elevation has a storage capacity of approximately 6.8 MCY, and the 14-foot fill elevation has a storage capacity of approximately 7.6 MCY

i. From the results of the column settling tests and the SETTLE model for the samples collected and the data from Wade 1994, the results indicate that the storage volume present in the CDFs along the Calcasieu River and Pass is not adequate for the storage of all the dredged material that is proposed to be removed in the next 1-3 years.

j. A long-term DMMP needs to performed on the Calcasieu River and Pass to address the issue of the lack of storage capacity for the placement of dredged material over the next 20 years. This DMMP would look at management of the existing CDFs and the siting of new disposal areas along with other uses of the dredged material such as beneficial uses and erosion control.

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APPENDIX A
COMPRESSION SETTLING DATA AND CURVES

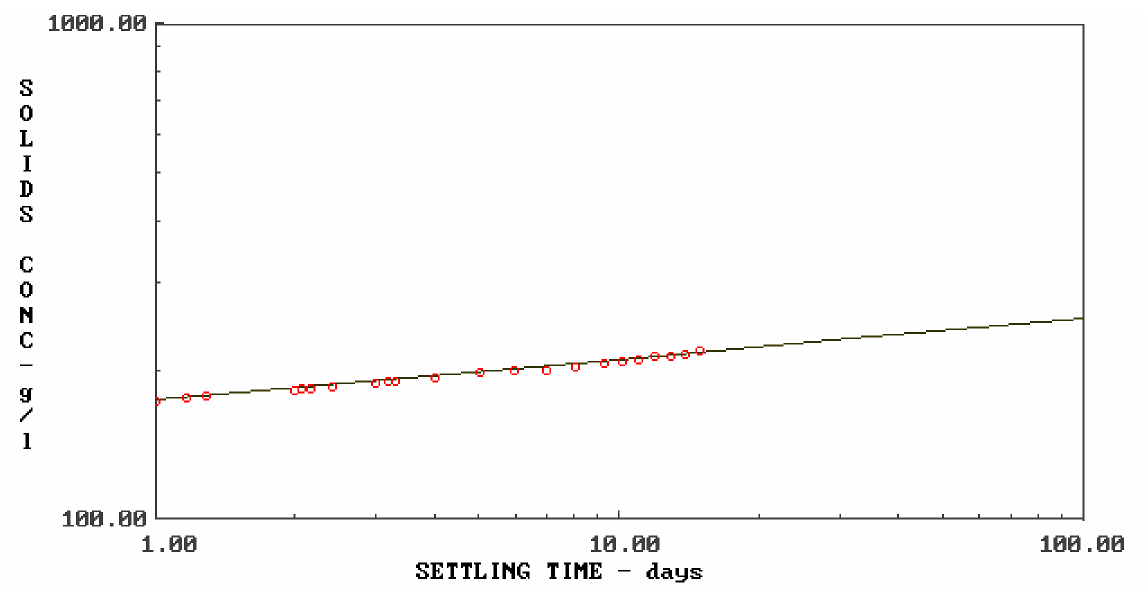
Table 3 Compression Settling Test Data For Sample A (Eustis)				
Date	**Time**	**Time Interval (Hours)**	**Time Interval (Days)**	**Interface Height (Ft)**
09 Dec 2003	0900	0	0	6.85
10 Dec 2003	0900	24	1	5.05
11 Dec 2003	0900	48	2	4.81
12 Dec 2003	0900	72	3	4.67
15 Dec 2003	0800	143	6	4.41
16 Dec 2003	0900	168	7	4.41
17 Dec 2003	1000	193	8	4.35
18 Dec 2003	1530	222.5	9	4.29
19 Dec 2003	1400	245	10	4.25
22 Dec 2003	0900	312	13	4.14
24 Dec 2003	0900	360	15	4.08

Table 3 Compression Settling Test Data For Sample A (EL Sample)				
Date	**Time**	**Time Interval (Hours)**	**Time Interval (Days)**	**Interface Height (Ft)**
09 Dec 2003	0900	0	0	6.24
10 Dec 2003	0900	24	1	4.23
11 Dec 2003	0915	48.25	2	3.98
12 Dec 2003	1000	73	3	3.83
15 Dec 2003	0930	144.5	6	3.58
16 Dec 2003	1000	169	7	3.51
17 Dec 2003	0900	192	8	3.45
18 Dec 2003	1100	218	9	3.40
19 Dec 2003	0915	240.25	10	3.36
22 Dec 2003	1000	313	13	3.24
24 Dec 2003	1000	361.5	15	3.18

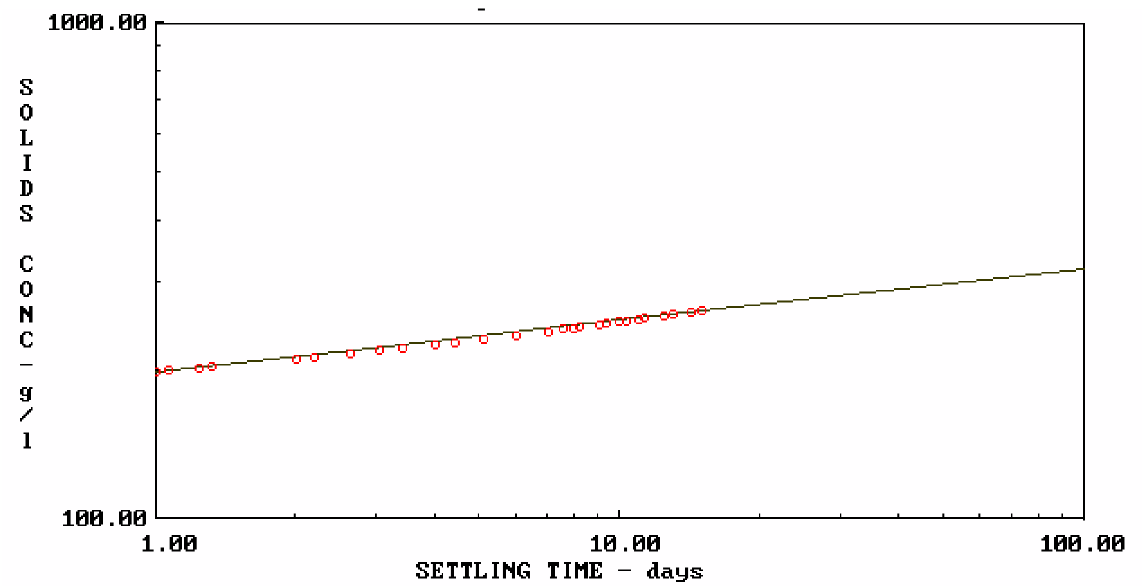
Table 3 Compression Settling Test Data For Sample B				
Date	**Time**	**Time Interval (Hours)**	**Time Interval (Days)**	**Interface Height (Ft)**
30 Dec 2003	0830	0	0	6.46
31 Dec 2003	0830	24	1	4.88
01 Jan 2004	0830	48	2	4.63
02 Jan 2004	0830	72	3	4.52
05 Jan 2004	0830	144	6	4.26
06 Jan 2004	0830	168	7	4.21
7 Jan 2004	1020	193.83	8	4.16
8 Jan 2004	0830	216	9	4.12
9 Jan 2004	1045	242.25	10	4.09
12 Jan 2004	1300	316.5	13	3.98
14 Jan 2004	0830	360	15	3.93

Table 3 Compression Settling Test Data For Sample C				
Date	**Time**	**Time Interval (Hours)**	**Time Interval (Days)**	**Interface Height (Ft)**
15 Jan 2004	0800	0	0	6.61
16 Jan 2004	0800	24	1	3.92
17 Jan 2004	0800	48	2	3.65
18 Jan 2004	0800	72	3	3.52
21 Jan 2004	1530	151	6	3.28
22 Jan 2004	0800	168	7	3.24
23 Jan 2004	1600	200	8	3.20
24 Jan 2004	1230	220.5	9	3.14
25 Jan 2004	1200	244	10	3.10
28 Jan 2004	0800	312	13	3.01
30 Jan 2004	0800	360	15	2.98

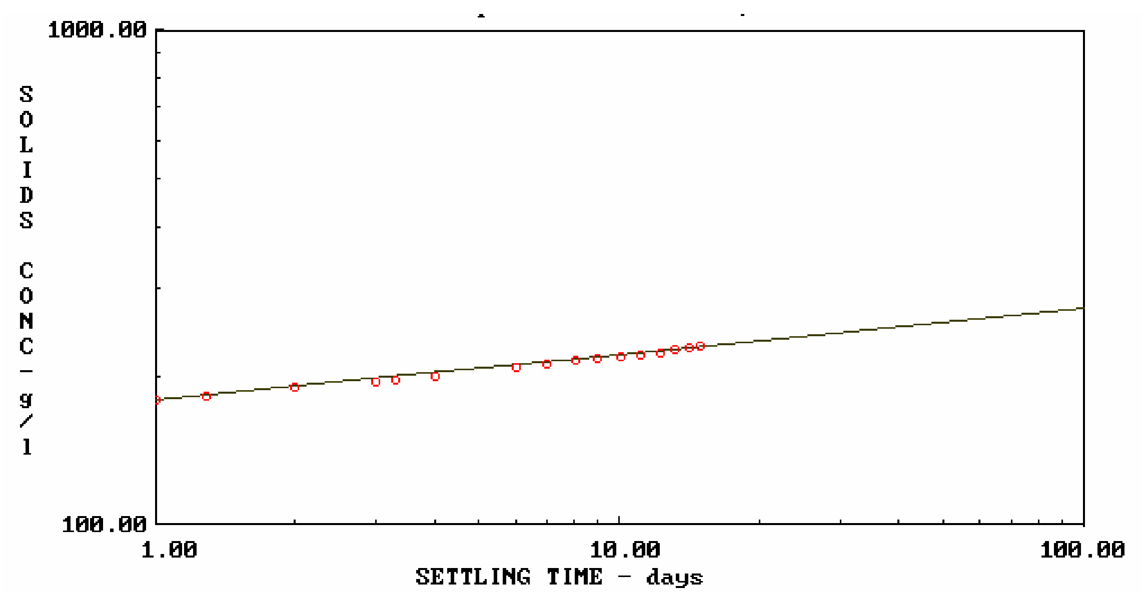
Table 3 Compression Settling Test Data For Sample D				
Date	Time	Time Interval (Hours)	Time Interval (Days)	Interface Height (Ft)
31 Jan 2004	0900	0	0	6.38
01 Feb 2004	0900	24	1	3.35
02 Feb 2004	0900	48	2	2.90
03 Feb 2004	0900	72	3	2.74
06 Feb 2004	0800	143	6	2.49
07 Feb 2004	0900	168	7	2.42
09 Feb 2004	1000	217	9	2.33
10 Feb 2004	1550	246.83	10	2.28
13 Feb 2004	1300	316	13	2.19
15 Feb 2004	0900	360	15	2.14



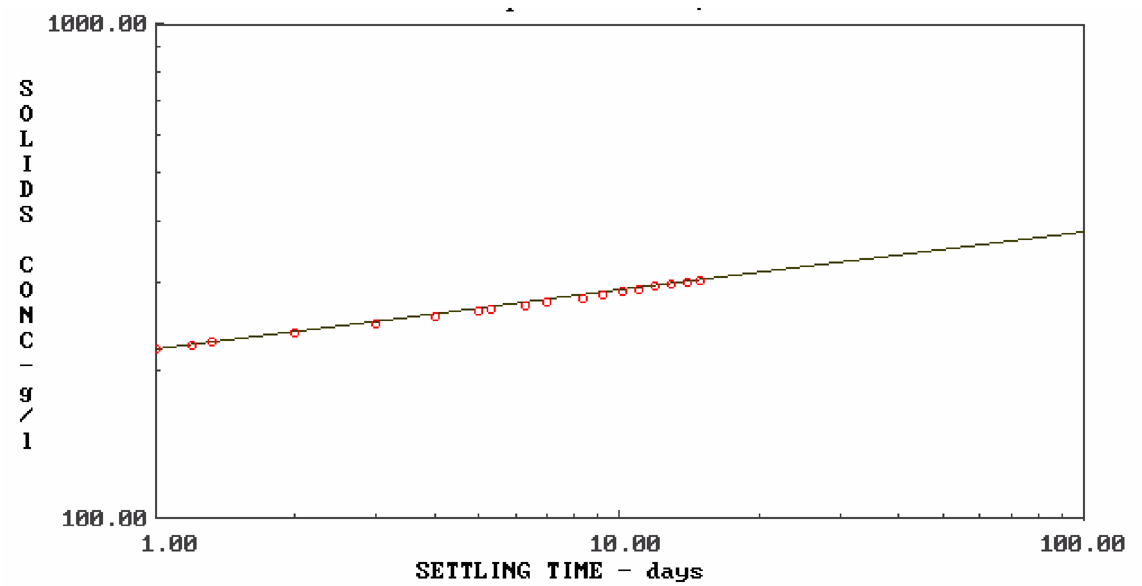
Calcasieu River Sample A (Eustis) compression settling curve



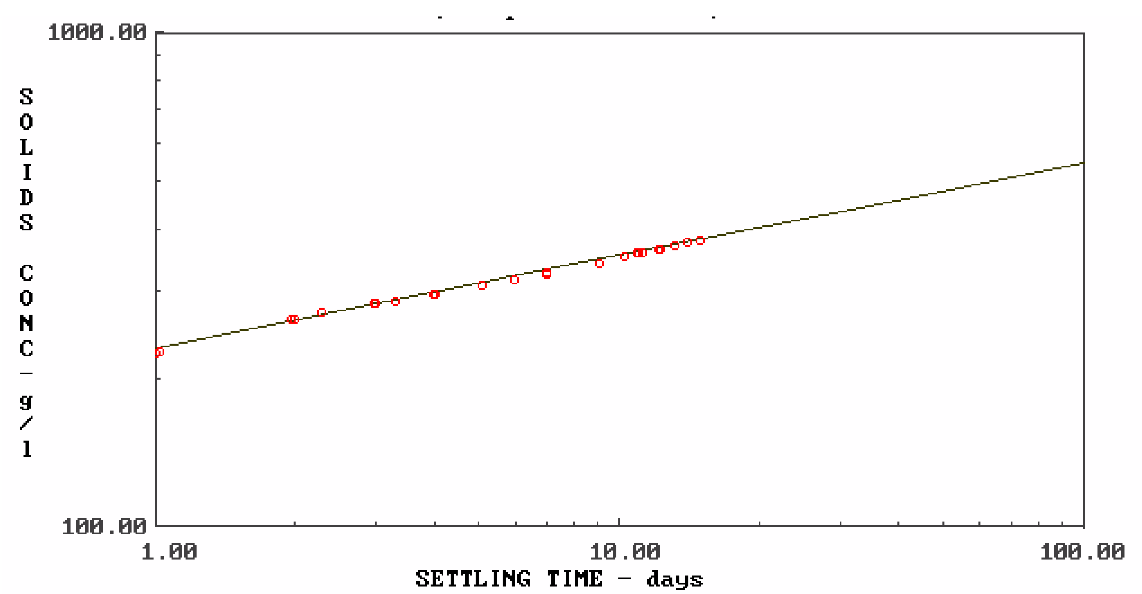
Calcasieu River Sample A (ERDC) compression settling curve



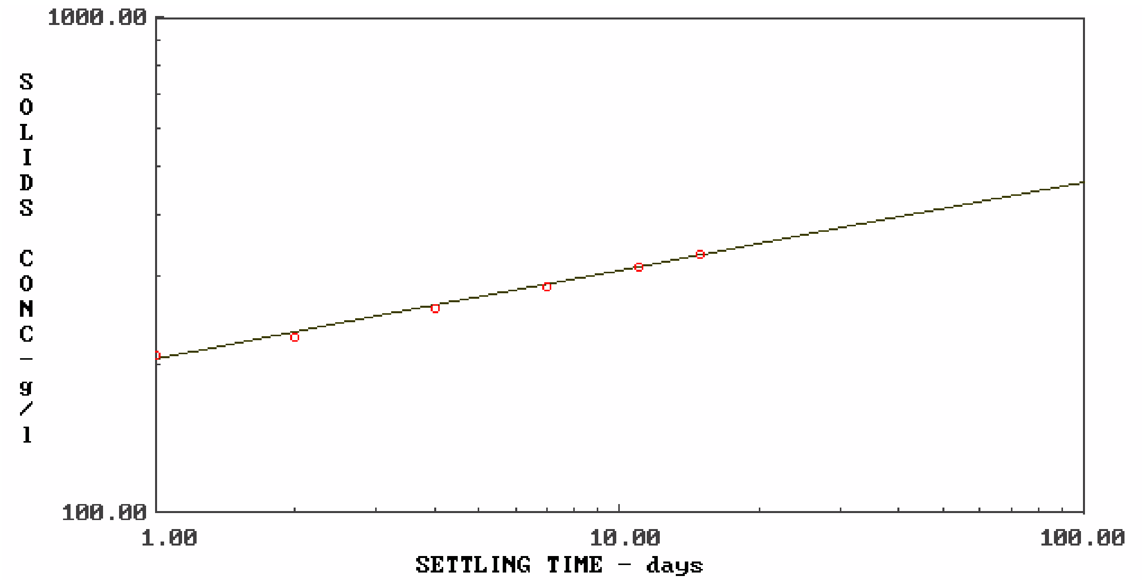
Calcasieu River Sample B compression settling curve



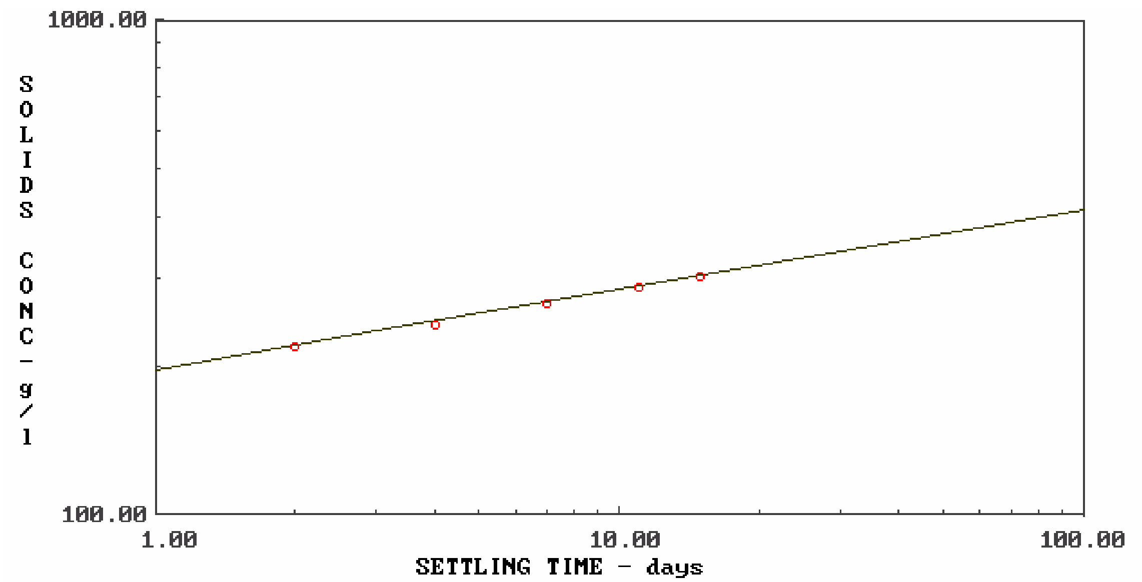
Calcasieu River Sample C compression settling curve



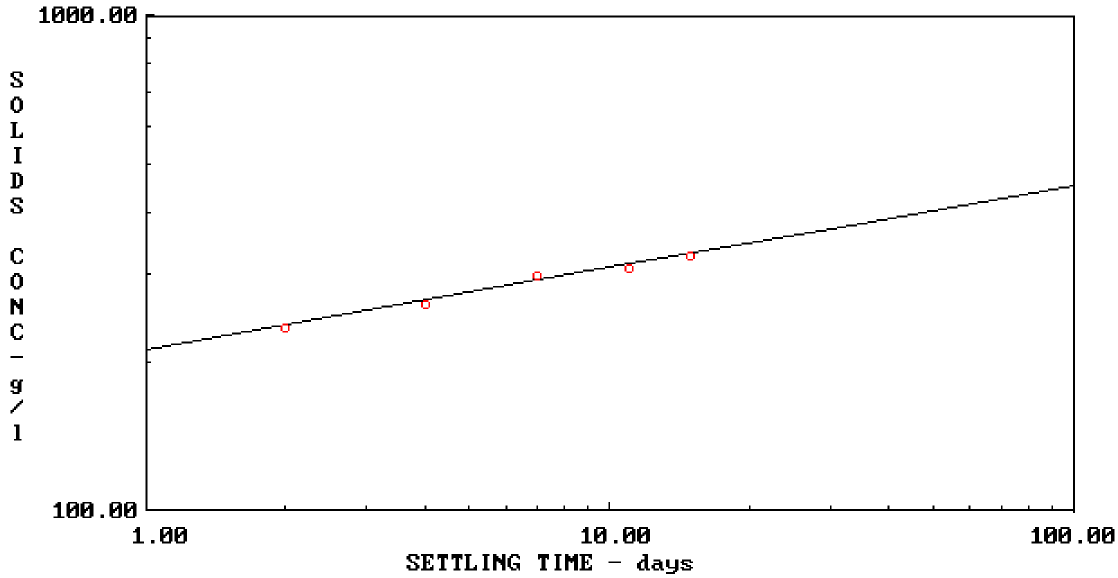
Calcasieu River Sample D compression settling curve



Calcasieu River Upper Reach 1 compression settling curve



Calcasieu River Upper Reach 2 compression settling curve



Calcasieu River Upper Reach 3 compression settling curve

APPENDIX B
ZONE SETTLING DATA AND CURVES

Table 4 Zone Settling Test Data Sample A

Time	Elapsed Time, hrs	Interface Height, ft
0900 09 Dec 2003	0.00	6.85
0930	0.50	6.82
1000	1.00	6.78
1030	1.5	6.76
1100	2.00	6.74
1130	2.5	6.72
1200	3.0	6.69
1300	4.0	6.58
1330	4.5	6.50
1400	5.0	6.41
1430	5.50	6.33
1500	6.0	6.21
1530	6.5	6.11
1600	7.0	6.01
1800	9.0	5.69
1900	10.0	5.51
2100	12.0	5.39
0900 10 Dec 2003	24.0	5.05

Notes: The slurry concentration was 127.65 g/L. The salinity was 26.5 parts per thousand.

Table 4 Zone Settling Test Data Sample A (Environmental Lab)

Time	Elapsed Time, hrs	Interface Height, ft
0900 09 Dec 2003	0.00	6.24
0930	0.50	6.24
0945	0.75	6.24
1000	1.0	6.22
1015	1.25	6.20
1030	1.5	6.17
1045	1.75	6.14
1100	2.0	6.115
1115	2.25	6.08
1130	2.5	6.04
1145	2.75	6.0
1215	3.25	5.91
1230	3.5	5.866
1240	3.66	5.86
1300	4.0	5.81
1330	4.5	5.715
1400	5.0	5.62
1430	5.5	5.54
1500	6.0	5.48
1530	6.5	5.38
1600	7.0	5.29
1700	8.0	5.14
1900	10.0	4.79
2130	12.5	4.53
2315	14.25	4.46
0200	17.0	4.367
0900 10 Dec 2003	24	4.23

Notes: The slurry concentration was 135.4 g/L. The salinity was 26.5 parts per thousand.

Table 4 Zone Settling Test Data Sample B

Time	Elapsed Time, hrs	Interface Height, ft
0830 30 Dec 2003	0.00	6.46
0845	0.25	6.44
0900	0.50	6.42
0915	0.75	6.40
0930	1.0	6.40
0945	1.25	6.38
1000	1.50	6.37
1030	2.0	6.36
1045	2.25	6.36
1100	2.5	6.35
1115	2.75	6.31
1130	3.0	6.31
1145	3.25	6.30
1200	3.50	6.28
1215	3.75	6.25
1230	4.0	6.22
1245	4.25	6.20
1300	4.50	6.16
1315	4.75	6.12
1330	5.0	6.08
1345	5.25	6.05
1400	5.50	6.01
1415	5.75	5.97
1430	6.0	5.93
1445	6.25	5.89
1530	7.0	5.78
2030	12.0	5.28
0830 31 Dec 2004	24	4.88

Notes: The slurry concentration was 125.46 g/L. The salinity was 26.5 parts per thousand.

Table 4 Zone Settling Test Data Sample C

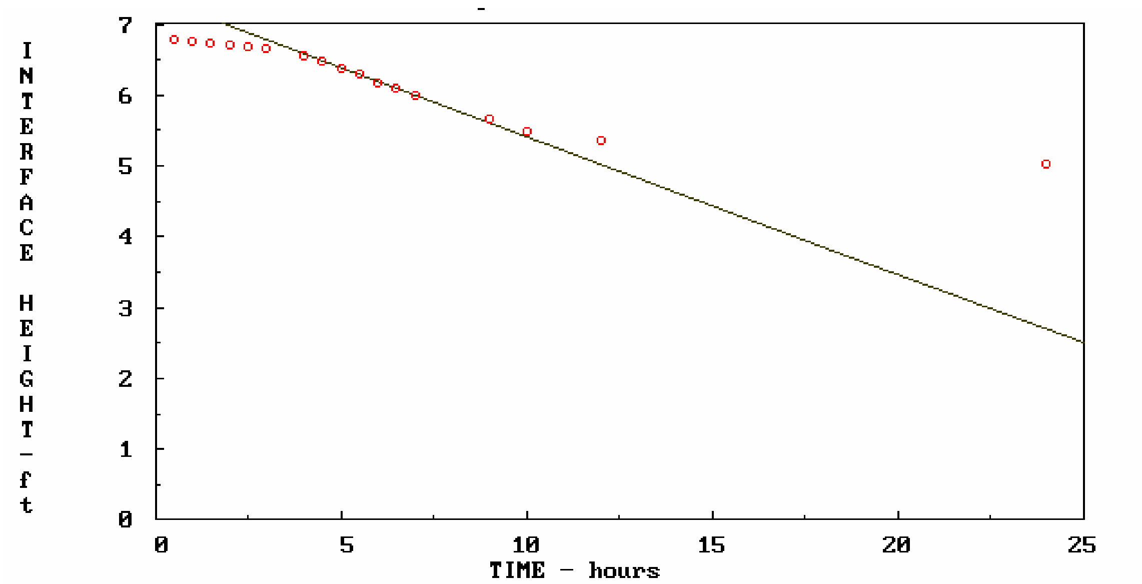
Time	Elapsed Time, hrs	Interface Height, ft
0800 15 Jan 2004	0.00	6.61
0815	0.25	6.60
0830	0.5	6.57
0845	0.75	6.54
0900	1.0	6.49
0915	1.25	6.47
0930	1.50	6.43
0945	1.75	6.37
1000	2.0	6.34
1030	2.5	6.26
1045	2.75	6.21
1115	3.25	6.10
1130	3.50	6.08
1200	4.0	6.00
1230	4.5	5.90
1245	4.75	5.83
1300	5.0	5.79
1315	5.25	5.74
1330	5.50	5.71
1345	5.75	5.66
1400	6.0	5.63
1415	6.25	5.58
1430	6.50	5.55
1445	6.75	5.50
1500	7.0	5.47
1530	7.50	5.42
1600	8.0	5.35
1730	9.5	5.13
2000	12.0	4.79
0800 16 Jan 2004	24	3.92

Notes: The slurry concentration was 127.65 g/L. The salinity was 26.5 parts per thousand.

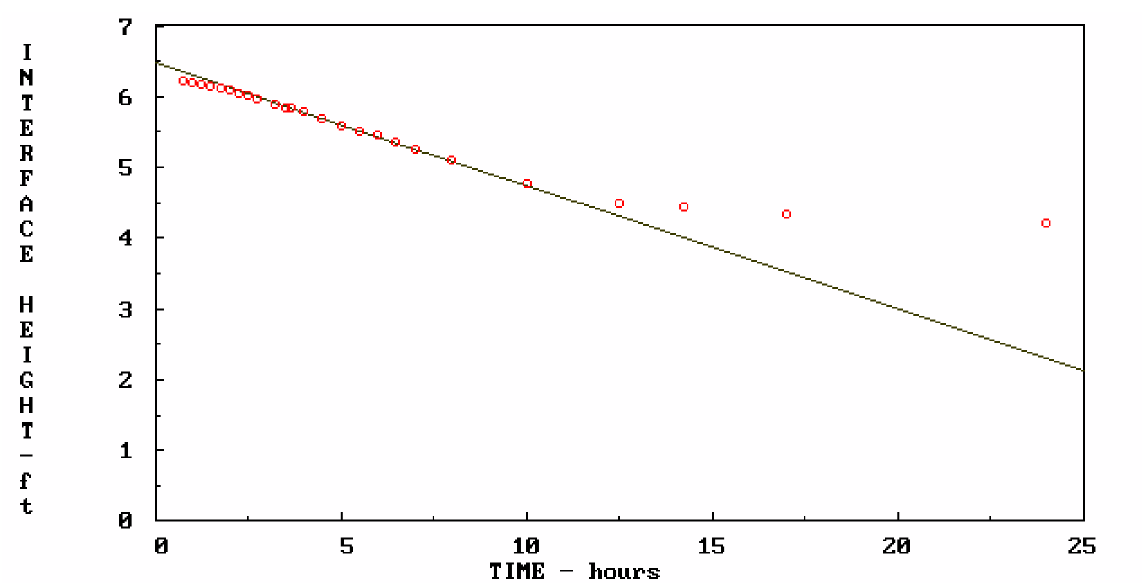
Table 4 Zone Settling Test Data Sample D

Time	Elapsed Time, hrs	Interface Height, ft
0900 31 Jan 2004	0.00	6.38
0915	0.25	6.36
0930	0.50	6.32
0945	0.75	6.28
1000	1.0	6.24
1015	1.25	6.21
1030	1.50	6.18
1045	1.75	6.15
1100	2.0	6.12
1115	2.25	6.09
1130	2.50	6.06
1145	2.75	6.03
1200	3.0	6.00
1215	3.25	5.96
1230	3.50	5.92
1245	3.75	5.88
1300	4.0	5.85
1315	4.25	5.82
1330	4.50	5.79
1345	4.75	5.76
1400	5.0	5.73
1415	5.25	5.69
1430	5.50	5.65
1445	5.75	5.62
1500	6.0	5.59
1515	6.25	5.56
1530	6.50	5.53
1545	6.75	5.49
1600	7.0	5.46
2100	12.0	4.84
0845 01 Feb 2004	23.75	3.36

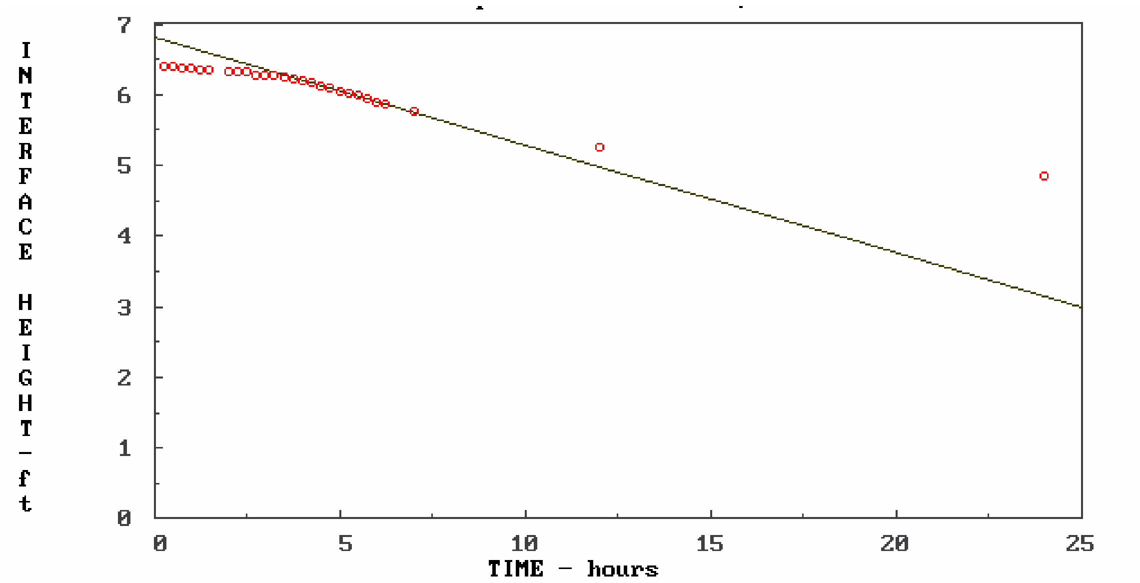
Notes: The slurry concentration was 113.12 g/L. The salinity was 26.5 parts per thousand.



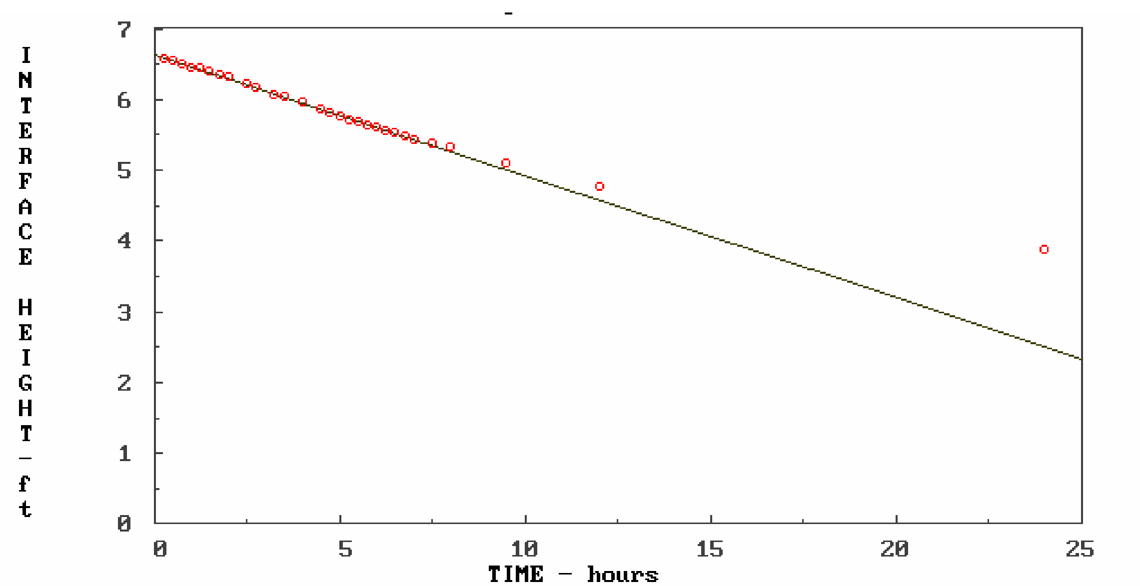
Calcasieu River Sample A (Eustis) zone settling curve



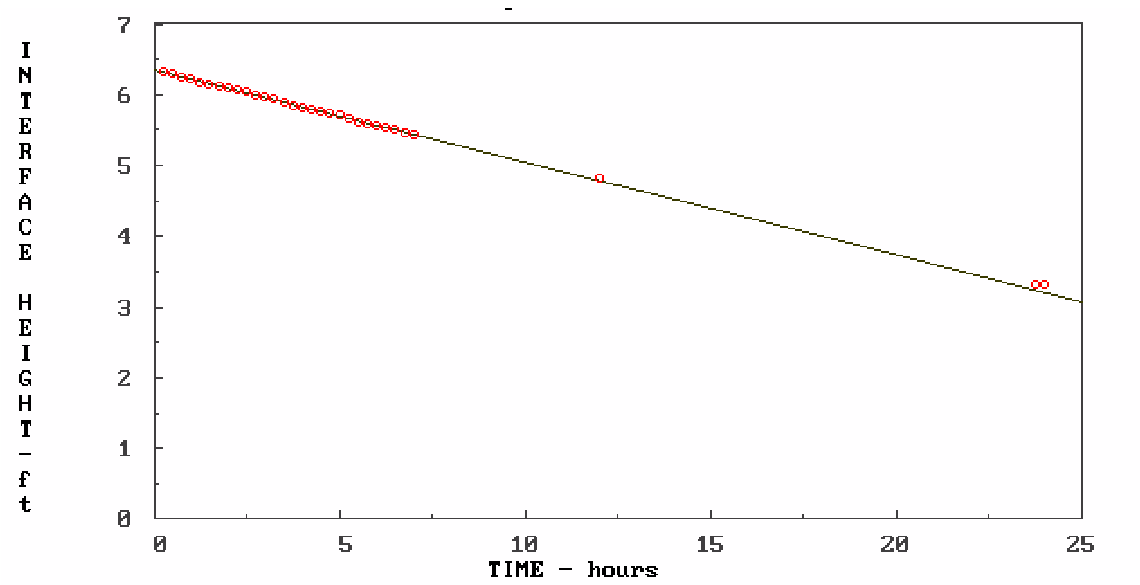
Calcasieu River Sample A (ERDC) zone settling curve



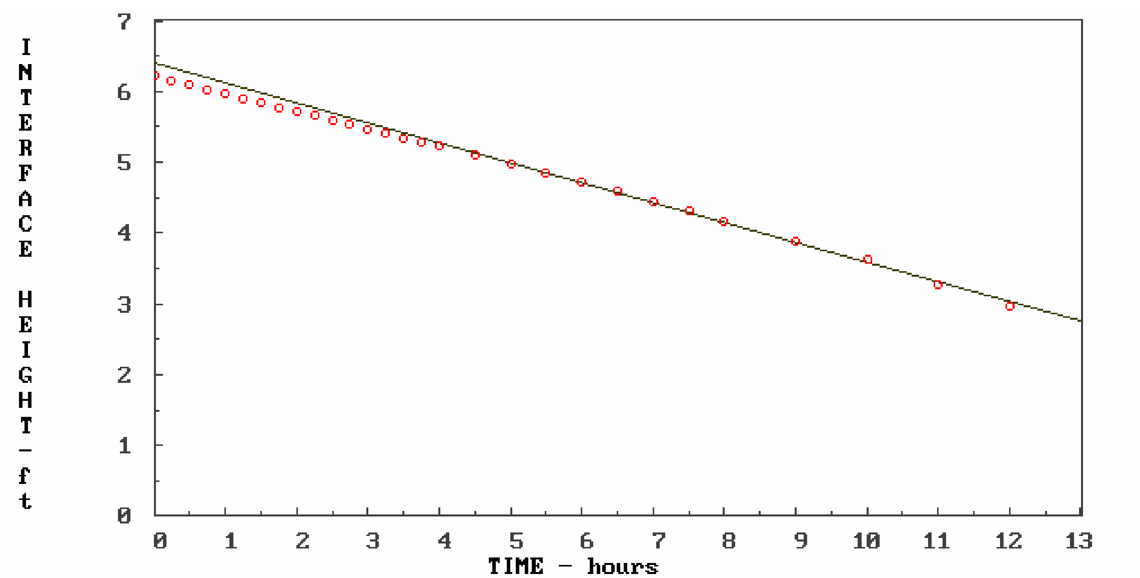
Calcasieu River Sample B zone settling curve



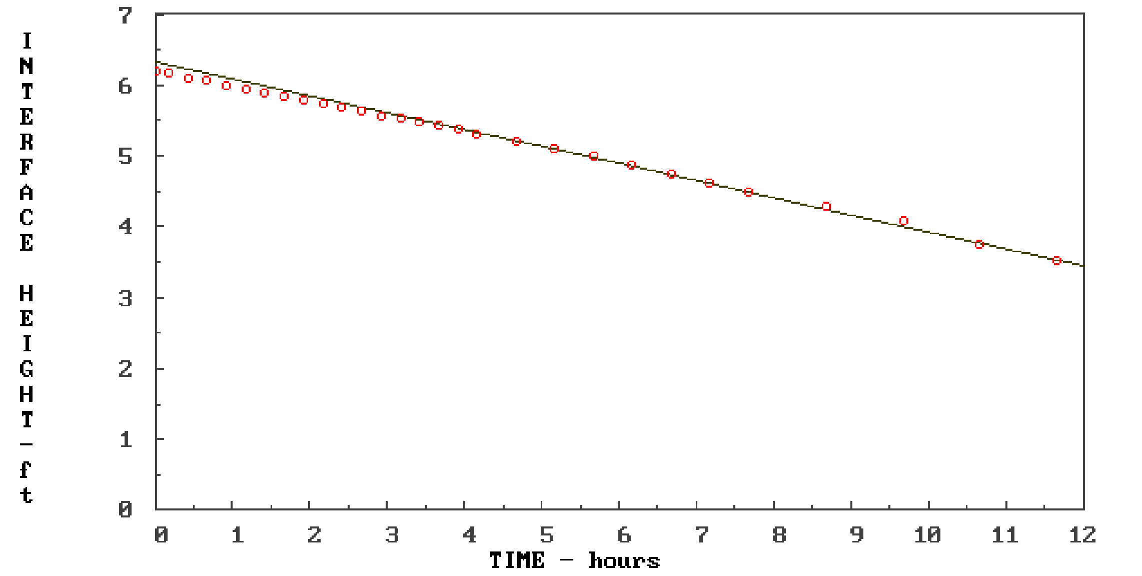
Calcasieu River Sample C zone settling curve



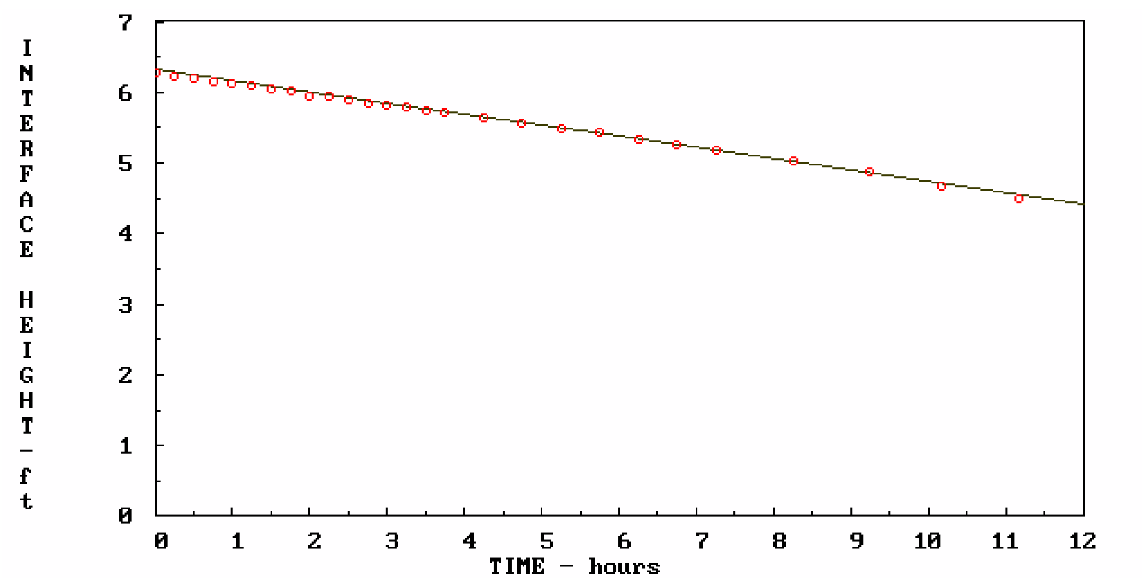
Calcasieu River Sample D zone settling curve



Calcasieu River Upper Reach 1 zone settling curve



Calcasieu River Upper Reach 2 zone settling curve



Calcasieu River Upper Reach 3 zone settling curve

APPENDIX C
FLOCCULENT SETTLING DATA AND CURVES

Flocculent Settling Test Data Sample A

Time, hr	Port Height, ft[1]							
	6.0	**5.5**	**5.0**	**4.5**	**4.0**	**3.5**	**3.0**	**2.5**
7	153	BI	BI	BI	BI	BI	BI	BI
12	76	76	BI	BI	BI	BI	BI	BI
24	67	76	134	BI	BI	BI	BI	BI
48	64	62	73	BI	BI	BI	BI	BI
72	32	57	71	158	BI	BI	BI	BI
96	35	41	96	66	BI	BI	BI	BI
168	32.67	46	85.56	38.10	BI	BI	BI	BI
264	22.22	27	70.97	41.76	44	BI	BI	BI
360		15.38	47.78	40	44.32	BI	BI	BI

[1]The initial slurry concentration was 127.65 g/L.
[2]Concentration at highest port used as initial supernatant concentration (mg/l).
BI = Port is Below Interface, and no sample was collected at this time interval.

Flocculent Settling Test Data Sample A (Environmental Lab)								
Time, hr	Port Height, ft[1]							
	6.0	5.5	5.0	4.5	4.0	3.5	3.0	2.5
3.5	113	BI	BI	BI	BI	BI	BI	BI
5	68	BI	BI	BI	BI	BI	BI	BI
7	58	63	BI	BI	BI	BI	BI	BI
12.5	23.4	39	24	BI	BI	BI	BI	BI
24	29	25	35	85	BI	BI	BI	BI
48		22.5	20	25	BI	BI	BI	BI
73		9.92	13.19	18.68	20	BI	BI	BI
96		7.75	9.73	9.69	7.54	BI	BI	BI
169		7	5.5	6.5	11.5	BI	BI	BI
240.25		8	5	9.5	5	14.5	BI	BI
361.5			2.65	4.4	4.04	5.86	BI	BI

[1]The initial slurry concentration was 135.4 g/L.

[2]Concentration at highest port used as initial supernatant concentration (mg/l).

BI = Port is Below Interface, and no sample was collected at this time interval.

Flocculent Settling Test Data Sample B								
Time, hr	Port Height, ft[1]							
	6.0	5.5	5.0	4.5	4.0	3.5	3.0	2.5
7	226	BI	BI	BI	BI	BI	BI	BI
12	78.72	70.08	206	BI	BI	BI	BI	BI
24	74.31	77	83	100	BI	BI	BI	BI
48		44	64	69.23	BI	BI	BI	BI
72		45	54	51.11	148	BI	BI	BI
96		38	54	41.93	87.64	BI	BI	BI
168		30	40.66	70.3	140	BI	BI	BI
264		23.76	29.52	27.78	76.9	217	BI	BI
360		17.43	21.74	30.43	124.78	159	BI	BI
							BI	BI
							BI	BI

[1]The initial slurry concentration was 135.4 g/L.

[2]Concentration at highest port used as initial supernatant concentration (mg/l).

BI = Port is Below Interface, and no sample was collected at this time interval.

Flocculent Settling Test Data Sample C

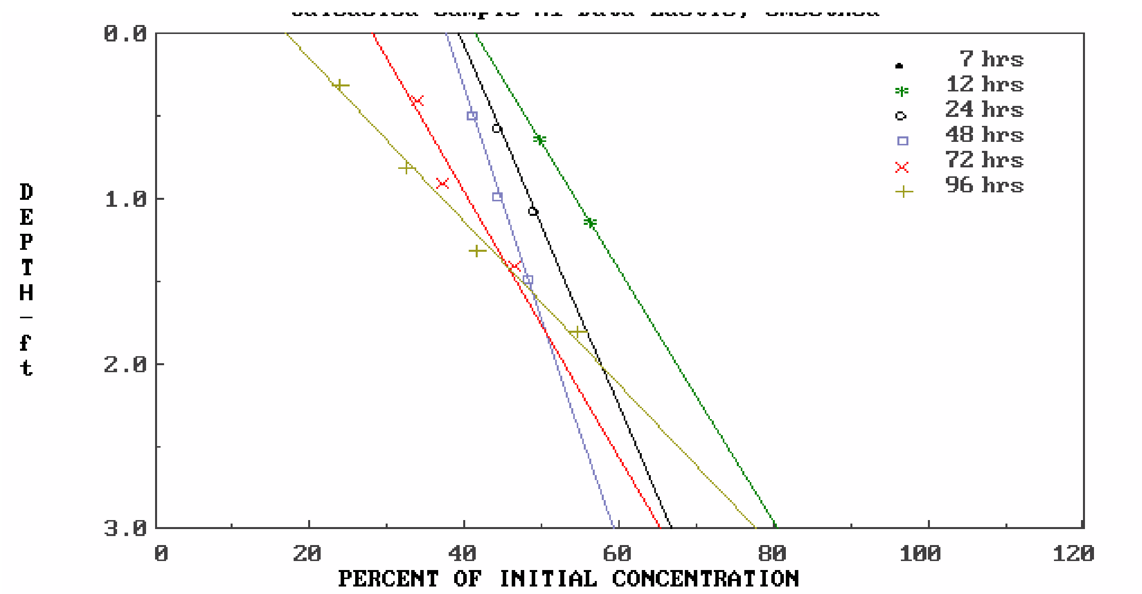
Time, hr	Port Height, ft[1]							
	6.0	5.5	5.0	4.5	4.0	3.5	3.0	2.5
4	129	BI	BI	BI	BI	BI	BI	BI
7	98.9	55.8	BI	BI	BI	BI	BI	BI
12	57.3	42.7	120	BI	BI	BI	BI	BI
24	12.6	30	45.6	101	53	BI	BI	BI
48	47.6	90	43.3	50	137	53.6	BI	BI
72	22.8	26.6	37.2	41.3	46.1	19.5	BI	BI
96		14.4	26.8	23.5	72.5	18.4	BI	BI
168		12.3	18.4	19.4	18.1	17.5	142	BI
264		10.2	18.1	17.1	14.6	11.5	26.7	BI
360		5.3	8.2	25.5	17.8	6.1	74	BI

[1]The initial slurry concentration was 135.4 g/L.
[2]Concentration at highest port used as initial supernatant concentration (mg/l).
BI = Port is Below Interface, and no sample was collected at this time interval.

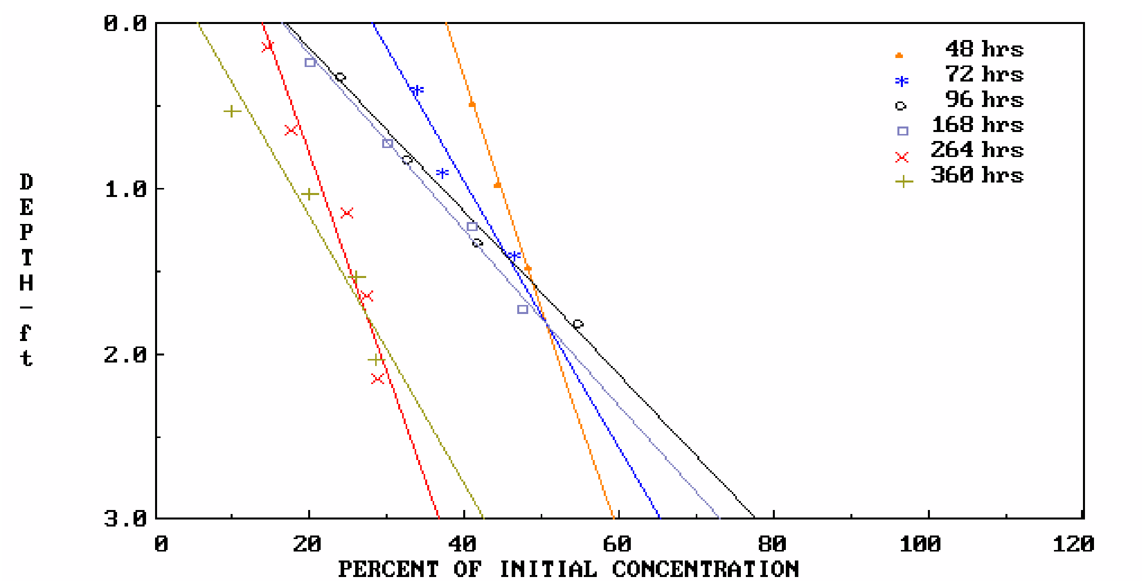
Flocculent Settling Test Data Sample D

Time, hr	Port Height, ft[1]							
	6.0	5.5	5.0	4.5	4.0	3.5	3.0	2.5
4	198	BI	BI	BI	BI	BI	BI	BI
7	8.2	39.3	BI	BI	BI	BI	BI	BI
12	21.6	34.4	36.6	BI	BI	BI	BI	BI
24	12.1	15.6	26.9	55.3	82.7	88	BI	BI
48		18.6	3.5	20.9	13	36.9	192	BI
72		4.4	11.6	16.3	56	15.3	220	BI
96		3.6	11.6	2.7	22.6	9.9	61	BI
168			2.7	5.3	10.8	8.6	45	66
264			4.8	6.9	2.7	5.9	19.4	160
360			3.4	5.4	8.5	6.1	18.8	45

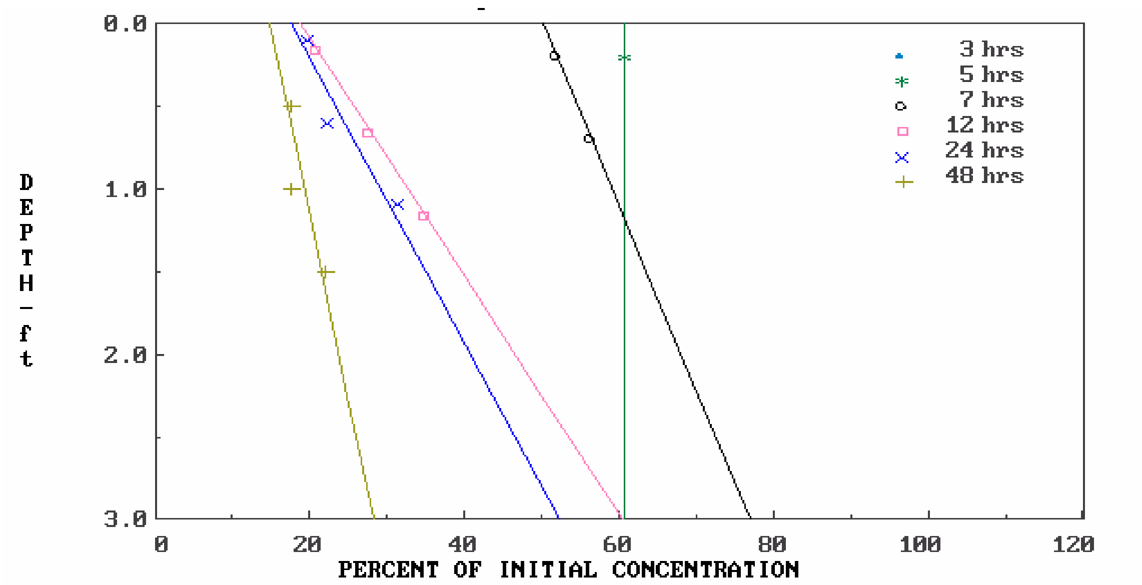
[1]The initial slurry concentration was 135.4 g/L.
[2]Concentration at highest port used as initial supernatant concentration (mg/l).
BI = Port is Below Interface, and no sample was collected at this time interval.



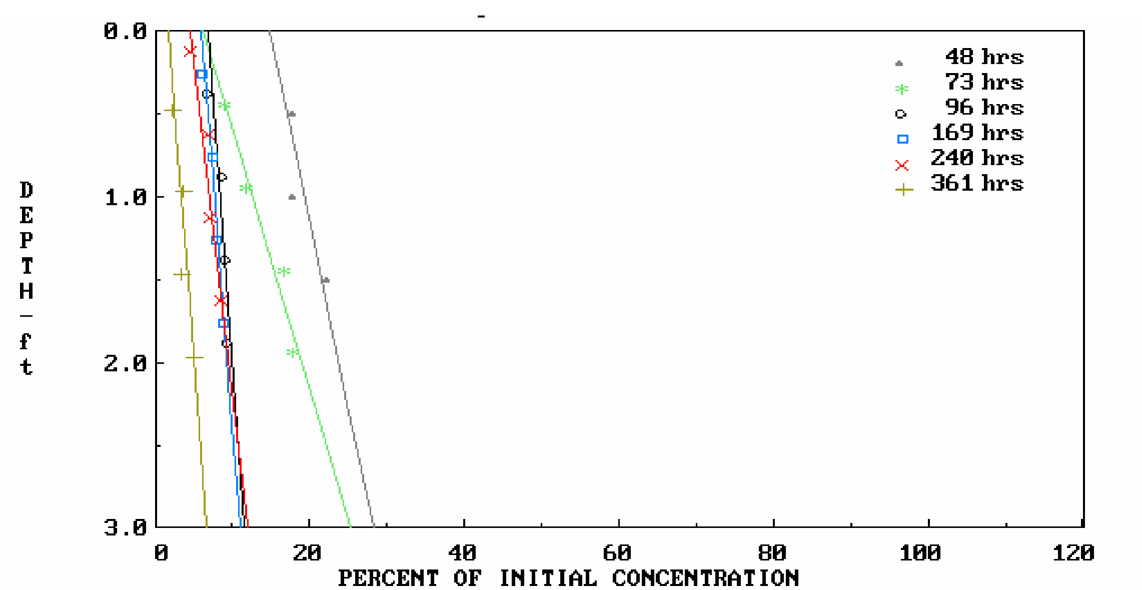
Calcasieu River Sample A (Eustis) flocculent settling curves, set 1



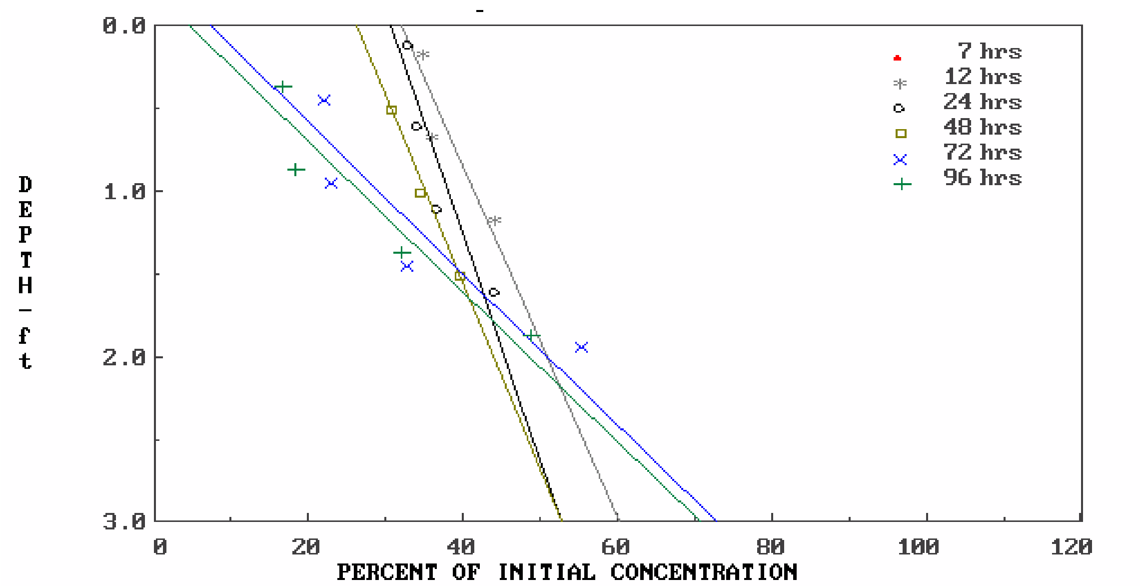
Calcasieu River Sample A (Eustis) flocculent settling curves, set 2



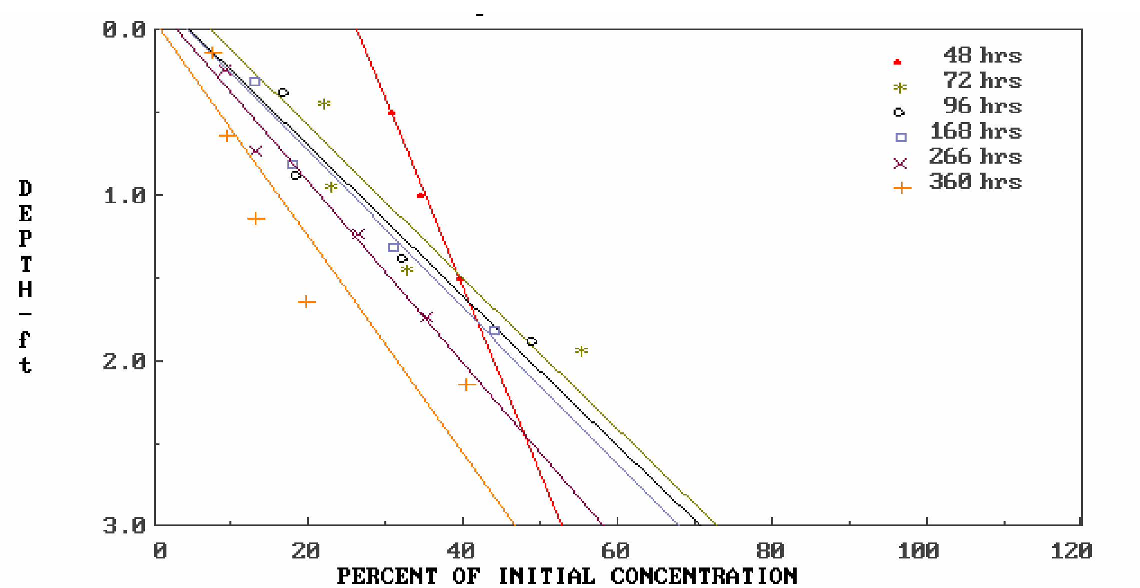
Calcasieu River Sample A (ERDC) flocculent settling curves, set 1



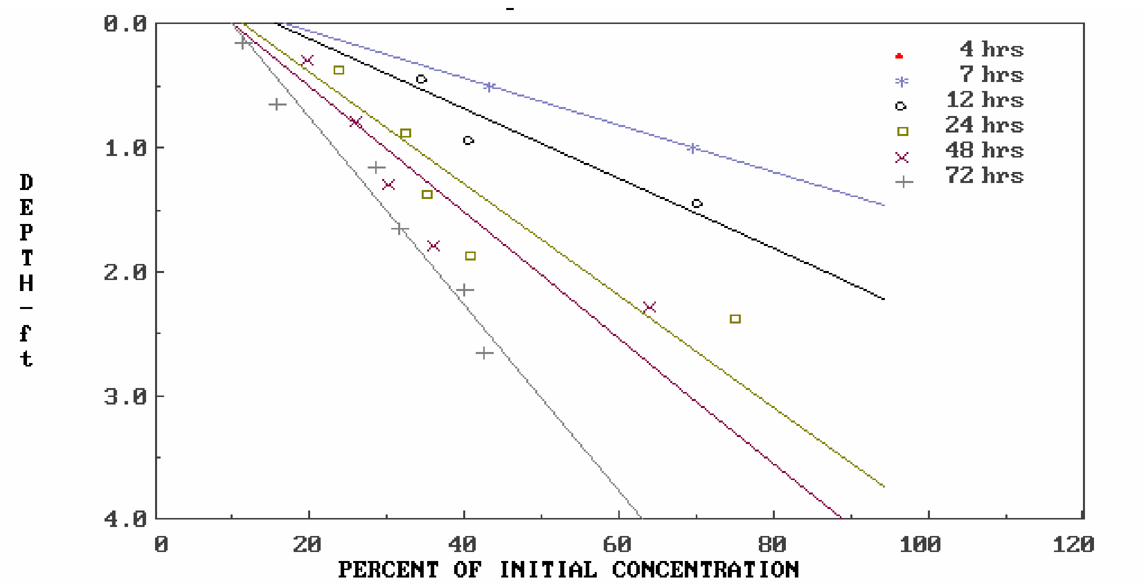
Calcasieu River Sample A (ERDC) flocculent settling curves, set 2



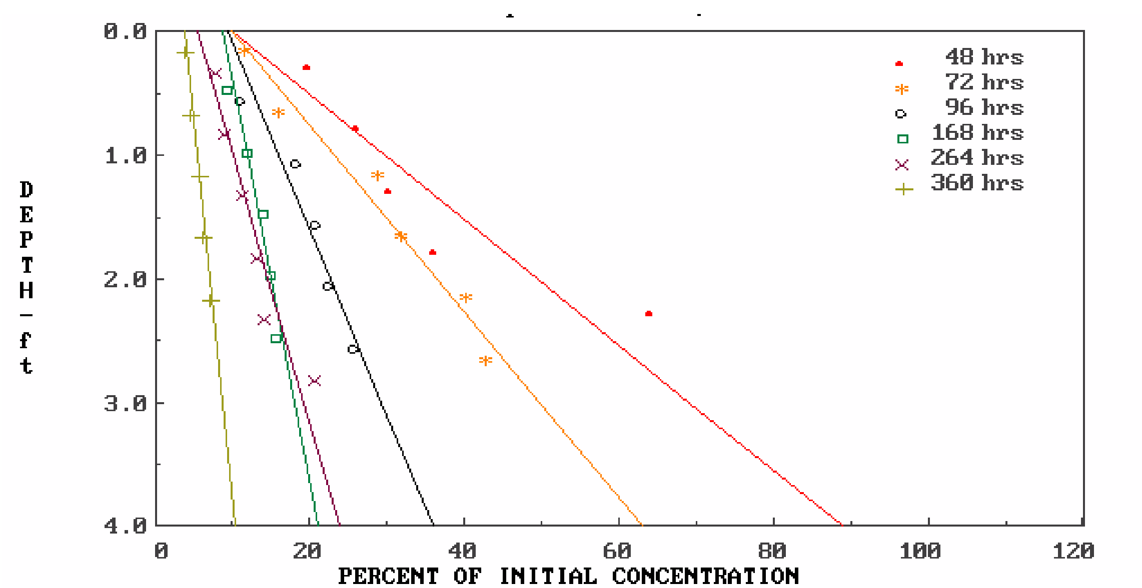
Calcasieu River Sample B flocculent settling curves, set 1



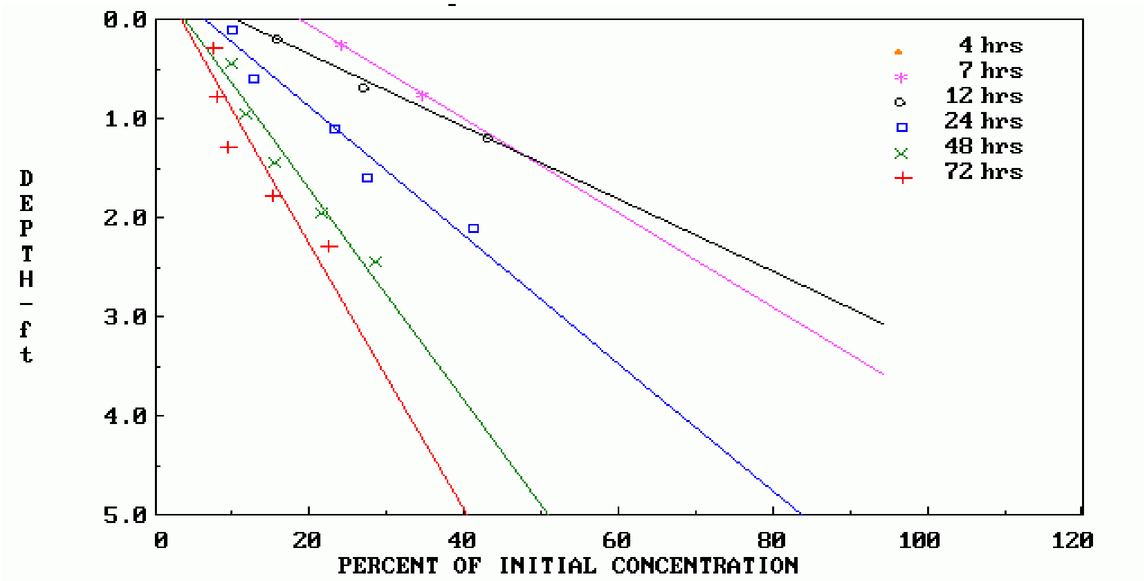
Calcasieu River Sample B flocculent settling curves, set 2



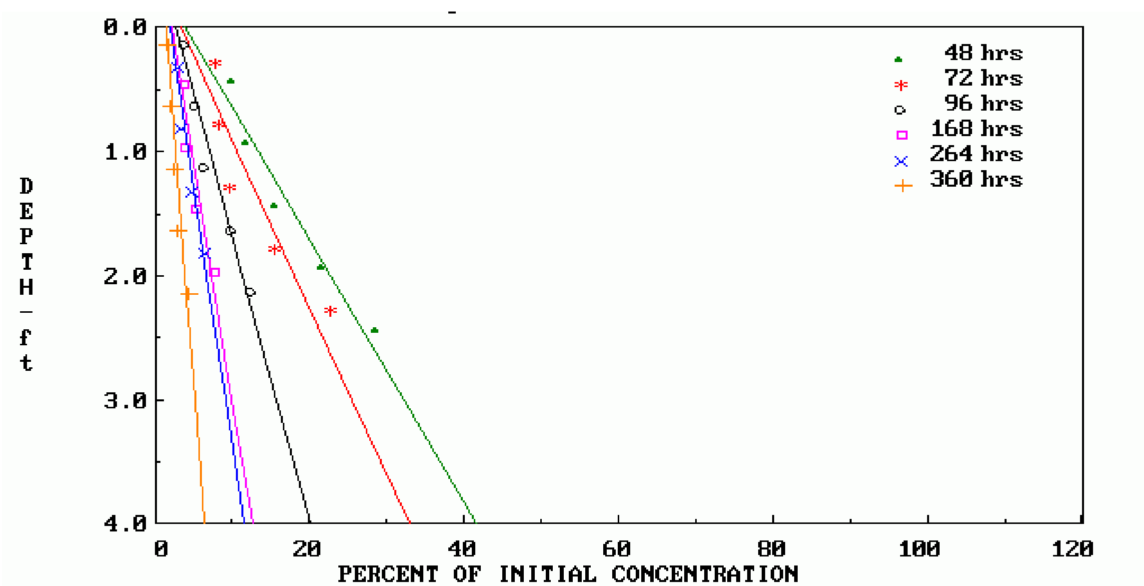
Calcasieu River Sample C flocculent settling curves, set 1



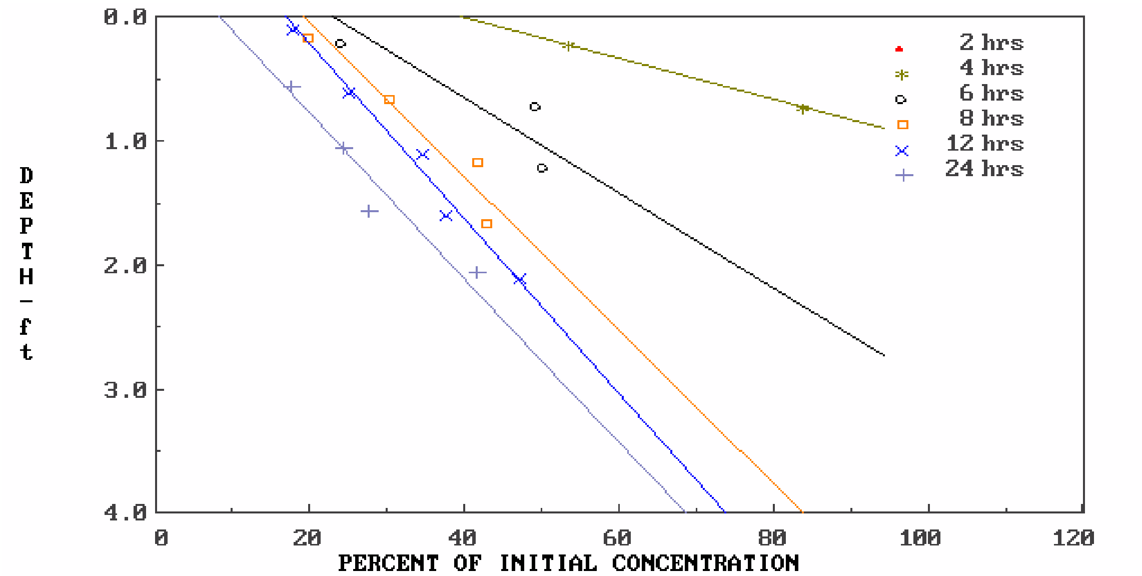
Calcasieu River Sample C flocculent settling curves, set 2



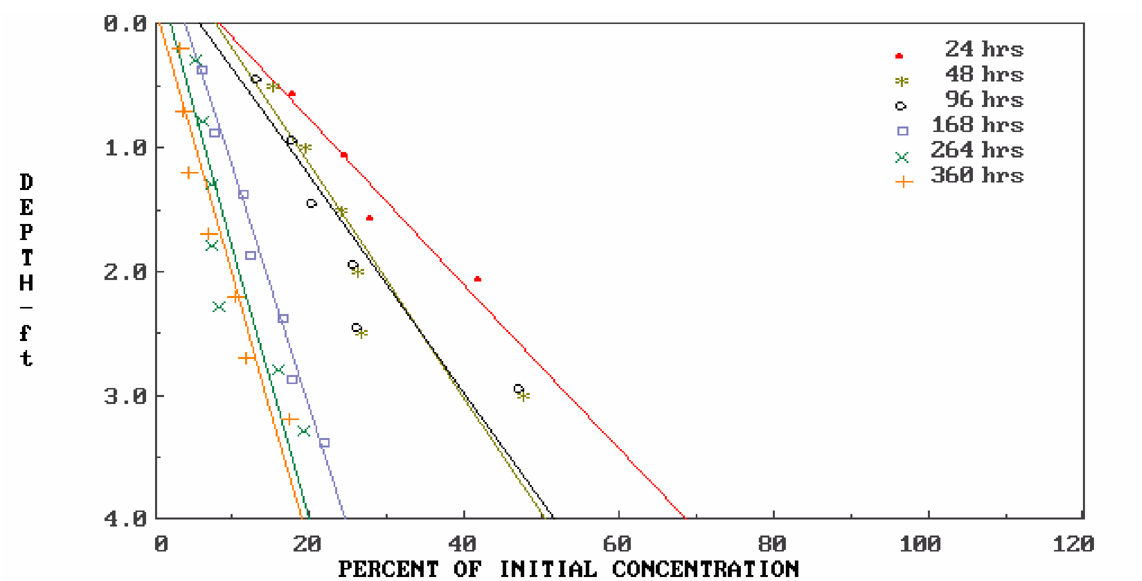
Calcasieu River Sample D flocculent settling curve, set 1



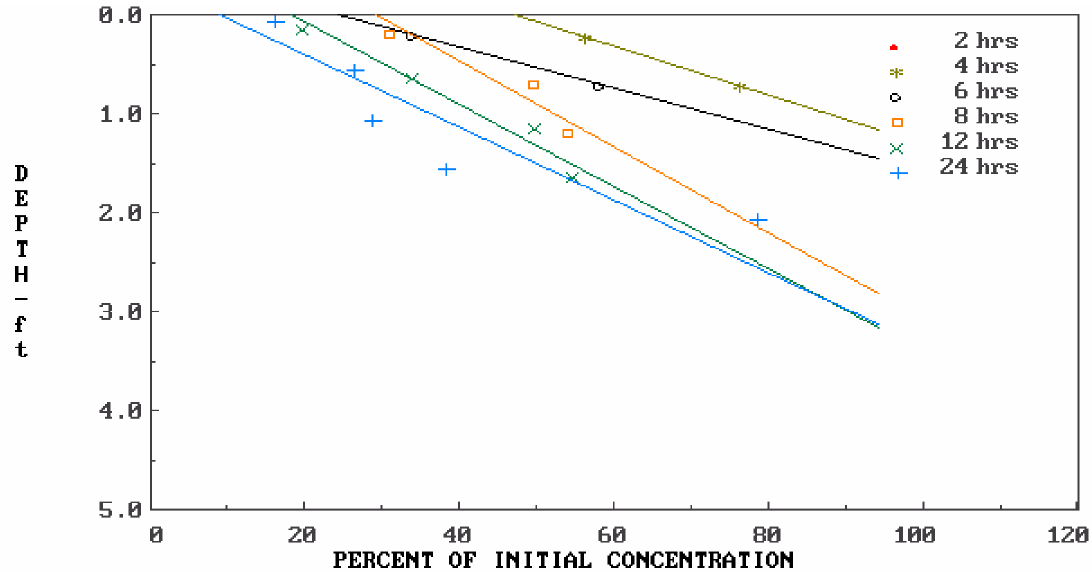
Calcasieu River Sample D flocculent settling curve, set 2



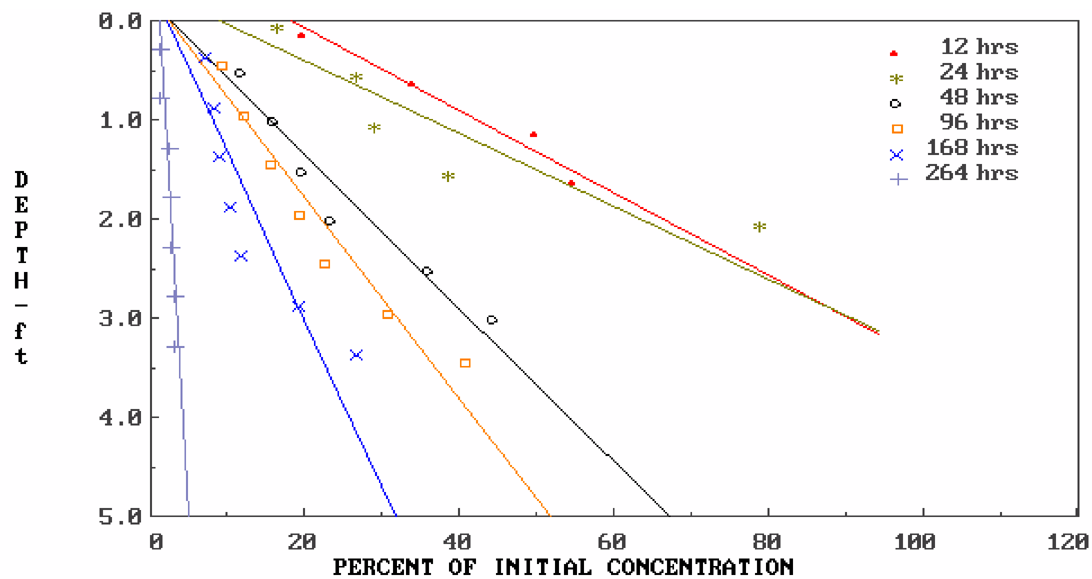
Calcasieu River Upper Reach 1 flocculent settling curves, set 1



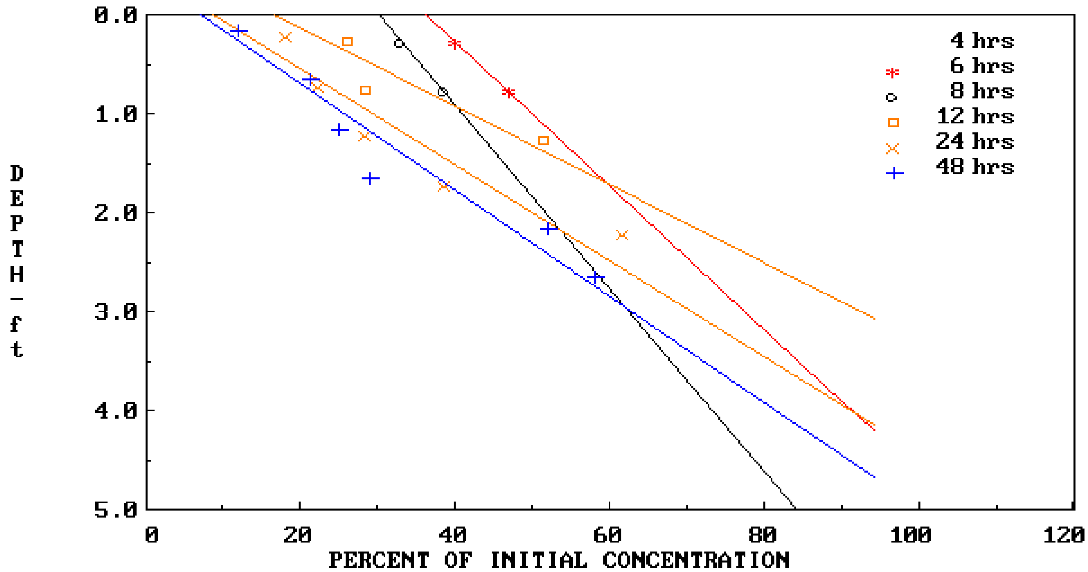
Calcasieu River Upper Reach 1 flocculent settling curves, set 2



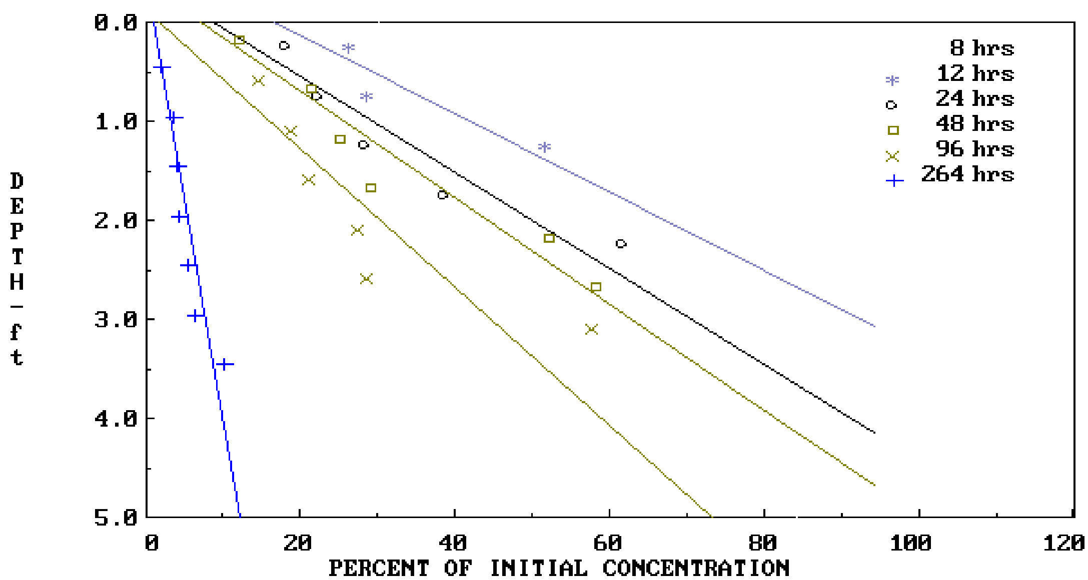
Calcasieu River Upper Reach 2 flocculent settling curves, set 1



Calcasieu River Upper Reach 2 flocculent settling curves, set 2



Calcasieu River Upper Reach 3 flocculent settling curves, set 1



Calcasieu River Upper Reach 3 flocculent settling curves, set 2

APPENDIX D
TSS vs TURBIDITY DATA AND CURVES

TSS Concentrations and Turbidity Measurements Sample A (Eustis)							
Time, hr	Port No.	TSS mg/L	Turbidity NTU	Time, hr	Port No.	TSS mg/L	Turbidity NTU
7	6	153	139	168	4.5	38.1	120
12	6	76	126	264	6	22.2	41.3
12	5.5	76	139	264	5.5	27	36.9
24	6	67	110	264	5	70.9	61.1
24	5.5	76	105	264	4.5	41.7	58.7
24	5	134	119	264	4	44	23.5
48	6	64	133	360	5.5	15.4	25.3
48	5.5	62	138	360	5	47.8	50.7
48	5	73	132	360	4.5	40	47.9
72	6	32	84	360	4	44.3	73.9
72	5.5	57	131				
72	5	71	140				
72	4.5	158	255				
96	6	35	102				
96	5.5	41	137				
96	5	96	94				
96	4.5	66	100				
168	6	32.67	52				
168	5.5	46	79				
168	5	85.5	103				

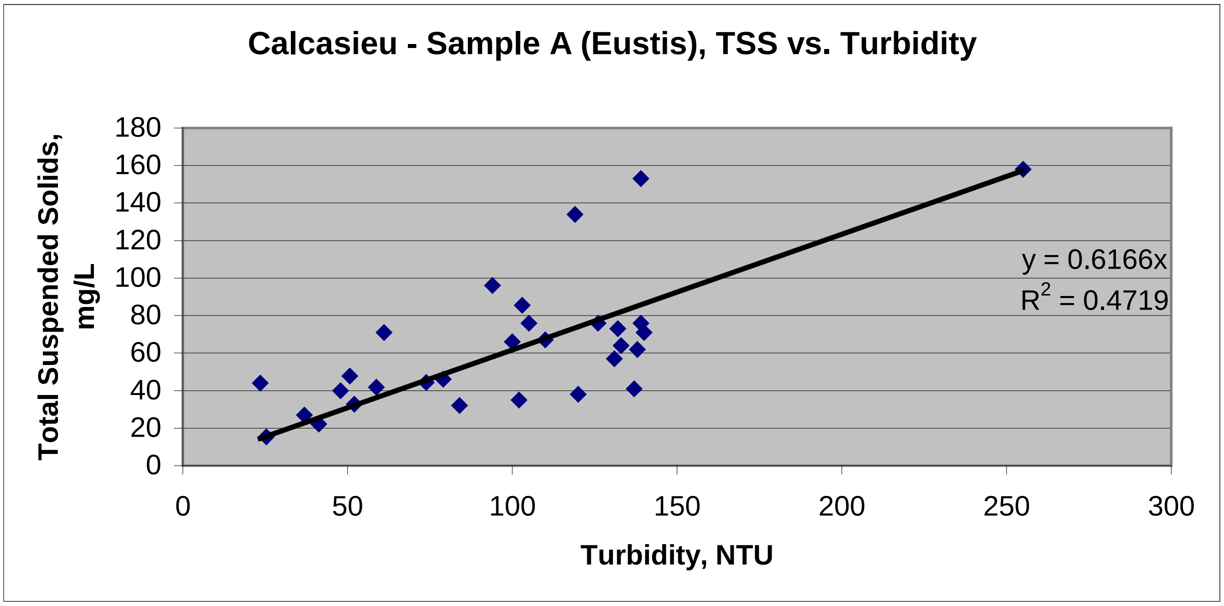
TSS Concentrations and Turbidity Measurements Sample A (Environmental Lab)							
Time, hr	Port No.	TSS mg/L	Turbidity NTU	Time, hr	Port No.	TSS mg/L	Turbidity NTU
3.5	6	118	71.5	96	5.5	7.75	6.71
3.5	6	108	71.5	96	5	9.7	6.55
3.5	6	113	71.5	96	4.5	9.7	6.17
5	6	68	42.9	96	4	7.5	6.69
7	6	58	36.4	169	5.5	7	7.79
7	5.5	63	49.5	169	5	5.5	6.8
12.5	6	23.4	14.5	169	4.5	6.5	7.17
12.5	5.5	39	21.9	169	4	11.5	9.45
12.5	5	24	19.8	240.25	5.5	8	6.49
24	6	29	16.3	240.25	5	5	4.93
24	5.5	25	15.7	240.25	4.5	9.5	4.98
24	5	35	20.8	240.25	4	5	4.89
24	4.5	85	47	240.25	3.5	14.5	5.12
48	5.5	22.5	12.4	361.5	5	2.6	2.6
48	5	20	12.4	361.5	4.5	4.4	2.6
48	4.5	25	11.4	361.5	4	4	2.6
73	5.5	9.9	4.46	361.5	3.5	5.8	3.7
73	5	13.2	8.56				
73	4.5	18.7	8.31				
73	4	20	11				

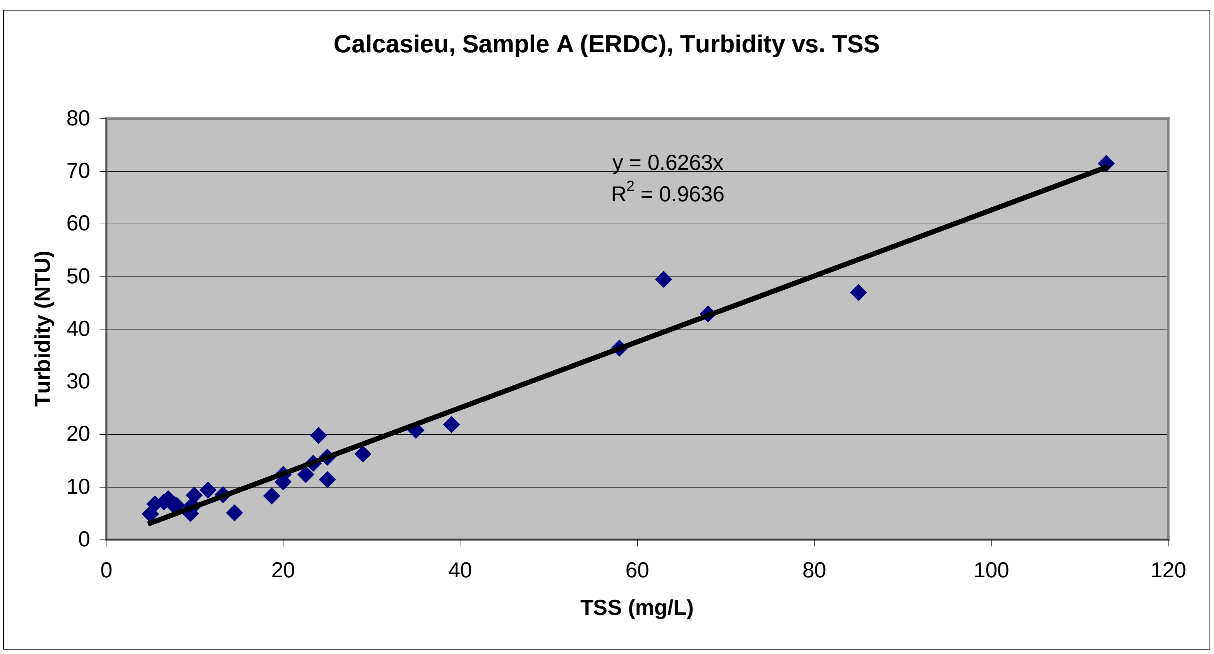
TSS Concentrations and Turbidity Measurements Sample B (Eustis)							
Time, hr	**Port No.**	**TSS mg/L**	**Turbidity NTU**	**Time, hr**	**Port No.**	**TSS mg/L**	**Turbidity NTU**
7	6	226	200	168	5	40.6	96
12	6	78.7	81.3	168	4.5	70.3	104
12	5.5	70	78.6	168	4	140	142
12	5	206	122	264	5.5	23.7	61.1
24	6	74.3	101	264	5	29.5	77.3
24	5.5	77	87.2	264	4.5	27.8	60
24	5	83	108	264	4	76.9	79.1
24	4.5	100	109	264	3.5	217	119
48	5.5	44	83.5	360	5.5	17.4	45.8
48	5	64	90	360	5	21.7	53.3
48	4.5	69.2	84.3	360	4.5	30.4	43
72	5.5	45	78.6	360	4	124	45.2
72	5	54	89.2	360	3.5	159	99.6
72	4.5	51.1	77.1				
72	4	148	111				
96	5.5	38	97.5				
96	5	54	84.8				
96	4.5	41.9	91.3				
96	4	87.6	121				
168	5.5	30	86.6				

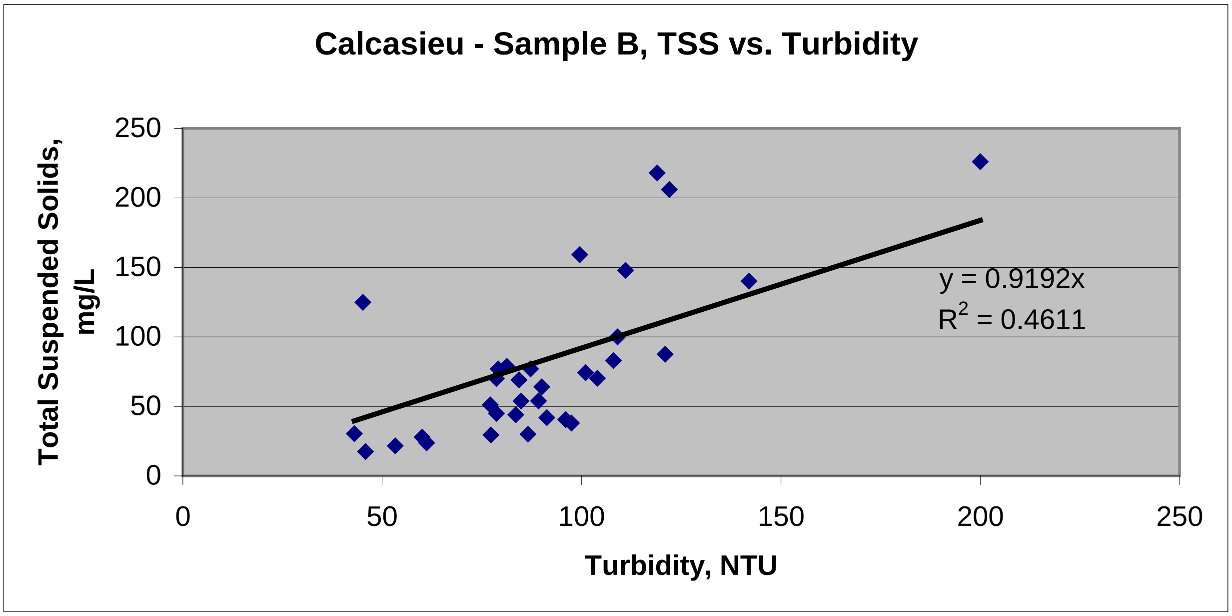
TSS Concentrations and Turbidity Measurements Sample C (Eustis)

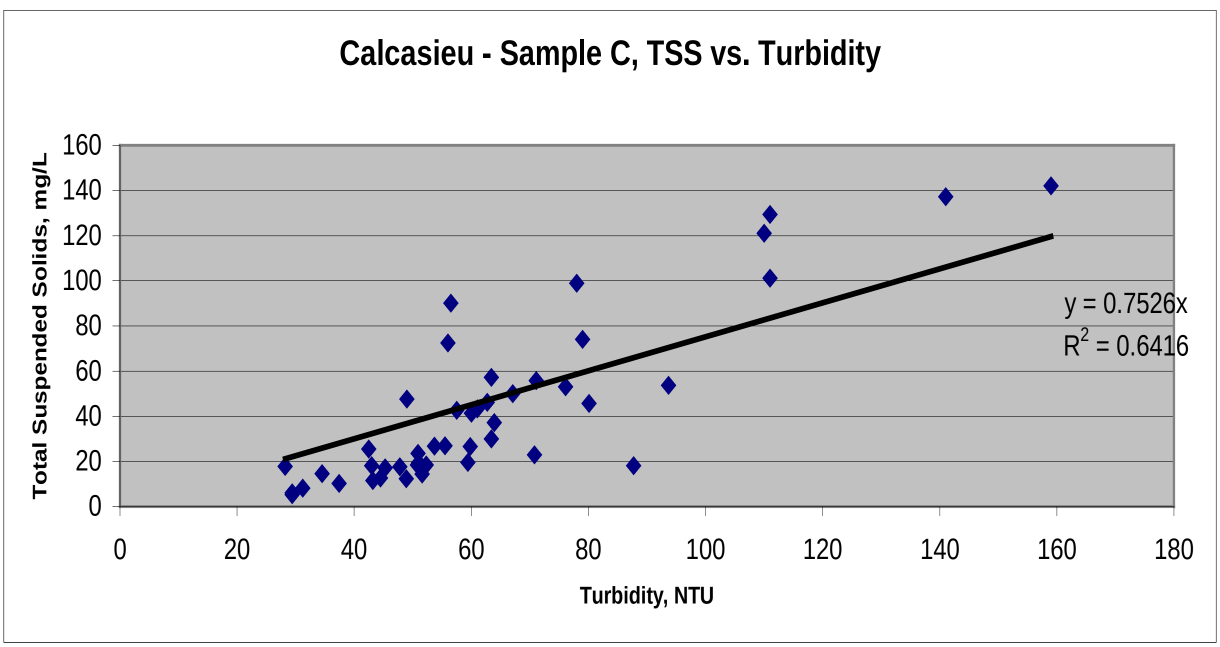
Time, hr	Port No.	TSS mg/L	Turbidity NTU	Time, hr	Port No.	TSS mg/L	Turbidity NTU
4	6	129	111	96	5.5	14.4	51.6
7	6	98.9	78	96	5	26.9	55.5
7	5.5	55.8	71.1	96	4.5	23.5	50.9
12	6	57.3	63.4	96	4	72.5	56
12	5.5	42.7	57.5	96	3.5	18.5	52.3
12	5	120	110	168	5.5	12.3	48.9
24	6	12.6	44.5	168	5	18.4	50.8
24	5.5	30	63.4	168	4.5	19.4	51
24	5	45.6	80.1	168	4	18.2	87.7
24	4.5	101	111	168	3.5	17.6	47.8
24	4	53	76.1	168	3	142	159
48	6	47.6	49	264	5.5	10.2	37.4
48	5.5	90.1	56.5	264	5	18	43
48	5	43.3	61	264	4.5	17.1	45.3
48	4.5	50	67.1	264	4	14.6	34.5
48	4	137	141	264	3.5	11.6	43.2
48	3.5	53.6	93.7	264	3	26.7	53.7
72	6	22.9	70.8	360	5.5	5.3	29.4
72	5.5	26.6	59.8	360	5	8.2	31.2
72	5	37.2	63.9	360	4.5	25.6	42.5
72	4.5	41.3	60	360	4	17.8	28.2
72	4	46.1	62.7	360	3.5	6.1	29.4
72	3.5	19.5	59.4	360	3	74	79

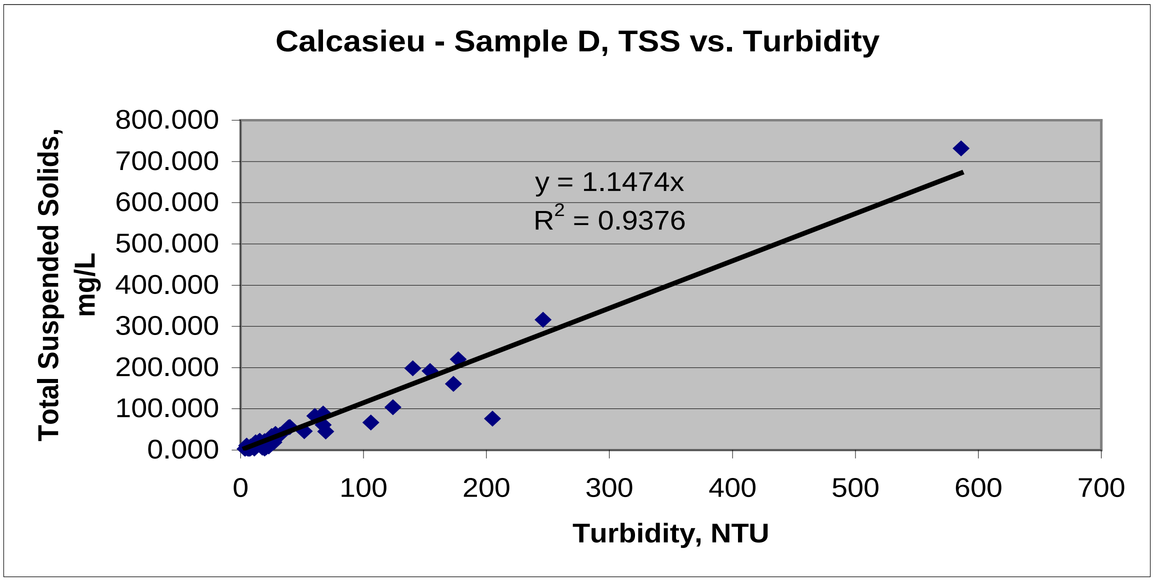
TSS Concentrations and Turbidity Measurements Sample D (Eustis)							
Time, hr	**Port No.**	**TSS mg/L**	**Turbidity NTU**	**Time, hr**	**Port No.**	**TSS mg/L**	**Turbidity NTU**
4	6	198	140	96	4.5	2.7	7.4
7	6	8.2	10.6	96	4	22.6	15.7
7	5.5	39.4	28.4	96	3.5	9.9	20
12	6	21.7	19.5	96	3	61	67.2
12	5.5	34.5	25.2	96	2.5	104	124
12	5	36.6	27.7	168	5	2.7	3.6
24	6	12.1	12.8	168	4.5	5.3	5.4
24	5.5	15.7	12.3	168	4	10.9	5
24	5	26.9	23.9	168	3.5	8.6	7.9
24	4.5	55.4	39	168	3	45.7	51.8
24	4	82.7	60.5	168	2.5	66.8	106
24	3.5	88.6	67.2	264	5	4.8	6.1
48	5.5	18.6	12.2	264	4.5	6.9	8.7
48	5	3.5	5.7	264	4	2.7	6.4
48	4.5	20.9	15	264	3.5	5.9	8.9
48	4	13	15.7	264	3	19.4	26.3
48	3.5	36.9	32.1	264	2.5	160	173
48	3	192	154	264	2	732	586
72	5.5	4.4	7	360	5	3.4	19.5
72	5	11.7	12.8	360	4.5	5.4	17.8
72	4.5	16.4	16.7	360	4	8.5	22.8
72	4	56	40.1	360	3.5	6.1	20.9
72	3.5	15.4	22.8	360	3	18.9	27
72	3	220	177	360	2.5	45.2	69.2
72	2.5	316	246	360	2	76.4	205
96	5.5	3.6	11.3				
96	5	11.6	11.9				


Calcasieu - Sample A (Eustis), TSS vs. Turbidity
Total Suspended Solids, mg/L
180
160
140
120
100
80
60
40
20
0
0
50
100
150
200
250
300
Turbidity, NTU
y = 0.6166x
R2 = 0.4719


Calcasieu, Sample A (ERDC), Turbidity vs. TSS
Turbidity (NTU)
80
70
60
50
40
30
20
10
0
0
20
40
60
80
100
120
TSS (mg/L)
y = 0.6263x
R2 = 0.9636


Calcasieu - Sample B, TSS vs. Turbidity
Total Suspended Solids, mg/L
250
200
150
100
50
0
0
50
100
150
200
250
Turbidity, NTU
y = 0.9192x
R^2 = 0.4611


Calcasieu - Sample C, TSS vs. Turbidity
Total Suspended Solids, mg/L
160
140
120
100
80
60
40
20
0
0
20
40
60
80
100
120
140
160
180
Turbidity, NTU
y = 0.7526x
R^2 = 0.6416


Calcasieu - Sample D, TSS vs. Turbidity
Total Suspended Solids, mg/L
800.000
700.000
600.000
500.000
400.000
300.000
200.000
100.000
0.000
y = 1.1474x
R2 = 0.9376
0
100
200
300
400
500
600
700
Turbidity, NTU

APPENDIX E
LIDAR SURVEY SEPTEMBER 2002

Calcasieu River CDF Capacities Based Upon Lidar Survey

Volume at Contour (CY)

Disp. Area	Total Acr.	App. Avg Dike Elev. (Ft)	Add. Dike Lift (Ft)	App. Disp Dike Elev. (Ft)	-2	2	4	6	8	10	12	14	16	18	20	Useable Vol. Cap. (CY)	Cap W/2:1 Bulk Fact.	Pay+Ovd Cap.
1	50	14	0	14	0	0	0	0	251,681	96,800	19,360	0				348,481		
2	45	16	0	16	0	0	0	0	0	290,401	32,267	24,200	0			322,668		
3 (Clooney Island)	112	14	2	16	0	0	0	0	238,774	629,202	183,921	0				1,051,897		
4	112	12	4	16	0	0	0	0	251,681	459,802	290,401					1,001,884		
5	30.5	14	2	16	0	0	58,080	242,001	70,987	67,760	0	0				438,828		
6	39	4	OUT	OUT												0		
7	255	16(front)-12(back)	2	14	0	0	0	0	1,422,966	245,228	80,667	0	-80,667			1,668,193		
8	188	12	2	14	0	0	0	0	1,819,847	0	0					1,819,847		
9	169	12(front)-8(back)	2	10	0	0	0	0	504,975	0	0					0		
10	127	10(front)-8(back)	2	10	0	0	0	819,577	0	0						819,577		
11	135	8	2	10	0	0	0	790,536	40,333							790,536		
12A	160	8	2	10	0	0	0	1,032,537	0							1,032,537		
12B	430	16(Flare)-12(North End)	2	14	0	0	0	0	759,883	1,087,391	345,255	0	-41,947			1,847,274	3,670,348	1,835,174
13 (Choupique Island)	700	16(front)-10(back)	2	12	0	0	0	0	1,516,539	645,336	0	-242,001	-225,868			1,516,539		
15	180	12	4	16	0	0	0	0	529,175	1,345,525	0					1,874,701		
16N	115	12	2	14	0	0	0	0	0	0	371,068					0		
16S	40	20	OUT	OUT												0		
17*	200	8	2	10	0	0	0	0	371,068	0						0		
22	135	14	2	16	0	0	0	0	0	0	580,802	145,201				580,802		
23	115	16	0	16	116,160	0	0	0	0	0	96,800	177,467	0	-48,400	-64,534	212,961		
D	250	16	0	16	0	0	0	0	0	726,003	484,002	177,467	0			1,210,005	5,395,008	2,697,504
E	150	12	4	16	0	0	0	0	451,735	1,113,204	0					1,564,939	6,959,947	3,479,974
H	140	10	2	12	0	0	0	0	658,243	93,574	0					658,243		
M	390	6	4	10	0	0	2,420,009	419,468	242,001							2,839,478		
N	215	8(front)-6(back)	4	10	0	0	0	1,290,672	48,400							1,290,672	4,788,392	2,394,196
																	18,101,671	9,050,835

* Large spoils mounds with max elevations at +22'. Spoil mounds are approx. 63 acres.

Calcasieu River CDF Capacities Based Upon Lidar Survey

Volume at Contour (CY)

Disposal Area	Add. Dike Lift (Ft)	Appr. Disp. Dike Elev. (Ft)	-2	2	4	6	8	10	12	14	16	18	20	Useable Vol. Cap. (CY)	Cap. W/2:1 Bulk Fact.	Pay+Ovd Cap.
1	0	14	0	0	0	0	41,947	108,094	141,974	156,494	161,334	161,334	161,334	150,041		
2	0	16	0	0	0	0	0	48,400	104,867	125,034	141,167	145,201	145,201	153,267		
3 (Clooney Island)	2	16	0	0	0	0	29,847	164,561	315,408	361,388	361,388	361,388	361,388	509,815		
4	4	16	0	0	0	0	31,460	139,554	288,788	361,388	361,388	361,388	361,388	459,802		
5	2	16	0	0	4,840	33,880	66,954	87,120	98,414	98,414	98,414	98,414	98,414	291,208		
6	OUT	OUT		124,227	125,034	125,840	125,840	125,840	125,840	125,840	125,840	125,840	125,840	out		
7	2	14	0	0	0	0	237,161	535,629	637,269	709,869	782,470	822,803	822,803	772,790		
8	2	14	0	0	0	0	303,308	606,616	606,616	606,616	606,616	606,616	606,616	909,924		
9	2	10	0	0	0	0	252,488	525,142	545,309	545,309	545,309	545,309	545,309	0		
10	2	10	0	0	0	204,894	409,788	409,788	409,788	409,788	409,788	409,788	409,788	204,894		
11	2	10	0	0	0	197,634	415,435	435,602	435,602	435,602	435,602	435,602	435,602	197,634		
12A	2	10	0	0	0	258,134	516,269	516,269	516,269	516,269	516,269	516,269	516,269	258,134		
12B	2	14	0	0	0	0	126,647	525,142	969,617	1,243,885	1,366,499	1,387,472	1,387,472	651,789	1,107,558	553,779
13 (Choupique Island)	2	12	0	0	0	0	379,135	1,080,938	1,653,673	2,024,741	2,202,209	2,258,675	2,258,675	379,135		
15	4	16	0	0	0	0	66,147	356,548	580,802	580,802	580,802	580,802	580,802	1,003,497		
16N	2	14	0	0	0	0	0	0	185,534	371,068	371,068	371,068	371,068	0		
16S	OUT	OUT		0	0	0	0	0	0	0	32,267	96,800	129,067	out		
17*	2	10	0	0	0	0	185,534	406,562	442,055	442,055	442,055	442,055	442,055	0		
22	2	16	0	0	0	0	0	0	145,201	363,001	435,602	435,602	435,602	145,201		
23	0	16	0	0	0	0	0	0	24,200	137,134	258,134	314,601	354,935	24,200		
D	0	16	0	0	0	0	0	121,000	363,001	572,736	734,070	806,670	806,670	484,002	2,036,035	1,018,017
E	4	16	0	0	0	0	56,467	298,468	484,002	484,002	484,002	484,002	484,002	838,937	2,874,971	1,437,486
H	2	12	0	0	0	0	164,561	375,908	437,215	451,735	451,735	451,735	451,735	164,561		
M	4	10	0	0	403,335	911,537	1,137,404	1,258,405	1,258,405	1,258,405	1,258,405	1,258,405	1,258,405	1,314,872		
N	4	10	0	0	0	322,668	669,536	693,736	693,736	693,736	693,736	693,736	693,736	322,668	1,802,100	901,050
														9,236,369	4,618,185	

* Large spoils mounds with max elevations at +22'. Spoil mounds are approx. 63 acres.

Disp. Area	Total Acr.	App. Avg. Dike Elev. (Ft)	Vol. at 10' (if dikes raised)	10' Dike Cap.(12' dk, 2' fb)	Vol. at 10' (current, w/ 2' fb)	Current Cap.	In Situ Dredge Vol	Cap. Needed (30" dredge)
1	50	14	150,041		150,041			
2	45	16	48,400		48,400			
3 (Clooney Island)	112	14	194,407		194,407			
4	112	12	171,014		171,014			
5	30.5	14	192,794		192,794			
6	39	4	out		out			
7	255	16(front)-12(back)	772,790		772,790			
8	188	12	909,924		909,924			
9	169	12(front)-8(back)	777,630		0	current dikes below 12'		
10	127	10(front)-8(back)	1,024,471		204,894			
11	135	8	1,048,671		197,634			
12A	160	8	1,290,672		258,134			
12B	430	16(Flare)-12(North End)	651,789	7,232,602	651,789	3,751,821	6,500,000	7,666,138
13 (Choupique Island)	700	16(front)-10(back)	1,460,072		379,135			
15	180	12	422,695		422,695			
16N	115	12	0		0			
16S	40	20	out		out			
17*	200	8	592,096		0			
22	135	14	0		0			
23	115	16	0		0			
D	250	16	121,000		121,000			
E	150	12	354,935	2,950,798	354,935	1,277,765	4,500,000	5,307,326
H	140	10	540,469		164,561			
M	390	6	3,710,681		403,335			
N	215	8(front)-6(back)	1,685,940	5,937,090	0	567,896	4,000,000	4,717,623
Total			16,120,490	16,120,490	5,597,482	5,597,482	15,000,000	17,691,088

*Estimated based on ratio of upper reach
I am currently revising these numbers.