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Effects of Organic Matter on Settling Velocity of Coastal Sediments Used in Coastal Restoration and Marsh Creation Projects

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Effects of Organic Matter on Settling Velocity of Coastal Sediments Used in Coastal Restoration and Marsh Creation Projects

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Abstract

Coastal wetland loss is a critical environmental problem across the United States. These ecosystems provide vital services to people and the environment including erosion control, flood protection, carbon sequestration, and maintenance of water quality. The natural flood protection has already been greatly weakened by coastal land loss in Louisiana and similar deltaic areas throughout the world. If this trend continues, many communities are at severe risk of physical and infrastructural damage. One of the proposed methods to reverse the erosion of the coastal wetlands is marsh creation. Comprehensive characterization of the dredged sediments is crucial in successfully constructing a marsh creation project. The settling characteristics of the dredged material are affected by organic content, solids concentration, and geotechnical properties of the sediments. The effects of organic content on settling characteristics are evaluated and discussed. The zone settling velocity was lower for dredged slurry with higher percentages of organic matter.

Keywords: Marsh creation projects, coastal master plan, organic content, sedimentation characteristics

Chapter 1 Introduction

The Mississippi river and its tributaries flow through a large portion of the continental United States. The river is fed by the Missouri river, which starts as far west as western Montana and flows for nearly 2,400 miles before join the Mississippi near St. Louis, Missouri. The Mississippi river is also fed by the Ohio river, which starts in Pennsylvania and flows to meet the Mississippi river in the southern tip of Illinois. There are many other smaller tributaries that feed into the Mississippi along its journey down to the southern tip of Louisiana where it spills into the Gulf of Mexico.

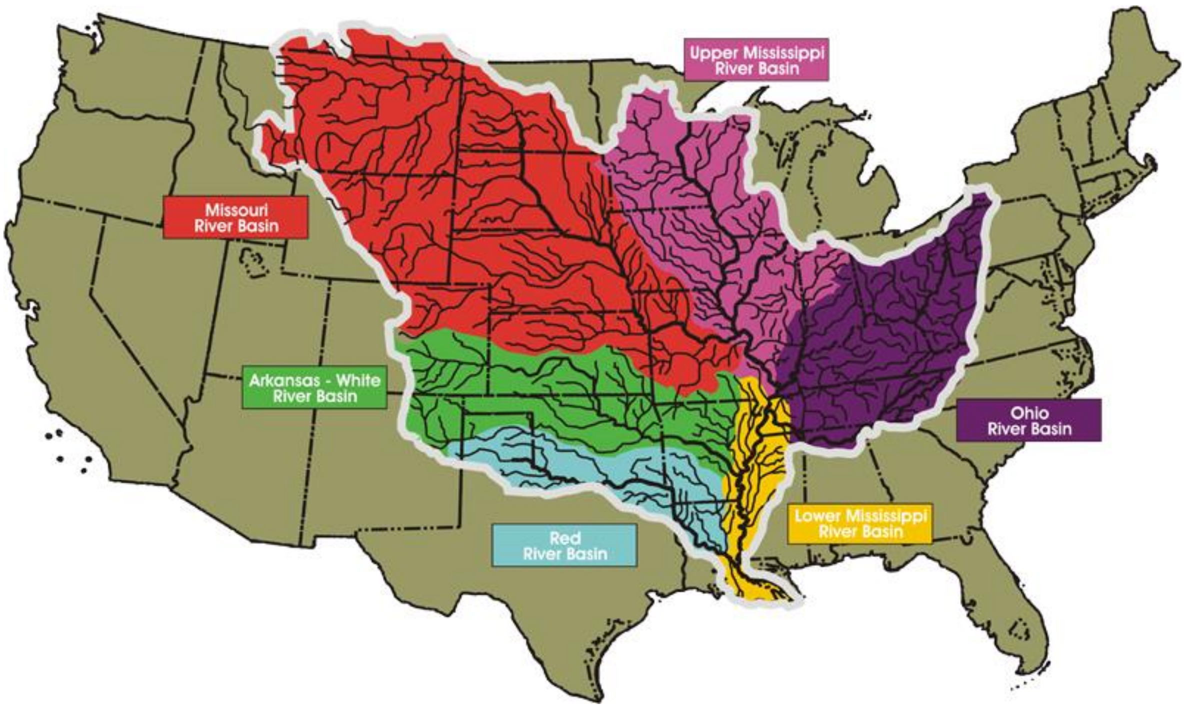


Figure 1.1: Mississippi river and tributaries (credit: https://www.mvd.usace.army.mil/About/Mississippi-River-Commission-MRC/)

Over time, the Mississippi river gradually moved over southern Louisiana depositing sediments, silts, and organic matter as it moved from east to west. This occurred with the river overflowing its banks following snowmelts and heavy rainfall from further north along its tributaries each year. Historically, the Mississippi river delta in southern Louisiana stretched across 7,000 square miles.

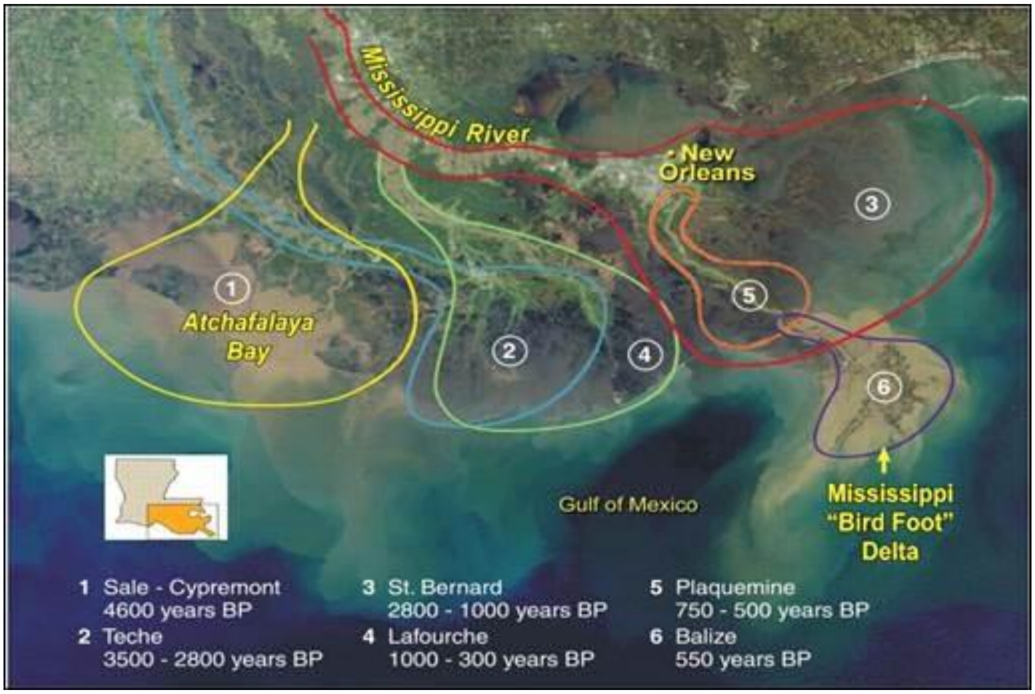


Figure 1.2: Mississippi River Delta Lobes (Credit: mississippiriverdelta.org)

In between high-water seasons, the river would deposit sediments and build up naturally occurring levees along its banks. Upon these naturally occurring levees, people began building their homes and livelihoods. In the 1930's the construction of early flood protection began with levees being built, which constricted the path of the Mississippi river. This constriction in turn caused the sediment that would normally be deposited along the Mississippi delta to be swept out into the Gulf of Mexico and resulted in the erosion of the surrounding areas including the barrier islands.

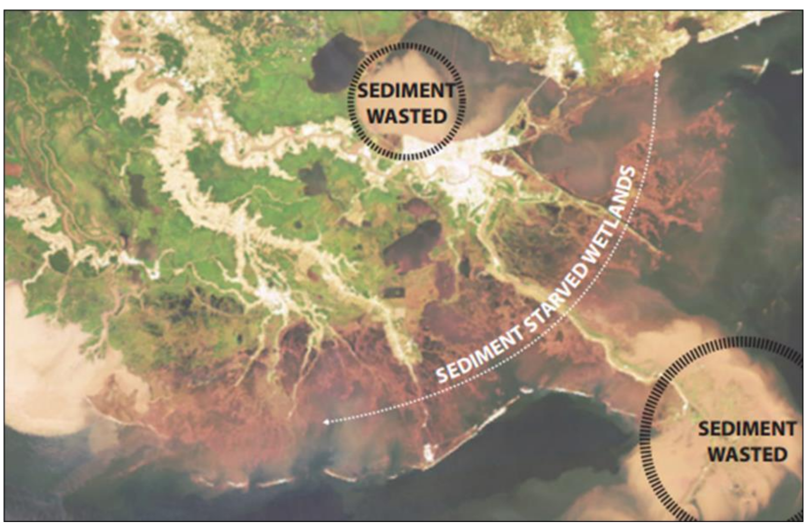


Figure 1.3: Sediment flowing from the Mississippi into the Gulf and Lake Pontchartrain. (Credit: http://www.mississippiriverdelta.org/)

This issue has been exacerbated by coastal property development, global climate change, sea level rise, as well as many other natural and man-made factors. These other influences have caused water degradation, wetland loss, reduced storm protection, decline in fisheries and habitat loss. Since the 1930's Louisiana's coast has lost over

2,000 square miles due to erosion with more recent years seeing even faster loss (Alshamaileh, et al, 2020). This could be a major hit to the local and national economy, as Louisiana's coast supports critical infrastructure with an estimated value of $48 billion (Louisiana Sea Grant College Program 1998). Over the next 50 years, the damage to commercial fisheries could result in an estimate $300 million in revenue lost annually and the wetland loss alone is projected to cost nearly $37 billion from public use value (Coast 2050). Louisiana also hosts 18% of the nation's oil production and 24% of the natural gas production, which produces another $16 billion annually in revenue that would also be threatened if no action were to be taken.

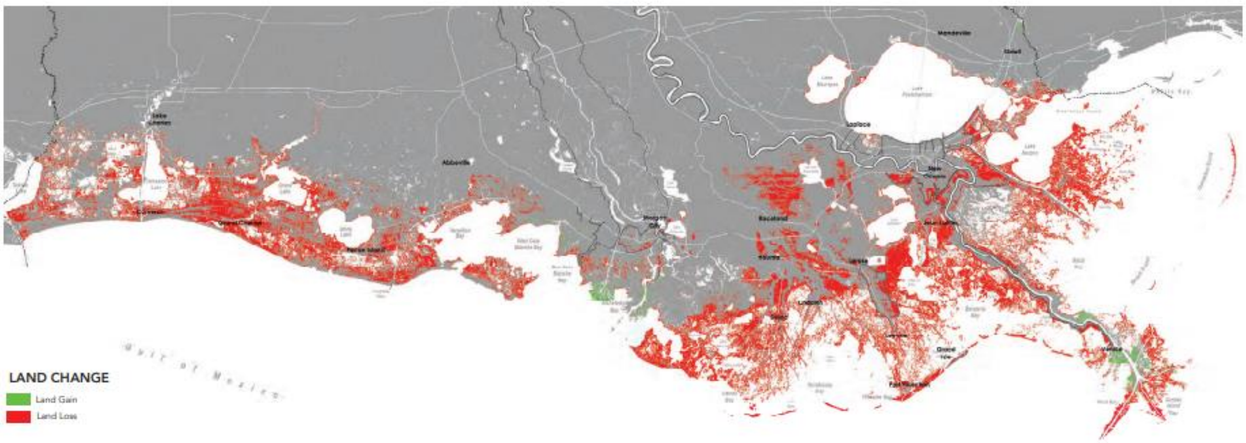


Figure 1.4: Predicted land loss and gain within next 50 years. (Coastal Master Plan 2017)

In response to the threat of further land loss and the resulting economic impact and infrastructure degradation, the Coastal Protection and Restoration Agency (CPRA) was created. The agency began work on their coastal master plan, which boasted 109 projects that would slow or reverse the effects of decades of unchecked erosion. These projects included the construction of oyster barrier reefs, ridge restoration, shoreline protection, marsh creation, sediment diversions, hydrologic restoration, and structural protection.

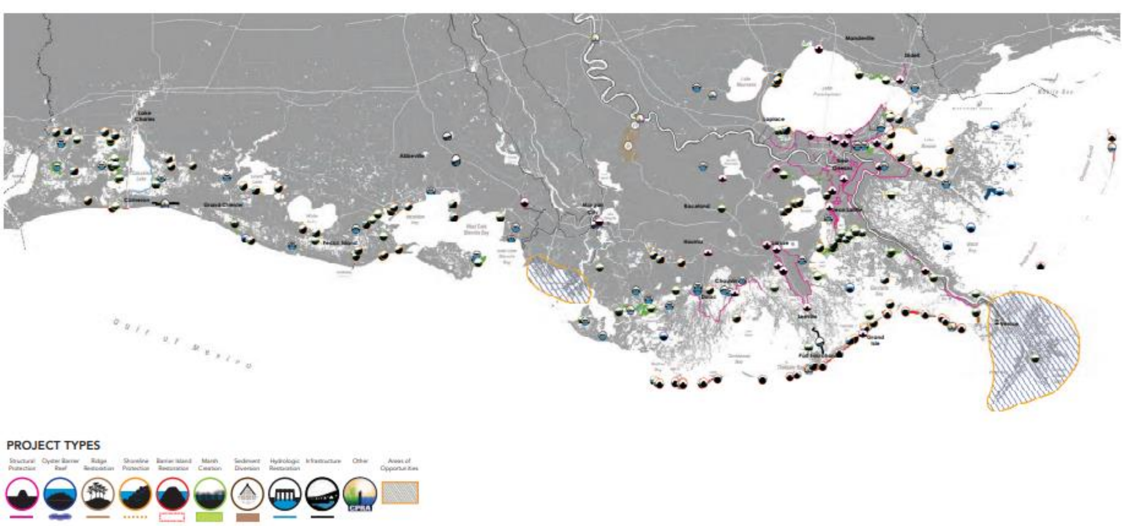


Figure 1.5: Coastal Master Plan 2017 (CPRA).

This study focused on the land creation methods of the Coastal Master Plan – sediment diversions and marsh creation. Sediment diversions work by building a large siphon system that pumps water from the Mississippi river, through the Mississippi River Levee system, into sediment starved marshland to rebuild large areas of marshland at a time. The marsh creation projects are a little more complicated. The marsh creation projects begin with selected a heavily eroded site and constructing a temporary dike around this site in sections. The figure below shows can example of a marsh creation project site:

Figure 1.6: Marsh Creation site aerial photo (Credit: CPRA)

Figure 1.6 shows a marsh creation site with the temporary dike mostly constructed around each section of future marshland. This photo is from March 2015. For the marsh creation projects, the section of marshland that will be created is divided into sections to make the work more manageable. After the temporary dike has been completed, each section will be filled in with a dredged slurry mix from a nearby borrow area. An example diagram marsh creation diagram can be seen below:

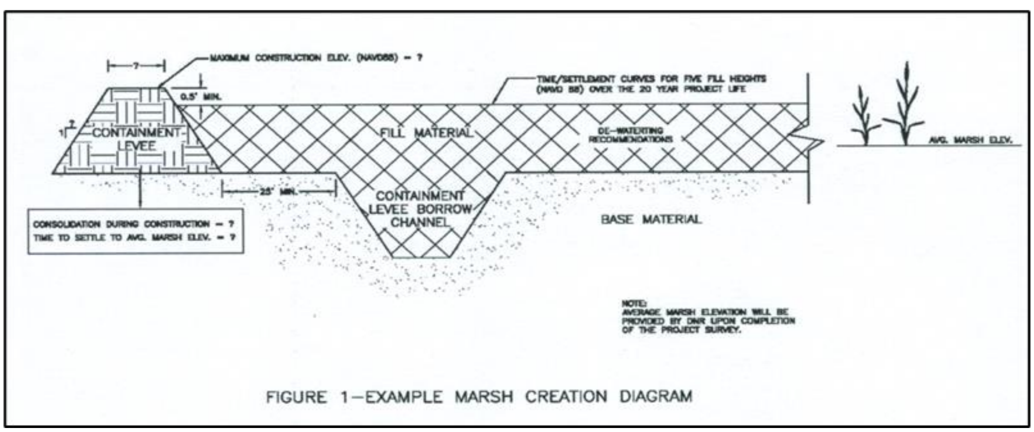


Figure 1.7: Marsh creation example diagram (credit: CPRA).

The dredged slurry is pumped into the site and allowed to settle for a few weeks to form new land. After the sediments within the slurry can settled, the temporary dikes are cut and the water from the slurry is let to flow back into the surrounding waterways. The results from the marsh creation project site can be seen in the photo (taken in August 2015) below:

Figure 1.8: Completed marsh creation project. (Credit: CPRA)

The design and undertaking of these marsh creation projects can be challenging as each project site has very different conditions and the nearest possible borrow areas may not be made up of ideal sediments to prevent or limit future erosion. Currently, many assumptions and estimations are made in the design of these projects. One such parameter that is routinely estimated is the settling velocity of the sediment particles. Borings and geotechnical tests are done to identify the geotechnical characteristics of the borrow sediments to estimate the consolidation of the sediment through the course of a project; however, there has been limited testing done to evaluate how organic content, solids concentration, and grain size distribution effect the sedimentation of a slurry mixture. The research performed in this study aims to evaluate and examine the possible effects of organic content, solids concentration, and grain size distribution on the settling velocity of sediment particles used in coastal restoration projects. This research will also attempt to evaluate the viability of high organic content sediments for future marsh creation projects.

Chapter 2 Literature Review

The main topic of this study was evaluating the effects of organic content on the sedimentation of the slurry mixes using the settling column as well as the mini columns. While researching previous studies for background knowledge on these topics it became clear that there was a gap in information. There were several studies done on the sedimentation of sludge for wastewater treatment plant design improvement, but very few studies on fine grained particle sedimentation like those used in marsh creation projects. There were even fewer studies utilizing the settling column to determine particle settling velocity, and fewer still examining the effects of organic content in sediments.

The following sections present an overview of the sedimentation theory and summary of related studies reviewed.

2.1 Settlement and Influencing Factors

There are a few different stages of settlement that occur starting with discrete settlement. Discrete settlement occurs when there is little to no contact or interaction between the solid particles as they begin to settle, which occurs in low concentrations (Mattson II 2014).

The second stage of settlement is known as flocculent settlement, and this stage tends to vary depending on the solids concentration as well as chemical and biological composition of the slurry mix. In flocculent settlement the soil particles tend to come together and settle as joined masses with a change in physical properties and settling rates (Mebust 2015).

The third stage of settlement is known as zone settling. In zone settlement the particles form a lattice structure, forming a distinct interface during the settling process (Montgomery 1983).

The next stage is hindered settlement, in which water movement is inhibited. In hindered settlement the particles will remain in suspension for longer and eventually join as flocs, which is similar to flocculent settlement but involves a larger number of flocs and the settling happens at a faster rate (Mebust 2015). Most fine-grained soils like those used in marsh creation projects tend to show flocculent or zone settling behavior (Mebust 2015).

The final stage of settlement is compression settling. This stage occurs after the previous three stages have already occurred or if there is a very high solids concentration present. In this stage, the solids settle under the weight of the other solids as they consolidate until the voids and water are slowly squeezed out (Mattson II 2014).

The settlement rate of a slurry can be impacted by solid concentration, particle size and shape, and physical-chemical properties such as salt and organic content. For example, a large diameter particle with a large surface area will have greater resistance and settle at a slower rate (Marshall 1996). One study noted that settling velocity and flocculation correlated positively with solids concentration while studying four different materials that varied in particle shape, size and distribution, clay structure, pH, and specific gravity (Nam 2008). Another study noted that the salt and organic content can cause particles to attract to one another to form flocs (Mebust 2015). The buoyancy and density of the particles can affect the settlement rate, and the new shapes of the resulting floc can be more aerodynamic or have more surface area (Gibbs 1995).

2.2 Settling Velocity

The theory behind settling velocity is based on Stoke's law and accounts for both buoyant and drag forces. The equation for drag force can be seen below:

$$F_D = \frac{C_D A_P v_s^2}{2} \qquad \text{(Equation 2.1)}$$

In this equation, F_D represents the drag force, A_P is the area of a given particle, and is the fluid density.

The equation for buoyant force can be seen below:

$F_G = (\rho_P - \rho)gV_p$ (Equation 2.2)

In the equation for buoyant force, F_G represents buoyant force, ρ_P represents the density of the particle, ρ is the fluid density, g represents the gravitational constant, and V_p represents the volume of the particle. Combining these two equations gives the equation for discrete settling velocity as seen below:

$$V_s = \sqrt{\frac{2(\rho_P - \rho)gV_p}{C_D A_p \rho}}$$ (Equation 2.3)

For a slurry with any hinderance affecting the sediment's settling velocity, the following formula is applied:

$$V_s = \frac{g(\rho_P - \rho)D_P{}^2}{18\mu}$$ (Equation 2.4)

In this equation µ represents the fluid viscosity and D_P represents the particle diameter.

However, these equations are meant for spherical particles in laminar flow conditions which may not be present in practice for march creation projects. Using the settling column, the settling velocity of a particular sediment can be evaluated experimentally. There are two models for this proposed by Vesilind (1968) and Dick (1972), which recorded the settlement of a slurry in a settling column then plotted the interface over time to produce a curve like the one below:

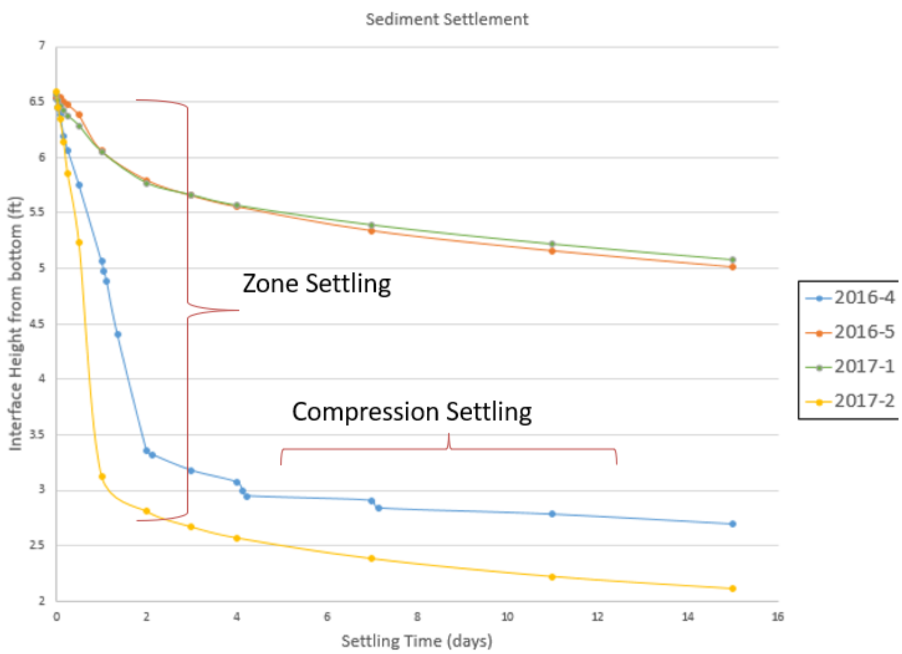


Figure 2.1: Example settling curves. (Source: InnovateUNO presentation spring 2017 by B. Roberts)

In the above figure, the vertical portion of the graph is known as zone settling, which is when the settlement rate is constant. As the curves flatten out, the sediment goes into compression settling during which the sediments are consolidating further under its own weight. The slope of the zone settling part of the curve can be plotted on another graph that shows the same sediment at different concentrations. An example of this type of graph can be seen below:

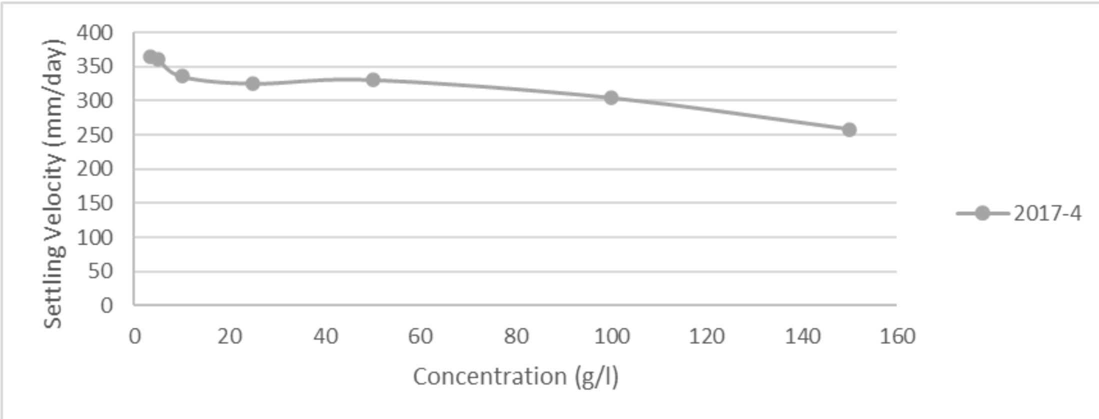


Figure 2.2: Example settling Velocity Analysis Graph developed from 2017-4 mini column data.

These graphs are used to determine the settling velocity of a particle by using the beginning portion of the slope to interpolate backwards toward the y-axis.

2.3 Previous Research

There is limited research utilizing the settling column for coastal restoration research, and even fewer that examined any possible relationship between organic content and settling velocity. Most of the existing settling column research pertains to the sedimentation of sludge to improve the efficiency of wastewater treatment. These studies do not relate to this research, but the basic principles can be applied.

2.3.1 Kelsey A. Fall, Carl T. Friedrichs, Grace M. Massey, David G. Bowers, and S. Jarrell Smith (2016)

A previous study done in 2016 by Fall, *et al* examined the relationship between floc size, organic content, and settling velocity. This study focused on estuarine flocs and used optical profiling instruments with transmissometers and irradiance meters to measure floc properties and possible correlations with organic content, local hydrodynamics, light propagation, and settling velocity in a mixed estuary. This study found that floc size, density, and settling velocity are strongly related to the relative concentrations of inorganic vs organic solids in suspension. It was found that particle size increased with increased total suspended solids, and particle size decreased as density increased. Organic content was found to negatively effect the settling velocity and resulted in a decrease in particle size.

2.3.2 Mebust (2015)

This study done in 2015 evaluated a possible trend for the particle size distribution, salinity, and solids concentration effects on settling velocity. The study found that salinity had little to no effect on the settling velocity or total suspended solids values. The study also found that as the initial concentration of the slurry increased, the settling velocity decreased. There was a positive correlation between total suspended solids and turbidity that yielded an equation to predict TSS values. The study examined particle size distribution and found that samples with higher percentages of fines had slower settling velocities due to the particles remaining in suspension for longer.

2.3.3 Jerolleman (2014)

This study focused on marsh creation projects in both Louisiana and Texas, in which coastal sediments were taken from the top settled soils in the settling column and used for Lick Shaker testing to determine the critical shear stress. This study found that there was a positive relationship between TSS and turbidity, and also that there was a positive correlation between time and erosion rate.

2.3.4 Landin, Webb, Knuston (1989)

Eleven habitat development field sites were built on dredged material and monitored by the U.S. Army Corps of Engineers (USACE) in response to questions about ecological contribution and durability. One such site at Southwest Pass was found to be a success. USACE pumped unconfined dredged material into shallow water areas to create marshland, and over 16 years with testing and soil sampling the results showed that using the dredged material was an economical, efficient method of creating marshland.

2.3.5 Vanderhasselt and Vanrollegheim (2000)

This study focused on predicting the sedimentation characteristics of batch sedimentation curves. The study compared two methods of determining settling velocity, namely the traditional approach using zone settling velocity and a new direct parameter relying on a single batch settling curve. This study focused on lower concentrations can this study did, and the settling column had different dimensions. The complete settling curve was predicted with slight accuracy, but the model still produced variable results.

2.3.6 Nam (2008)

This study focused on channeling during the self-weight and settling of cohesive sediments. The study found that flocculation impacts sedimentation, channeling, and interface formation. Particles tended to floc and discontinuities between the flocs created vertical channels. Which allowed for excess pressure to dissipate. The study found that channels helped to disperse excess pore pressures and accelerate consolidation. There was a positive correlation found between the degree of flocculation during settlement and channel development with increasing slurry concentration.

2.3.7 Daphne, Utomo, Kenneth (2011)

The focus of this research was to determine a correlation between turbidity and TSS. A positive correlation between TSS and turbidity was discovered, which the research team hypothesized that turbidity could be used to estimate TSS values.

2.3.8 Mattson (2014)

This study focused on the effects of grain size distribution, salinity, and initial concentration on settling velocity. The sediments were sampled from on-going or future possible marsh creation sites. This study found that higher salinity correlates negatively with settling velocity during compression settling. The study also noted that TSS and turbidity values were lower with high salinity slurries, and that higher percent fines had slower settling velocities with high TSS and turbidity values. This study also found that higher initial concentration settling tests resulted in lower settling velocities.

2.3.9 Lo, Bentley, Xu (2014)

This study evaluated the processes of consolidation and re-suspension, and how these factors impact retention of fine sediment transported by river diversion. This study found that consolidation rates correlated with initial concentrations, as a few previous studies had, and that shear stresses increased with longer consolidation time.

2.3.10 Wildman (2018)

As part of a master’s thesis, Wildman studied the viability of recycled crushed glass for use in beach nourishment and marsh restoration projects. This study utilized the settling column for zone settling tests of the material. This study concluded that the recycled crushed glass was occasionally suitable for use along the Louisiana Gulf Coast, if the Gulf coast beach consisted of similar grain size.

2.3.11 Bou-Mekhayel (2019)

As part of a master’s thesis, this research evaluated the different properties from CPRA and other databases to find correlations between a soil’s compressive strength, consolidation properties, Atterberg limits, moisture content, and geothermal conductivity. This study found a positive correlation between the compression index and liquid limit, and developed a relationship between thermal conductivity and moisture content.

2.3.12 Filostrat (2014)

As part of a master’s thesis, this research used modeling to evaluate the critical shear stress and re-suspension of silt and clay sediments used in marsh creation projects. The critical shear stress results showed a very high resuspension rate if the inter-storm period neared a day.

2.3.13 Stacey E. Kulesza, PhD, PE, M. ASCE1, Malay Ghose Hajra, PhD, PE, M. ASCE, Mark Mathis, and Brittany M. Roberts (2020)

This study evaluates the effects of organic content and salinity on settling velocity and erodibility of dredged sediments. The study found that organic content had a negative correlation with settling velocity, and that higher organic content increased the erosion potential of the sediment regardless of salinity. The study also found that increased salinity increased the sediment erosion potential regardless of organic content.

Based on extensive review of research journals, it was clear that effects of organic matter on the settling characteristics of fine-grained coastal sediment has not been studied elsewhere. This provided the basis for our research goals and objectives, as indicated in chapter 3 of this document.

Chapter 3 Goals and Objectives

The main objective of this research was to evaluate the effects of organic matter on sedimentation characteristics of coastal sediments used in Louisiana coastal restoration and marsh creation projects.

The above objective was met by accomplishing the following specific goals:

1) Determine the engineering properties of coastal sediments with varying concentrations of organic matter.
2) Determine the effects of organic matter on the settling characteristics of coastal sediments.
3) Estimate the settling velocity of coastal sediments.

Chapter 4 Methodology

4.1 Introduction

The objective of this research was to investigate the effects of organic matter on the sedimentation characteristics of coastal sediments used in coastal restoration and marsh creation projects in Louisiana. To determine the effects of organic content, particle size, and initial solids concentration on sedimentation, settling column tests as well as mini column tests were conducted during this research.

Laboratory testing for the current research was done to characterize the sediment samples and evaluate the effects of organic content, grain size distribution, and solids concentration on the sedimentation characteristics of the samples. The testing was done in the soil mechanics laboratory at the University of New Orleans (UNO). For the laboratory testing, fine grained coastal sediments and organic soils were obtained from southeast Louisiana. The samples were tested individually, and then mixed to prepare three samples (2018-1, 2018-2, and 2019-1) with varying organic content. Additionally, other coastal sediments (sample 2017-1, 2017-2, 2017-3, and 2017-4) were used in the laboratory to evaluate geotechnical characteristics of coastal sediments. The samples were tested in general accordance with ASTM and other applicable standard procedures. This chapter will describe the materials and methods used for laboratory testing.

4.2 Sample Identification and Preparation

For this research, the coastal sediments and organic peat samples were obtained from the field in grab samples. The samples were brought to the lab in sealed containers to be visually identified. After visual identification was done, the samples were put into a large container and mixed to homogenize the samples. The then homogenized samples were divided into sealed containers for testing.

(a) (b)

Figure 4.1: (a) 2018-2 – 15.6% laboratory created sample, (b) 2019-1 – 29.7% organic peat sample

4.3 Geotechnical Characterization Tests

Geotechnical characterization tests were conducted on each sample. These tests help determine the engineering properties of the samples used for the research. The engineering properties are evaluated using mathematical models and determine whether a soil is suitable for a given project. The following geotechnical tests were used for this research: Atterberg limits, Grain size distribution, Specific gravity, and hydrometer tests.

4.3.1 Grain Size Distribution Tests

The complete grain size distribution test is made up of the following individual tests: wet sieve, dry sieve, and hydrometer. These tests were conducted in general accordance with the ASTM standards. The resulting graphs from the dry sieve test and hydrometer test were combined to create a complete grain size distribution curve for the sample.

For samples determined to be made up primarily of fine-grained sediments or sediments with cementitious characteristics a wet sieve analysis was conducted. A wet sieve analysis involves washing a sample through a #200 sieve in general accordance with ASTM D422. Any portion of the sample retained in the #200 sieve is dried and weighed to evaluate the coarse-grained (>0.075 mm) percentage and then characterized further using the dry sieve analysis. The dry sieve analysis was conducted in accordance with ASTM D6913. For the dry sieve analysis, the samples were dried, crushed, and weighed before being passed through the following sieves: #4, #10, #20, #40, #60, #100, #120, #140, and #200. The portions of sample retained in each sieve was weighed to determine the coarse-grained part of the grain size distribution curve.

Figure 4.2: Dry Sieve Shaker with sieves

To further characterize the fine-grained materials in the samples, the hydrometer test was performed in general accordance with ASTM D1140. Fifty grams of soil were taken from the portions of the samples that passed through the #200 sieve in the dry sieve test. The fifty grams of soil was mixed with deflocculating agent, and then placed in a 1000 ml cylinder with distilled water. The sample was then allowed to settle over the course of 48 hours while temperature and hydrometer readings were taken to determine the percent of fine-grained soil particles in the mixture.

4.3.2 Specific Gravity

To evaluate the weight-volume relationship of the samples, the specific gravity test was performed in general accordance with ASTM D854. Before testing the sample, the pycnometer was filled with water and weighed. The pycnometer was then drained and allowed to dry. The dried sample was placed in a pycnometer which was then filled 2/3 with distilled water. The water and sample were then mixed and boiled on a hot plate for approximately 2 hours, and then cooled in an insulated cooler. The formula below was used to calculate the specific gravity:

$$G_s = \frac{M_0}{[M_0 + (M_a - M_b)]} \quad \text{(Equation 4.1)}$$

In which M_0 represents the weight of the dry soil, M_a is the weight of the flask plus water, and M_b is the weight of the flask combined with the weight of water and soil.

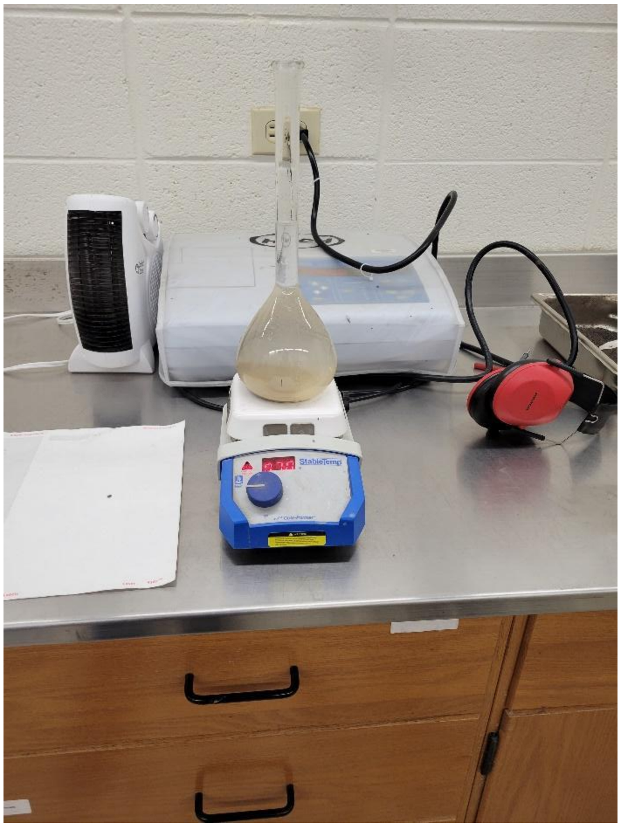


Figure 4.3: Specific Gravity Testing

4.3.3 Atterberg Limits

The liquid limit and plastic limits of each sample were determined using the Atterberg Limits tests performed in general accordance with ASTM D4318 standards. The liquid limit test determines the highest moisture content that a given soil can have and still hold form. The plastic limit determines the lowest moisture content a given soil can have and still hold form. All the soil sample used for both of these tests is passed through a #40 sieve prior to the tests. To perform the liquid limit testing, the sample is placed in the Casagrande device, smoothed out over the bottom of the dish where a groove is then cut through the sample. The dish is then dropped a number of times until the groove closes. The plastic limit test involves rolling a sample until it reaches a diameter of 1/8-inch and begins to crumble. Formulas are applied to determine the liquid limit, plastic limit, and plasticity index of a give sample. The Atterberg limits test results of each sample are included in the appendix.

Figure 4.4 Atterberg Limits device

4.3.4 Organic Content

The amount of organic material present in each sample can effect the physical, biological, and chemical properties of a given soil sample. Organic content testing was done in general accordance with ASTM D29754 standards. This test expresses the organic content as a percentage, using the ratio of the mass of the sample compared to the mass of dried soil solids. Each sample was dried in an oven at 105℃ to remove moisture, and then weighed to determine the mass of dried soil particles. The samples were then placed in a muffle furnace at 440℃ for 48 hours. After the 48 hours in the furnace, the samples were weighed again to determine the mass of organics burnt off in the furnace. The following equation was used to determine the organic content:

$$O_c = \frac{M_o}{M_D} * 100 \qquad \text{(Equation 4.2)}$$

In this formula, M_o is the mass of organic material and M_D is the mass of dried soil solids in grams. The organic content testing was done for each soil sample and for multiple column and mini column tests, the results of which are in the appendix.

The following table provides a summary of the geotechnical characterization tests for all the coastal sediments used in this research. Chapter 5 provides results and discussion of the laboratory tests performed for this research.

Table 4-1 Master List of Sample Variables

Sample ID	Sample Source	Liquid Limit/PI (%)	Specific Gravity	Organic Content (%)	Grain Size Distribution		Initial Solids Concentration (g/l)	pH	Salinity (ppt)
					% Fines	% Coarse			
2017-1	Port Cameron	81/53	2.59	4.2	90	10	150	NA	2.84
2017-2	Terrebonne Parish	81/53	2.69	3.6	95.85	64	100	7.8	3
2017-3	North Lake Borgne	59/16	2.65	11.7	24.93	75.07	70	7.8	1.4
2017-4	North Lake Borgne	38/19	2.64	4.9	79.6	20.4	150	9.1	8.02
2018-1	Lab prepared sample	41/21	2.63	1.0	91.5	8.5	103	8.7	2.41
2018-2	Lab prepared sample	82/53	2.5	15.6	64	36	98	6.4	1.72
2019-1	Lab prepared sample	259/141	2.28	29.7	63	37	99	5.7	1.18

4.4 Column Settling Test

The settling column test simulates the settling characteristics of a given slurry mix that could be used in a coastal restoration project. The test utilizes a nearly 7-foot-tall acrylic column that the slurry mix is pumped into using an industrial pump and mixer. The slurry mix is then left to settle over the course of 15 days during which slurry samples are drawn from specified ports installed at various heights along the column. Concentration, organic content, total suspended solids, and turbidity tests were done on each sample drawn from the ports to track the changes in these values over the course of the column tests. The settling column tests were done for each sample and were conducted in accordance with USACE Engineering Manual 1110-2-5027.

4.4.1 Sample Preparation for Column Settling Test

The homogenized soil samples were placed into a large container and mixed with water using an industrial mixer to create the slurry mixes that would be pumped into the settling column. In most cases, these samples would be mixed with site water to best simulate the conditions of the marsh creation project that the dredge material may be used for. In this case tap water was used to eliminate other possible variables that may be introduced by using site water, such as salinity variances or other organic matter being introduced to the tests beyond what naturally occurred in the sediments. Each sample was thoroughly mixed and tested for correct concentration several times. If the concentration tests showed that the slurry had too little or too much water, then the slurry would be altered, remixed, and retested until the desired concentration was met and verified. Once the desired concentration was achieved, the slurry mix would be pumped into the column and the column test would begin. The below figure shows the typical set up for the settling column test.

(a) (b)

Figure 4.5: Photos of the settling column test for 2017-4 (a) at 0 hour and (b) after day 15.

In addition to the standard settling column testing procedure, there were three tests done in the settling column to compare and evaluate the effects of organic content on the sedimentation velocity of soil particles. These three samples were prepared in the laboratory to minimize other variables: 2018-1 (1% organic content), 2018-2 (15.6% organic content), and 2019-1 (29.7% organic content). During these three tests, samples were drawn from ports No. 3, 6, and 10 to test for organic content and track the behavior of the sample in the water column throughout the column tests. The below figure shows the location of these ports on the settling column.

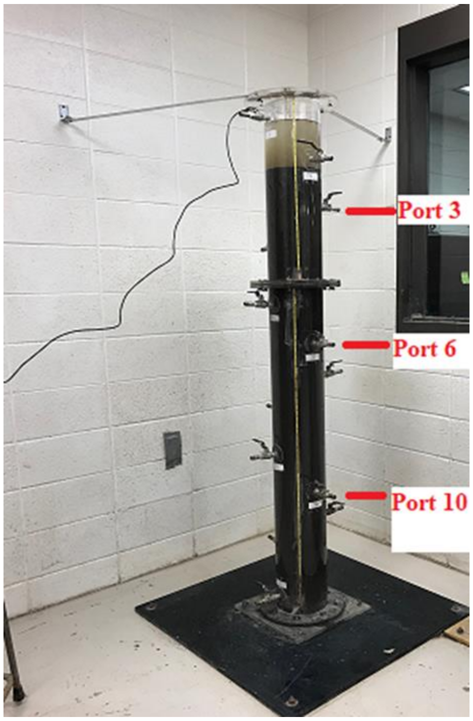


Figure 4.6: Location of organics testing port locations on settling column.

4.4.2 Slurry Testing

Turbidity, Total Suspended Solids, particulate concentration, and organic content tests were also performed on all the samples in this study. Turbidity was conducted using a nephelometer according to standard procedure and the unit manual provided. Total suspended solid testing was done in accordance to EPA standards to compare these values to those of the turbidity tests for each sample. Particulate concentration was performed to check the concentration of the slurry mix used in each standard and mini column test, as well as to track the change in concentration over time throughout the column tests. Particulate concentration tests were performed in accordance with the ASTM standard. Organic content tests were done following the concentration testing. Each set of organic content tests were left in a furnace at 440℃ for 48 hours, after which the remaining portion of soil was weighed, and organic content determined.

4.5 Total Suspended Solids and Turbidity

To determine the amount of suspended matter in the water column, total suspended solids and turbidity testing was performed for each column settling test. These tests were done for samples drawn from specified ports along the main column as well as the middle of the mini columns for each reading interval during the 15 days. Total Suspended Solids analysis was performed in general accordance with the Environmental Protection Agency (EPA) Environmental Sciences Section (ESS) Method 340.2. To perform this test, each sample was poured through a 0.47-micron pore size filter and then the weight of the solids remaining on the filter was recorded. The following formula was used to calculate the Total Suspended Solids:

$$TSS = \frac{W_p}{V_t} * 10^6 \quad \text{(Equation 4.3)}$$

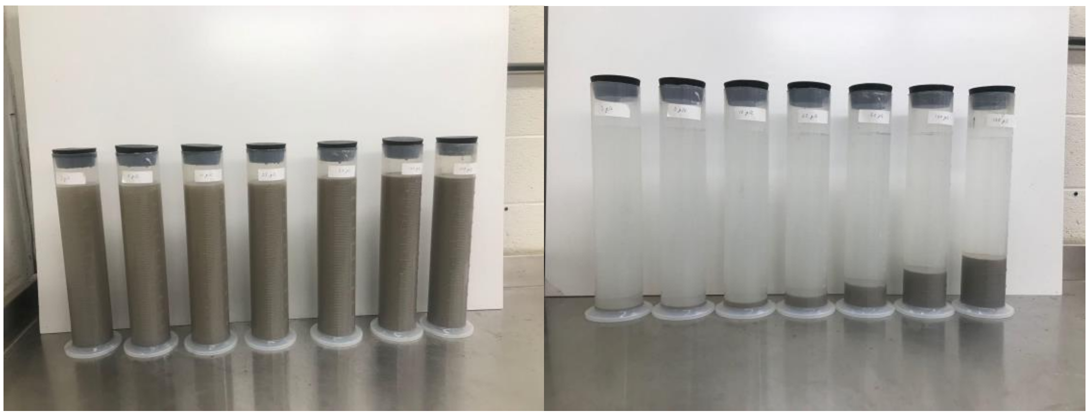
In this formula W_p represents the weight of the dried particles on the filter paper and V_t is the volume of the sample in liters.

Turbidity testing was also done as an additional measure for the suspended solids in each sample. For this test, the samples were poured into a vial which was wiped clean and inverted before being placed in the turbidimeter.

The turbidity values given by the turbidimeter were recorded in NTUs. The results from both the Total Suspended Solids analysis and the turbidity testing are available in the appendix.

4.6 Mini Column Test

Similar to the standard column test, the mini column test is a smaller scale consolidation test done in sets to compare the same sediment sample's consolidation rate at different concentrations over 15 days. The goal of the mini column tests is to determine settling velocity of fine-grained dredged sediments. The value of settling velocity is used in multiple coastal evaluations. The mini columns are each 2-liter graduated cylinders filled to the 2000 ml line with a given sample's slurry mix and sealed to prevent or limit evaporation. For this study, the concentrations were 3 mg/l, 5 mg/l, 10 ml/g, 25 mg/l, 50 mg/l, 100 mg/l, and 150 mg/l. The figure below shows a typical setup for the mini column tests done in this research.



(a) (b)

Figure 4.6: Photos of the mini column testing for 2017-4 (a) at 0 hour and (b) after day 15.

4.7 Sample Preparation for Mini Column Test

The sample preparation for the mini column test is like the standard column test. The homogenized sample is divided into the number of different concentrations required for a particular set. In this case, the homogenized sample was divided among seven different containers to be mixed with tap water at the seven different concentrations used for this study. These slurry mixes were prepared simultaneously, with concentration tests being done to verify that the desired concentration had been achieved for each mixture. Once all seven of the mixtures were completed, they were resuspended using an industrial mixer and poured into their respective, labeled column. Each of the seven mini columns are inverted 60 times, simultaneously, to resuspend the sediment and ensure that the consolidation starts as closely to the same time as possible.

4.8 Sample Collection for Mini Column Test

Unlike the standard column test which involved drawing slurry samples from ports at specific intervals, the mini column test normally consists of pictures being taken at more frequent intervals. In this case, however, small samples were drawn from the midpoint of each mini column (at the 1000ml mark) after 24 hours, 168 hours, 264 hours, and 360 hours using the same syringes that were used on the standard column test. For each sample drawn during the mini column tests of each sediment slurry the following tests were performed: total suspended solids, turbidity, particulate concentration, and organic content.

Chapter 5 Results and Discussion

The results from the geotechnical characterization and column settling tests will be presented in this chapter. The effects of grain size distribution, initial solids concentration, and organic matter on sedimentation properties of fine-grained Louisiana coastal sediments was evaluated. As discussed in chapter 4, Table 5.1 below shows the master list with each of the samples tested during this research with the soil properties.

Table 5-1: Summary of Sediment samples tested

Sample ID	**Sample Source**	**Liquid Limit/ PI (%)**	**Organic Content (%)**	**Grain Size Distribution**		**Initial Solids Concentration (g/l)**	**Specific Gravity**
				% Fines	**% Coarse**		
2017-1	Port Cameron	81/53	4.2	90	10	150	2.59
2017-2	Terrebonne Parish	81/53	3.6	95.85	64	100	2.69
2017-3	North Lake Borgne	59/16	11.7	24.93	75.07	70	2.65
2017-4	North Lake Borgne	38/19	4.9	79.6	20.4	150	2.64
2018-1	Lab prepared sample	41/21	1.0	91.5	8.5	103	2.63
2018-2	Lab prepared sample	82/53	15.6	64	36	98	2.5
2019-1	Lab prepared sample	259/14 1	29.7	63	37	99	2.28

A settling curve was created for each test by recording the height of the solid-water interface with sedimentation time as shown in Figure 5.1. A typical settling curve has a sharp vertical decline where most of the settlement occurs with an asymptote occurring along the x-axis. The x-axis is the sedimentation time in days and the y-axis is the solid-water interface height (measured from bottom of the column). The linear portion of the settling curve is the zone settling where the slurry settles due to various sedimentation characteristics. The portion of the curve that has plateaued is called compression settling - at this point, most of the settlement has already occurred and the slurry is settling under its own weight. To compare the resulting settling curves from each test, the curves were normalized – converting the x-axis to $\frac{H}{H_0}$.

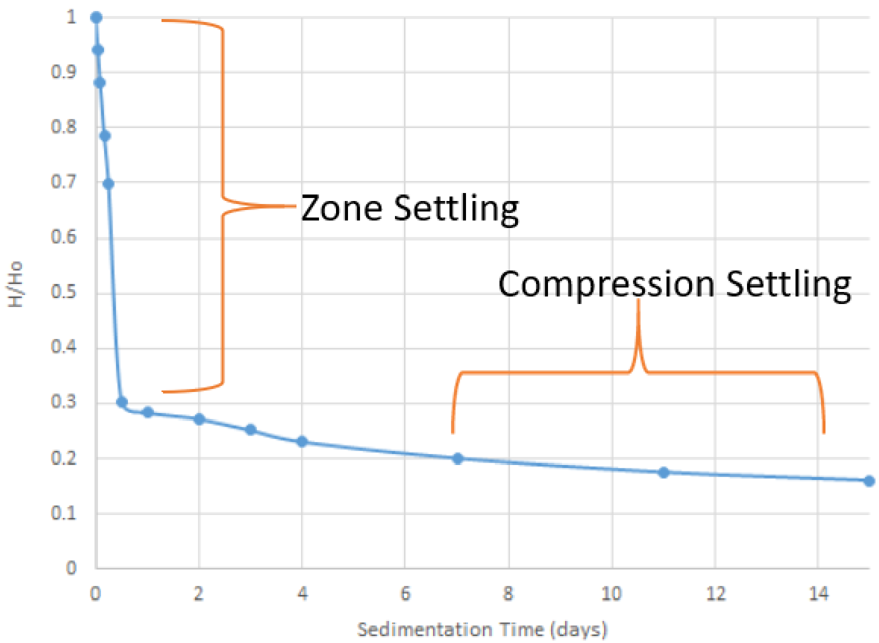


Figure 5.1: Example of a typical settling curve

The following sections of this chapter will look at different sediment properties and their effects on the settling characteristics.

5.1 Effects of Organic Content on Settling Velocity of Dredged Sediments

To evaluate the effects of organic content on sedimentation, a silt-clay material with a low organic content (1%) was used as a comparison against an organic peat sample with high organic content (29.7%), and then both were blended at roughly 50% by weight which produced a lab-created sample with an organic content of 15.6%. Each sample was homogenized prior to testing. The samples were mixed in the laboratory with tap water to prepare slurry samples for column testing. The table below summarizes the characteristics of the samples tested to evaluate the effects of organic content.

Table 5-2: Characteristics of samples used in evaluating effects of organic content on sedimentation.

Sample ID	**Sample Source**	**Initial Solids Concentration (g/l)**	**Liquid Limit (%)**	**PI (%)**	**Organic Content (%)**	**Fines (%)**	**Coarse (%)**	**Specific Gravity**
2018-1	Lab prepared sample	103	41	21	1	91.5	8.5	2.63
2018-2	Lab prepared sample	98	82	53	15.6	64	36	2.50
2019-1	Lab prepared sample	99	259	141	29.7	63	37	2.28

The resulting sedimentation graph from the column tests performed on the above-mentioned samples can be seen below.

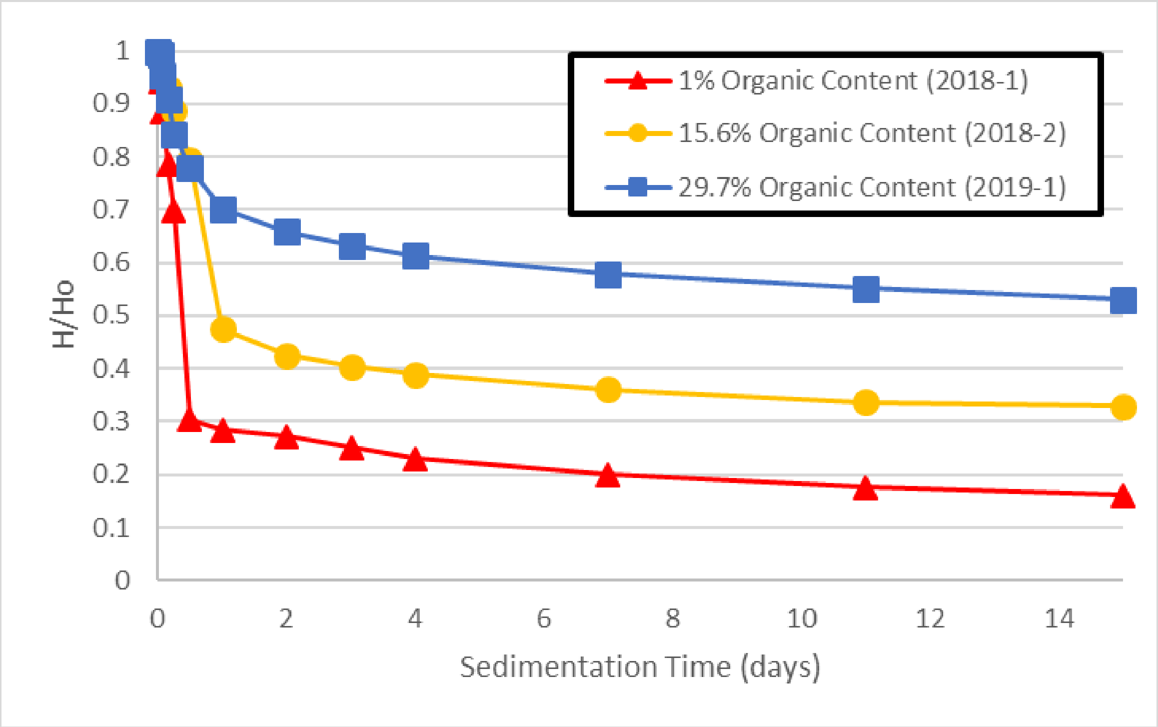


Figure 5.2: Settling Curves for effects of organic content on the sedimentation of dredged sediments

In this graph H_o represents the initial height of the slurry at the start of the test and H represents the height of the interface (between solids and supernatant water) at any given time during the test. In this figure, the sediments with lower organic content settled and consolidated at a much faster rate than those with higher organic content. Zone settling and compression settling can both be seen clearly on this graph. The high settling velocity of the lowest organic content sample (2018-1) resulted in a shorter duration of zone settling. The zone settling portion of the graphs (the first 24 hours) can be seen plotted separately in the graph below.

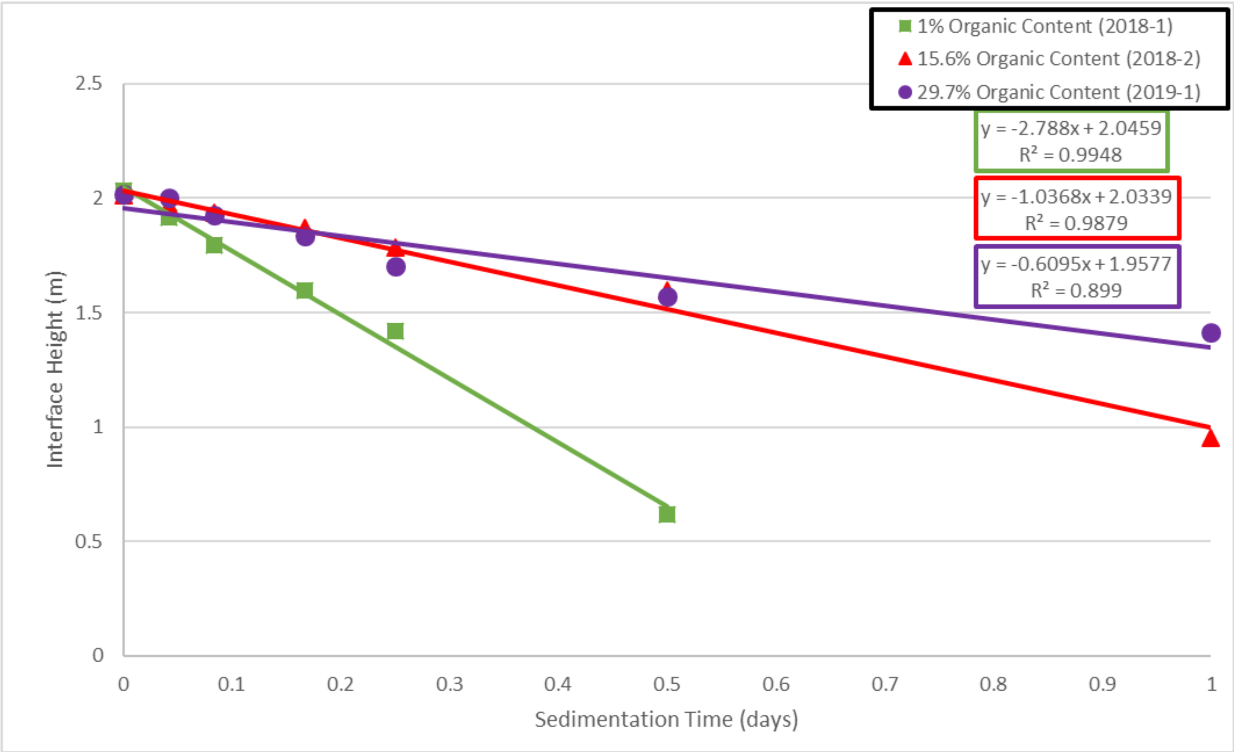


Figure 5.3: Zone settling graphs showing the resulting settling velocities of 2018-1, 2018-2, and 2019-1.

In the above figure 5.3 the slope of the regression line which correlates to the settling velocities is shown. The regression lines in the graph above are from the tests used to examine the effects of organic on sedimentation. The sample with the lowest organic content (2018-1) had the highest settling velocity of the three samples at 2.788 meters per day while the sample with the highest organic content (2019-1) has the lowest settling velocity at 0.6095 meters per day. This indicates that the organic matter in the samples hinders the settlement, and that the organic content of the samples has a negative relationship with the settling velocities of the sample.

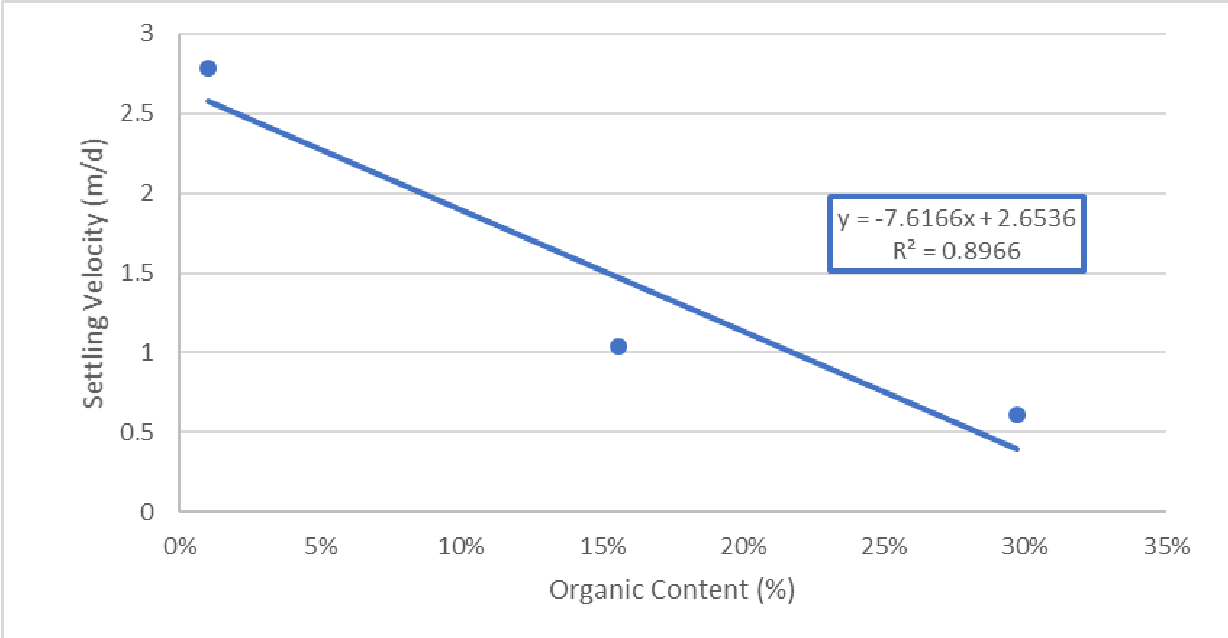


Figure 5.4: Correlation between organic content and settling velocity**.**

Figure 5.4 shows the correlation between the organic contents and the settling velocities that were estimated during testing. The formula shows that an approximation of settling velocity may be made based on the organic content of a given sample. This formula and correlation will be elaborated on further in the following chapter.

As indicated in chapter 4, mini column tests were also performed on the coastal sediments containing various percentages of organic matter. The following figure (Figure 5.5) illustrates the effects of organic matter for an initial solids concentration of 100 g/l.

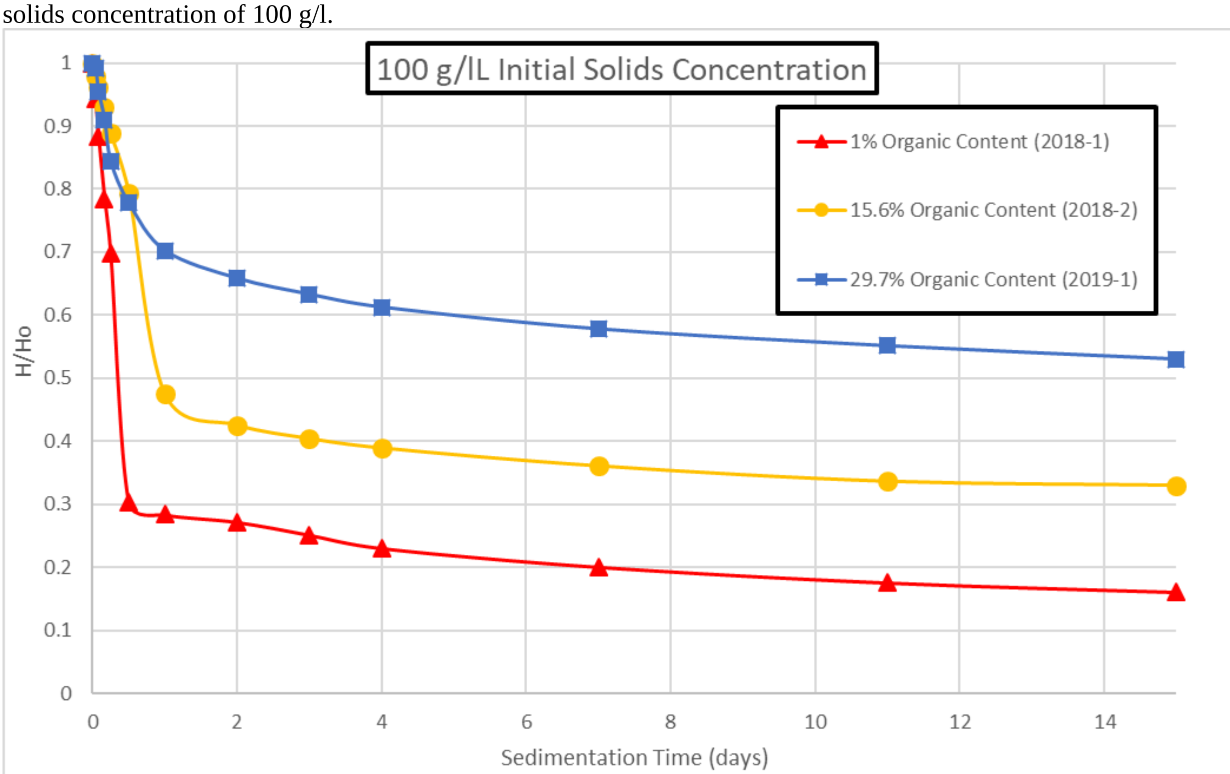


Figure 5.5: Resulting Settling Curves from samples 2018-1, 2018-2, and 2019-1.

Similar to the large column tests, Figure 5.5 shows the sediments with lower organic content settled and consolidated at a much faster rate than those with higher organic content.

5.2 Estimation of Settling Velocity using Mini column tests

The table listed below shows the geotechnical engineering characteristics of the samples used in modified mini columns tests using 2000 ml graduated cylinders. In typical mini column testing photos, temperature, and depth readings are done at each reading to track sedimentation of a given sample in different concentrations over the course of the 15-day test (test for 2019-1 was extended to 93 days). For these three tests, samples were drawn from the middle of each column (at the 1000 ml mark) to track the organic content over the course of the test. In this table, a list of the initial solids concentrations for each set of mini column tests are listed.

Table 5-3: Characteristics of samples for organic testing used in mini column tests

Sample ID	**Sample Source**	**Liquid Limit (%)**	**Plasticity Index (%)**	**Organic Content (%)**	**Fines (%)**	**Coarse (%)**	**Initial Solids Concentration (g/l) Range**
2018-1	Lab prepared sample	41	21	1	91.5	8.5	3, 5, 10, 25, 50, 100, 150
2018-2	Lab prepared sample	82	53	15.6	64	36	3, 5, 10, 25, 50, 100, 150
2019-1	Lab prepared sample	259	141	29.7	63	37	3, 5, 10, 25, 50, 100, 150

The following figures (Figures 5.6, 5.7, and 5.8) show the resulting settling trend from the mini column tests on these three samples. In general, for the same organic content, a higher initial solids concentration resulted in shallower settling characteristics.

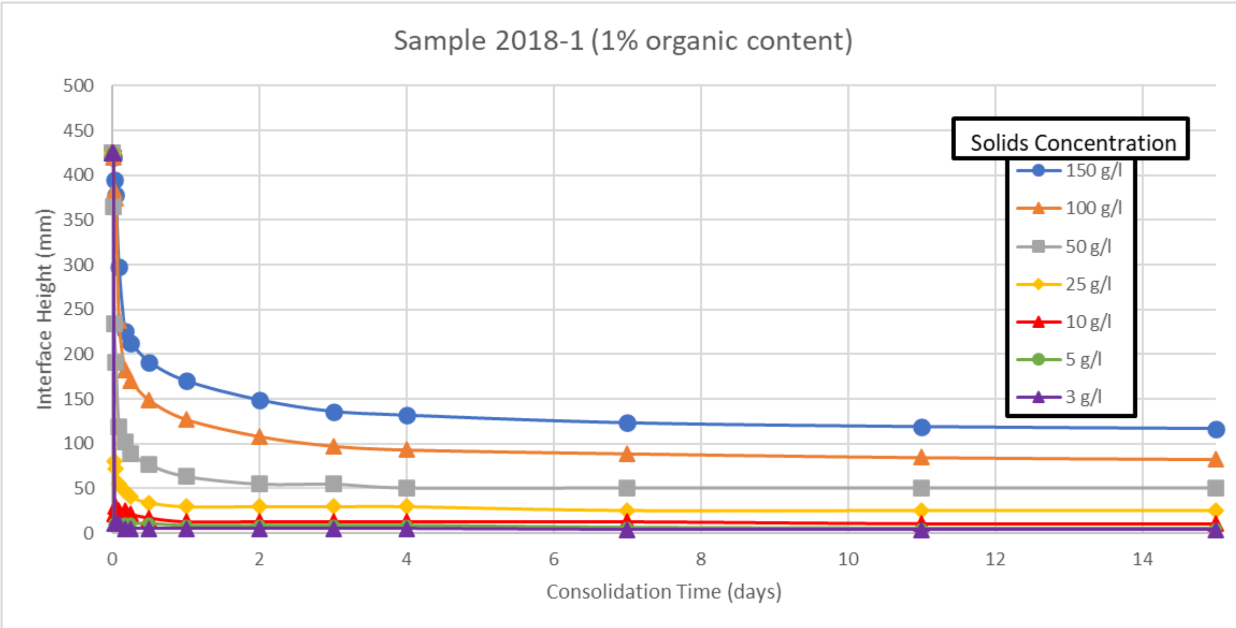


Figure 5.6: 2018-1 mini column consolidation results.

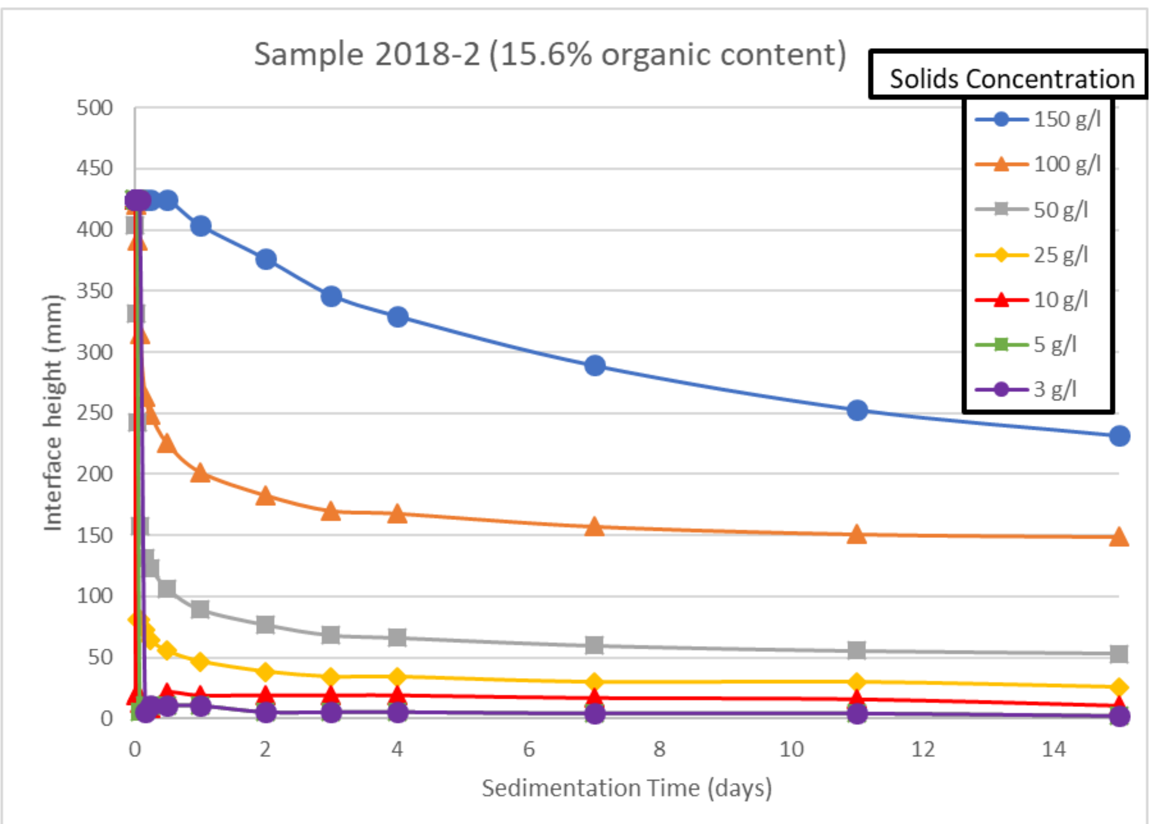


Figure 5.7: 2018-2 mini column consolidation results.

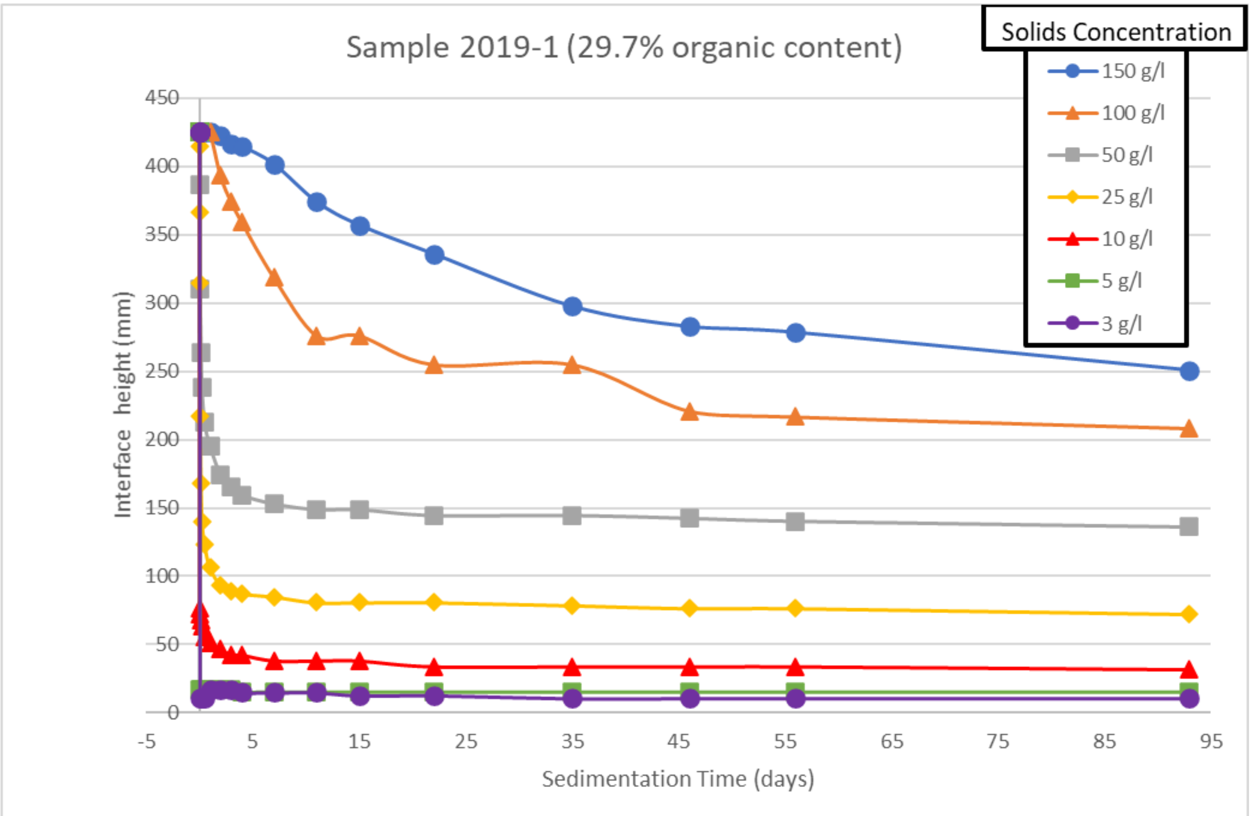


Figure 5.8: 2019-1 mini column consolidation results.

In figures 5.6, 5.7, and 5.8, the resulting sedimentation data from each series of mini column tests for 2018-1, 2018-2, and 2019-1 can be seen. In these graphs the zone settling and compression settling portions of multiple settling curves can be seen side by side. In comparing the 2018-1 and 2019-1 settling curve results shown in figures 5.6 and 5.8 the zone settling portion of 2018-1 (1% organic content) is much steeper and more pronounced than in 2019-1 (29.7% organic content). Also, the 2019-1 sample was run for a total of 93 days instead of the typical 15 days to get a fuller picture of the behavior of a high organic content sample slurry. Like the main column settling curve for 2019-1, each initial solids concentration of the sample showed similar characteristics such as the brief zone settling portion of the curves. The two highest initial solids concentration samples showed very uneven settlement at the solids interface throughout the test and had very little consolidation whereas the 2018-1 series of mini column tests had a mostly level solids interface and consolidated along the insides of the cylinders.

As the organic content of the sample increased, the settling velocity decreased as did rate of consolidation. The water column in the tests became increasingly murky over the duration of the tests for 2018-2 and more so for 2019-1. It was also observed that the murkiness in the water column was worst along the solids interface (Figures 5.9, 5.10, and 5.11).

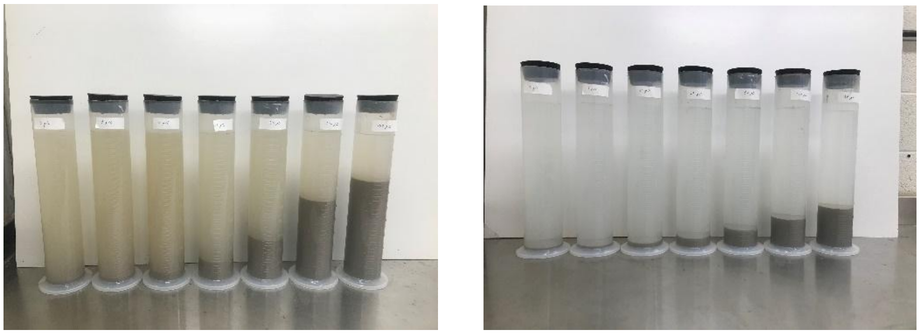


Figure 5.9: 2018-1 mini columns at 2-hour reading (left) and 360-hour reading (right)

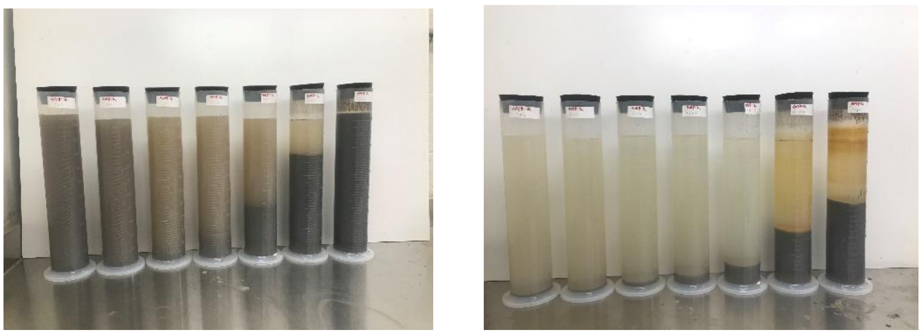


Figure 5.10: 2018-2 mini columns at 2-hour reading (left) and 360-hour reading (right)

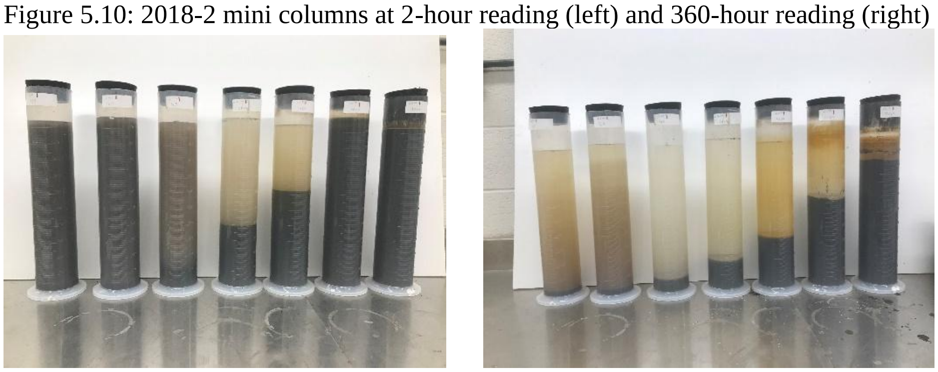


Figure 5.11: 2018-2 mini columns at 2-hour reading (left) and 360-hour reading (right)

Using the sample graph for 2018-1, the highest initial solids concentration had the lowest overall slope at 1505.8 mm/d while the two lowest initial solids concentration had the highest overall slope value at 20321 mm/d. In figure 5.12 below, 2018-1 is used as an example to show how the settling velocity is estimated based on this data. For each settling curve in the mini column test series the slope is calculated within the zone settling portion of the graph and an equation is developed using linear regression.

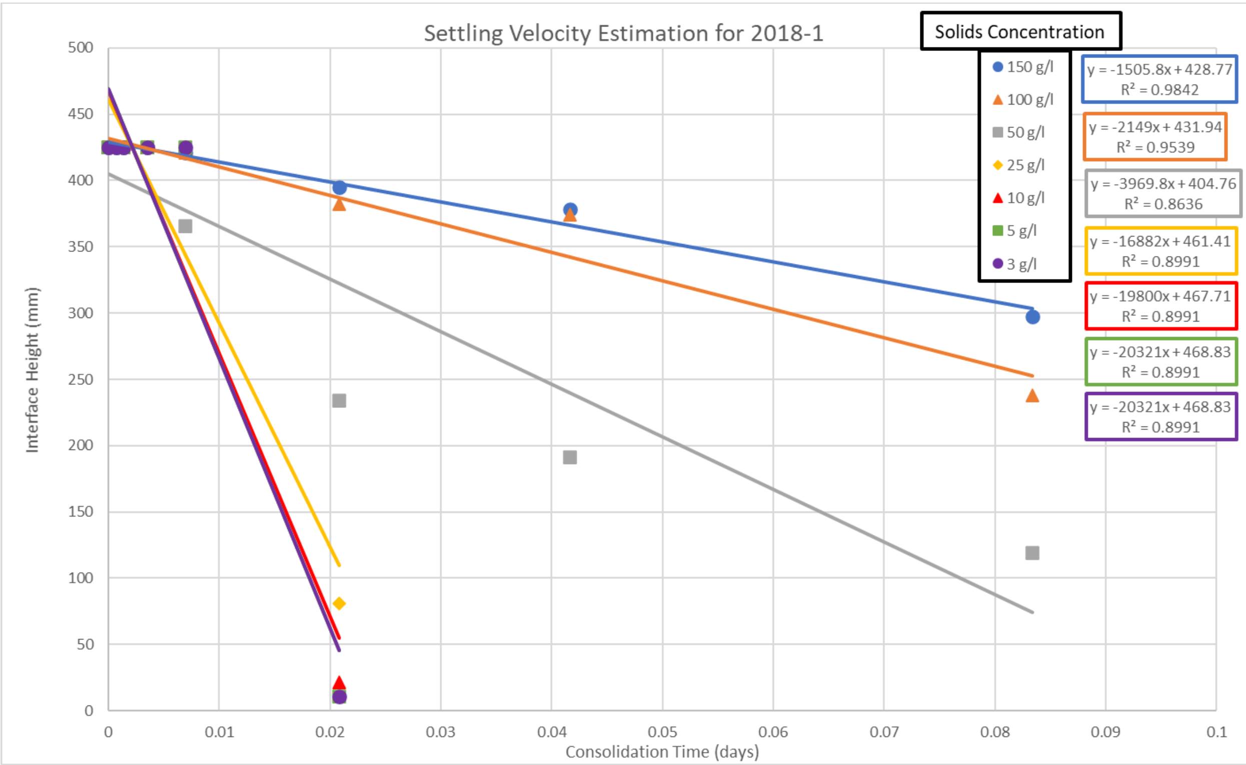


Figure 5.12: Example showing the estimation of setting velocities from the mini column data.

Figure 5.13 shows the relationship between settling velocity and initial solids concentration obtained from the mini column tests. The settling velocity is presented under different concentration ranges which correspond to different settling characteristics (zone settling, hindered settling, and compression settling).

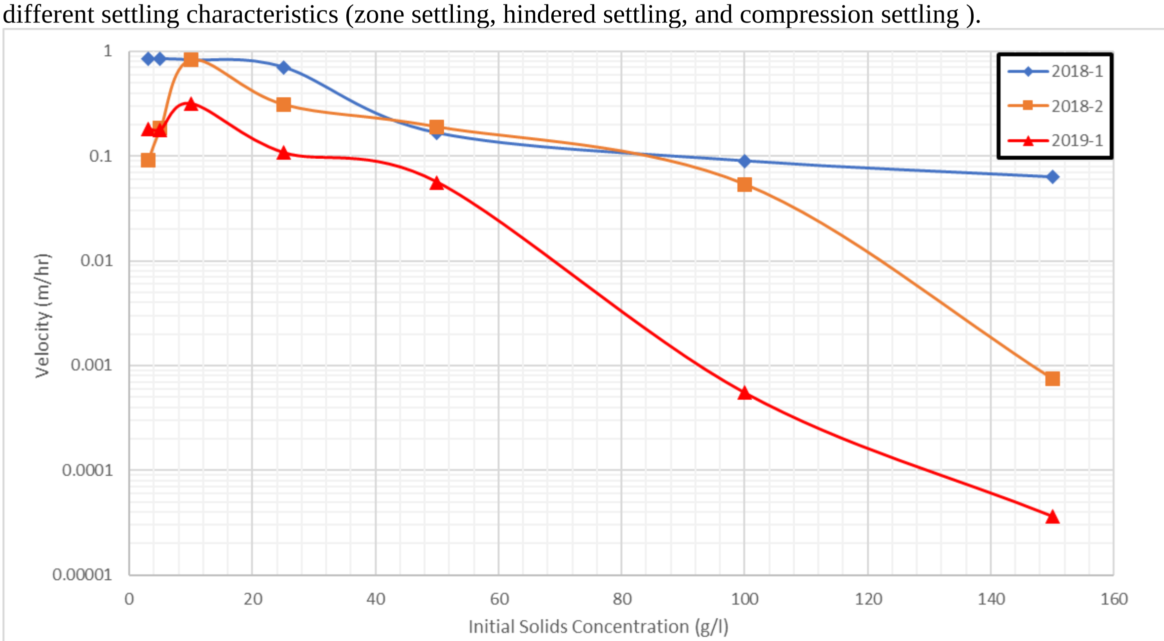


Figure 5.13: Variation of settling velocity with Initial solids concentration

In Figure 5.13, samples 2018-2 and 2019-1 both show an initial decline in settling velocity with short peaks appearing in the graph among the lowest solids concentrations. This is due to the hinderance of the inorganic material settling due to the presence of organic matter. The decline in settling velocity in the lower concentrations may also be due to flocculation occurring between the inorganic matter interacting with the organic material in the water column.

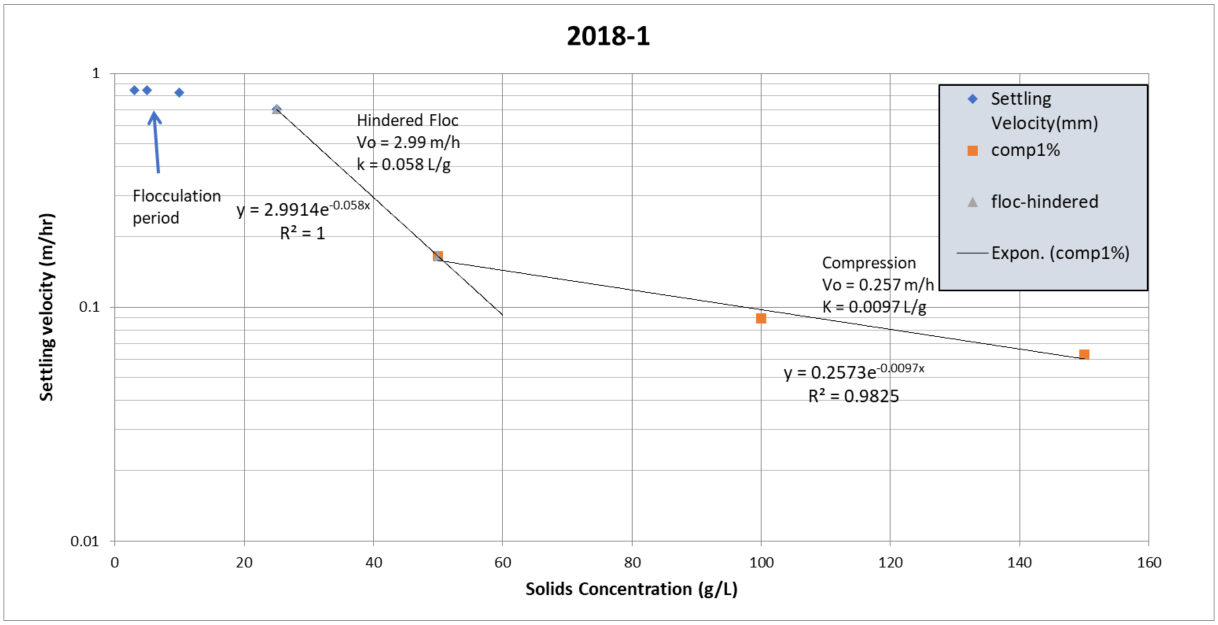


Figure 5.14: Sample 2018-1 settling velocity graph

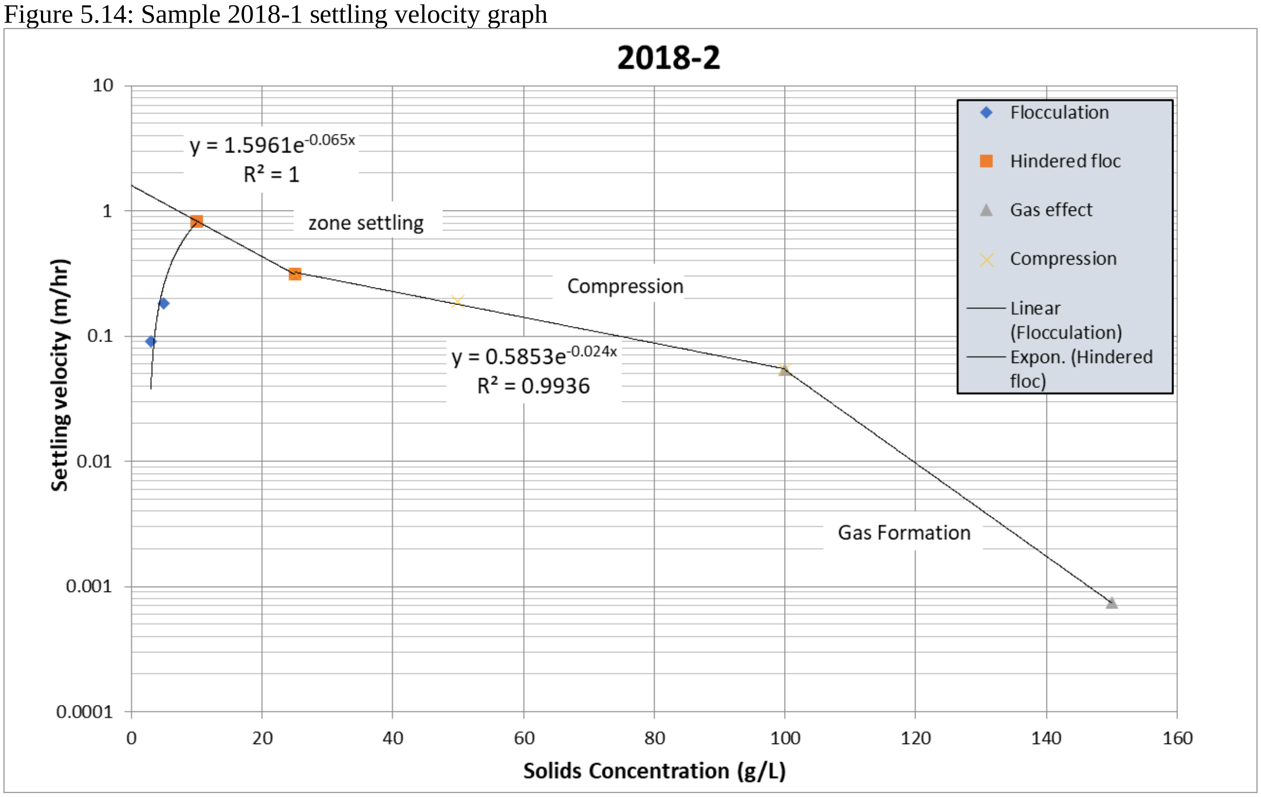


Figure 5.15: Sample 2018-2 settling velocity graph

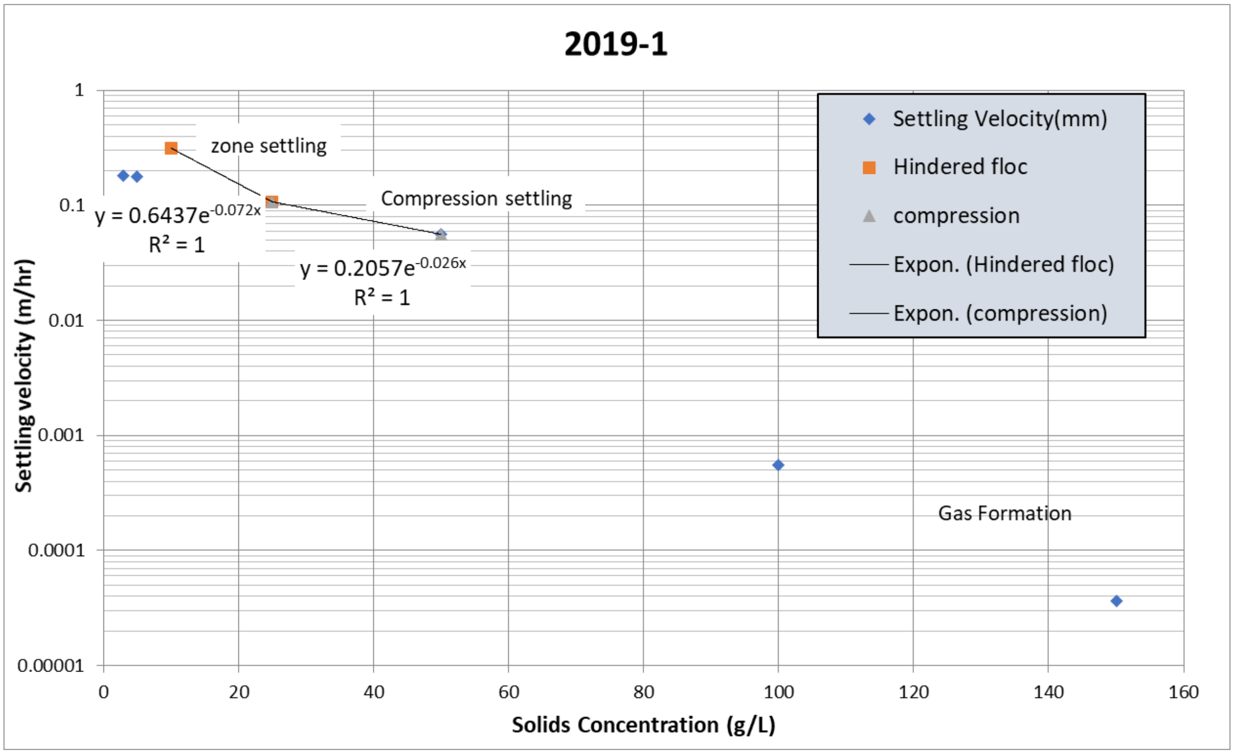


Figure 5.16: Sample 2019-1 settling velocity graph

The above graphs in Figures 5.14, 5.15, and 5.16 show the zone settling, hindered settling, and compression settling of samples 2018-1, 2018-2, and 2019-1. The research revealed four phases of settling: a flocculation period (as shown in Figure 5.14), zone settling, compression settling, and a final phase effected by methane production.

In figure 5.14, a flocculation period in the lower concentrations is apparent prior to hindered flocculation phase of settlement leading into zone settling. 5.14 shows a typical settlement graph whereas figures 5.15 and 5.16 show the gas formation phase that accompanied the higher organic contents of these samples.

Table 5.4 below summarizes the values of the settling velocity for the different zones and their corresponding slope values. As can be seen from the table, V_o decreases with increasing organic content. k_o increases with increasing organic content within the zone settling phase of sedimentation. Unfortunately, there was not an apparent consistency within the compression phase, likely due to methane production effecting the determination of the parameters. In future research, more testing at lower concentrations should be done in order to find more consistency within the compression phase of sedimentation for sediments with high organic content. The effects of the gas formation appear to begin at roughly the 60 g/l concentration for high organic content samples.

Table 5-4: Settling Velocity Summary Table

Sample ID	Organic Content (%)	Zone Settling		Compression Settling	
		V_o (m/hr)	k_o (g/l)	V_c (m/hr)	k_c (g/l)
2018-1	1	2.99	0.058	0.257	0.0097
2018-2	15.6	1.6	0.065	0.585	0.024
2019-1	29.7	0.644	0.072	0.206	0.026

In the above table, V_o represents the zone settling velocity (m/hr) at a solid's concentration of 0 g/l; k (g/l) represents the slope of the zone settling portion of the settling curve; V_c represents the compression setting velocity (m/hr); and Kc represents the slope of the compression settling portion of the curve.

To calculate these values, the settling velocity verses concentration curves are separated into the different phases of sedimentation. In figure 5.14, the sedimentation data for the 2018-1 sample was broken into three phases: flocculation, zone settling, and compression settling. In this example, the Vo value comes from the y-intercept of the best fit line through the data points in that section of the curve. In the case of 2018-1, the y-intercept is approximately 2.99. The k_o value comes from the rate of the best fit line through the data points. In the graph for 2018-1, it can be seen that the rate (or Ko) is roughly 0.058.

5.3 Zone Settling Regression Analysis

Using the zone settling portion of these graphs from figures 5.14, 5.15, and 5.16, the following table was developed.

Table 5-5: Zone Settling Parameters

Organic Content (%)	V_o (m/hr)	k_o (g/l)
1	2.99	0.058
15.6	1.6	0.065
29.7	0.644	0.072

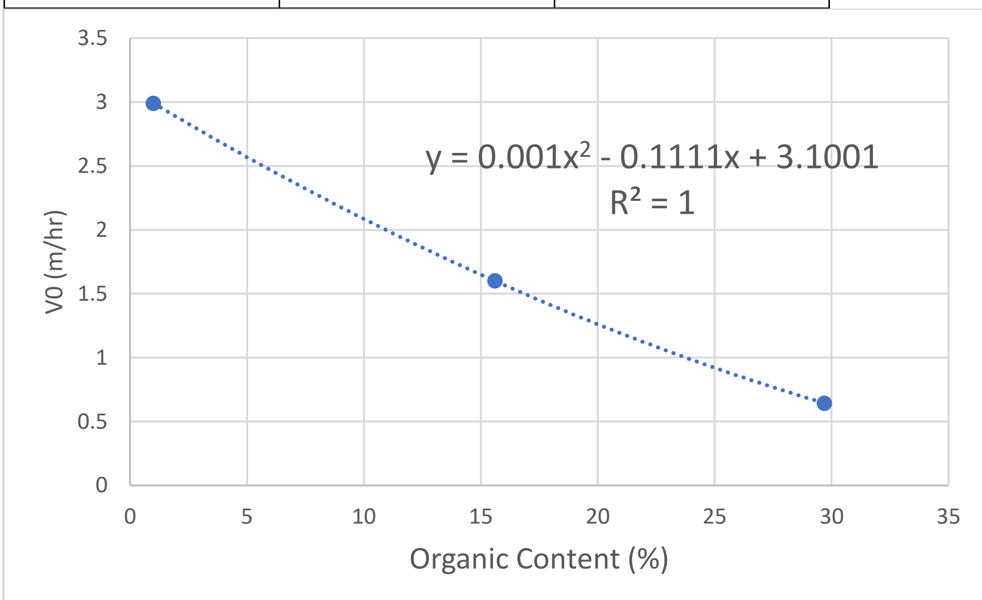


Figure 5.17: Polynomial equation for organic content as a function of velocity.

In figure 5.17, the polynomial equation for the relationship between the samples' organic contents and the samples' zone settling velocities is shown. In this equation x represents the organic content as a whole number and y represent the zone settling velocity.

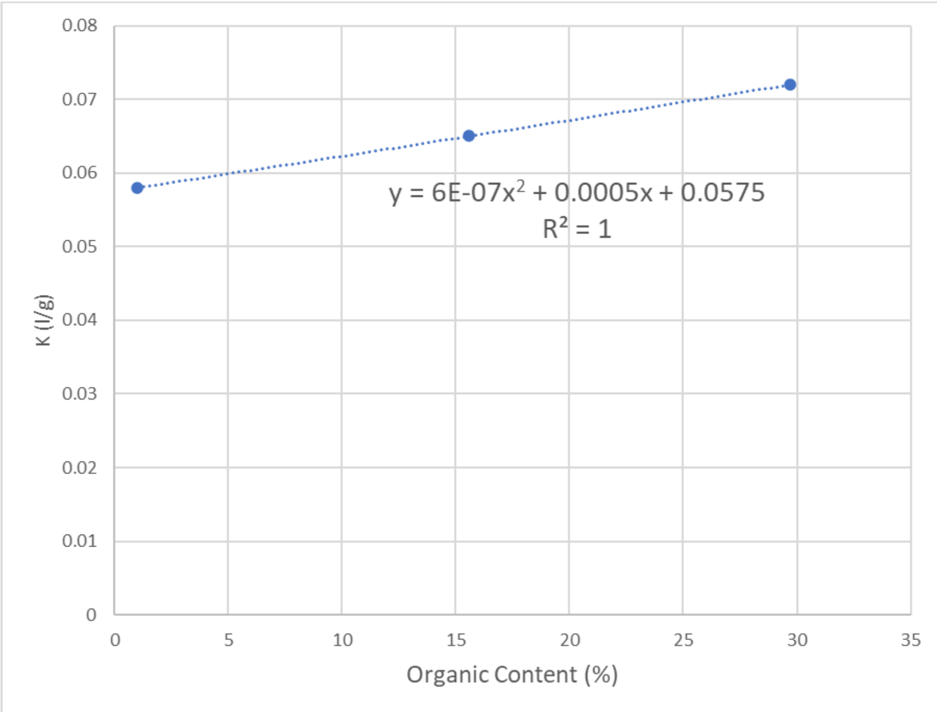


Figure 5.18: Polynomial equation for organic content correlation with k value

In the above Figure 5.18, the polynomial equation for the correlation between organic content of the samples and their corresponding k values can be seen. Combining these two equations gives the following equation:

$$Vs = (0.001 * [organic\ content]^2 - 0.1111[organic\ content] + 3.1001e^{(-0.0005[organic\ content]+0.0575)*[concentration]} \quad \text{(Equation 5.1)}$$

In this equation, organic content is expressed as a whole number and concentration is in grams per liter. The Vs value will result in meters per hour. This equation could provide an estimation of zone settling velocity based on the initial solids concentration and the organic content of a given sample.

5.4 Effects of Initial Solids Concentration on Settling Velocity of Dredged Sediments

The following section discusses the effects of solids concentration on the settling characteristics. Settling characteristics of coastal sediments over time of consolidation obtained from large column tests are plotted for sample 2017-1, 2018-1, and 2019-1 (Figure 5.19 and 5.20).

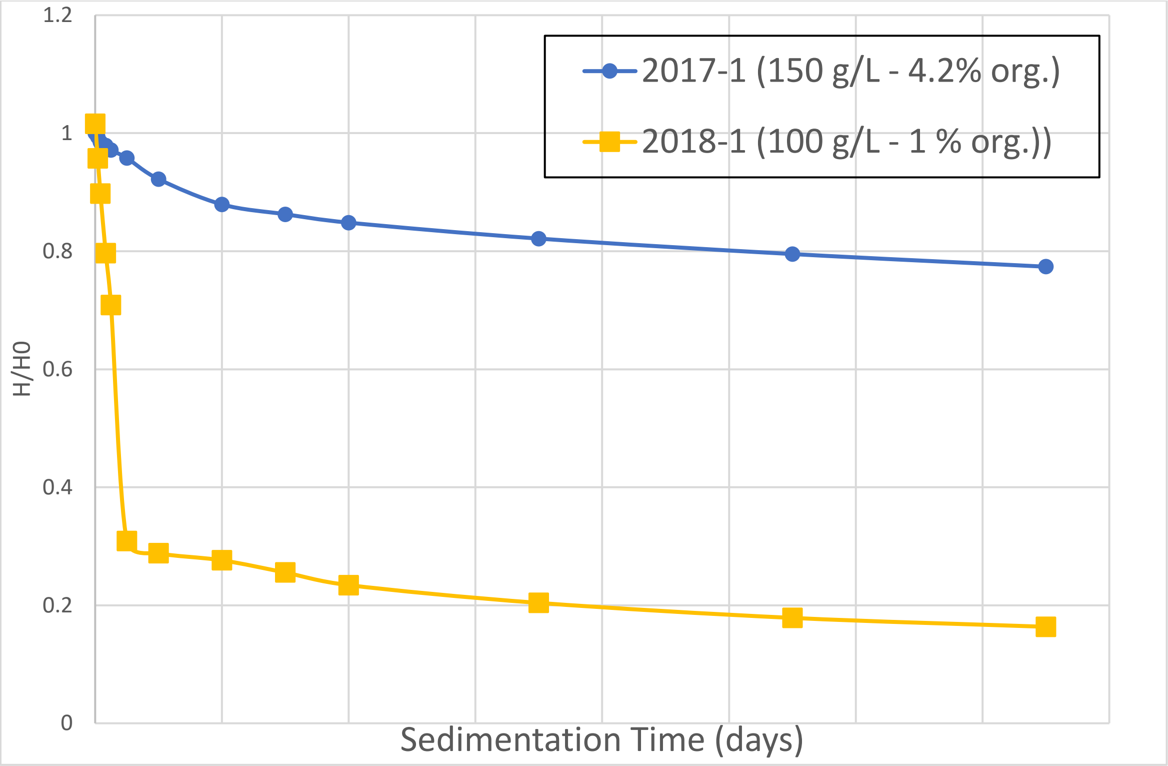


Figure 5.19: Settling characteristics under varying initial solids concentration

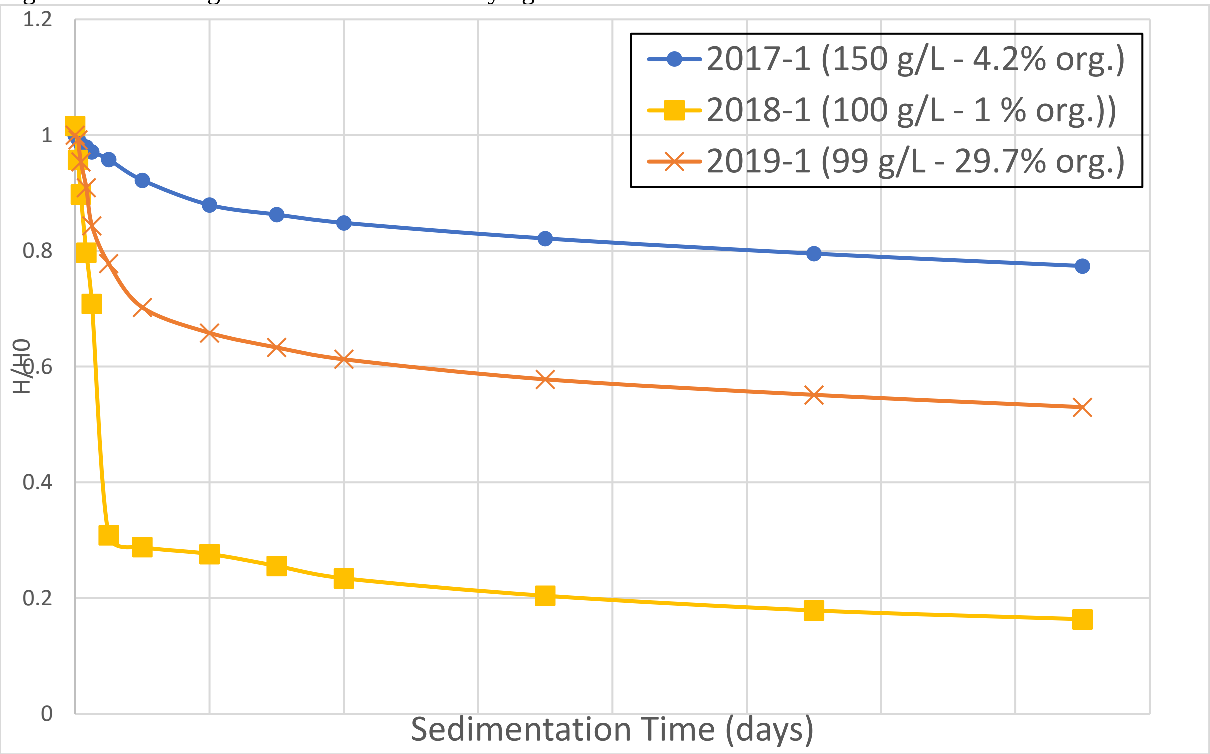


Figure 5.20: Settling characteristics under varying initial solids concentration

As seen from this figure 5.19, the rate of sediment consolidation increases with a decrease in initial solids concentration of the slurry. However, when comparing samples 2018-1 and 2018-2, even though the initial solids concentration is similar (around 100 g/L), the settling of sediments is slower and lower when the organic content is higher (1% for 2018-1 versus 15.6% for 2018-2).

To evaluate the effects of initial solids concentration on each sample, testing was also done using a series of 2000 ml graduated cylinders mini column tests) to compare varying concentrations side by side. These series of tests were done on all but one sample (2017-2) to examine the settling velocity of each sample at varying concentrations simultaneously. Using 2019-1, the figure below shows the results of the mini column tests, and the following figure shows the resulting estimates for settling velocity at the various concentrations tested in the series.

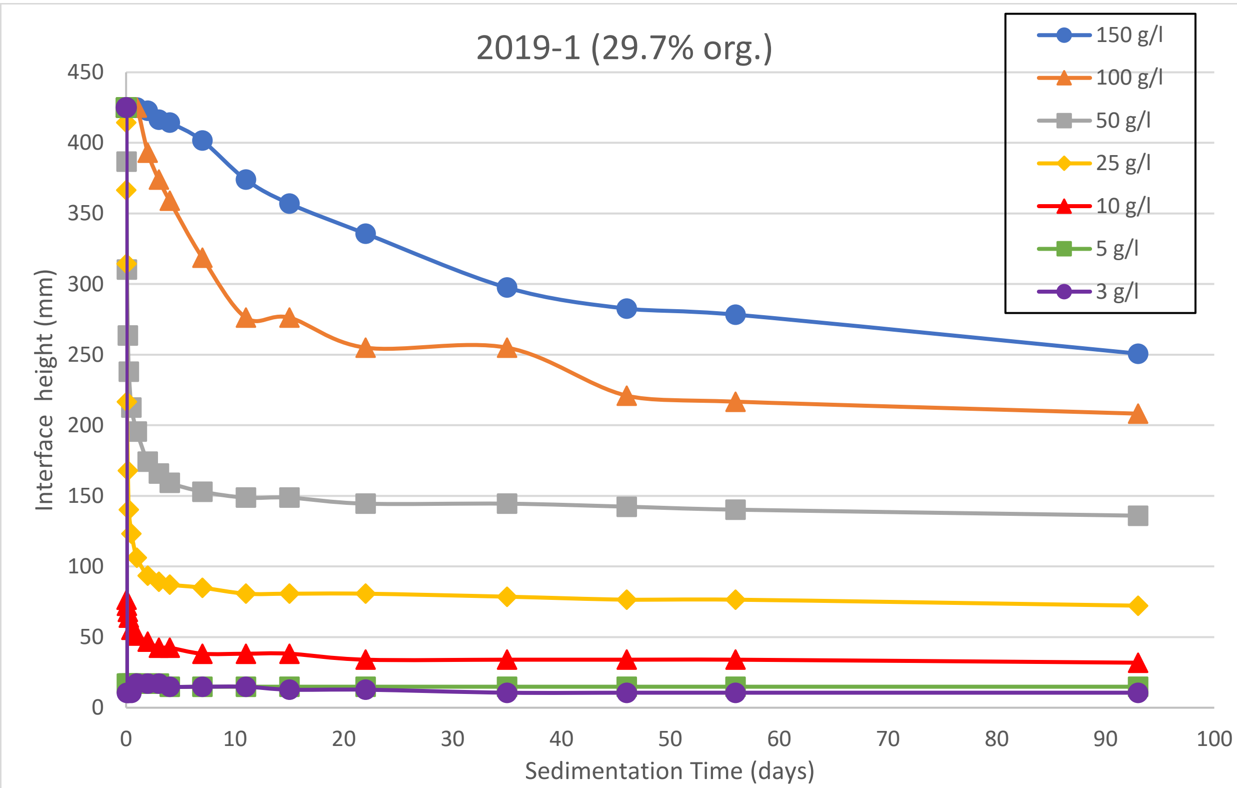


Figure 5.21: Settling curve tests evaluating the effects of initial solids concentration on settling *velocity*

The above figure (figure 5.21) shows the settling column test results for the high organic sample (29.7%) tested at initial solids concentrations of 3 g/l, 5 g/l, 10 g/l, 25 g/l, 50 g/l, 100 g/l, and 150 g/l. Based on this graph, it can be concluded that rate of settling of fine grained sediments is faster and higher with lower initial solids concentration. Similar trends were observed with the other samples tested in the laboratory.

5.5 Effects of Grain Size Distribution on Settling Velocity of Dredged Sediments

Several different samples were used to examine the effects of grain size distribution on settling velocity. A total of seven tests were done on samples from different sources with varying grain size distributions. Four of the samples were grab samples with settling column tests performed with site water while the last three were laboratory created samples using material taken from two locations in New Orleans with varying organic content. The percent fines for these tests along with the grain size distribution graph are presented in Figure 5.22.

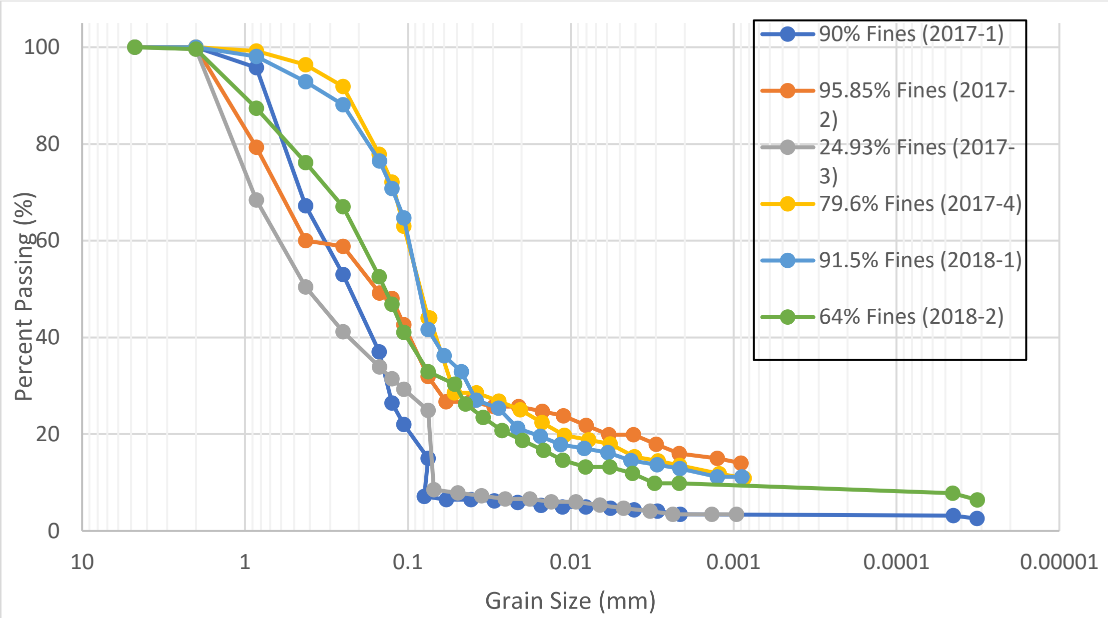


Figure 5.22: Grain size distribution curve for effects of grain size on settling velocity of soil particles.

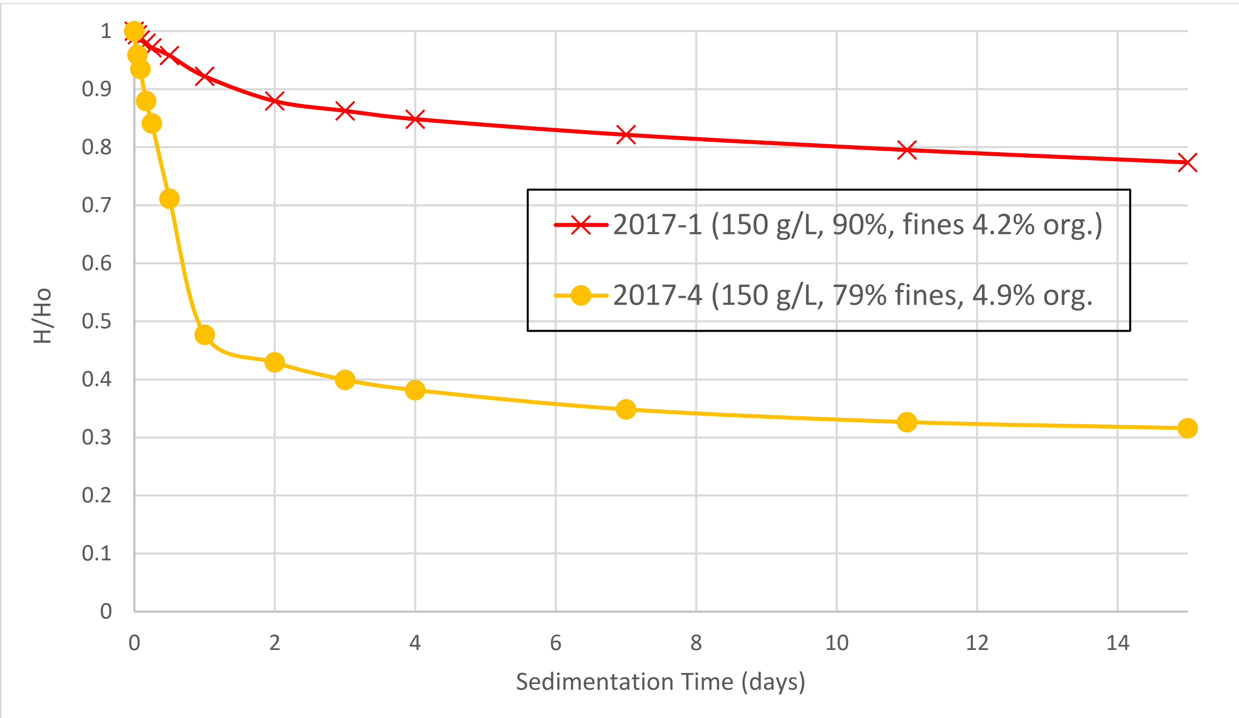


Figure 5.23: Sedimentation graph showing results from settling tests of each sample.

As can be seen in Figure 5.23, keeping other variables constant (initial solids concentration, and percent organic matter), the settling of coastal sediments is faster for samples with less fines (or coarser materials).

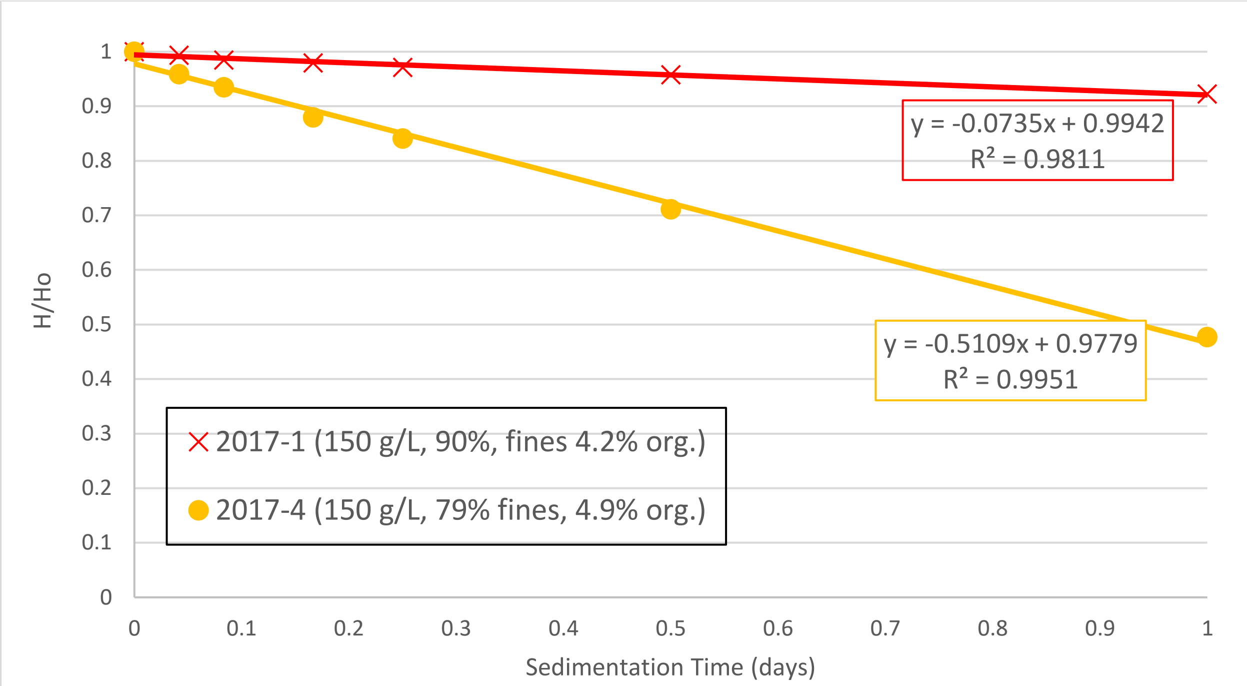


Figure 5.24: Estimation of settling velocities using zone settling data from large settling column tests.

From figure 5.24, it appears that a sample with lower fines (79%) had higher settling velocity. The settling column tests for these samples were done at differing concentrations as well; however, all but one (2017-2) of these samples were also tested using the mini columns. Selecting for a varied range (90%, 24.93%, and 64%) of percent fines the following comparison graph (Figure 5.25) was generated using the 100 g/l mini column test result from each sample.

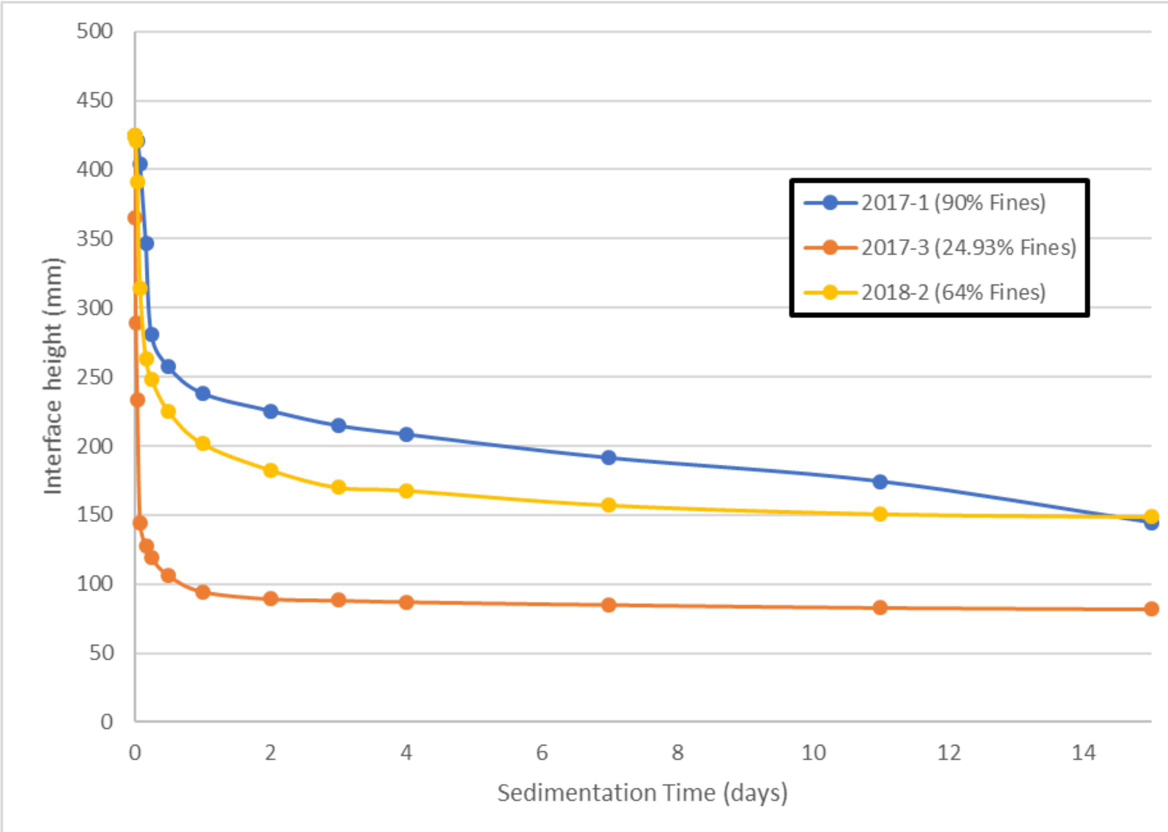


Figure 5.25: Sedimentation graph of various % fine grained samples each tested at 100 g/l concentration.

From the above graph, the sample with the highest percent fines (90%) had the lowest sedimentation rate while the sample with the lowest percent fines (24.93%) had the highest sedimentation rate.

Chapter 6 Summary and Conclusions

The samples used in this research were made up of coastal sediments from southeastern Louisiana nearby or within the city of New Orleans. These samples varied in organic content and were used to evaluate the effects of organic content on the settling velocity of sediments used in coastal restoration projects. Three samples were homogenized and blended in the laboratory in order to evaluate the effects of organic content (2018-1, 2018-2, and 2019-1). The following conclusions found in this research are summarized below.

1. The testing revealed that as the organic content of a sample increased the settling velocity decreased. The organic matter significantly hindered the settling of the sediment particles.

2. The zone settling was velocity was decreased in samples with higher organic content.

3. The rate of sediment consolidation increases with a decrease in initial solids concentration of the slurry.

4. Keeping other variables constant (initial solids concentration, and percent organic matter), the settling of coastal sediments is faster for samples with less fines (or coarser materials).

5. Zone and Compression settling velocities were estimated as a function of organic content of the coastal sediments:

Organic Content (%)	Zone Settling		Compression Settling	
	V_o (m/hr)	k_o (g/l)	V_c (m/hr)	k_c (g/l)
1	2.99	0.058	0.257	0.0097
15.6	1.6	0.065	0.585	0.024
29.7	0.644	0.072	0.206	0.026

6. An equation for the settling velocity was developed with both organic content and solids concentration as variables:

$$Vs = (0.001 * [organic\ content]^2 - 0.1111[organic\ content] + 3.1001e^{(-0.0005[organic\ content]+0.0575)*[concentration]}$$

Recommendations for Future Research

The results of this study can be used as a starting point in developing a mathematical model or in a database of engineering characteristics of the dredged sediments used in Louisiana coastal restoration and marsh creation projects. It is recommended that more studies be performed to verify and expand upon the findings of this research.

There were 3 different organic contents in this study with the highest being roughly 29.7%. Samples with higher organic content being tested and compared could help to expound upon the correlation found between settling velocity and organic content. It is also recommended that more testing be done on the varying organic contents. For example, this research used two samples with very different organic contents that were tested separately initially, and then blended at approximately 50% by weight of the raw samples before being tested once more. It would be beneficial for future research to have even more variance in the organic contents between each test, particularly in the lower concentration range (0.5 g/l, 1 g/l, or 2 g/l, etc.).

The chemical composition of the sediment should be considered as well. The highest organic content sample in this study showed the possibility of gaseous build-up that may have prevented the sediment from consolidating throughout the test. This sample had a strong Sulphur or methane-like scent as the test continued, and it was evident that the sample did not consolidate at the bottom of the column despite appearing as if it had. Due to this incidence, chemical testing of future samples should be done to know if other factors are affecting the results. This data would be paramount to future coastal restoration projects, due to the sediment's chemical composition having a direct effect on the quality and quantity of vegetation that would grow in the project areas.

Another topic to consider is how the sediment particles behave during the test. If possible, a microscopic camera could be used to take photos or brief videos of the sediments at specified intervals. This may allow one to see if the particles are sticking or not as they settle, or if the finer particles remain in suspension throughout the test. This detail would be important in showing how much of the sediment would consolidate at a project site and to what extent the sample would likely consolidate. Adding to this is the threat of erosion after a project's completion. Erosion testing on sediments with various organic contents should be performed to understand how these sediments withstand erosion to better understand the long-term viability of sediments with high organic contents in marsh creation projects.

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Appendix A

Sample 2019-1

Engineering Properties of Sample 2019-1

Sample ID	Project Location	Column Test Initiation	Sample Type	Sample Source	Initial Solids Concentration (g/L)	Type of Water	Salinity (ppt)	pH
2019-1	Lab Created Sample	2/15/2019	Grab	UNO	99	Tap	1.18	5.7

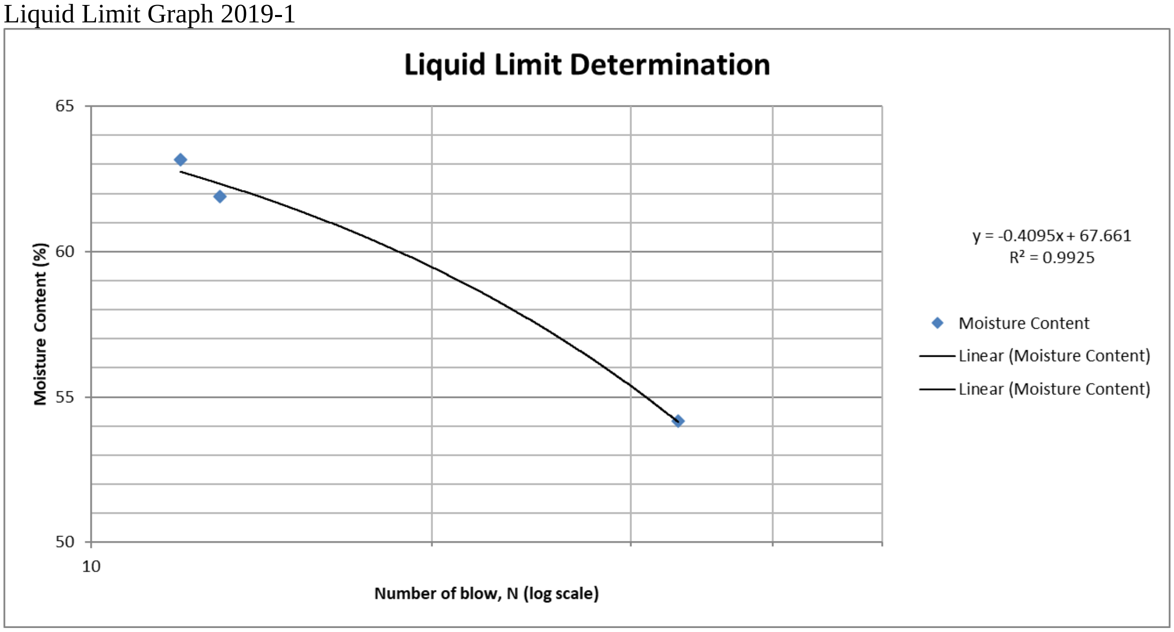
Specific Gravity	Organic Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Grain Size Distribution	
					Coarse (%)	Fines (%)
2.28	29.7	259	118	141	37	63

Sample ID	Tare #	Tare Weight (g)	Initial weight of sample (g)	final weight of sample (g)	Final weight - tare weight (g)	% Coarse	%Fine
2019-1	6	121.5	100	158.5	37	37.00%	63.00%

Liquid Limit Determination 2019-1

Liquid Limit				
Test No.	**1**	**2**	**3**	
Can No.	48	G8	L14	
Number of Blows, N	12	13	33	
Weight of Can, W1 (g)	14.00	13.50	13.50	
Weigh of Can + Moist Soil, W2 (g)	29.50	30.50	32.00	
Weight of Can + Dry Soil, W3 (g)	23.50	24.00	25.50	
Weight of Water, W2-W3	6.00	6.50	6.50	
Weight of Dry Soil W3-W1	9.50	10.50	12.00	
Moisture Content	*63.16%*	*61.90%*	*54.17%*	
Liquid Limit*	**57**		R Squared	0.99248451
****Liquid Limit is calculated using the best fit line provided on the graph.***			avg	59.74%

Liquid Limit Graph 2019-1



Plastic Limit Determination 2019-1

Plastic Limit				
Test No.	**1**	**2**		
Can No.	EA	16		
Weight of Can, W1 (g)	14.00	14.00		
Weigh of Can + Moist Soil, W2 (g)	20.50	21.00		
Weight of Can + Dry Soil, W3 (g)	18.50	19.00		
Weight of Water, W2-W3	2.00	2.00		
Weight of Dry Soil W3-W1	4.50	5.00		
Moisture Content	*44.44%*	*40.00%*		
Plastic Limit	**42**	*Difference Check*	*0.044444444*	*OK*

Plastic Index	**15**
Soil Classification:	**Medium plasticity**
A-Line PI Curve Value	**27**
U-Line PI Curve Value	**31**

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
44	26	18

Organic Content Determination for 2019-1

Organic Content	
Dish No.	2
Weight of Dish, W_1 (g)	114
Weight of Dish + Oven-dried Soil, W_2 (g)	119
Weight of Dish + Ash, W_3 (g)	117.5
Weight of Ash, $W_3 - W_1$ (g), W_4	3.5
Weight of Soil, W_2 - W_1 (g), W_5	5
Ash content	70.0%
Organic Content	30.0%

Specific Gravity Determination for 2019-1

Specific Gravity		
Flask Number		12
Temperature of Water °C,	T_a	23.5
Temperature of Water + Soil °C,	T_b	25.2
Weight of Flask + Water at T_b (g),	M_a	702.19
Weight of Dry Soil (g),	M_o	50
Weight of Flask + Water + Soil at T_b (g),	M_b	730.58
Specific Gravity at T_b	M_o/ [M_o + (M_a	2.31
Correction Factor "K"	(Table 2)	0.9991
Specific Gravity at 20° C	K x (G at T_b)	2.31

Specific Gravity Temperature Correction Factor "K"

Specific Gravity Temperature Correction Factor "K"

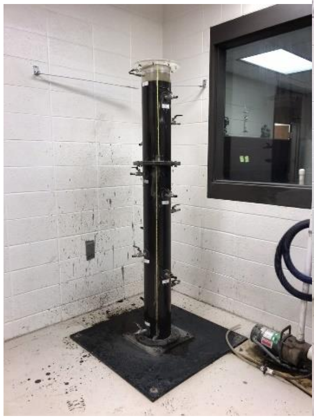
Temp (°C)	K	Temp (°C)	K
16	1.0007	23.5	0.9992
16.5	1.00065	24	0.9991
17	1.0006	24.5	0.999
17.5	1.0005	25	0.9989
18	1.0004	25.5	0.99875
18.5	1.0003	26	0.9986
19	1.0002	26.5	0.99845
19.5	1.0001	27	0.9983
20	1	27.5	0.99815
20.5	0.9999	28	0.998
21	0.9998	28.5	0.99785
21.5	0.9997	29	0.9977
22	0.9996	29.5	0.99755
22.5	0.9995	30	0.9974
23	0.9993	30.5	0.99725

Photographs During Column Settling Test for 2019-1


Initial


1 hour


2 hours


4 hours


12 hours


24 hours


48 hours


72 hours


96 hours


168 hours


360 hours


21 days


26 days

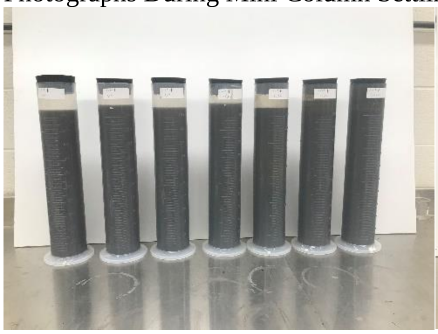

31 days


37 days

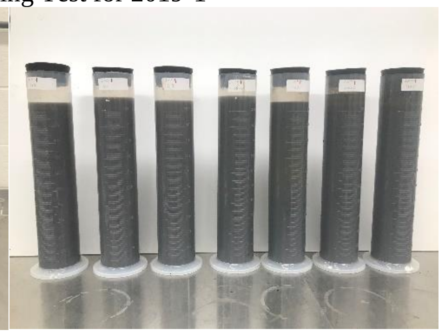

42 days


47 days

Photographs During Mini Column Settling Test for 2019-1



Initial



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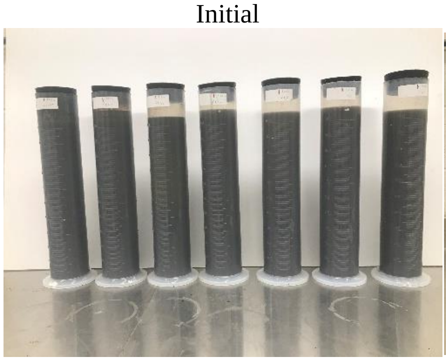
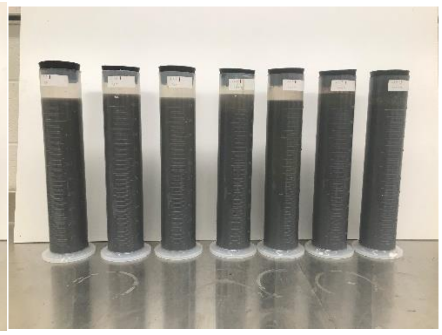
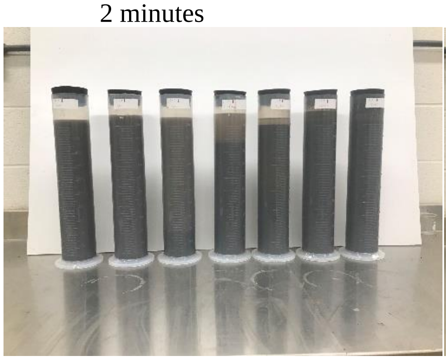


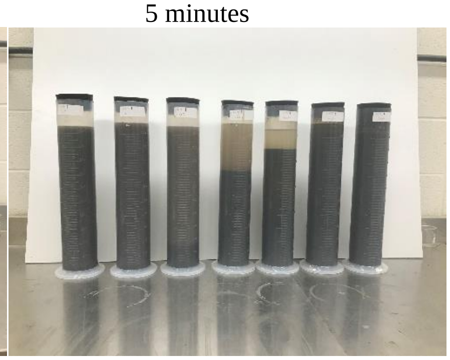
2 minutes



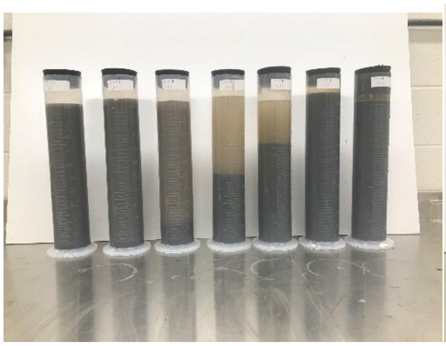
5 minutes



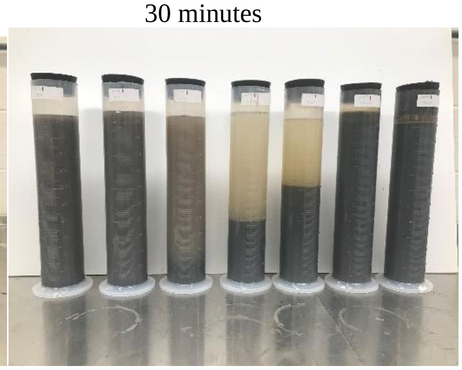
10 minutes



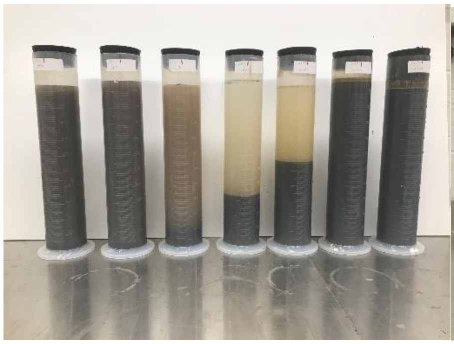
30 minutes



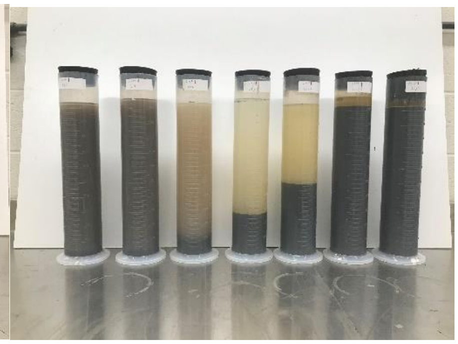
1 hour



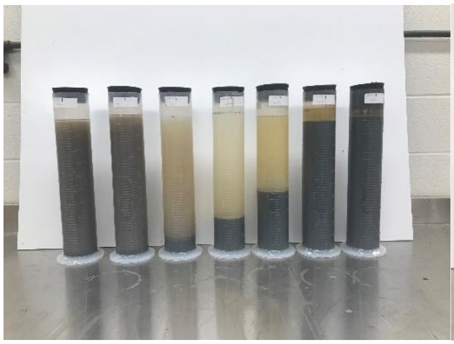
2 hours



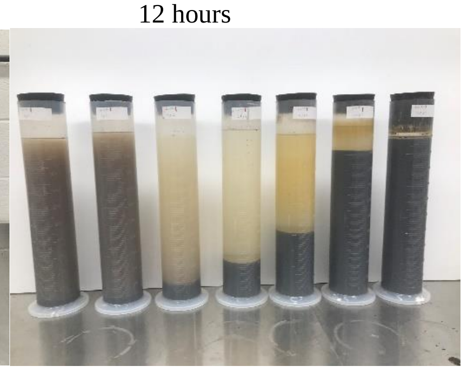
6 hours



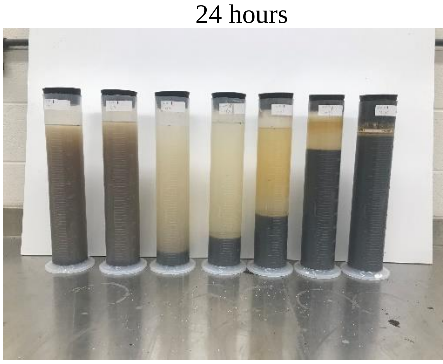
12 hours



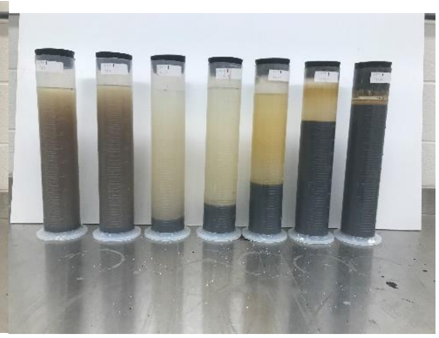
24 hours



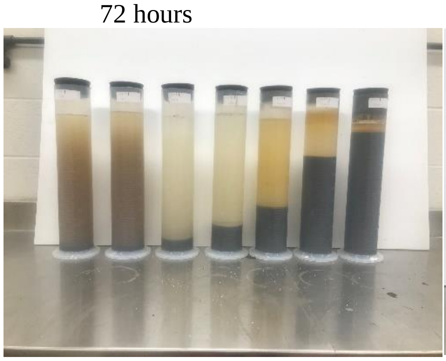
48 hours



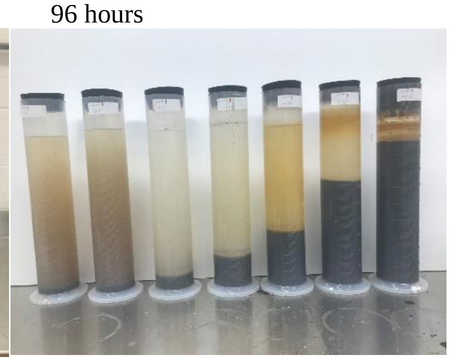
72 hours



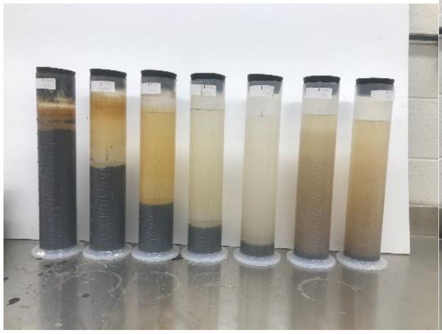
96 hours

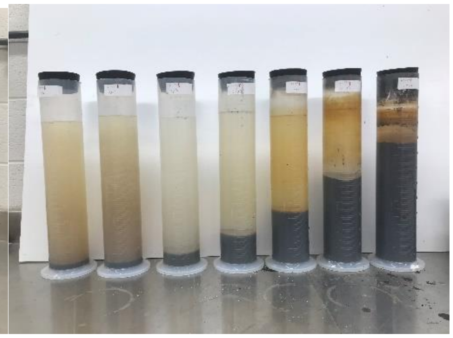


168 hours



12 days





15 days 22 days

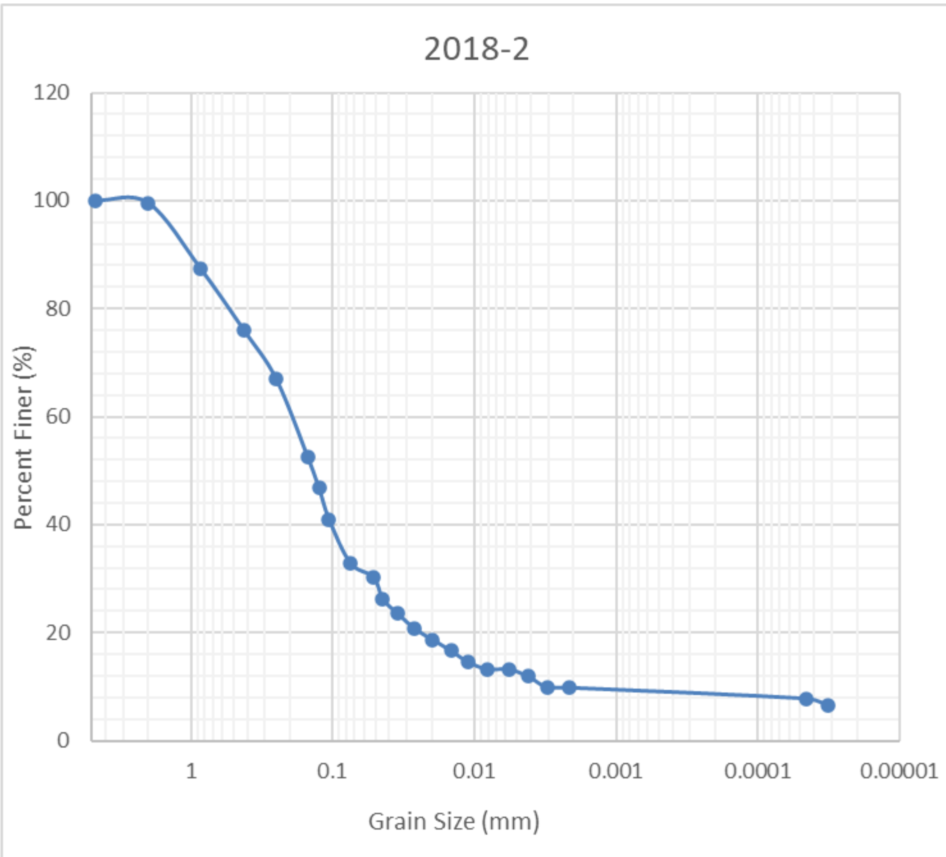
Appendix B

Sample 2018-2

Engineering Properties of Sample 2018-2

Sample ID	Project Location	Column Test Initiation	Sample Type	Sample Source	Initial Solids Concentration (g/L)	Type of Water	Salinity (ppt)	pH
2018-2	Lab mixed sample	6/22/2018	Grab	UNO	98 g/l	Tap	1.72	6.4

Specific Gravity	Organic Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Grain Size Distribution	
					Coarse (%)	Fines (%)
2.50	15.6	82	29	53	8.50	91.50



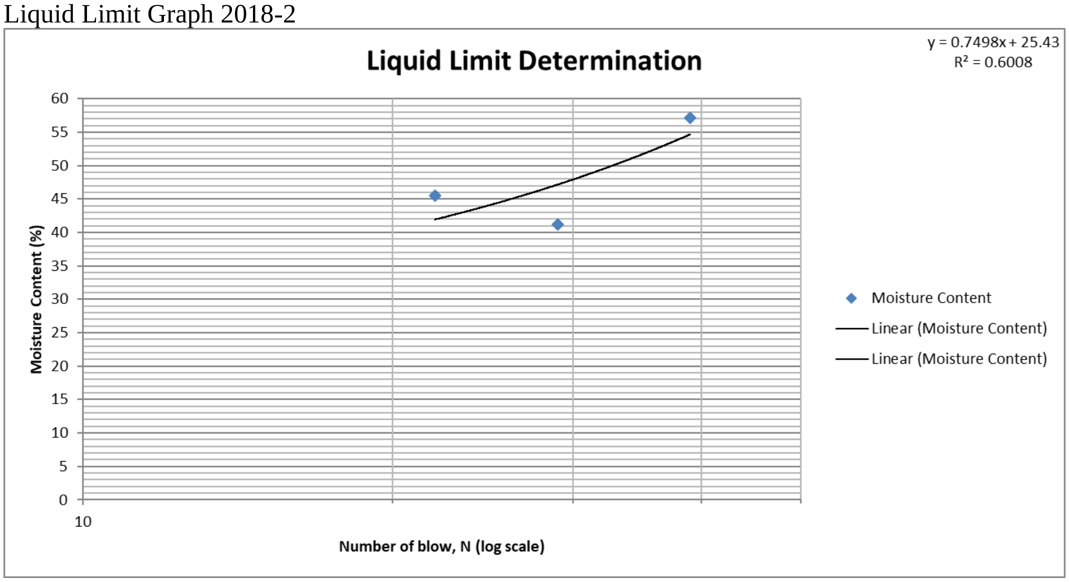
Grain Size Distribution Graph for 2018-2

Coarse (%)	Fine (%)
36	64

Liquid Limit Determination 2018-2

Liquid Limit				
Test No.	**1**	**2**	**3**	
Can No.	G8	48	B	
Number of Blows, N	22	39	29	
Weight of Can, W1 (g)	13.50	14.00	14.00	
Weigh of Can + Moist Soil, W2 (g)	29.50	25.00	26.00	
Weight of Can + Dry Soil, W3 (g)	24.50	21.00	22.50	
Weight of Water, W2-W3	5.00	4.00	3.50	
Weight of Dry Soil W3-W1	11.00	7.00	8.50	
Moisture Content	*45.45%*	*57.14%*	*41.18%*	
Liquid Limit*	**44**		R Squared	0.600845548
****Liquid Limit is calculated using the best fit line provided on the graph.***			avg	47.92%

Liquid Limit Graph 2018-2



Plastic Limit Determination 2018-2

Plastic Limit				
Test No.	**1**	**2**		
Can No.	A100	A31		
Weight of Can, W1 (g)	14.00	14.00		
Weigh of Can + Moist Soil, W2 (g)	21.50	21.00		
Weight of Can + Dry Soil, W3 (g)	20.00	19.50		
Weight of Water, W2-W3	1.50	1.50		
Weight of Dry Soil W3-W1	6.00	5.50		
Moisture Content	*25.00%*	*27.27%*		
Plastic Limit	**26**	*Difference Check*	*0.022727273*	*OK*
Plastic Index	**18**			
Soil Classification:	**Medium plasticity**			
A-Line PI Curve Value	**18**			
U-Line PI Curve Value	**16**			

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
44	26	18

Organic Content Determination for 2018-2

Organic Content	
Dish No.	7/
Weight of Dish, W_1 (g)	117.43
Weight of Dish + Oven-dried Soil, W_2 (g)	125.07
Weight of Dish + Ash, W_3 (g)	123.86
Weight of Ash, $W_3 - W_1$ (g), W_4	6.43
Weight of Soil, W_2 - W_1 (g), W_5	7.64
Ash content	84.2%
Organic Content	15.8%

Specific Gravity Determination for 2018-2

Specific Gravity		
Flask Number		1
Temperature of Water °C,	T_a	22.3
Temperature of Water + Soil °C,	T_b	22
Weight of Flask + Water at T_b (g),	M_a	702.5
Weight of Dry Soil (g),	M_o	54
Weight of Flask + Water + Soil at T_b (g),	M_b	735.5
Specific Gravity at T_b	M_o/ [M_o + (M_a	2.57
Correction Factor "K"	(Table 2)	0.9996
Specific Gravity at 20° C	K x (G at T_b)	2.57

Specific Gravity Temperature Correction Factor "K"

Specific Gravity Temperature Correction Factor "K"

Temp (°C)	K	Temp (°C)	K
16	1.0007	23.5	0.9992
16.5	1.00065	24	0.9991
17	1.0006	24.5	0.999
17.5	1.0005	25	0.9989
18	1.0004	25.5	0.99875
18.5	1.0003	26	0.9986
19	1.0002	26.5	0.99845
19.5	1.0001	27	0.9983
20	1	27.5	0.99815
20.5	0.9999	28	0.998
21	0.9998	28.5	0.99785
21.5	0.9997	29	0.9977
22	0.9996	29.5	0.99755
22.5	0.9995	30	0.9974
23	0.9993	30.5	0.99725

Photographs During Column Settling Test for 2018-2

Initial

1 hour

2 hours

4 hours

6 hours

12 hours

24 hours

48 hours

72 hours

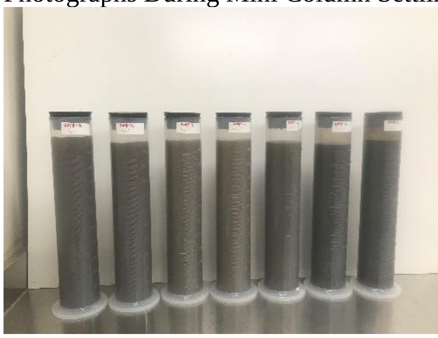

96 hours


168 hours


264 hours


360 hours

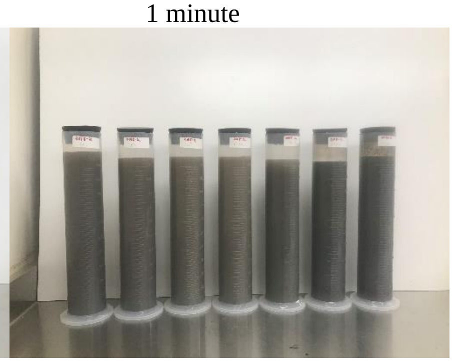
Photographs During Mini Column Settling Test for 2018-2



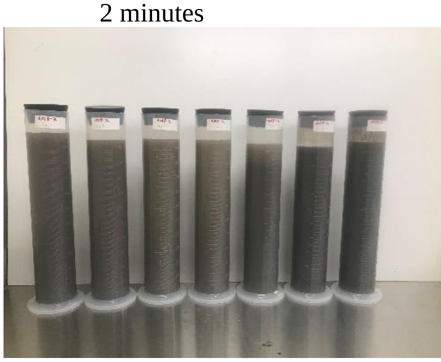
Initial

1 minute

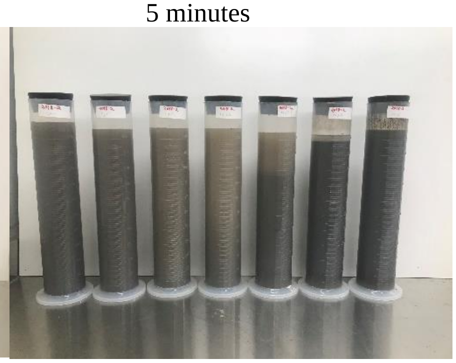
2 minutes



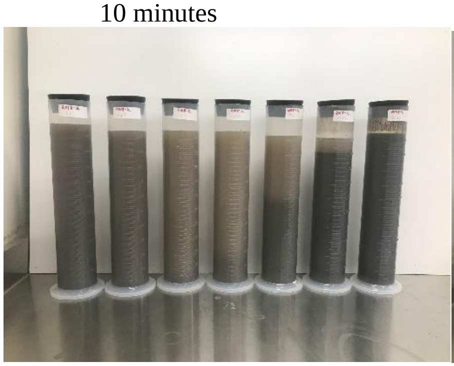
5 minutes



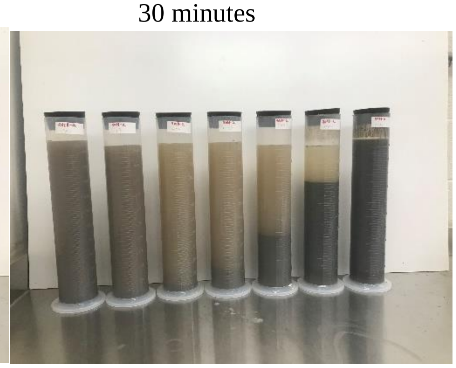
10 minutes



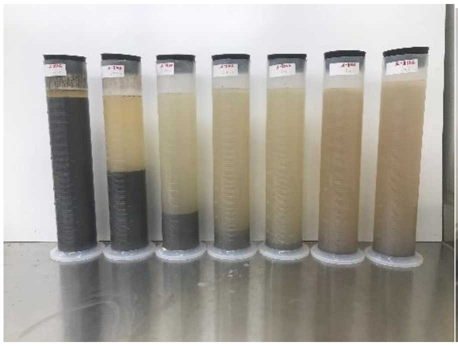
30 minutes



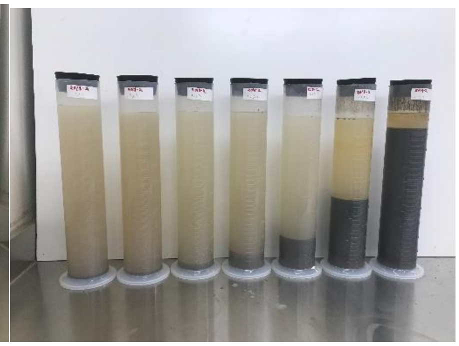
1 hour



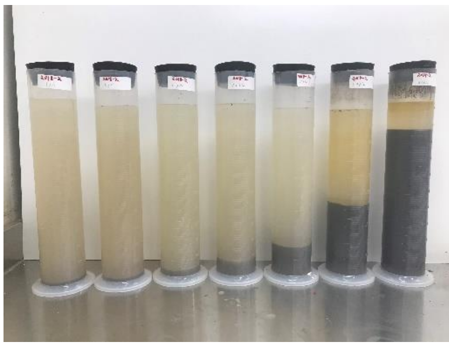
2 hours



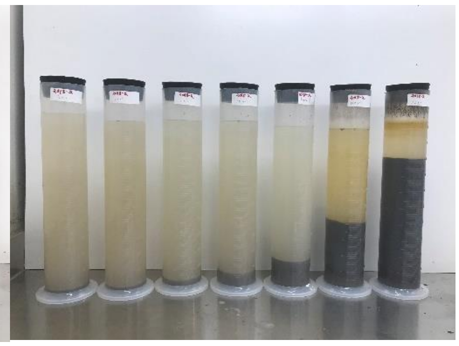
12 hours



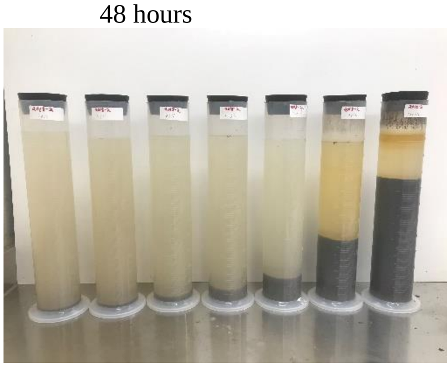
24 hours



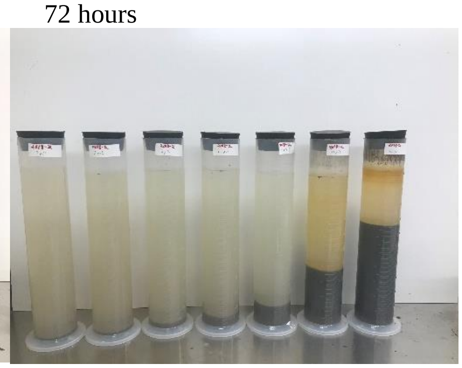
48 hours



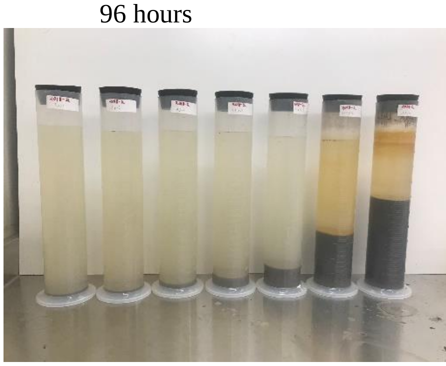
72 hours



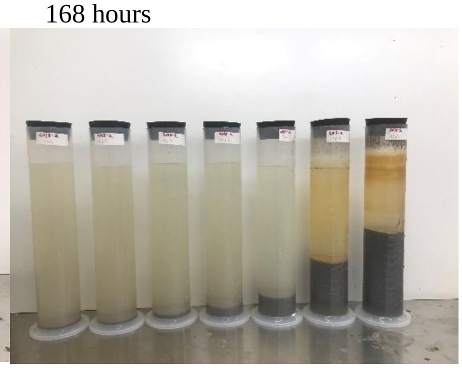
96 hours



168 hours



264 hours



360 hours

Appendix C

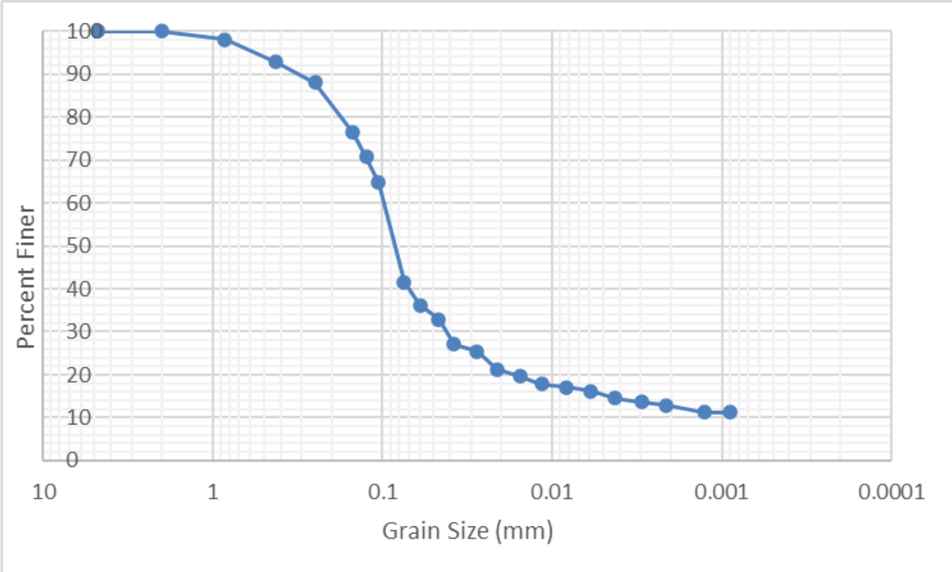
Sample 2018-1

Engineering Properties of Sample 2018-1

Sample ID	Project Location	Column Test Initiation	Sample Type	Sample Source	Initial Solids Concentration (g/L)	Type of Water	Salinity (ppt)	pH
2018-1	Lab Created Sample	6/22/2018	Grab	UNO	103 g/l	Tap	2.41	8.7

Specific Gravity	Organic Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Grain Size Distribution	
					Coarse (%)	Fines (%)
2.63	1.0	41	20	21	8.50	91.50

Site Vicinity Map for 2018-1



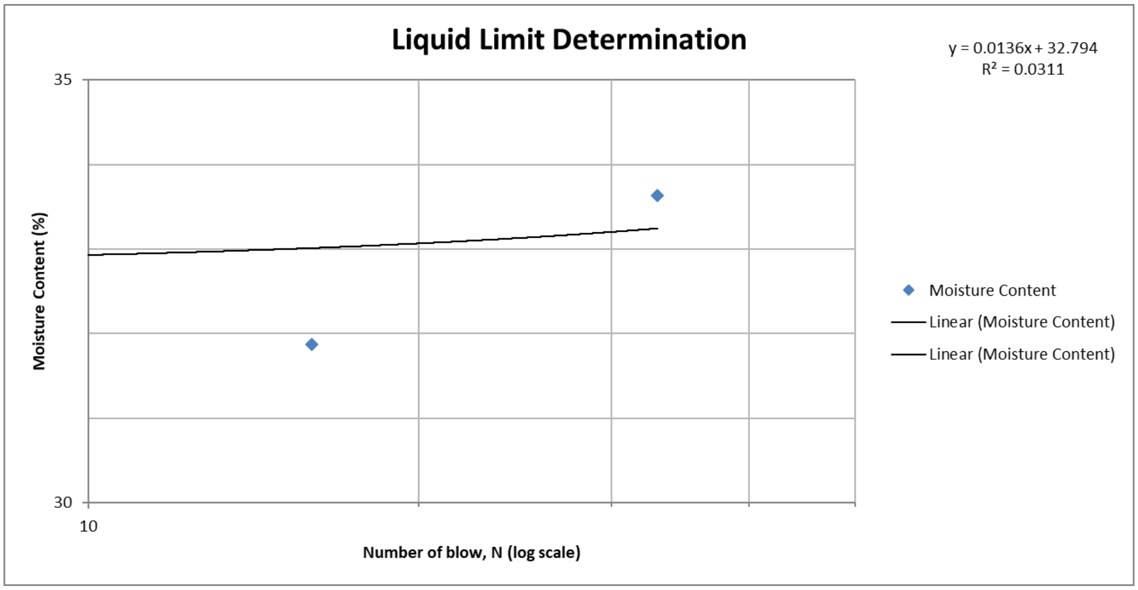
Grain Size Distribution Graph for 2018-1

Coarse (%)	Fine (%)
8.50	91.50

Liquid Limit Determination 2018-1

Test No.	1	2	3	
Can No.	c14	549	A74	
Number of Blows, N	7	33	16	
Weight of Can, W1 (g)	13.73	13.70	13.96	
Weigh of Can + Moist Soil, W2 (g)	24.06	26.85	24.18	
Weight of Can + Dry Soil, W3 (g)	21.46	23.54	21.71	
Weight of Water, W2-W3	2.60	3.31	2.47	
Weight of Dry Soil W3-W1	7.73	9.84	7.75	
Moisture Content	*33.64%*	*33.64%*	*31.87%*	
Liquid Limit*	**33**		R Squared	0.031105599
****Liquid Limit is calculated using the best fit line provided on the graph.***			avg	33.05%

Liquid Limit Graph 2018-1



Plastic Limit Determination 2018-1

Test No.	1	2		
Can No.	c14	A74		
Weight of Can, W1 (g)	13.73	13.96		
Weigh of Can + Moist Soil, W2 (g)	23.45	22.37		
Weight of Can + Dry Soil, W3 (g)	21.86	20.43		
Weight of Water, W2-W3	1.59	1.94		
Weight of Dry Soil W3-W1	8.13	6.47		
Moisture Content	*19.56%*	*29.98%*		
Plastic Limit	**25**	*Difference Check*	*0.104273485*	*OK*
Plastic Index	**8**			
Soil Classification:	**Low plasticity**			
A-Line PI Curve Value	**10**			
U-Line PI Curve Value	**15**			

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
33	25	8

Organic Content Determination for 2018-1

Dish No.	10
Weight of Dish, W_1 (g)	122.02
Weight of Dish + Oven-dried Soil,	165.26
Weight of Dish + Ash, W_3 (g)	164.91
Weight of Ash, $W_3 – W_1$ (g), W_4	42.89
Weight of Soil, W_2 - W_1 (g), W_5	43.24
Ash content	99.2%
Organic Content	0.8%

Specific Gravity Determination for 2018-1

Flask Number		12
Temperature of Water °C,	T_a	21.6
Temperature of Water + Soil °C,	T_b	23.8
Weight of Flask + Water at T_b (g),	M_a	666.9
Weight of Dry Soil (g),	M_o	50.01
Weight of Flask + Water + Soil at T_b (g),	M_b	691.26
Specific Gravity at T_b	M_o/ [M_o + (M	1.95
Correction Factor “K”	(Table 2)	0.9991
Specific Gravity at 20° C	K x (G at T_b)	1.95

Specific Gravity Temperature Correction Factor “K”

Specific Gravity Temperature Correction Factor “K”

Temp (°C)	K	Temp (°C)	K
16	1.0007	23.5	0.9992
16.5	1.00065	24	0.9991
17	1.0006	24.5	0.999
17.5	1.0005	25	0.9989
18	1.0004	25.5	0.99875
18.5	1.0003	26	0.9986
19	1.0002	26.5	0.99845
19.5	1.0001	27	0.9983
20	1	27.5	0.99815
20.5	0.9999	28	0.998
21	0.9998	28.5	0.99785
21.5	0.9997	29	0.9977
22	0.9996	29.5	0.99755
22.5	0.9995	30	0.9974
23	0.9993	30.5	0.99725

Photographs During Column Settling Test for 2018-1

Initial

1 hour

2 hours

4 hours

6 hours

12 hours

24 hours

48 hours

72 hours

96 hours

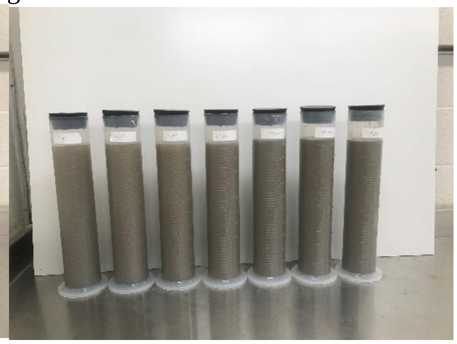
168 hours

264 hours

360 hours

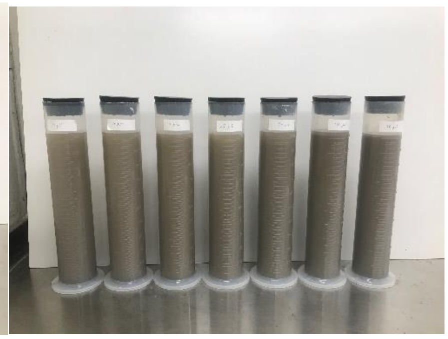
Photographs During Mini Column Settling Test for 2018-1

Initial

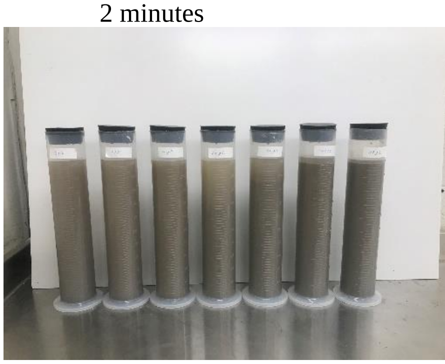


1 minute

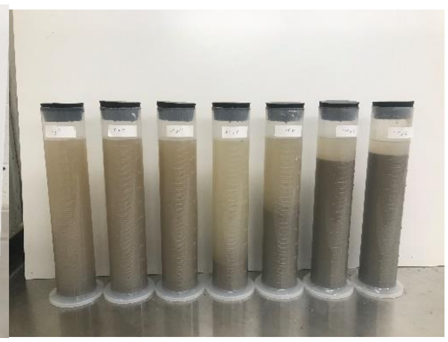
2 minutes



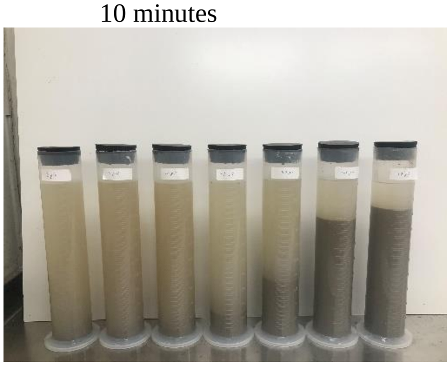
5 minutes



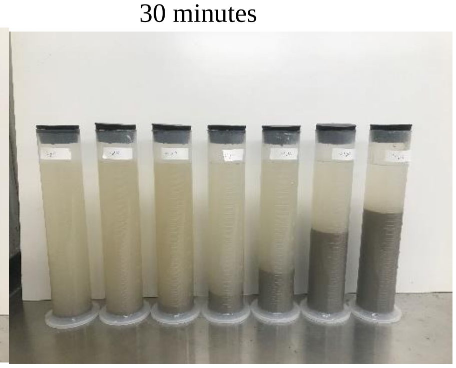
10 minutes



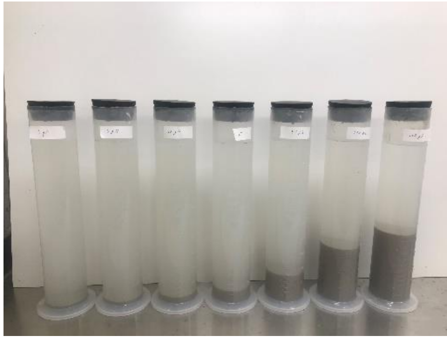
30 minutes



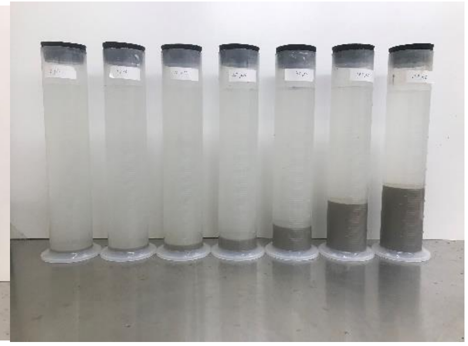
1 hour



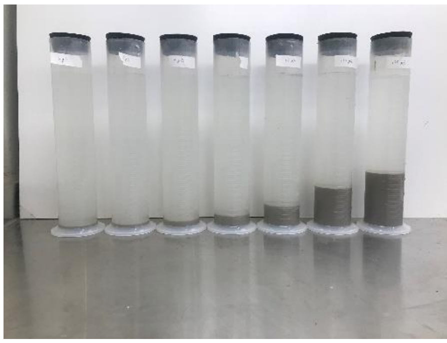
2 hours



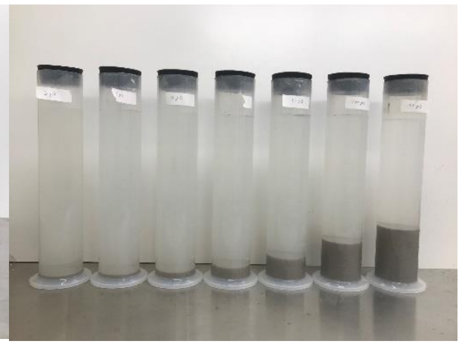
12 hours



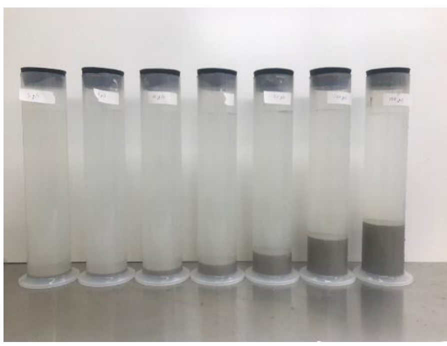
24 hours



48 hours

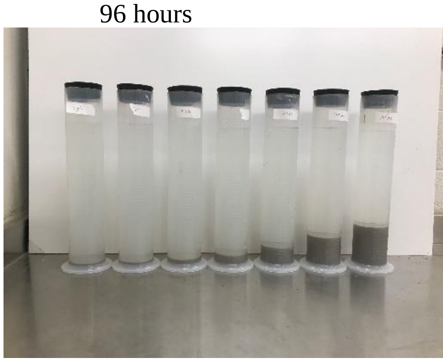


72 hours

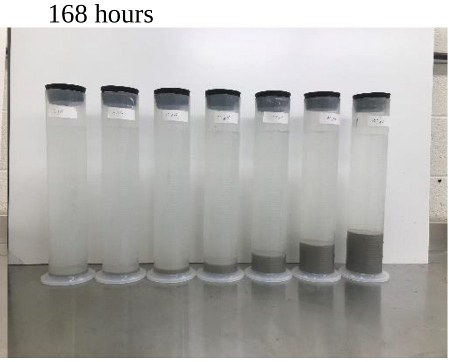


96 hours

168 hours



264 hours



360 hours

Appendix D

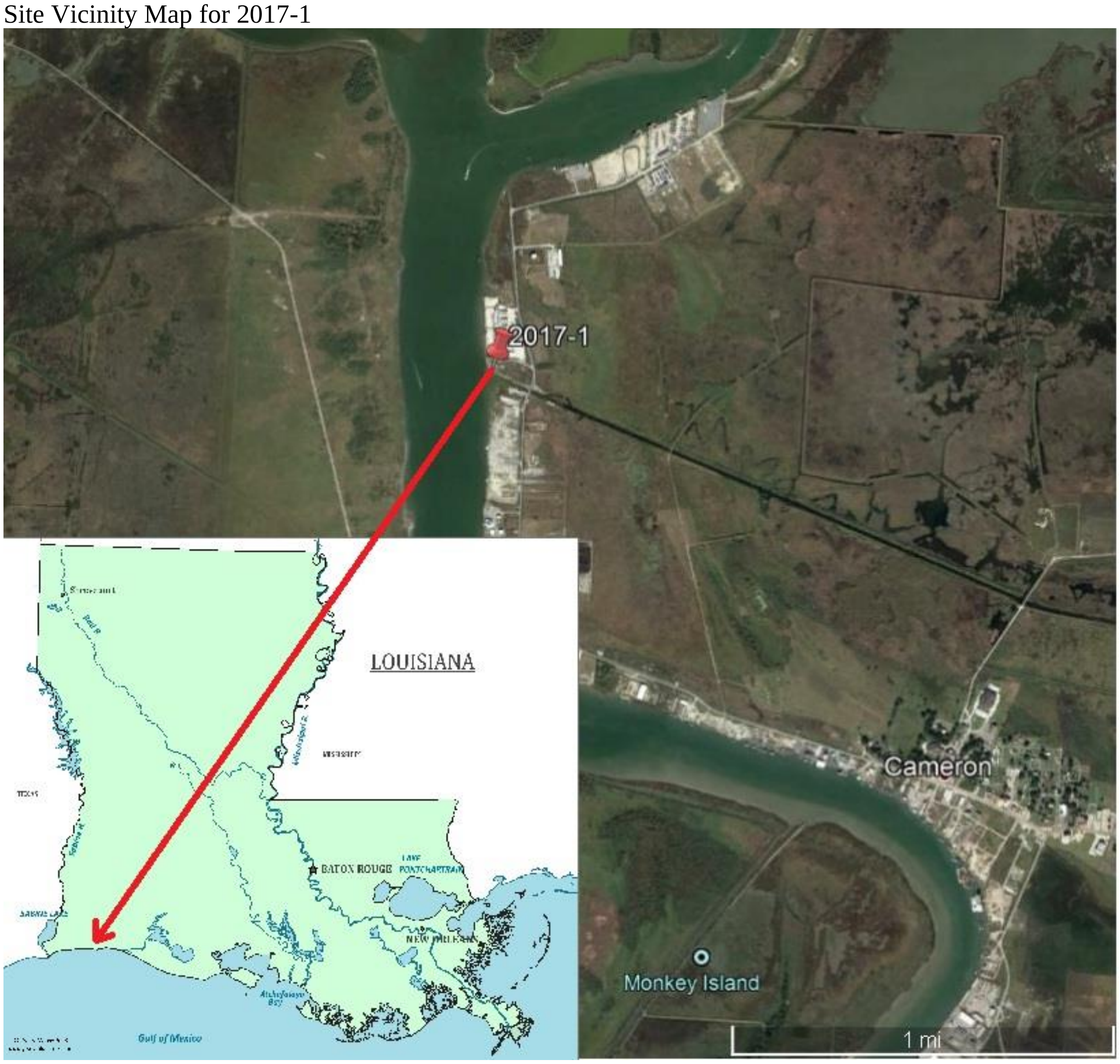
Sample 2017-1

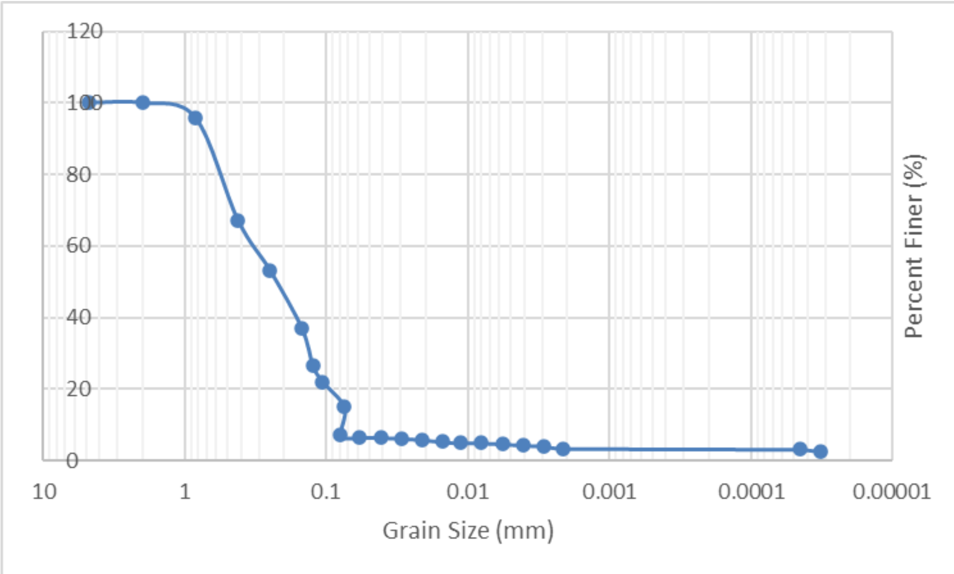
Engineering Properties of Sample 2017-1

Sample ID	Project Location	GPS Coordinates	Column Test Initiation	Sample Type	Sample Source	Initial Solids Concentration (g/L)	Type of Water	Salinity (ppt)
2017-1	Port Cameron	29º48’43.39” N 93 º20’45.39”W	1/23/2017	Grab	PSI	150 g/l	Site	2.84

Specific Gravity	Organic Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Grain Size Distribution	
					Coarse (%)	Fines (%)
2.59	4.2	61	22	39	10	90

Site Vicinity Map for 2017-1



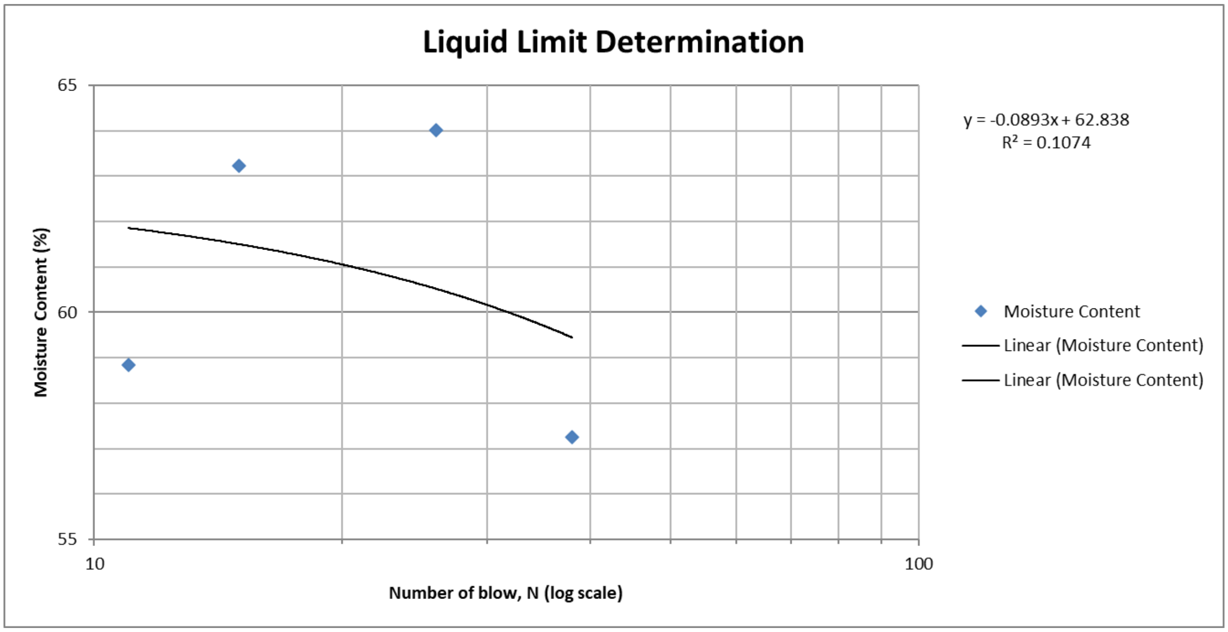


Grain Size Distribution Graph for 2017-1

Coarse (%)	Fine (%)
10	90

Liquid Limit Determination 2017-1

Liquid Limit				
Test No.	**1**	**2**	**3**	**4**
Can No.	4	12	2	B
Number of Blows, N	38	26	15	11
Weight of Can, W1 (g)	133.91	117.79	119.59	126.97
Weigh of Can + Moist Soil, W2 (g)	158.33	146.10	137.74	154.75
Weight of Can + Dry Soil, W3 (g)	149.44	135.05	130.71	144.46
Weight of Water, W2-W3	8.89	11.05	7.03	10.29
Weight of Dry Soil W3-W1	15.53	17.26	11.12	17.49
Moisture Content	*57.24%*	*64.02%*	*63.22%*	*58.83%*
Liquid Limit*	**61**		R Squared	0.674703976
****Liquid Limit is calculated using the best fit line provided on the graph.***			avg	61.49%



Liquid Limit Graph 2017-1

Plastic Limit Determination 2017-1

Plastic Limit				
Test No.	**1**	**2**	**3**	
Can No.	3	X	Z	
Weight of Can, W1 (g)	114.11	121.07	124.84	
Weigh of Can + Moist Soil, W2 (g)	120.33	127.34	131.12	
Weight of Can + Dry Soil, W3 (g)	119.23	126.18	130.02	
Weight of Water, W2-W3	1.10	1.16	1.10	
Weight of Dry Soil W3-W1	5.12	5.11	5.18	
Moisture Content	*21.48%*	*22.70%*	*21.24%*	
Plastic Limit	**22**	*Difference Check*	*0.012162121*	*OK*
Plastic Index	**39**			
Soil Classification:	**High plasticity**			
A-Line PI Curve Value	**30**			
U-Line PI Curve Value	**13**			

Organic Content Determination for 2017-1

Organic Content	
Dish No.	
Weight of Dish, W_1 (g)	124.8
Weight of Dish + Oven-dried Soil,	173.06
Weight of Dish + Ash, W_3 (g)	171.02
Weight of Ash, $W_3 - W_1$ (g), W_4	46.22
Weight of Soil, W_2 - W_1 (g), W_5	48.26
Ash content	95.8%
Organic Content	4.2%

Specific Gravity Determination for 2017-1

Specific Gravity		
Flask Number		12
Temperature of Water °C,	T_a	17.2
Temperature of Water + Soil °C,	T_b	17.6
Weight of Flask + Water at T_b (g),	M_a	667.25
Weight of Dry Soil (g),	M_o	50
Weight of Flask + Water + Soil at T_b (g),	M_b	697.91
Specific Gravity at T_b	M_o/ [M_o + (M	2.59
Correction Factor "K"	(Table 2)	1.0005
Specific Gravity at 20° C	K x (G at T_b)	2.59

Specific Gravity Temperature Correction Factor "K"

Temp (°C)	K	Temp (°C)	K
16	1.0007	23.5	0.9992
16.5	1.00065	24	0.9991
17	1.0006	24.5	0.999
17.5	1.0005	25	0.9989
18	1.0004	25.5	0.99875
18.5	1.0003	26	0.9986
19	1.0002	26.5	0.99845
19.5	1.0001	27	0.9983
20	1	27.5	0.99815
20.5	0.9999	28	0.998
21	0.9998	28.5	0.99785
21.5	0.9997	29	0.9977
22	0.9996	29.5	0.99755
22.5	0.9995	30	0.9974
23	0.9993	30.5	0.99725

Photographs During Column Settling Test for 2017-1

Initial

1 hour

4 hours

6 hours

12 hours

24 hours

2 days

3 days

4 days

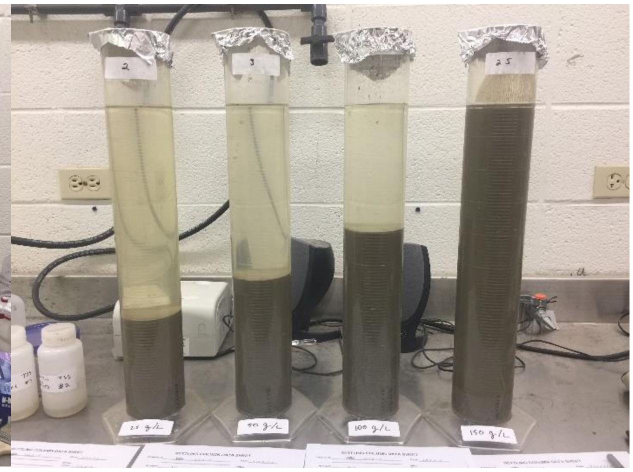
7 days

11 days

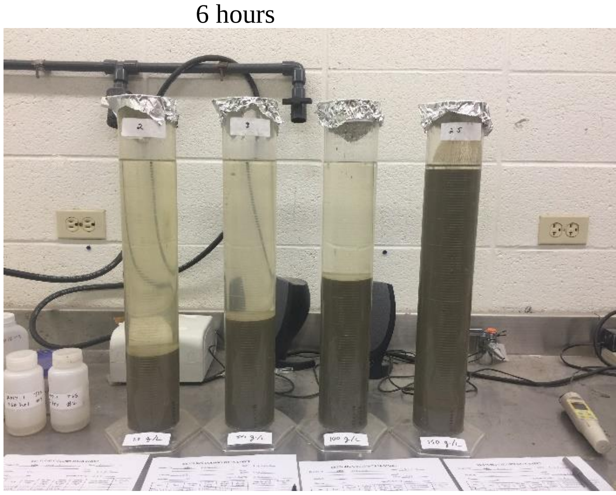
15 days

Photographs During Mini Column Settling Test for 2017-1

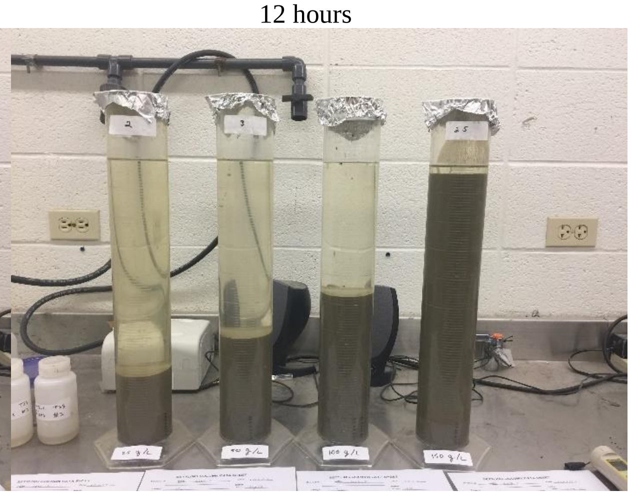
6 hours



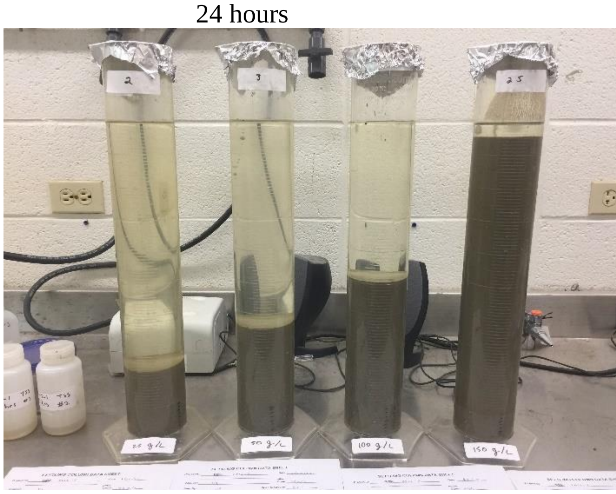
12 hours



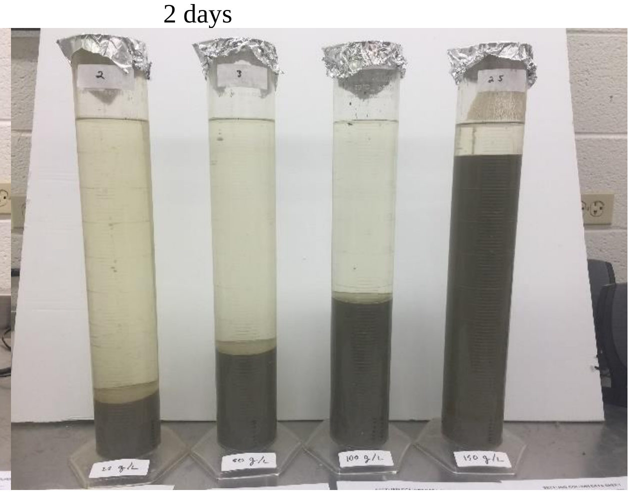
24 hours



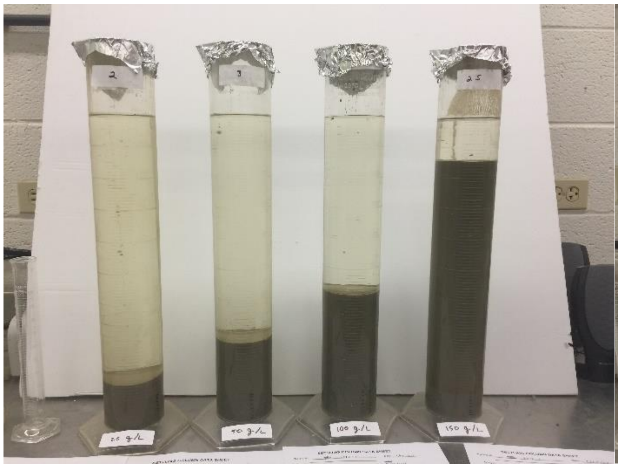
2 days



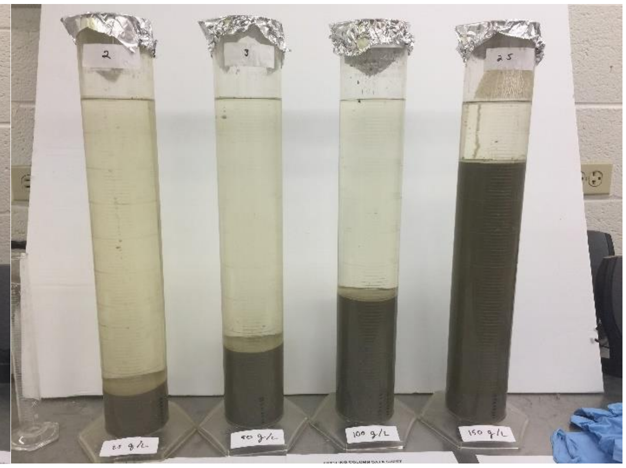
3 days



7 days



11 days



15 days

Appendix E

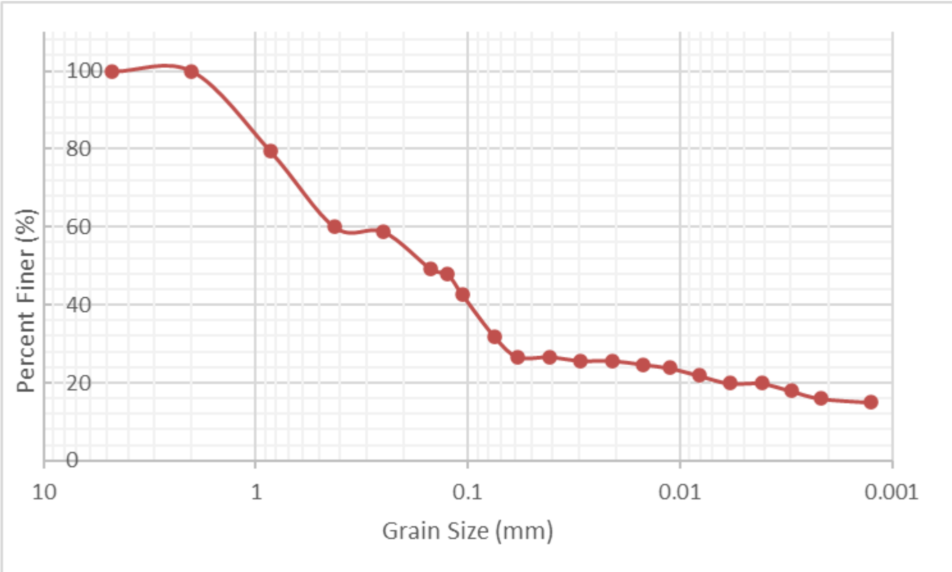
Sample 2017-2

Engineering Properties of Sample 2017-2

Sample ID	Project Location	GPS Coordinates	Column Test Initiation	Sample Type	Sample Source	Initial Solids Concentration (g/L)	Type of Water	Salinity (ppt)	pH
2017-2	Terrebonne Parish	29.30273 N, 90.6262 W	1/25/2017	Grab	UNO	100 g/l	Site	3	7.8

Specific Gravity	Organic Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Grain Size Distribution	
					Coarse (%)	Fines (%)
2.69	3.6	81	28	53	4.15	95.85

Site Vicinity Map for 2017-2

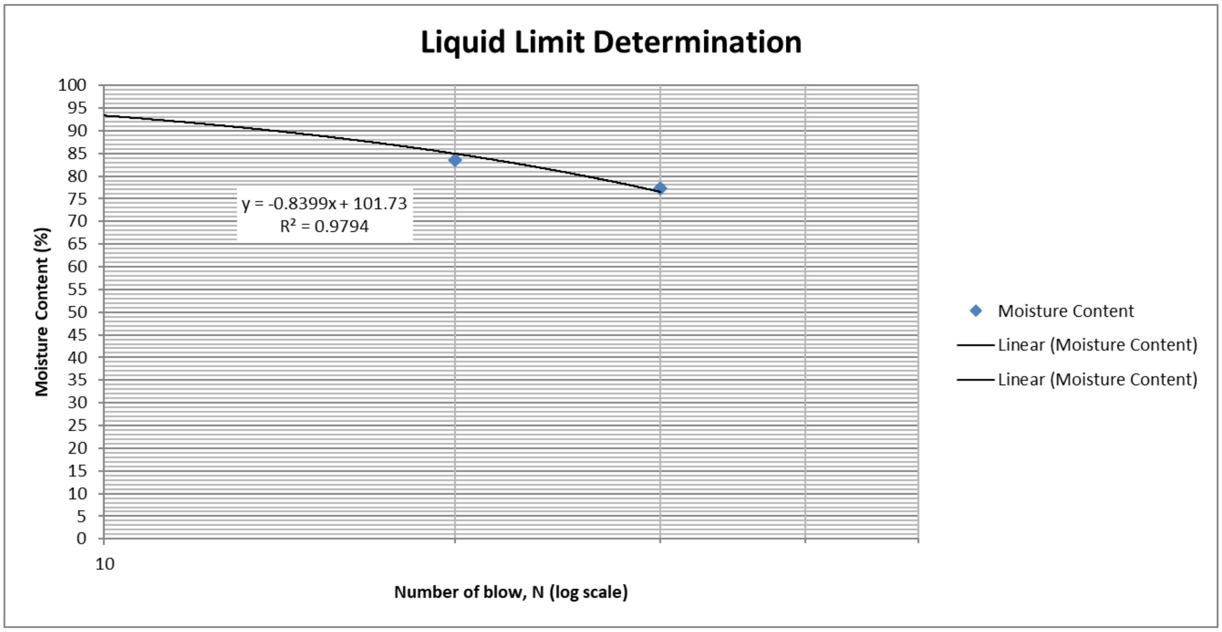


Grain Size Distribution Graph for 2017-2

Coarse (%)	Fine (%)
4.15	95.85

Liquid Limit Determination 2017-2

Liquid Limit				
Test No.	**1**	**2**	**3**	
Can No.	L1	L17	A3	
Number of Blows, N	30	20	9	
Weight of Can, W1 (g)	13.80	13.80	14.00	
Weigh of Can + Moist Soil, W2 (g)	18.80	18.90	21.60	
Weight of Can + Dry Soil, W3 (g)	16.62	16.58	17.90	
Weight of Water, W2-W3	2.18	2.32	3.70	
Weight of Dry Soil W3-W1	2.82	2.78	3.90	
Moisture Content	*77.30%*	*83.45%*	*94.87%*	
Liquid Limit*	**81**		R Squared	0.979399795
****Liquid Limit is calculated using the best fit line provided on the graph.***			avg	85.21%



Liquid Limit Graph 2017-2

Plastic Limit Determination 2017-2

Plastic Limit				
Test No.	**1**	**2**		
Can No.	L11	L39		
Weight of Can, W1 (g)	13.70	13.60		
Weigh of Can + Moist Soil, W2 (g)	19.76	20.69		
Weight of Can + Dry Soil, W3 (g)	18.46	19.12		
Weight of Water, W2-W3	1.30	1.57		
Weight of Dry Soil W3-W1	4.76	5.52		
Moisture Content	*27.31%*	*28.44%*		
Plastic Limit	**28**	*Difference Check*	*0.011311046*	*OK*
Plastic Index	**53**			
Soil Classification:	**High plasticity**			
A-Line PI Curve Value	**44**			
U-Line PI Curve Value	**18**			

Organic Content Determination for 2017-2

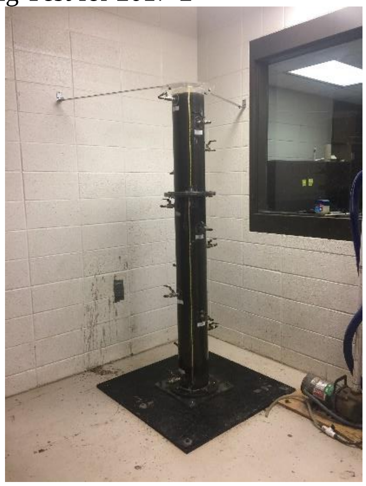
Organic Content	
Dish No.	z
Weight of Dish, W_1 (g)	124.86
Weight of Dish + Oven-dried Soil, W_2 (g	149.59
Weight of Dish + Ash, W_3 (g)	148.7
Weight of Ash, $W_3 - W_1$ (g), W_4	23.84
Weight of Soil, W_2 - W_1 (g), W_5	24.73
Ash content	96.4%
Organic Content	3.6%

Specific Gravity Determination for 2017-2

Specific Gravity		
Flask Number		1
Temperature of Water °C,	T_a	22
Temperature of Water + Soil °C,	T_b	23
Weight of Flask + Water at T_b (g),	M_a	721.7
Weight of Dry Soil (g),	M_o	50
Weight of Flask + Water + Soil at T_b (g),	M_b	753.1
Specific Gravity at T_b	M_o/ [M_o + ($M_a - M_b$)]	2.69
Correction Factor "K"	(Table 2)	0.99933
Specific Gravity at 20° C	K x (G at T_b)	2.69

Photographs During Column Settling Test for 2017-2

Initial



1 hour

2 hours

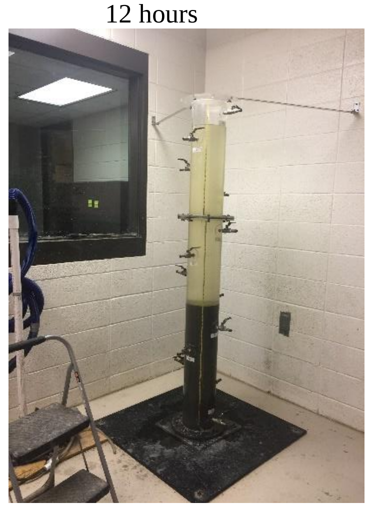
4 hours

6 hours

12 hours

1 day

2 days



3 days

7 days

11 days

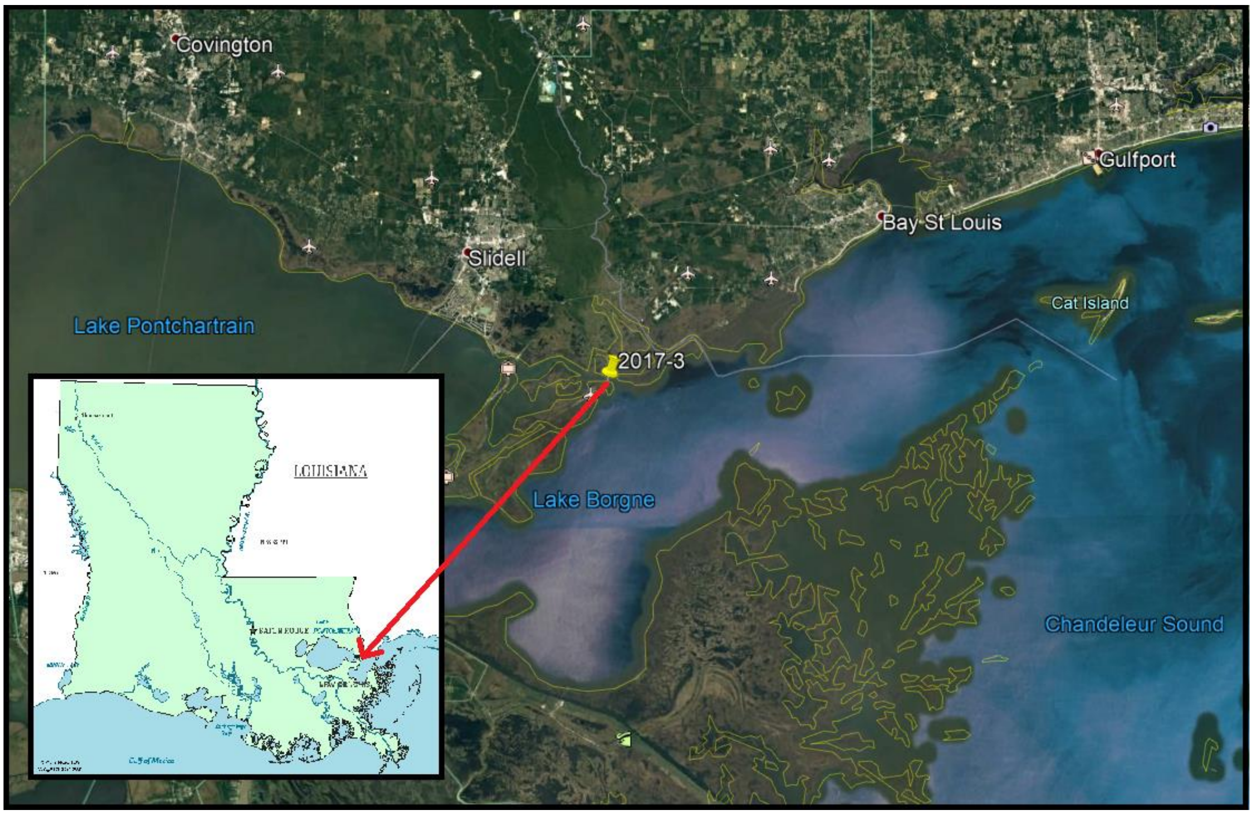
Appendix F

Sample 2017-3

Engineering Properties of Sample 2017-3

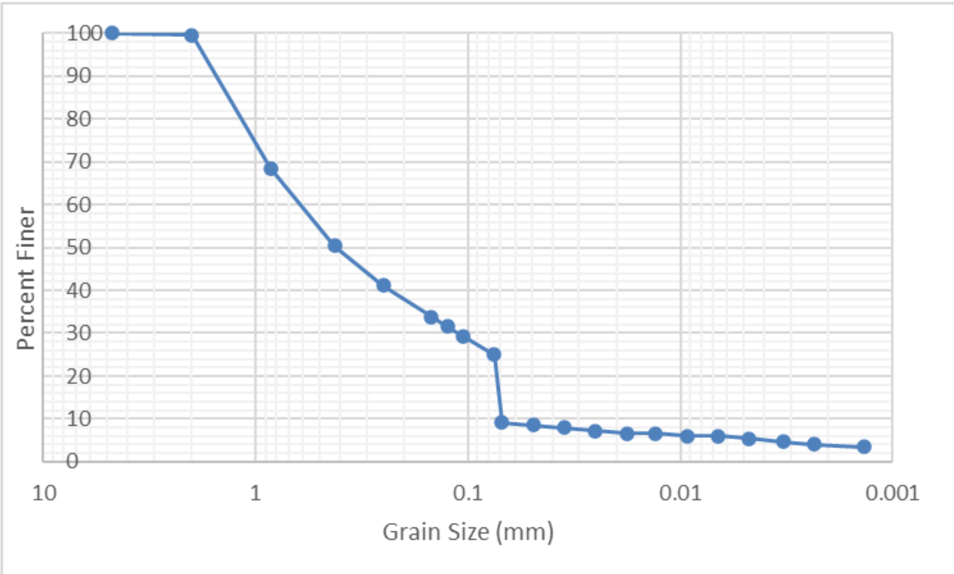
Sample ID	Project Location	GPS Coordinates	Column Test Initiation	Sample Type	Sample Source	Initial Solids Concentration (g/L)	Type of Water	Salinity (ppt)	pH
2017-3	North Lake Borgne	30° 9'2.38" N 89°37'51.96"W	2/13/2017	Grab	UNO	100 g/l	Site	1.4	7.8

Specific Gravity	Organic Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Grain Size Distribution	
					Coarse (%)	Fines (%)
2.65	11.7	59	42	16	75.07	24.93



Site Vicinity Map for 2017-3

Site Vicinity Map for 2017-3

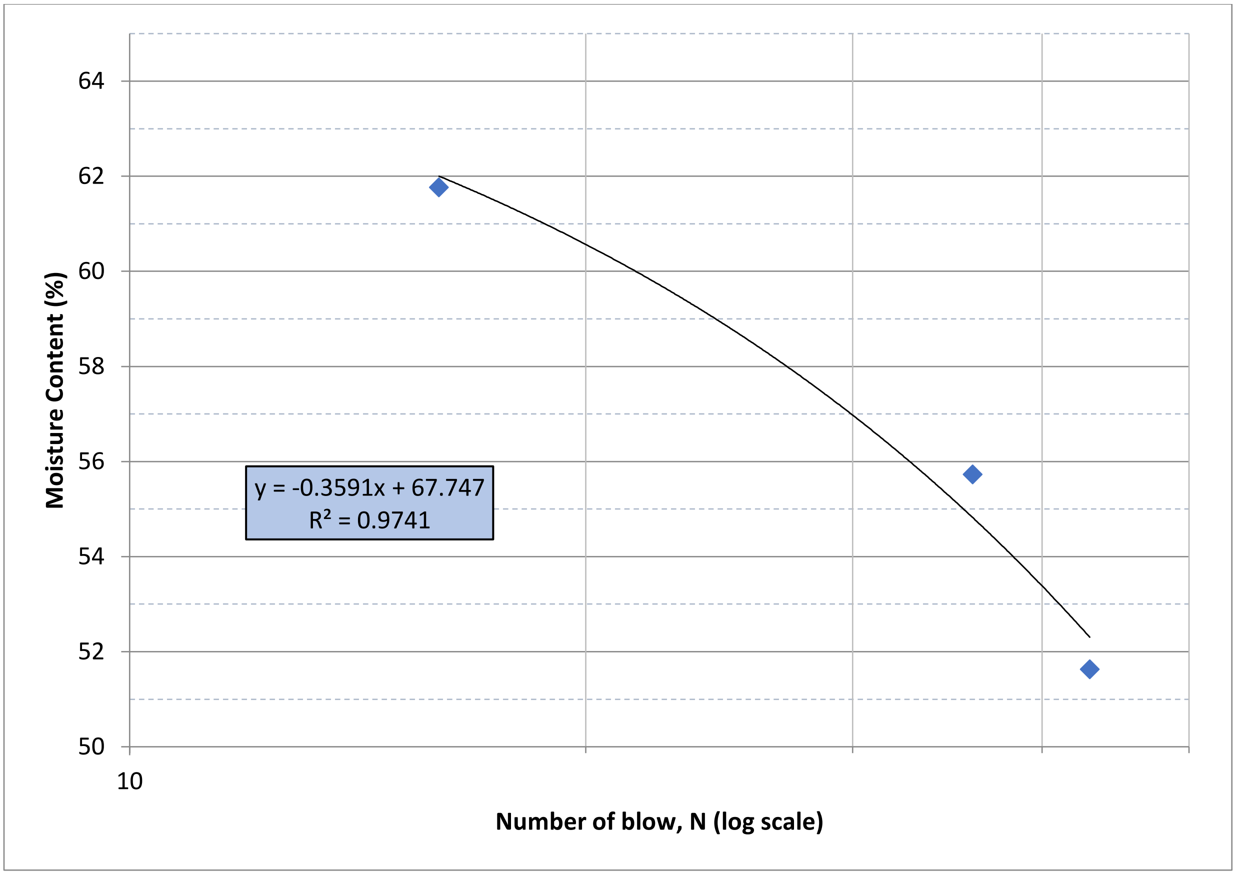


Grain Size Distribution Graph for 2017-3

Coarse (%)	Fine (%)
75.07	24.93

Liquid Limit Determination 2017-3

Liquid Limit				
Test No.	**1**	**2**	**3**	
Can No.	L21	L31	L17	
Number of Blows, N	43	36	16	
Weight of Can, W1 (g)	13.97	13.78	13.92	
Weigh of Can + Moist Soil, W2 (g)	28.86	29.54	30.42	
Weight of Can + Dry Soil, W3 (g)	23.79	23.90	24.12	
Weight of Water, W2-W3	5.07	5.64	6.30	
Weight of Dry Soil W3-W1	9.82	10.12	10.20	
Moisture Content	*51.63%*	*55.73%*	*61.76%*	
Liquid Limit*	**59**		R Squared	0.974128425
****Liquid Limit is calculated using the best fit line provided on the graph.***			avg	56.38%



Liquid Limit Graph 2017-3

Plastic Limit Determination 2017-3

Plastic Limit		
Test No.	**1**	**2**
Can No.	L39	L14
Weight of Can, W1 (g)	13.63	13.75
Weigh of Can + Moist Soil, W2 (g)	20.72	20.44
Weight of Can + Dry Soil, W3 (g)	18.52	18.54
Weight of Water, W2-W3	2.20	1.90
Weight of Dry Soil W3-W1	4.89	4.79
Moisture Content	*44.99%*	*39.67%*
Plastic Limit	**42**	*Difference Check*
Plastic Index	**16**	
Soil Classification:	**Medium plasticity**	
A-Line PI Curve Value	**28**	

U-Line PI Curve Value	**31**	

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
56.38	42	16

Organic Content Determination for 2017-3

Dish No.	6
Weight of Dish, W_1 (g)	121.22
Weight of Dish + Oven-dried Soil, W_2 (g)	136.49
Weight of Dish + Ash, W_3 (g)	134.7
Weight of Ash, $W_3 - W_1$ (g), W_4	13.48
Weight of Soil, W_2 - W_1 (g), W_5	15.27
Ash content	88.3%
Organic Content	11.7%

Specific Gravity Determination for 2017-3

Specific Gravity		
Flask Number		12
Temperature of Water ºC,	T_a	21.6
Temperature of Water + Soil ºC,	T_b	23.8
Weight of Flask + Water at T_b (g),	M_a	660.25
Weight of Dry Soil (g),	M_o	50.01
Weight of Flask + Water + Soil at T_b (g),	M_b	691.39
Specific Gravity at T_b	$M_o / [M_o + (M_a - M_b)]$	2.65
Correction Factor “K”	(Table 2)	0.99914
Specific Gravity at 20º C	K x (G at T_b)	2.65

Photographs During Column Settling Test for 2017-3

Initial

1 hour

2 hour

6 hours

1 day

2 days

3 days

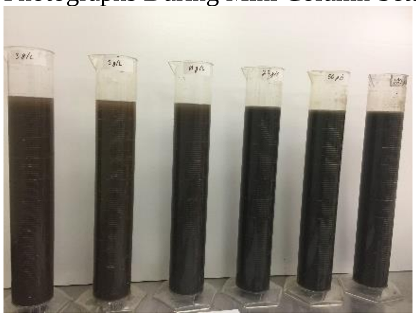
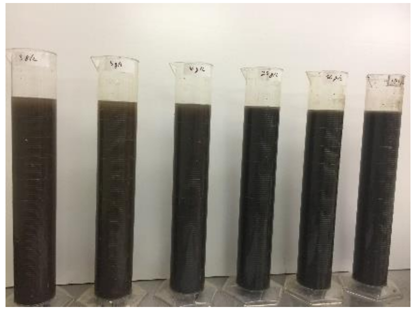
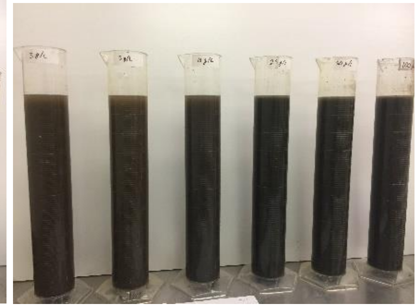
4 days

7 days

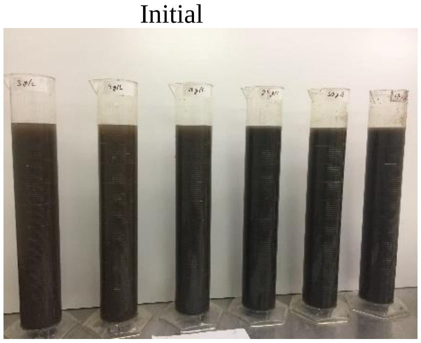
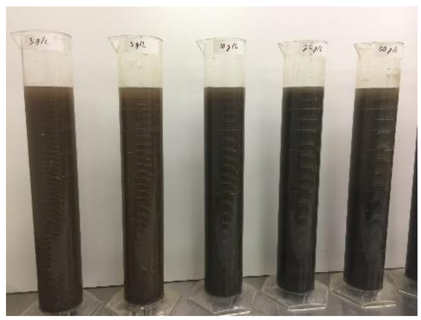
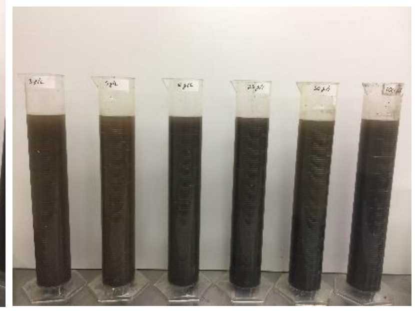
11 days

15 days

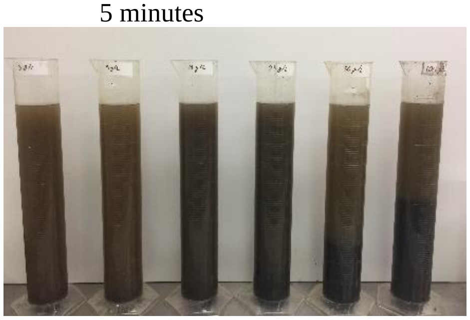
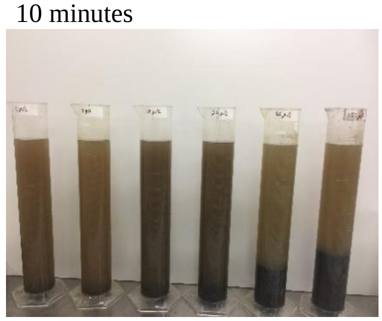
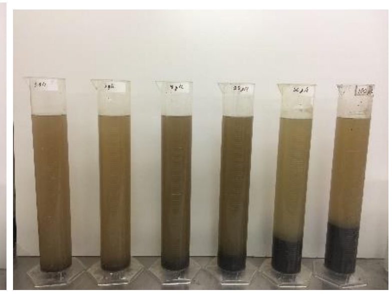
Photographs During Mini Column Settling Test for 2017-3

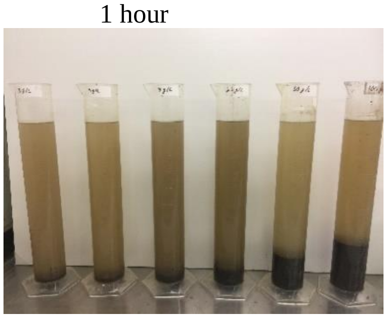
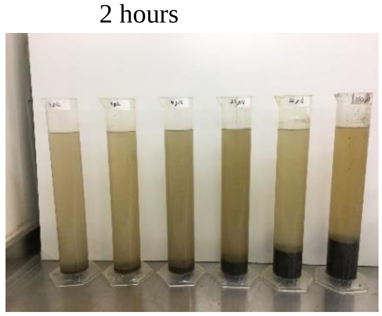
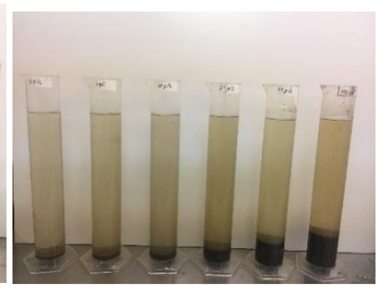
Initial 1 minute 2 minutes

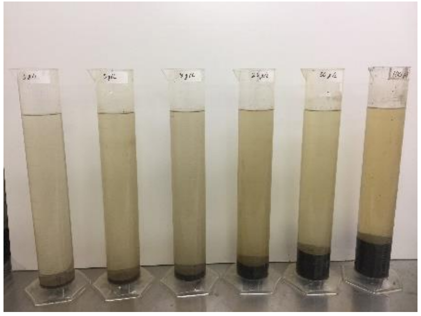
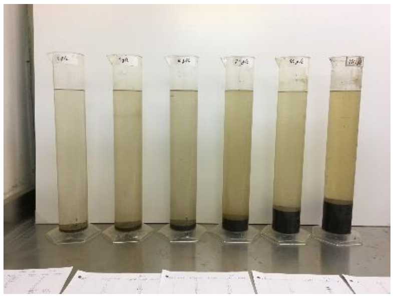
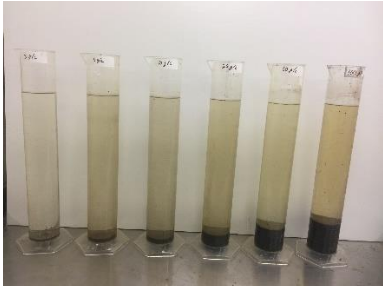
5 minutes 10 minutes 30 minutes

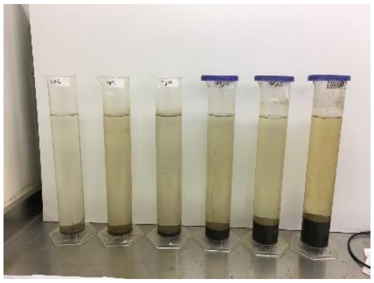
1 hour 2 hours 4 hour

6 hours 12 hours 48 hours

72 hours 96 hours 168 hours



360 hours

Appendix G

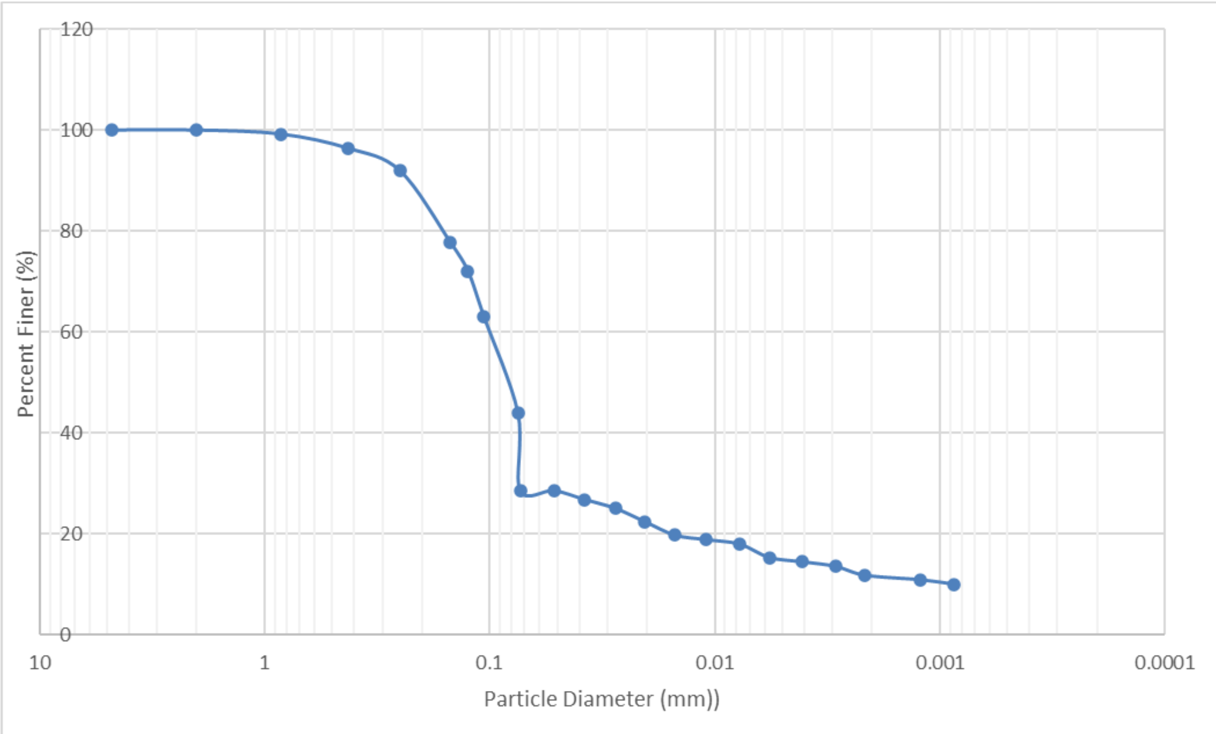
Sample 2017-4

Engineering Properties of Sample 2017-4

Sample ID	Project Location	GPS Coordinates	Column Test Initiation	Sample Type	Sample Source	Initial Solids Concentration (g/L)	Type of Water	Salinity (ppt)	pH
2017-4	North Lake Borgne	30.15066 N 89.6311 W	7/20/2017	Grab	UNO	150 g/l	Site	8.02	9.1

Specific Gravity	Organic Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Grain Size Distribution	
					Coarse (%)	Fines (%)
2.64	4.6	38	20	19	20.4	79.6

Site Vicinity Map for 2017-4

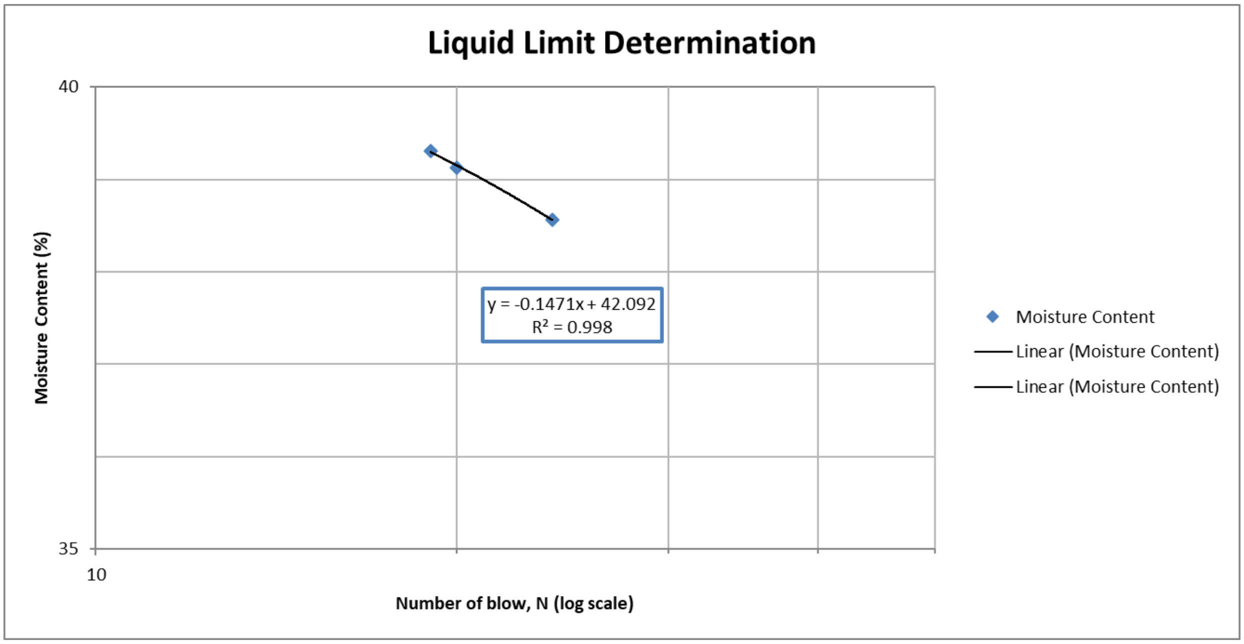


Grain Size Distribution Graph for 2017-4

Coarse (%)	Fine (%)
20.4	79.6

Liquid Limit Determination 2017-4

Liquid Limit				
Test No.	**1**	**2**	**3**	
Can No.	L31	A3	L19	
Number of Blows, N	24	20	19	
Weight of Can, W1 (g)	13.80	14.01	13.85	
Weigh of Can + Moist Soil, W2 (g)	16.89	19.13	25.19	
Weight of Can + Dry Soil, W3 (g)	16.03	17.69	21.99	
Weight of Water, W2-W3	0.86	1.44	3.20	
Weight of Dry Soil W3-W1	2.23	3.68	8.14	
Moisture Content	*38.57%*	*39.13%*	*39.31%*	
Liquid Limit*	**38**		R Squared	0.997966816
****Liquid Limit is calculated using the best fit line provided on the graph.***			avg	39.00%



Liquid Limit Graph 2017-4

Plastic Limit Determination 2017-4

Plastic Limit				
Test No.	**1**	**2**		
Can No.	L36	L28		
Weight of Can, W1 (g)	13.99	14.11		
Weigh of Can + Moist Soil, W2 (g)	19.90	19.53		
Weight of Can + Dry Soil, W3 (g)	18.97	18.60		
Weight of Water, W2-W3	0.93	0.93		
Weight of Dry Soil W3-W1	4.98	4.49		
Moisture Content	*18.67%*	*20.71%*		
Plastic Limit	**20**	*Difference Check*	*0.020379961*	*OK*
Plastic Index	**19**			
Soil Classification:	**Medium plasticity**			
A-Line PI Curve Value	**13**			
U-Line PI Curve Value	**11**			

Organic Content Determination for 2017-4

Organic Content

Organic Content	
Dish No.	1
Weight of Dish, W_1 (g)	118.46
Weight of Dish + Oven-dried Soil,	199.24
Weight of Dish + Ash, W_3 (g)	195.5
Weight of Ash, $W_3 - W_1$ (g), W_4	77.04
Weight of Soil, W_2 - W_1 (g), W_5	80.78
Ash content	95.4%
Organic Content	4.6%

Specific Gravity Determination for 2017-4

Specific Gravity

Specific Gravity		
Flask Number		1
Temperature of Water °C,	T_a	24.3
Temperature of Water + Soil °C,	T_b	24.8
Weight of Flask + Water at T_b (g),	M_a	666.97
Weight of Dry Soil (g),	M_o	53
Weight of Flask + Water + Soil at T_b (g),	M_b	699.89
Specific Gravity at T_b	M_o/ [M_o + (M_a – M_b)]	2.64
Correction Factor "K"	(Table 2)	0.99981
Specific Gravity at 20° C	K x (G at T_b)	2.64

Specific Gravity Temperature Correction Factor "K"

Temp (°C)	K	Temp (°C)	K
16	1.0007	23.5	0.9992
16.5	1.00065	24	0.9991
17	1.0006	24.5	0.999
17.5	1.0005	25	0.9989
18	1.0004	25.5	0.99875
18.5	1.0003	26	0.9986
19	1.0002	26.5	0.99845
19.5	1.0001	27	0.9983
20	1	27.5	0.99815
20.5	0.9999	28	0.998
21	0.9998	28.5	0.99785
21.5	0.9997	29	0.9977
22	0.9996	29.5	0.99755
22.5	0.9995	30	0.9974
23	0.9993	30.5	0.99725

Photographs During Column Settling Test for 2017-4

Initial

1 hour

2 hours

4 hours

6 hours

12 hours

1 day

2 days

3 days


4 days

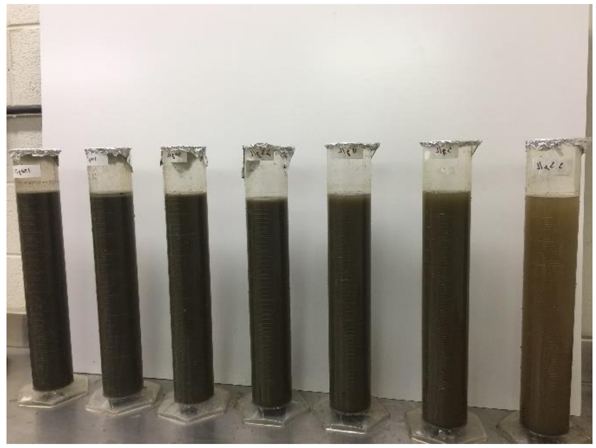

7 days


11 days

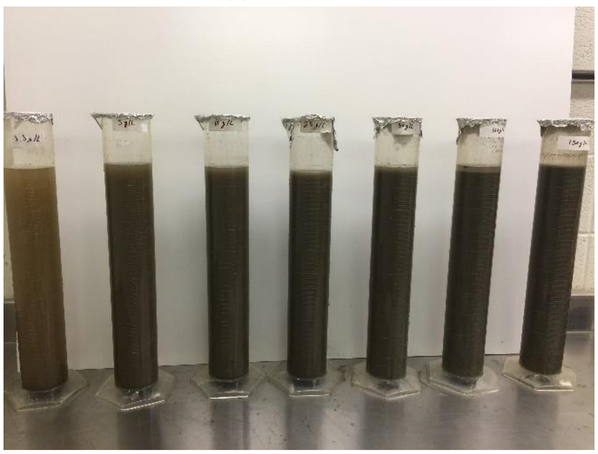

15 days

Photographs During Mini Column Settling Test for 2017-4

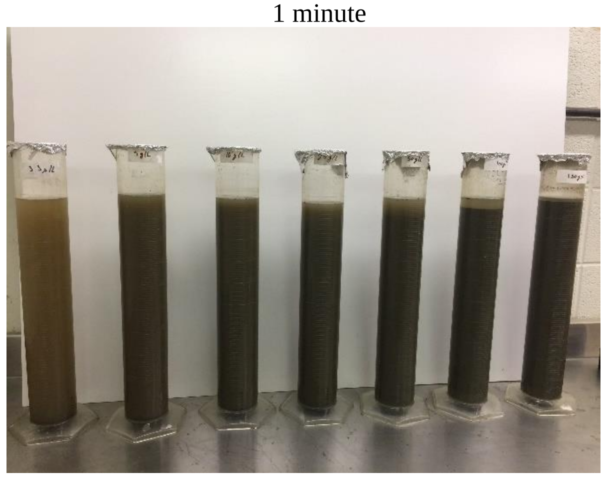
Initial



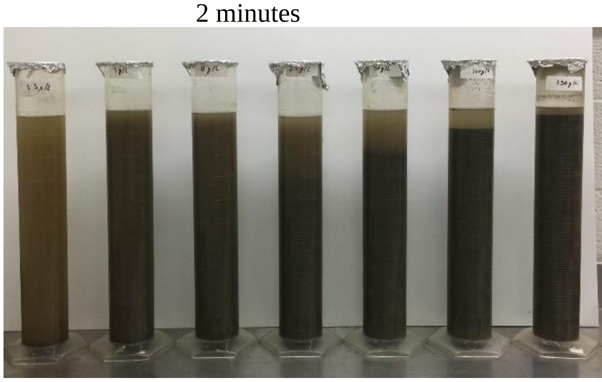
1 minute



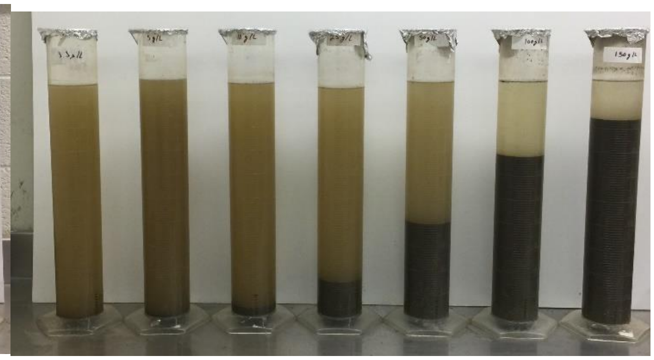
2 minutes



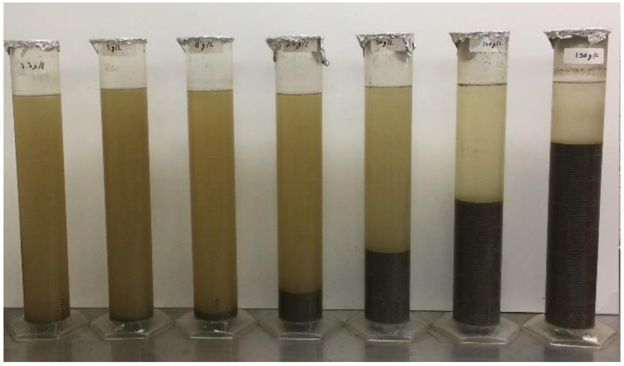
5 minutes



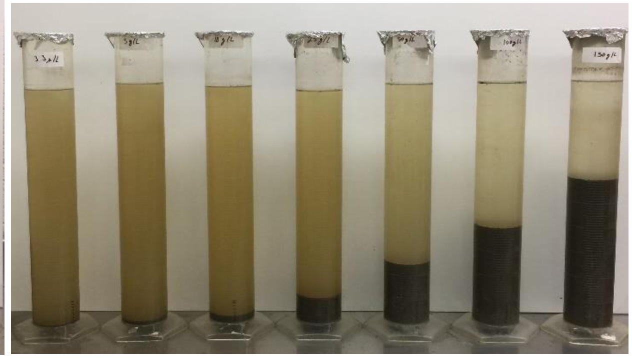
10 minutes



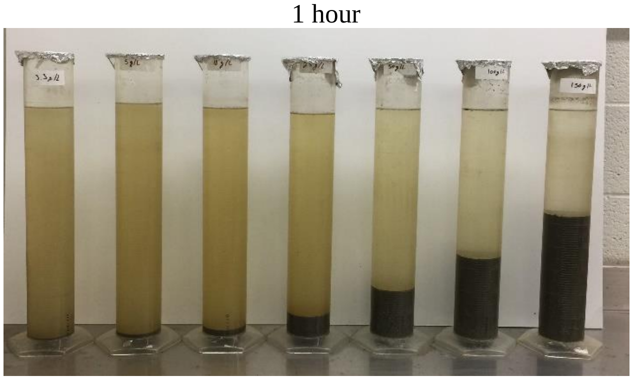
30 minutes



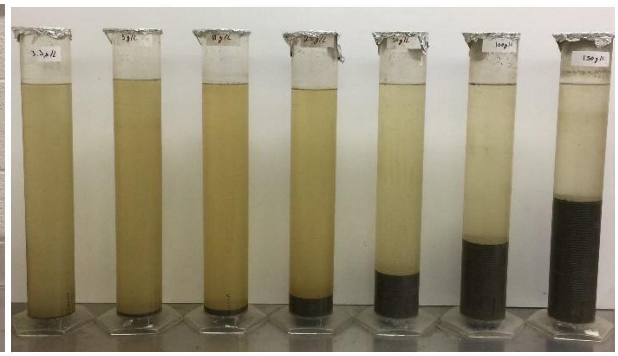
1 hour



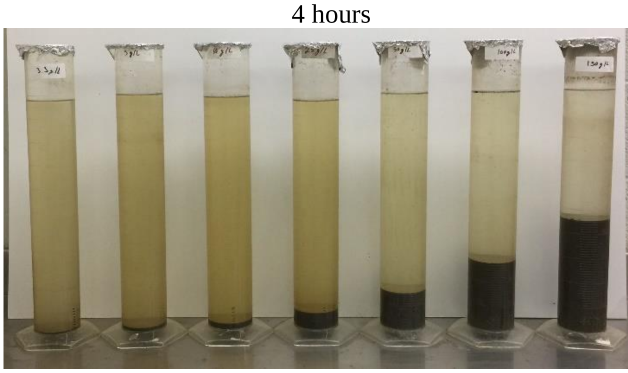
2 hours



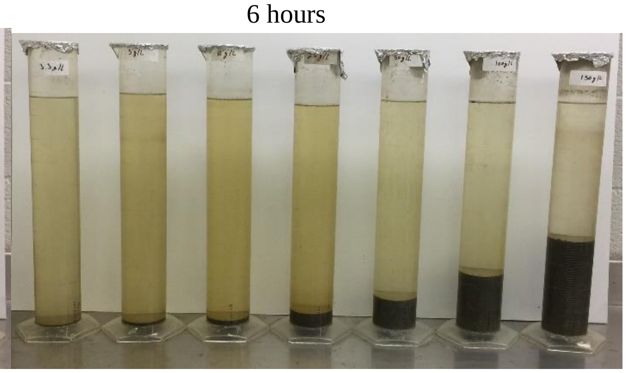
4 hours



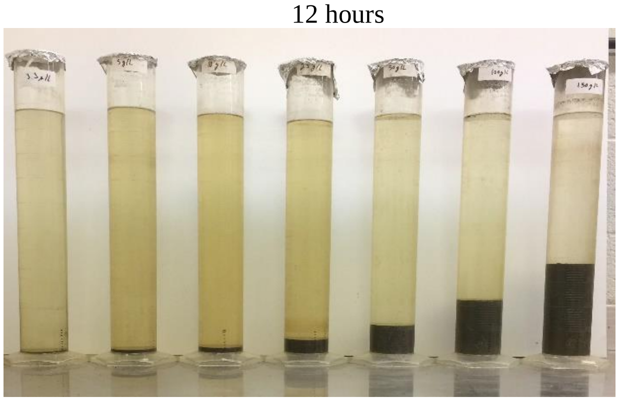
6 hours



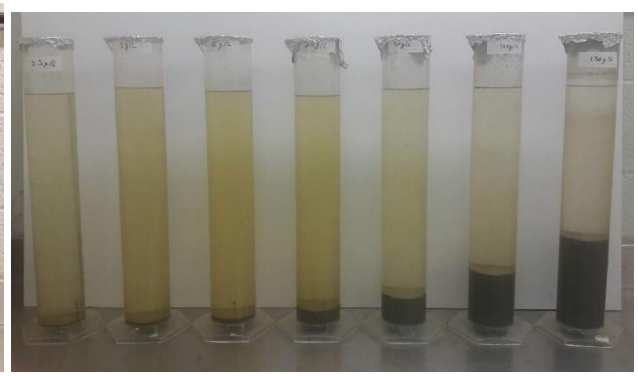
12 hours



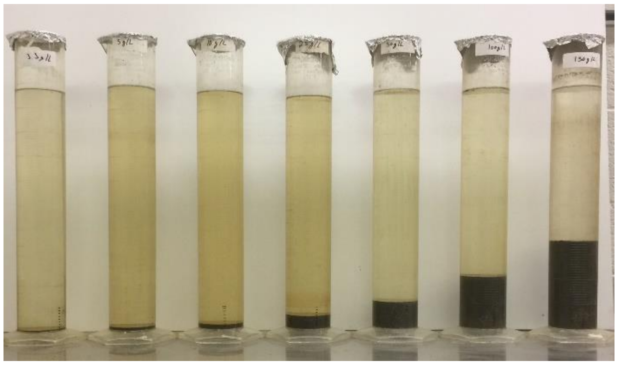
24 hours

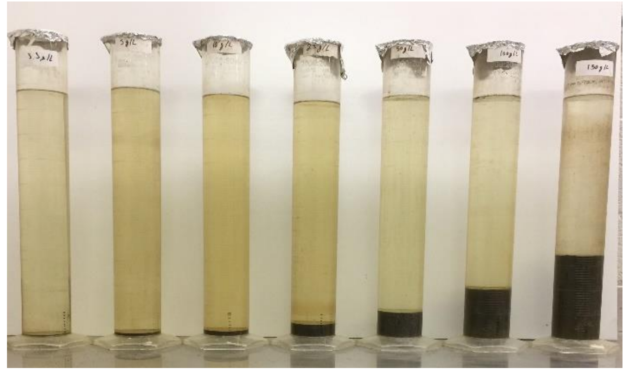


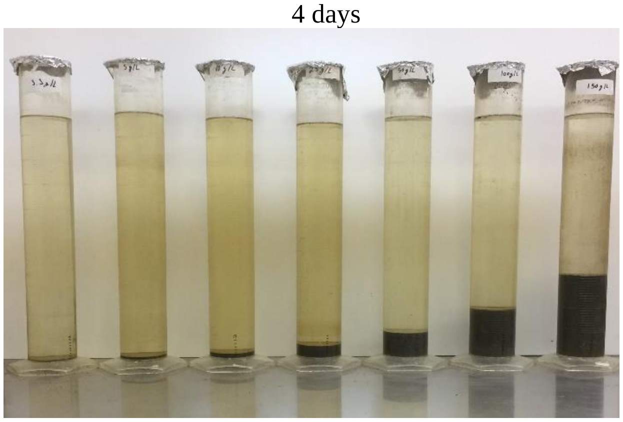
2 days

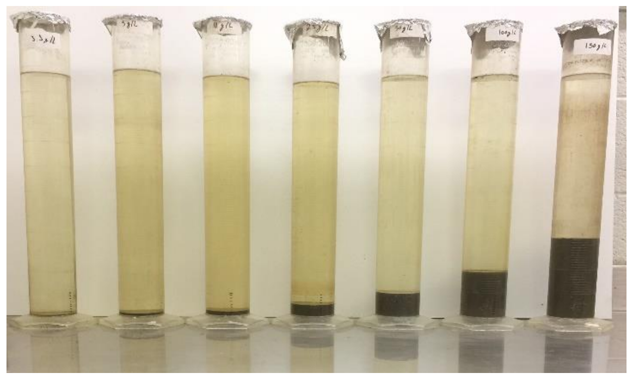


3 days


4 days


7 days


11 days


15 d

Vita

The author was born in New Orleans, Louisiana. She obtained her Bachelor's degree in Civil and Environmental Engineering from the University of New Orleans in 2017. In the same year she began working on undergraduate research under Dr. Malay Ghose-Hajra's guidance. She presented her research at three academic competitions, two of which while completing her undergraduate studies. Later during 2017 she joined the University of New Orleans Civil Engineering graduate program to pursue a Master of Science and became a graduate research student for Dr. Malay Ghose-Hajra. Since then, she has published three papers and presented her research at two national conferences. In addition to her graduate student responsibilities, Ms. Roberts was a field inspector and engineer intern at the Flood Protection Authority in Orleans, LA.

Publications from the research:

- Alshamaileh, L., Ghose Hajra, M., McCorquodale, J.A., and Roberts, B.M. (2020). "Geo-hydrodynamics and Erosion Potential of fine-grained cohesive sediments in coastal systems,' proceedings of the 10th International Conference on Scour and Erosion (ICSE-10), Arlington, VA, November 15-18, 2020

- Kulesza, S. Ghose Hajra, M. Mathis, M., and Roberts, B.M. (2020). "Effects of organic matter and salinity on fine- grained sediment erosion," proceedings of the 10th International Conference on Scour and Erosion (ICSE-10), Arlington, VA, November 15-18, 2020

- Ghose Hajra, M., and Roberts, B. (2020). "Effects of Organic Matter on Settling Characteristics of Coastal Sediments." *Proceedings of 2020 Geo-Congress*, Feb 25-28, 2020, Minneapolis, MN.