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Analysis of Sedimentation Characteristics of Dredge Sediment Used in Coastal Restoration and Marsh Creation Projects

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Used in Coastal Restoration and Marsh Creation Projects

A Thesis

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This thesis is dedicated to my parents, Merrie and Jim, my sister, Lainey, and my grandparents for their endless support and encouragement.

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Publications and Presentations

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Nomenclature and Abbreviations

AFS	artificial floating systems
ASCE	American Society of Civil Engineers
ASTM	American Society for Testing Material
BUG	Beneficial Use Group
cm	centimeter
CPRA	Coastal Protection and Restoration Authority
CWPPRA	Coastal Wetlands Planning, Protection, and Restoration Act
EPA	Environmental Protection Agency
ESS	Environmental Sciences Section
ft/day	feet per day
g	grams
g/L	grams per liter
GIS	Geographic Information Systems
in	inches
in^3	cubic inches
LL	liquid limit
mg/L	milligrams per liter
mL	milliliter
mm	millimeter
mS/m	miliSiemens per meter
NTU	Nephelometric turbidity units
PCDDF	Primary Consolidation and Desiccation of Dredged Fill
PL	plastic limit
PI	plasticity index
ppt	parts per thousand
R^2	coefficient of determination
TDS	total dissolved solids
TSS	total suspended solids
UNO	University of New Orleans
USACE	US Army Corps of Engineers

Abstract
There is a demand to reestablish a healthy coastal ecosystem by rebuilding wetlands with river diversion or dredged sediments in coastal Louisiana. Land building projects using dredged sediments from adjacent canals and river beds, can be used to protect the coastal properties and infrastructure systems from flood damages and storm surges. To predict the long term behavior of the dredged sediments and foundation soils, math models require input parameters based on engineering properties and material characteristics of the sediments. It is critical to have proper characterization of these dredged sediments for accurate design of coastal restoration projects. The sedimentation characteristics of the dredged material and their effects on the rate of settlement of the suspended solid particles and underlying foundation soil depend, among other factors, on the grain size distribution of the dredged material, salinity (fresh, brackish, or saltwater) of the composite slurry, and concentration of the slurry solid particles.

Keywords: settlement, dredged sediments, marsh creation, bulk density, settling velocity

1 Introduction

1.1 Background

Louisiana's coastline provides a critical contribution to the United States economy. The oil and gas industry contribute more than $1 trillion for the United States economy, approximately 7.5 percent of the nation's wealth. This contributes about $85 million daily in revenue to the federal government (Scott 2014). The commercial fishing industry produces 25 percent of the nation's seafood, accounting for the highest shrimp and oyster production in the United States. Louisiana is home to the Western Hemisphere's largest concentration of crude oil refineries, natural gas processing plants, and petrochemical production facilities (DOA Louisiana). Baton Rouge is the nation's farthest inland port for sea-going ships and the only port in the United States compatible for superships (DOA Louisiana) and Louisiana accounts for more than 25 percent of the nation's marine exports.

In addition to the industrial economic benefits Louisiana provides, there is also a large recreation and tourism industry. The coastline of Louisiana provides recreational areas to local residents and tourists, alike. Over $10.8 billion was spent by visitors in Louisiana in 2013 and $807 million of state tax revenue was generated by travel and tourism activities in Louisiana (DCRT). This precious coastline is considered a working coastline and natural deltaic processes are what shaped much of southern Louisiana.

The Louisiana coastline has become increasingly degraded in the last 60 years. The majority of the land loss is wetland and marshland areas. These areas once acted as buffers to more populated areas and have been converted into open water areas. This leaves significant portions of Louisiana exposed to the open ocean. The erosion is caused by both natural and manmade processes, including levees and floodgates, oil and gas canals, sea level rise, subsidence, and storms. This puts more communities, people, and infrastructure at risk along the Louisiana coastline.

The first Louisiana Coastal Master Plan was first developed in 2007 by the Coastal Protection and Restoration Authority (CPRA) after Hurricanes Katrina and Rita. A new Master Plan is revised and developed every five years. The next version of the Coastal Master Plan was approved in 2012. In the 2017 Louisiana Coastal Master Plan has come up with several initiatives to combat this land loss. These methods include converting these open water areas into wetlands with sediment diversions using river, canal, and lake sediment. Another method described in the plan the creation of new wetlands in open water areas through sediment dredging and placement using pipelines to convey the sediment.

The objective of this research was to perform laboratory testing to characterize the dredged sediments used in these Louisiana coastal restoration projects. The effects of salinity, grain size distribution, and initial particle concentration on slurry sedimentation rate were evaluated. Additionally, the effects of zeta potential on the flocculation during the settlement of the slurry were analyzed.

1.2 History of Coastal Louisiana

1.2.1 Louisiana Land Formation Methodology

The Mississippi River delta and adjacent coastal wetlands were constructed from six delta complexes (1) Maringouin-Sale-Cypremort, (2) Teche, (3) St. Bernard, (4) Lafourche, (5) Plaquemines-Balize, and (6) Atchafalaya-Wix Lake (Blum and Roberts, 2009). Figure 1.2 displays the lobes created at each delta complex. The modern Mississippi River Delta is a product of a dynamic process, the delta cycle, over the last 7,000 years (How the Delta Formed 2014). This has created most of coastal Louisiana over the past 100,000 years (Russel et al. 1936; Fisk 1944; Kolb and van Lopik 1695; Frazier 1967, others). The delta cycle has two primary phases. The first is a river-dominated phase where the delta complex is expanding and growing onto the sea flood. The second is a marine dominated phase where the

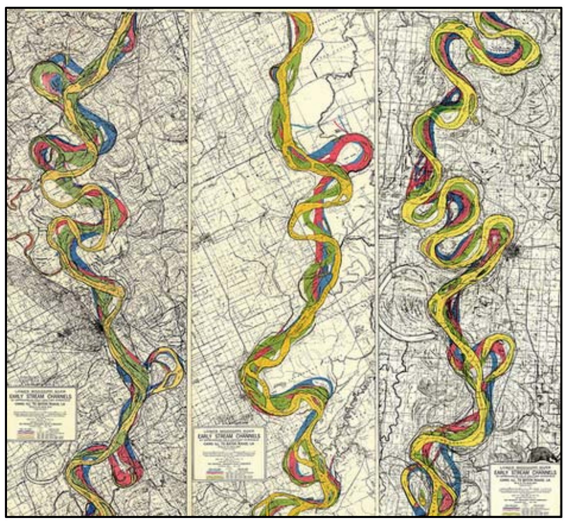

Figure 1.1- Early stream channels of the Mississippi River USACE)

delta complex is gradually abandoned by the river, the delta subsides, and the perimeter of the delta is slowly reworked and eroded by wave action (USGS 2012). The Plaquemines-Balize (also known as the "Birdfoot") and Atchafalaya-Wax Lake are currently two delta complexes active on the Mississippi Delta Plain. Currently, the Plaquemines-Balize delta complex is in the river-dominated phase, but is gradually transitioning into a marine dominated phase.

The Mississippi River carries sediments, allowing them to deposit and accumulate to create land formations. After enough sediment builds up, vegetation begins to grow and more sediment and organic material accumulate as the plants thrive and develop (How the Delta Formed 2014). Additionally, the flooding from the Mississippi River and its tributaries flooded over the years allowed sediment to accumulate to create land formations. These land masses allowed for vegetation growth and delta formation. These processes have been occurring repetitively for the past thousands of years, creating most recently the birds foot delta (Russel et al. 1936).

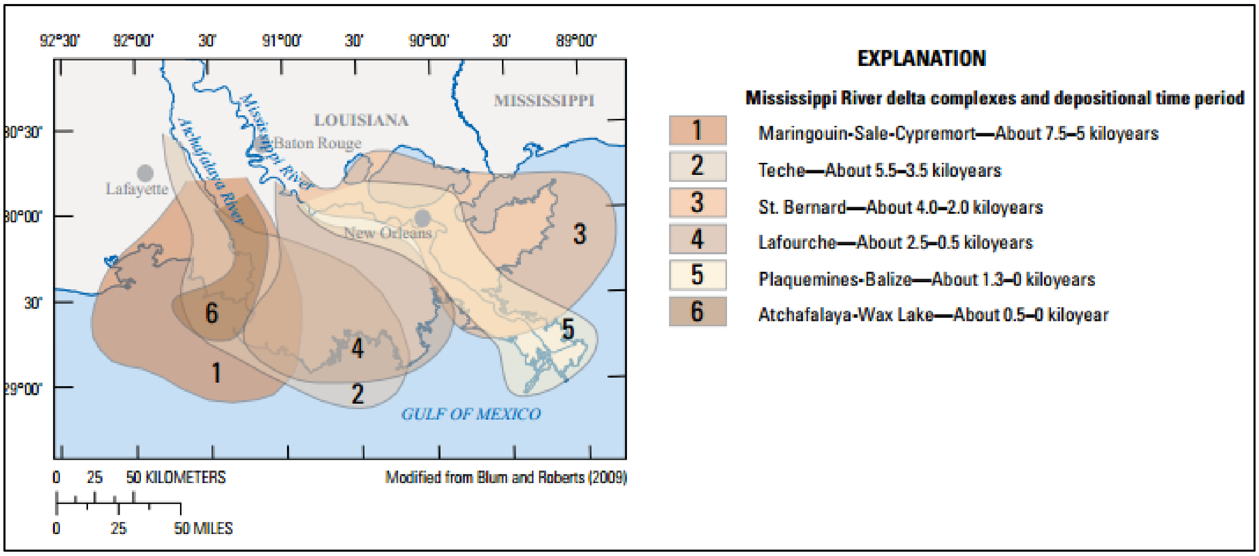

Figure 1.2- Generalized extend and depositional time periods of the Mississippi River Delta complexes (USGS)

Coastal Louisiana is a product of sediment deposition from the Mississippi River. The annual flooding from the Mississippi River would feed the adjacent wetland areas depositing sediment and over time creating land masses. As the Mississippi River develops the delta lobes, the path to the Gulf becomes longer and the river changes course to find a more direct route to the Gulf. When these lobes are abandoned, they sink and erode and form lakes, bays, sounds and estuaries. As the river cuts through new

Figure 1.3- Lock and Dam 27 on Mississippi River in St. Louis (USACE)

areas, new lobes form, building up new land for marsh plants to grow. These processes make up a natural delta, where it is constantly changing (Frazier 1967; How the Delta is Formed 2014). The iconic bird's foot configuration is typical of alluvial deposition in deeper waters. With these deeper waters, larger volumes of sediment are required to create land and the land creation processes cannot keep up with the rate of erosion (CWPPRA 2011).

The coastal areas in the Mississippi River Delta Basin are dependent on the suspended sediments carried by the Mississippi River. The dams built in the upper portions of the Mississippi River in the 1950s drastically decreased the amount of suspended sediment in the river. Prior to the major engineering projects, the combined Mississippi-Atchafalaya River system transported an estimated annual average of 400 million metric tons of sediment to coastal Louisiana (Meade and Parker, 1985, Kesel and others, 1992). The annual sediment transport decreased by about 60% to the Louisiana coastline from 1987 to 2006, only receiving an estimated 170 million metric tons (Rehich and Demcheck, 2007; Meade and Moody, 2010).

The Atchafalaya-Wax Lake delta complex began the middle 20th century (USGS 2012). Once the Europeans settled in this area, the delta lobes of the Mississippi River Delta provided profitable opportunities for commerce and transportation in the New Orleans area and other port cities. By the mid-20th century, it was evident that the Atchafalaya River, a distributary about 100 miles west of the birdsfoot, was seeing more of the river's flow. If the river continued on its natural course, the ports of Baton Rouge and New Orleans would be cut off. This sparked the US Army Corps of Engineers (USACE) to construct large water control structures to prevent the river from changing its course. These control measures have allowed for economic and social thrive in southern Louisiana, however by preventing the river form naturally changing its course, the natural processes that have built up this area are not replenishing the coastal wetlands (How a Delta is Formed 2014).

1.2.2 Louisiana Land Loss

Since the 1930s, the coastline of southern Louisiana has been steadily declining. Nearly 1,880 square miles of Louisiana coastal land has been lost (Louisiana Master Plan 2012). Louisiana has 30% of the total coastal marsh areas and accounts for 90% of the coastal marsh land loss in the continental United States (Louisiana Sea Grant College Program 1998). The wetlands are mainly converting into open water areas (USGS 2012). In the early 20th century, the land loss rates were 17.4 square kilometers per year and by the 1970s the rates increased as high as square kilometers per year (USGS 2012). The rate of land loss has increased in the last 20 years and is projected to only get worse if nothing is done to combat these processes. Figure 1.4 projects the land loss over the next 50 years if there is not action taken to prevent the land loss; the red areas denote land that will be lost.

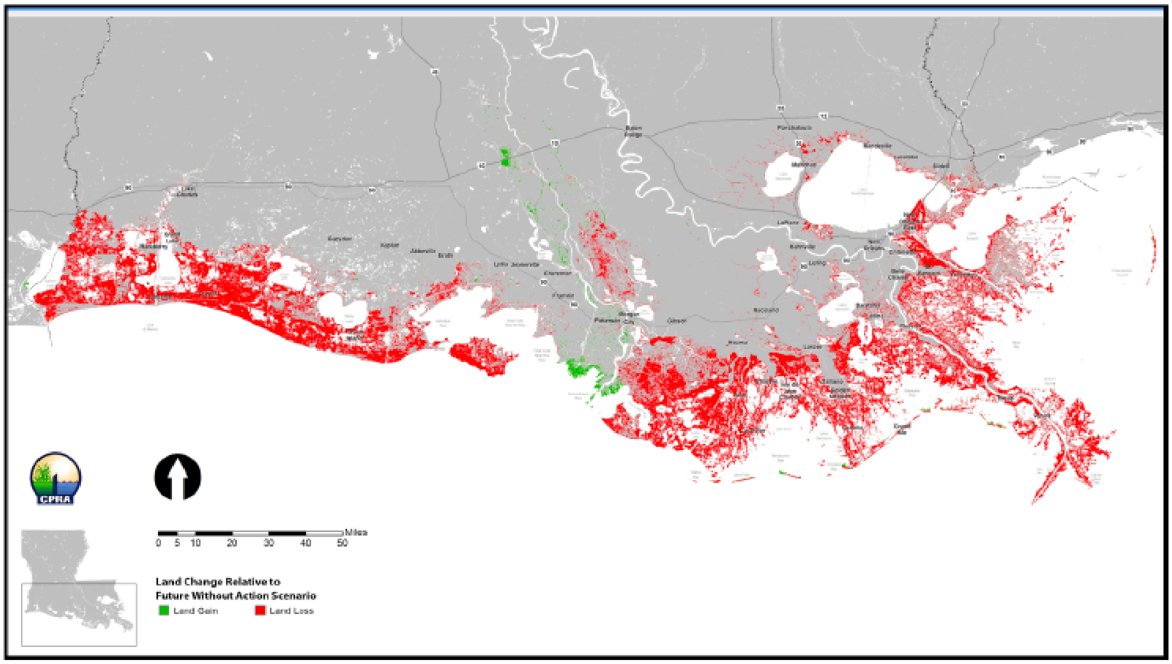

Figure 1.4-Projected Land Loss by Year 2061 (Louisiana Master Plan 2012)

1.2.3 Causes of Land Loss

The land loss in coastal Louisiana can be attributed to a combination of natural and manmade processes. The natural processes that impact the land loss are sea level rise, increasing intensity of storm systems, and regional subsidence (Ramsey and Moslow 1897; Penland et al. 1989; Ramsey 1990). The combination of these has caused the landmass elevations to decrease which increases flooding events causing more erosion.

The manmade processes include levee and flood protection system construction and oil and gas canals. The levee and other flooding protection system construction along the Mississippi River keep the communities safe from flooding; however it prevents fresh water and sediment from nourishing the wetlands, causing these marsh areas to deplete and over time turn into open water areas (Reed 2004). Prior to the levee and flooding protection systems construction, the flooding of the river would deposit freshwater and sediment into these coastal wetlands to naturally replenish these areas and since the construction of these protection systems this material is carried into the Gulf of Mexico (Kesel 1988). The channelization of the Mississippi River for flood control and commercial navigation has one of the largest negative impacts on the coastal wetlands in Louisiana. The reduced amount of sediment carried by the river (due to reservoir and dam construction upriver) by passes the wetland marsh areas and is wasted out the Birdfoot into the Gulf, pictured in Figure 1.5.

Additional wetland loss is directly attributed to the reduced sediment transport to the lower Mississippi River due to reservoir construction upstream (Paola and other 2011). Saltwater intrusion and

Figure 1.5- Sediment by passing wetland areas in coastal Louisiana (Louisiana Coastal Master Plan

enhanced subsidence from petroleum fluid extraction have also been noted as potential causes for wetland distress and loss (Mallman and Zoback 2007).

1.2.4 Effects of Land Loss

The effects of the land loss in coastal Louisiana can be felt on a local and national economic level. The Louisiana coastal area serves as a vital life line, supporting critical infrastructure across the nation. The coastal infrastructure of Louisiana is estimated at $150 billion (Coastal Erosion 2012). The coastal wetlands of Louisiana provide storm surge protection for ports in Louisiana; they account for 18% of all waterborne commerce in the United States (LADNR).

The infrastructure in Louisiana provides for ¼ of the country's energy supply (Coastal Erosion 2012). Coastal Louisiana transports, processes, or produces 18% of the nation's oil production and 24% of the nation's natural gas production (LADNR). This brings in about $16 billion in revenue per year (LADNR). There are over 20,000 miles of pipelines located offshore and inland of Louisiana and risk damages to the pipelines and passing water traffic with loss of wetlands (Coastal Erosion 2012).

Louisiana wetlands support the largest commercial fishery in the continental U.S. (Couvillion and others 2011). Coastal Louisiana is home to a diverse group of ecological habitats that house many species of fish, wildlife, and waterfowl. Louisiana's commercial fisheries account for 30% of the nation's total catch (LADNR). The annual expenditure for non-commercial fishing is about $1.7 billion and employs almost 20,000 people (NOAA 2011). The projected annual loss by 2050 is estimated at $550 million and $200 million for commercial and recreational fisheries, respectively (Coastal Erosion 2012). Coastal

Louisiana has a large presence in the local and national economy, producing revenue and jobs. Billions of dollars are at risk with continuing land loss in coastal Louisiana.

1.3 Louisiana Coastal Restoration

In 1978, the State of Louisiana began regulating activities impacting wetland loss, in response to the increasing awareness of potential economic and ecological consequences of coastal wetland loss. The Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA) was enacted in 1990 by the U.S. Congress. This allocated between 30 and 80 million dollars annually and funded about 150 coastal restoration or protection projects in Louisiana (USGS 2012). Since 1990, the funds from CWPPRA have created and protected an estimated 450 and 2,200 square kilometers of coastal wetlands, respectively (CWPPRA 2011).

1.3.1 Louisiana Coastal Master Plan

The Coastal Protection and Restoration Authority (CPRA) was created in response to the projections of land loss, infrastructure damages, and economic impacts. CPRA was restructured from the Wetland Conservation and Restoration Authority in December 2005 after Hurricanes Katrina and Rita. This organization was approved by Congress in 2006 by Public 109-48, Act 8 (CPRA). Act 8 extended the membership, duties, and responsibility of the group, including implementation a comprehensive coastal protection plan. This plan would include a Master Plan that would be updated every five years. The plan would also include projects to help restore the coast and create a sustainable environment.

The first master plan was approved in 2007. The Louisiana 2012 Coastal Master Plan outlines 109 projects with potential for reckonable benefits for our coastal communities and ecosystem (Louisiana 2012 Master Plan). These projects have an estimated cost of $50 billion and would be constructed over the next 50 years. The goals of these projects emphasize protection and restoration of existing and future coastal areas. Improvements would be made to reduce flood risk and build new land. The project types include shoreline protection, ridge restoration, marsh creation, sediment diversion, and structural projection that include levees and floodwalls. The 2017 Louisiana Coastal Master Plan is currently being developed.

1.3.2 Land Creation Methods

The two primary methods for land building are sediment diversion and placing dredge material in enclosed or open water areas (Louisiana 2012 Master Plan). These restoration methods have the ability to build and/or sustain land.

1.3.2.1 Mississippi River Sediment Diversion

Sediment diversions are designed for land building in open water areas. Freshwater diversions are designed to flow into existing, but degrading marsh systems to reverse or slow the rates of degradation (NOAA 2012). Sediment diversion is a process where a structure or channel is created to divert sediment and freshwater from the Mississippi and Atchafalaya Rivers into adjacent shallow, degrading wetland areas (NFWF 2013). The freshwater is used to offset the salt water intrusion in many wetland areas. This will help change the water quality and add nutrients that typical wetland marsh areas need to thrive (NOAA 2012). Typically the sediment diversions do not carry large volumes or sediment, so the process land building via diversions is slow; it can take years for sediment to accumulate and create land. By reintroducing freshwater and sediment from the Mississippi River into open water areas the deltaic processes can reestablish to build, sustain, and maintain the marsh land (Coastal Master Plan). This process of land building gives potential for land growth over time and into the future (Coastal Master Plan).

1.3.2.2 Land Building by Conveyance of Dredged Sediments

Placement of dredged material builds most of land as soon as the project is constructed. Sediment is dredged from a nearby lake, river, or channel into an enclosed or open water area. However, over time that land may erode and subside with storm events and sea level rise (Coastal Master Plan). Land building projects using dredged sediments involve the use of sediment that is routinely dredged for maintenance of navigation canals and access channels, or material dredged for the sole purpose of creating new land. The dredged sediments are placed in an enclosed damaged wetland area at specified elevations so marsh plants can cultivate to create a new replenished marsh. The next section explains the dredged sediment method.

1.3.3 Beneficial Use of Dredged Sediments

One of the many goals outlined in the Louisiana 2012 Coastal Master Plan was to use dredged sediments for land creation in open water areas via barge or pipeline to reestablish a healthy coastal ecosystem. The USACE routinely dredges waterways throughout Louisiana to maintain depth clearances. Typically, this material has been released to flow out into the Gulf or placed in designated disposal areas. About 300 million cubic yards every year are dredged by the USACE and can be repurposed to build in land in coastal Louisiana (Louisiana 2012 Master Plan). The sediments can be dredged mechanically or hydraulically in fresh, brackish, or a saltwater environment and transported via pipeline to distribute in open water areas for marsh recreation. A containment dike is built around the designated marsh creation area to hold the dredge material in place. The material settles to a target elevation and then the area is dewatered to expose the newly created land. Figure 1.6 shows a typical profile of a marsh creation site.

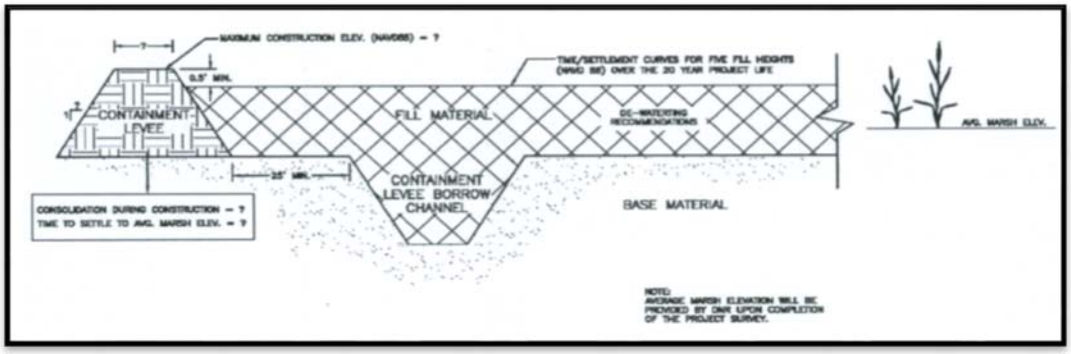

Figure 1.6 - Typical Marsh Creation Diagram

1.3.4 Current Practice

The design of marsh creation area varies with the site conditions. Each project area is different and should be treated as such. Currently the design processes involves the estimation and assumption of many variables during the design phases. Sedimentation characteristics of the dredged material are one of the most prevalent unknown variables. During the design phase, soil borings are drilled at the borrow and fill sites to determine the geotechnical characteristics of the dredged material. There has been limited testing done to evaluate the sedimentation characteristics of the dredged sediments that make up the slurry.

Predictive modeling is used to predict how these creation projects will run and assist in foreseeing the sustainability of a particular project. The coastal modeling can determine the different types of land building that will occur with different project types. These models have countless variables and many of them are unknown. In many cases the data is assumed in these math models, due to the lack of knowledge of the sediment characterization. There is a need for more data on the sediments used in these coastal restoration projects. These models help determine how the coast changes over time and how different projects might influence those changes. However, there is a lack of data regarding how the sediment will act in the projects. The research presented in this thesis strives to improve the characterization of the dredged material used in coastal Louisiana marsh restoration and land creation projects.

2 Scope of Research

2.1 Research Objectives

The objective of this research was to determine the characteristics and evaluate the engineering properties of the dredged sediment collected from various areas of on-going or future land creation and restoration projects in coastal Louisiana.

2.2 Specific Objectives

This research was performed to evaluate the following items:

1. Determine the effects of salinity on sedimentation characteristics of dredged slurry
2. Determine the effects of grain size distribution on sedimentation characteristics of dredged slurry
3. Determine the effects of initial solids concentration on sedimentation characteristics of dredged slurry
4. Estimate the settling velocity of solid sediment
5. Evaluate correlations between total suspended solids (TSS) and turbidity values
6. Estimate dry bulk density values
7. Evaluate correlations between initial sediment concentration and dry bulk density values
8. Evaluate clay ionic potential
9. Create a GIS database

2.3 Research Tasks

The objectives listed above were conducted through a comprehensive laboratory evaluation. In order to fulfill the research objectives above, the following tasks were performed. The sediment slurry underwent a complete geotechnical characterization in the soil mechanics laboratory at the University of New Orleans (UNO). The geotechnical testing included Atterberg Limits, grain size distribution, organic content, specific gravity, and soil resistivity. Additionally, the pH and conductivity were tested. The evaluation of effects on sedimentation was done by performing the column settling tests. This test included a settlement analysis, measurement of total dissolved solids (TDS), TSS, and turbidity of suspended solid particles. All tests performed during the research were completed in general accordance of American Society for Testing Material (ASTM) standards, USACE methods, and other applicable testing standards. The results from the laboratory investigation were evaluated and recommendations are provided.

3 Literature Review

3.1 Introduction

A review of earlier studies is important to have an understanding of previous findings on sedimentation characteristics and compare the results of the present study to verify typical behaviors. Most of the previous studies have been conducted on sludge material for sedimentation tank design in wastewater treatment facilities. There have been very few studies focusing on fine-grained sedimentation and settlement of sediments in marsh creation projects. The following section discusses literature review on sediment settling characteristics and previously performed studies in this subject area.

3.2 Settling of Sediments

Sediments have two basic forms of initial settlement when thoroughly mixed in a slurry form. They either settle as an individual particle or settle while in contact with other particles. In this individual form of settlement, also referred to as discrete particle settling, there is no interaction between soil particles. Typically, this happens in very low solid particle concentrations where soil particles are anticipated to settle as individual grains.

The second form of settlement occurs when there is contact between the soil particles. Depending on the concentration of the slurry, the degree of contact can vary causing three types of settlement: flocculent, hindered, and compression settling (Marshall 1996). In addition to the slurry concentration, the type of settlement can depend on the biological and chemical properties of the water and the individual soil particles. The factors governing the sedimentation of dredged materials are the initial slurry concentration and the flocculating properties of the solid particles (Montgomery 1983). Typically, dredged fine-grained materials tend to flocculate, either falling into flocculent or zone settling behavior; each of the settling types are explained below (Montgomery 1983).

Flocculent settlement occurs at relatively high solid particle concentrations. The flocculation of the soil particles come together because of biological and/or chemical reactions and then each flocculation settle as a mass. The particles agglomerate during settling with a change in physical properties and settling rates (Montgomery 1983).

Zone settling is where the flocculent suspension forms a lattice structure and settles as a mass, demonstrating a distinct interface during the settling process (Montgomery 1983).

During hindered settlement, the solid particle concentrations are high and the water movement is inhibited. Typically, particles will remain in suspension longer and there will be a point where the particles are so close together that they no longer settle as an independent particle. In this case, the particles form together in flocs similar to type 2 settlement, but there are a large number of flocs present and settling of the particles can happen at a faster rate.

Compression settlement occurs after the first three types of settlement have already taken pace or if there is an extremely high concentration of solids in the slurry. In this form of settlement, the particles settle consolidate under the weight of the overlying soils. The void spaces are gradually filled during the compression settling and water is squeezed out of the medium.

3.3 Factors Effecting Settling Rate

There are numerous factors that impact the rate of settlement, including the size, shape, and density of the particles (Martin 1998). A larger diameter particle will have a larger surface area and have a greater resistance, leading to a slower settling rate (Marshall 1996). The shape of the sediment can also influence the settlement. A flatter particle will settle different than a particle with rougher edges or with a rounder shape. Settlement will occur faster as the particles become denser.

There are also electro-chemical properties of clay particles that can cause flocculation (Maggi 2005). Clay particles have a negatively charged surface with an outer surface of cations that create an energy barrier (Van Leussen 1998). The particles repel each other because of the energy barrier until collisions overcome the barriers and the particles stick together (Van Leussen 1998). If there is a higher salt concentration in the slurry, there are more free anions and cations produced that decrease the energy barrier (Van Leussen 1998). As the salt concentrations increase, the barriers decrease until they disappear at very high salt concentrations. According to Drake (1976), two (2) parts per thousand (ppt) increases the mineral cohesion and allows aggradation. However, Van Leussen (1994) and McAnally (1999) suggest other salt concentrations for different minerals. Soils with organic material can cause similar processes that can cause ionic boding and increased flocculation. These effects can vary based on the exact composition of the sediment.

Physical-chemical factors also have impacts on settling characteristics, specifically the salt and organic content.. These factors can spark the flocculation process, where the particles are attracted to one another and the individual particles come together to form larger masses or flocs. Depending on the density and buoyancy of the particles, the settlement will occur faster or slower (Gibbs 1995). The new shape of the floc can impact the rate of settlement including increased surface area or a more aerodynamic shape (Gibbs 1995).

Previous studies have indicated that as solid particle concentration increases, flocculation will tend to increase (Nam 2008). Nam et al studied four different materials that varied in particle shape, size and distribution, clay structure, pH, and specific gravity. These studies concluded that the settling velocity and flocculation increased with solids concentration.

3.4 Settling Velocity

The settling velocity theory for spherical particles under laminar flow conditions are defined by a series of equations based on the type of settlement. The theory of settling velocity is based on Stoke's Law and involves two forces: buoyant force and drag force. Buoyant force is defined by the following equation:

$$F_g = (\rho_p - \rho) g V_p \tag{3.1}$$

where F_g is the buoyant force, ρ_p is the particle density, ρ is the fluid density, g is the gravitation constant, and V_p is the particle volume. Drag force is defined by the following equation:

$$F_D = \frac{C_D A_p \rho v_s^2}{2} \tag{3.2}$$

where F_D is the frag force, A_p is the particle area, ρ is the fluid density, and v_s is the settling velocity. The combination of the buoyant and drag forces produces the equation for settling velocity. For type 1 settling or free settling, the settling velocity is defined by the following equation:

$$V_s = \sqrt{\frac{2(\rho_p - \rho) g V_p}{C_D A_p \rho}} \tag{3.3}$$

For hindered settling, the settling velocity is defined by the following equation:

$$V_s = \frac{g(\rho_p - \rho) d_p^2}{18\mu} \tag{3.4}$$

where μ is the fluid viscosity and d_p is the particle diameter.

The conditions in reality may differ from laminar conditions and spherical particles and in these cases, the settling velocity of a particular type of sediment can be determined experimentally. Vesilind (1968) and Dick (1972) have the best-known models for experimentally determining settling velocity. In order to produce a settling curve, the height of the interface is plotted against time. In Figure 3.1, H is the height solid-water interface and H_o is the height of the column.

This produces a graph with a linear portion of the curve termed zone settling and asymptote portion termed compression settling. The zone settling portion of the curve is the period when the slurry is settling at a constant rate. The settling velocity of any particular slurry concentration is determined by this zone settling portion of the curve. Each concentration that is tested will have a different slope in the linear portion of the curve. The slope of the settling curve is plotted against slurry solids concentration to

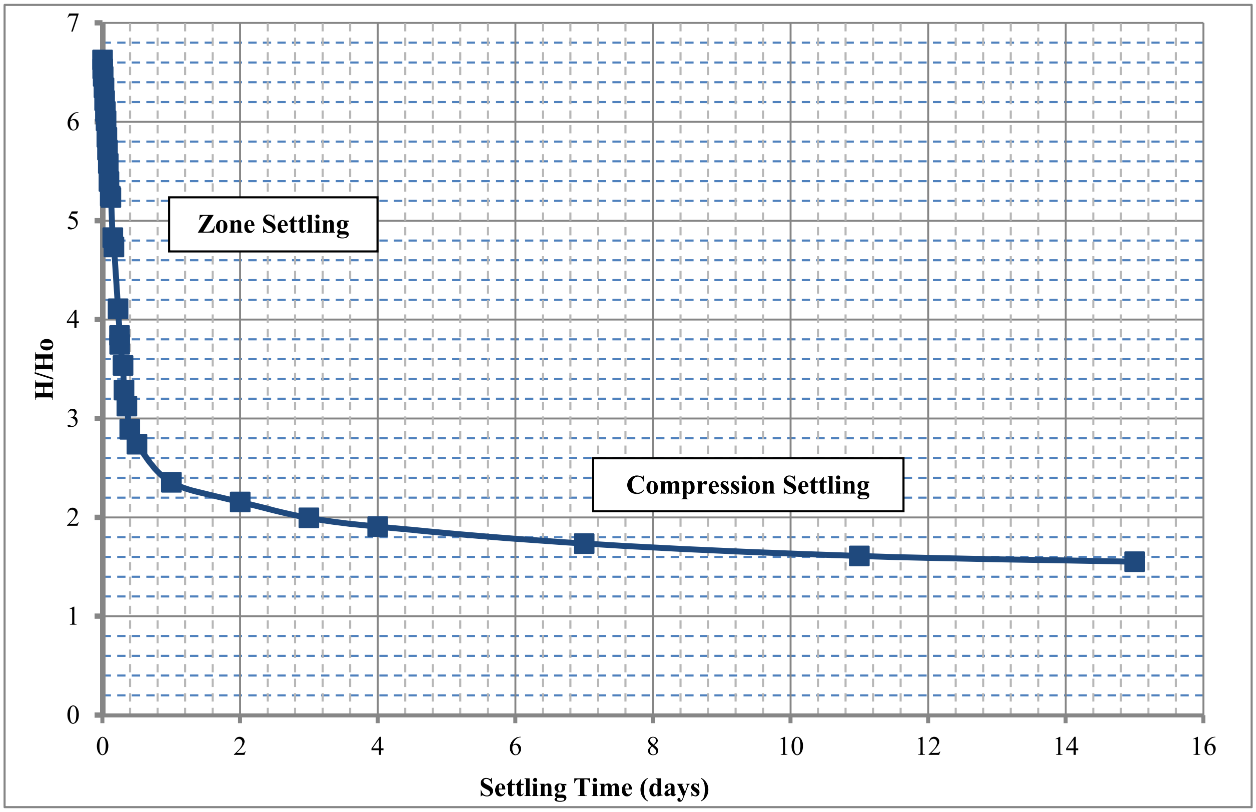

Figure 3.1- Example Settling Curve (Mattson 2014)

generate a curve for settling velocity (Figure 3.2). The slope of the early portion of the graph can be interpolated back towards the y-axis to determine the settling velocity of the sediment particle.

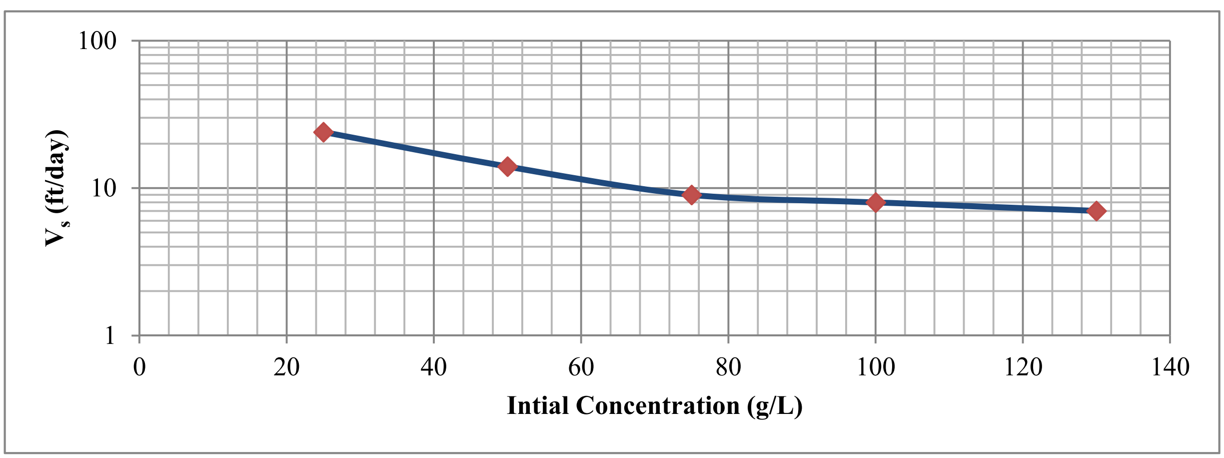

Figure 3.2- Settling Velocity Analysis Graph (Mattson 2014)

3.5 Self-Weight Consolidation of Sediments

There are three zones in settling and sedimentation of fine grained particles: supernaent, suspension, and consolidation zones (Nam 2008). The compression settlement occurs after the primary settlement has taken place. The compression settlement or the self-weight consolidation of the settlements continues to take place as the slurry settles under its own weight. The elevation of the newly placed dredge material continues to drop. The settlement can range between a few inches to several feet.

3.5.1 Previous Studies

3.5.1.1 Sridharan and Prakash (2003)

In 2003, Sridharan and Prakash performed a study on the compressibility characteristics of soft sediments. They concluded the lowest initial moisture contents yielded in homogenous sediments and highest initial moisture contents produced segregated sediments. The e-log p' curves of segregated sediments indicated grain size sorting occurred. High void ratios of the upper segregated sediment layers were caused by the flocculation in the case of kaolintic soils and double layer repulsive forces in the case of montomorllonitic soils.

3.5.1.2 Ganesalingam, Sivakuga, ASCE, Ameratunga (2013)

In 2013, research was performed on the influence of settling behavior of soil particles on the consolidation properties of dredged fine grained material. This study confirmed the settling behavior of soil particles in soil-water slurry did influence the consolidation properties and homogeneity of the final sediment. The freshwater slurries saw a high degree of segregation and their consolidation properties varied significantly over the depth. The saltwater slurries formed relatively homogenous sediments, when compared to the freshwater sediment.

3.6 Re-suspension Characteristics of Sediments

Once dredge material has been placed in an open water area, there is potential for re-suspension and erosion from wave action. Erosion or re-suspension of sediments can be minimized reduced with the growth of vegetation on the marsh land. The re-suspension characteristics should also be analyzed during the design of a marsh creation project. These properties can be evaluated using the Lick Shaker apparatus.

3.6.1 Previous Studies

3.6.1.1 Lick and Tsai (1986 and 1987)

The Lick Shaker devise, named after Wilbert Lick, was outlined in his paper, co-authored by Tasi (Lick and Tsai 1987). A devise was created to measure sediment suspension in the field, to provide quick and consistent laboratory results. The Lick Shaker is a cylinder filled with coastal sediments and water, where a plunger is lowered into the cylinder to mimic the oscillations that waves would induce on the sediment bed in the field. This test measures at what shear stress material is re-suspended into the water column after a specified amount of consolidation time. In this study, a numerical model was developed to measure changes in the sediment bed with time with respect to re-suspension, deposition, and compaction.

3.6.1.2 Lick and Huang (2003)

As a part of a technical summary for the US Department of the Interior, Minerals Management Service, a study was done on the re-suspension, deposition, and flocculation characteristics of drilling muds and bottom sediments. In this study they found that median particle sizes decreases as the shear stress increases and decreases as the particle concentration increases. The settling speeds of a floc produced a low shear stresses are lower than those flocs produced at higher shears.

3.6.1.3 Jerolleman (2014)

As part of his Masters non-thesis report, Jerolleman performed research on re-suspension of dredged sediments from coastal restoration projects in Louisiana and Texas. Coastal sediments were taken from the top settled soils from the column settling test and placed in the Lick Shaker container. The material was then placed under the Lick Shaker machine and the critical shear stress was measured. During this study, several relationships were developed: a correlation between total suspended solids (TSS) and turbidity and consolidation time verses erosion rate.

3.7 Zeta Potential

Zeta potential is the measure of the magnitude of the electrostatic or charge repulsion/ attraction between particles. It helps determine cause of dispersions, aggregation, or flocculation. The magnitude of zeta potential determines potential stability of the colloidal system. High zeta potential values (positive or negative) tend to repel each other, and have no tendency for the particles to come together. Low zeta potential values have no force to prevent particles from flocking together. The factors that impact zeta potential include: pH, conductivity, and concentration of a formulation component.

3.8 Summary of Previous Findings

There is limited research on the evaluation of dredge material, particularly the settling characteristics and use in land creation projects. In regards to analyzing settlement characteristics, most of the research pertains to wastewater sludge and its characteristics with respect to sedimentation tank design. These studies do not directly relate to this research, but the ideas and basic principles can be applied. The following section summaries results from prior studies

3.8.1 Montgomery (1983)

As a part of Montgomery (1983) doctoral dissertation at Vanderbilt University, the study included comparisons between laboratory and field results. This study focused on developing procedures for designing dredged material sedimentation basins. The procedures developed in this study can be used for designing sedimentation basins for other slurries having high suspended solids concentrations. The settling behaviors of sediments in freshwater environments were best described by a flocculent settling test and those in salt-water environment were best defined by a zone settling test. The settling tests were performed in an 8 in diameter column. Salinity increases the agglomeration of dredged material sediments (Montgomery 1983). During Montgomery's study, the sampling intervals were based on the type of settling, flocculent or zone. Field verification work was performed to confirm the laboratory testing. It indicated that conservative values could be estimated from the lab testing for solids concentrations expected in dredged material sedimentation basin (Montgomery 1983). Montgomery concluded that the column settling tests could be enhanced with further knowledge in dredged material sedimentation basic design and with more lab testing.

3.8.2 Palmero and Thackston (1988)

In 1988, Palmero and Thackston conducted a study on the flocculent settling above the slurry-water interface. The study evaluated the settling characteristics of fine particles initially remaining in the water column and developed procedure for predicting the effluent concentration as a function of retention time and other relevant operational conditions. Fifteen day column settling tests were run on slurry solid concentrations equivalent to what was used in the field and field data was taken from actual sites for comparison. The sampling schedule varied from the one used in this research and only total-suspended solids were tested. Due to turbulence and solids suspensions in field conditions, the field settling efficiency was less than the settling efficiency documented in the lab (Palmero 1988). Three simultaneous settling columns were tested at an initial slurry concentration of 56 g/L. The data showed little variation between the replicate tests.

3.8.3 Landin, Webb, Knuston (1989)

The U.S. Army Corps of Engineers (USACE) built 11 habitat development field sites on dredged material and monitored from 1974-1987. This was done in response to questions about their ecological contribution and durability in comparison to natural habitats. One of the sites was at Southwest Pass in southern Louisiana, where the USACE pumped unconfined dredged material into shallow water areas to create marsh areas. Over 16 years, analysis of aerial photographs, ground trothing, and soil sampling indicated that unconfined dredged material placement is an economical, efficient method for creation or nourishment of intertidal marshes (Landin, Webb, Knuston (1989).

3.8.4 Seidensticker and Nailon (1990)

As a part of the Coastal Society Conference preceding, Seidensticker and Nailon evaluated wetlands creation as a treatment for shoreline erosion in Galveston Bay, Texas. This study evaluated the feasibility of using smooth cordgrass as an alternative erosion control method and measure long-term effects of vegetation on sedimentation and turbidity in the Galveston Bay system (Seidensticker and Nailon 1990). They performed field salinity, sedimentation, and turbidity readings at four sites in Galveston Bay. While, they were not specifically analyzing the sedimentation characteristics of the material in the bay, they were looking at the accumulation or erosion of sediment. They found that high turbidity level measurement directly correlated between high erosion conditions and high levels of suspended sediment in the water column (Seidensticker and Nailon 1990).

3.8.5 Beneficial Use Group (1994)

The Beneficial Use Group (BUG) developed a plan to utilize dredged materials. Some of the uses include creating and restoring wetlands lost in Galveston Bay, restoration of Goat Island and shoreline protection. This plan analyzed the dredged sediments for use in marsh creation projects. They performed the Corps' Primary Consolidation and Desiccation of Dredged Fill (PCDDF) model to determine the shrinkage and consolidation characteristics of the dredge material.

3.8.6 Texas General Land Office (1998)

In 1998, the Texas General Land Office conducted field surveys to inventory and evaluate wetland restoration, enhancement, and creation projects. They evaluated the projects original design, criteria, objectives, physical characteristics, geomorphology, hydrology, site stability, vegetation, success in performance goals, and potential for large scale application. The goal was to evaluate and synthesize criteria considered important to successfully implement large-scale restoration and creation projects.

3.8.7 Vanderhasselt and Vanrollegheim (2000)

In 2000, Vanderhasselt and Vanrollegheim conducted research on predicting the sedimentation characteristics of batch sedimentation curves. This study compared two methods of determining settling velocity: (i) traditional approach using zone settling velocity data obtained from dilution experiment and (ii) new direct parameter estimation method relying on a single batch settling curve. This study compared different mathematical models to the settling curves of vary concentration. The settling column used in this study had different dimensions and different materials were tested. The study focused on lower solid concentrations than the ones used in this thesis. The Cho et al (1993) model successfully predicted the complete settling curve with slight accuracy. This model still produced variable results with varying concentrations (Vanderhasselt and Vanrollegheim 2000).

3.8.8 NRCS and CPRA (2005)

The Natural Resources Conservation Service and CPRA implemented a floating marsh project in areas of Barataria and Terrebonne Basins where diversion or beneficial use of dredged sediments would not work. The floating marsh project consists of two components where buoyant vegetated mats or artificial floating systems (AFS) were developed and tested with various plant, structure materials, and substrates combinations. The second phase of the projects included deploying the AFS into open water areas for field testing.

3.8.9 Nam (2008)

In 2008, Nam studied channeling during settling and self-weight consolidation of cohesive sediments. The experiments indicated the ability of a material to flocculate and this impacts the sedimentation and channeling characteristics and the interface formation. The particles tended to floc together and discontinuities between these flocs, allowing for excess pressure to dissipate, ultimately creating vertical channels. The degree of flocculation during sedimentation, and channel development increases with increasing slurry concentration. The hydraulic gradient in suspension and consolidation zones change drastically because of channeling. Channels help disperse excess pore pressures and accelerate consolidation.

3.8.10 Daphne, Utomo, Kenneth (2011)

Daphne, Utomo, and Kenneth performed testing to correlate between turbidity and total suspended solids (TSS) in Singapore Rivers. In their study, a positive correlation between TSS and turbidity was developed, indicating that turbidity could be used to estimate the TSS (Daphne, Utomo, Kenneth 2011). They determined an R^2 value of 0.8 for concentrations less than or equal to 50 milligrams per liter (mg/L) (Daphne, Utomo, Kenneth 2011).

3.8.11 Camenen, Bang (2011)

The study done by Camenen and Bang analyzed the settling characteristics of highly concentrated suspended solids (cohesive and non-cohesive) and the initial consolidation of cohesive sediments. They presented the effects of hindered settling formula on predicting sedimentation for non-cohesive material. The study found uncertainties with prediction of cohesive sediments due to organic content and flocculation.

3.8.12 Haught, Manning, Schoellhamer (2012)

Haught, Manning, and Schoellhamer performed a study on the settling velocity and characteristics of flocculated suspended material using a Floc Camera. Settling characteristics of cohesive material is more difficult to determine due to flocculation, than non-cohesive material. A floc camera can capture the settling velocities and other desired characteristics of individual flocs in situ. Within certain constrains, the floc camera and software can capture and analyze floc settling velocities and size characteristics.

3.8.13 Mattson (2014)

As part of his master's thesis, Mattson (2014) conducted similar research on characterizing dredged sediments used in coastal restoration and marsh creation projects. In this study, he looked at the grain size distribution, salinity, and initial slurry concentrations and their effects on sedimentation. The study concluded higher salinity relates to lower sedimentation rate during compression settling zone and TSS and turbidity values were lower with higher salinities. The higher percent fines had slower settling rates and highest TSS and turbidity values. The higher initial solids concentrations correlated to lower settling rates of sediments. Correlations were also developed between initial solids concentration and bulk density.

3.8.14 Lo, Bentley, Xu (2014)

A study was done in 2014 to evaluate processes of sediment consolidation and re-suspension in a coastal environment and how these processes impact retention of fine sediment transported by a river diversion. Several conclusions were made at the end of the study. Consolidation rates correlated with initial concentrations. Shear stresses increased with longer consolidation time.

Results and convulsions from the previous studies were evaluated during the present research work. Wherever applicable, results obtained from the current study were compared with previous studies.

4 Laboratory Testing Procedures

4.1 Introduction

The purpose of the laboratory testing program was to characterize the dredged sediments and evaluate the effects of salinity, grain size distribution, and initial slurry solids concentration on the sedimentation characteristics of the dredged sediments. The dredged sediments and water samples used in this research were obtained from coastal restoration project sites and other potential coastal restoration sites located in Louisiana. These sediments were tested in general accordance with ASTM and other applicable standard procedures. This chapter details the material and methods used in the laboratory testing for this research.

4.2 Sampling Identification and Preparation

The soil samples were obtained from the field from soil borings, vibracores, or as grab samples. Each sample was visually identified in the soil mechanics laboratory at UNO and was homogenized using an industrial mixer. This homogenized mixture was used to perform the various tests to characterize the dredged material. The remaining sample was stored in sealed containers for future testing. Figure 4.1 shows a Shelby tube sample and sample storage in bucket.


Figure 4.1- Sample Collection (left) and Storage (right)

4.3 Geotechnical Characterization Tests

In order to further classify and confirm visual classifications, geotechnical tests were performed on each sample collected from different field sources. In addition to measuring different soil properties, these tests help determine the suitability of the material for use in a marsh creation project. The following sections outline the various geotechnical tests performed during the course of this research.

4.3.1 Atterberg Limits

The Atterberg Limit test was run in general accordance with ASTM D4318 Standards. This test determines the critical water contents of fine-grained soils. The liquid limit (LL) test and the plastic limit (PL) test make up the Atterberg Limit test. The liquid limit and plastic lmit test determine highest and lowest moisture content that a material can have and hold form, respectively. For the Atterberg limit test, the material that passes the No. 40 sieve is used to run the test. The liquid limit test consists of placing the soil into a Casagrande device, where a groove is created, and the device is dropped until the gap from the groove closes. The plastic limit test consists of rolling the sample until it crumbles when it reaches a diameter of 1/8-inch. Formulas are applied to determine the liquid limit, plastic limit, and plasticity index (PI).

$$PI = LL - PL \quad (4.1)$$

Figure 4.2- Atterberg Limit Equipment

Figure 4.2 shows the equipment used to run the Liquid Limit and Plastic Limit tests. The Atterberg Limit test results for each sample is included in Appendix B of this thesis.

4.3.2 Grain Size Distribution

Grain size distribution of the soil determines the percentage of gravel, sand, silt, and clay present in the soil samples. Clays and silt and considered fine grained material, that is any material passing the No. 200 sieve. When 90% of the sample is fine grained material, a hydrometer test is used to determine the grain size distribution of the sample. In most cases, the samples used to conduct the Column Settling Test (described later) consisted of material that had more than 90% fines. The grain size distribution test is comprised of (i) a sieve analysis and (ii) a hydrometer analysis. The sieve analysis and hydrometer tests were run in general accordance with ASTM D6913 and D422-63 Standards, respectively.

A collective amount of material was taken from the sample and dried overnight in the oven to begin the process of determining the grain size distribution. Once the sample was dried, the material was crushed using a mallet and then placed in the grinder to break down the material for the sieve analysis and hydrometer analysis tests.

For the sieve analysis, 300 grams of material was washed through the No. 200 sieve. The portion of the sample retained on No. 200 sieve was dried and placed in the sieve shaker. The sieves used in the sieve analysis included the No. 4, 10, 20, 40, 60, 140, and 200 sieves. The soil retained on the individual sieves was cumulatively weighted to generate a sieve analysis curve.

The characterization of material consisting 90% or more fines started with mixing 50 grams of dried sample with 25 mL of a deflocculating agent, sodium hexametaphosphate, and letting it soak for 16 hours. The mixture was then placed in a 1000 mL cylinder with distilled water and allowed to settle over

Figure 4.3- Equipment used in Sieve Analysis (left) and Hydrometer Analysis (right)

the course of 48 hours. Routine hydrometer and temperature readings were taken to determine the percent fines in the sample. After 48 hours of settling, the sample is washed through the No. 200 sieve and the material caught on the No. 200 sieve is dried and placed in the sieve shaker, repeating the sieve analysis procedure. Figure 4.3 shows the equipment used to perform the sieve analysis and hydrometer analysis. The curves (percent passing verses grain size) obtained from these two procedures were combined to obtain the complete grain size distribution curve. The grain size distribution curves for each sample used in this research is included in Appendix B of this thesis.

4.3.3 Organic Content

Organic material presented in a soil impacts various physical, chemical, and biological properties of soil, including soil structure, soil compressibility, and shear strength. The amount of organic material (termed organic content) present in each sample was determined by performed a test in general accordance with ASTM D2974 Standards. This test is the ratio, expressed as a percentage, of the mass of organic material in a given soil sample to the mass of the dry soil solids. The sample was oven dried at 105˚C for 12 hours to remove moisture. The oven-dried sample was placed in a labeled porcelain dish, weighed, and placed in a muffle furnace at 440˚C for 24 hours. The porcelain dish was weighed after the organics are burnt off in the furnace, shown in Figure 4.4. This weight is used to determine the organic content with the following equation:

$$O_c = \frac{M_o}{M_D} * 100 \quad (4.2)$$

where O_c is the organic content in percentage, M_o is the mass of organic matter in grams, M_D is the mass of dried soil solids in grams. The results of the organic content test for each sample used in this research are included in Appendix B of this thesis.

Figure 4.4- Muffle furnace used in organic content determination

4.3.4 Specific Gravity

Specific gravity is the ratio of the mass of unit volume of soil at a specified temperature to the mass of the same volume of gas-free distilled water at a specified temperature. There are two methods typically used to remove the air from the soil sample, vacuum and boiling methods. The boiling method was used for all specific gravity tests for this research. The specific gravity test of a sample was conducted in general accordance with ASTM D854 Standards. In this method 50 grams of dried sample is placed in a 500 mL pyncometer, filled 2/3 with distilled water. The soil and distilled water was mixed and boiled on a hot plate for approximately 2 hours (Figure 4.5). The sample is then cooled in an insulated cooled. Water is added to the water soil mixture to completely fill the pyncometer and weighed. The pyncometer is then filled with just distilled water and weighed. The specific gravity of the soil sample was determined using the following equation:

$$G_s = \frac{M_o}{M_o + (M_a + M_b)} \tag{4.3}$$

where G_s is the specific gravity, M_O is 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 plus water and soil. The results of the specific gravity tests for all the samples are included in Appendix B of this thesis.

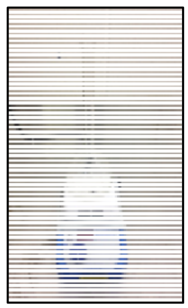

Figure 4.5- Specific Gravity Apparatus

4.3.5 Soil Resistivity

Soil resistivity looks at the corrosion potential of soils and aggregates to metal pipe, earth-reinforcing strips, and other metal materials in earthwork. Resistivity decreases as the moisture content of a material increases until the minimum resistivity is attained. The resistivity test of the soil sample was performed in general accordance with ASTM G187 Standards. The soil resistivity test includes pouring

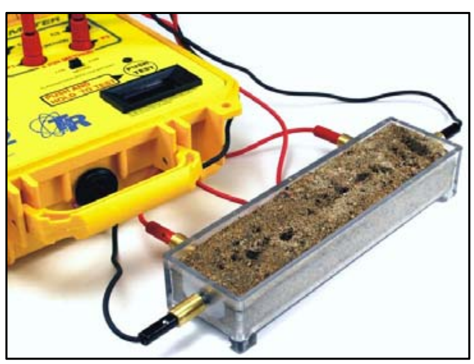

Figure 4.6- Soil Resistivity Apparatus

or tamping the sample to be tested into soil box until the sample is flush with the top of the soil box. The equipment includes a soil resistivity field box with four cables extending from the box. These cables hook up to the soil box and the resistivity is measured and recorded in Ohms.

4.3.6 pH

The pH measures the degree of acidity or alkalinity in soil materials. The pH of the soil sample slurry was determined in general accordance with ASTM D4972-13. This test is useful in determining the solubility of soil minerals and the mobility of ions in the soil.

4.3.7 Conductivity

The conductivity of the soil slurry was determined by the use of a conductivity meter, which measures the ability of a material to transmit an electrical current and it is typically expressed in units of miliSiemens per meter (mS/m). Soil electrical conductivity correlates with particle size and soil texture, sands have low conductivity and clays have high conductivity (Barbosa and Overstreet). The electrical conductivity of a sample is higher when salts are present (Hanlon 2012).

4.4 Column Settling Test

The column settling test was conducted in general accordance with USACE Engineering Manual 1110-2-5027. This laboratory test (conducted over a period of 15 days) simulates the settling characteristics of a soil slurry mixture that would be used in a coastal restoration project. The column is 80 inches high with 13 sampling ports. Various tests were performed to determine the sedimentation rate, engineering and material properties of the slurry, and the amount of suspended sediment in the water column at a specified time during the test. The different components of the column settling test are described below.

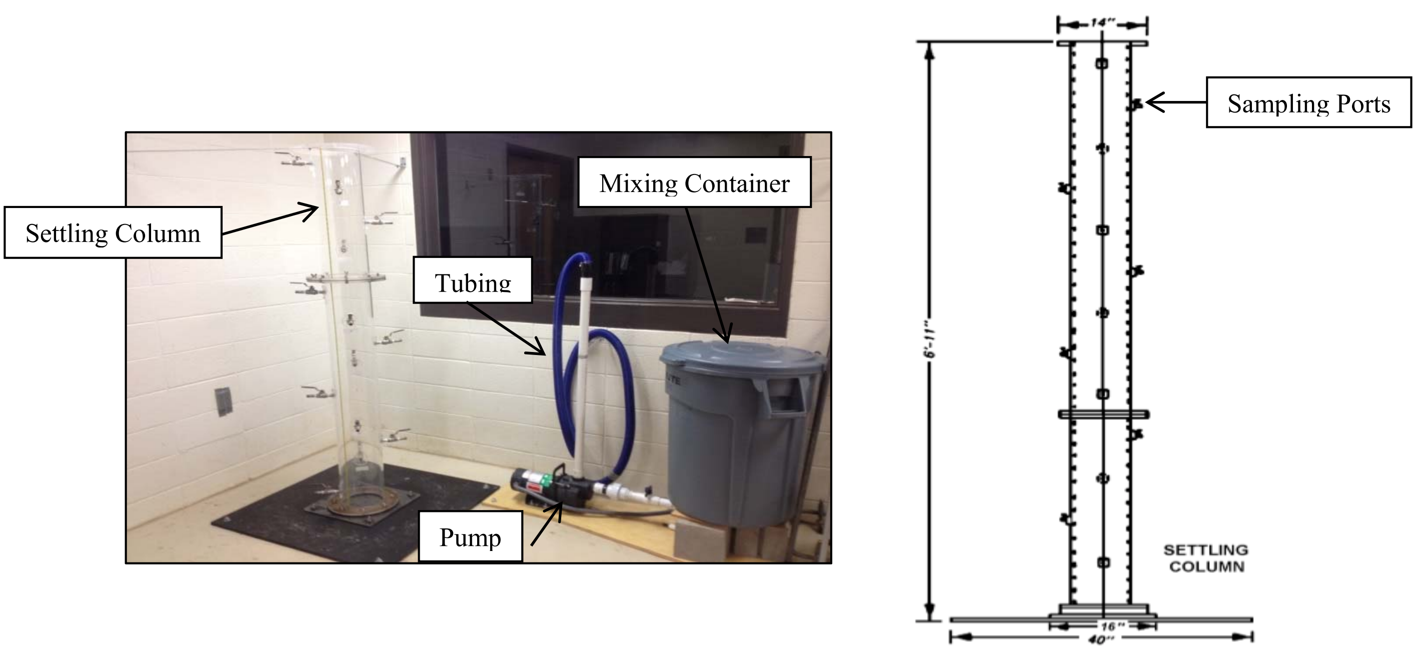

Figure 4.7- Column Settling Test: set up (left) and schematic (right)

4.4.1 Sample Preparation

The homogenized sample was used to create the slurry for the column settling test. The homogenized sample was placed in a mixing container and water was added until desired concentration was achieved, which ranged between 95 grams per liter (g/L) and 105 g/L. The desired salinity for a particular column settling test was created by using tap water, water from the site, salt or any combination of the three. An industrial paint mixer is used for 15 minutes or until the sample is completed mixed. The mixed slurry was left to settle for about five minutes to allow any coarse material to fall to the bottom. Once the slurry had achieved the desired concentration, the slurry was carefully transferred to pumping container, only scooping off the top to avoid the coarse material that has settled to the bottom.

The salinity and concentration were adjusted until desired levels were reached for a particular test. The slurry solids concentration was measured by determining its total dissolved solids (TDS). A slurry sample was collected and oven dried to measure the dissolved solids in the slurry. The TDS was calculated using the following formula:

$$TSD = \frac{1000 * W_p}{\frac{W_p}{G_s} + W_w} \quad (4.4)$$

where TDS is the total dissolved solids or solids particle concentration, W_p is weight of dry particles, G_s is the specific gravity, W_w is the weight of water.

A salinity meter was used to determine the salinity of the slurry. The salinity meter could measure salinities up to 10 parts per thousand (ppt). When the salinity was greater than 10 ppt, a manual method was used where a sample of water was oven dried to weigh the amount of salt in the water. The equation below determined the salinity of the slurry: where S is the salt content, W_s is the weight of the oven dried salt, and W_{pw} is the weight of the salt water.

$$S = W_s * \frac{100}{W_{pw}} \quad (4.5)$$

where S is the salt content, W_s is the weight of the oven dried salt, and W_{pw} is the weight of the salt water.

After the slurry was prepared to the desired solids concentration and salinity, it was pumped into the settling column using an electric water pump. The column was filled to a height of 79.5 inches within one minute using the pump. The sample was continuously mixed during the pumping process to prevent cavitation and to ensure that a homogenous slurry was pumped into the column. Figure 4.8 shows the process of transporting the slurry from the mixing container to the settling column.

Figure 4.8- Mixing container (left) and pumping slurry into the column (right)

4.4.2 Sampling Protocol

At specified time intervals, soil samples from the column were collected to perform additional testing. The sampling protocol used for each test was based on the USACE Engineering Manual 1110-2-5027. All sampling was performed using a 60 mL syringe, stopper, and needle, to extract samples from the center of the column. The sampling apparatus was rinsed between samples to prevent cross contamination. Immediately after the slurry was pumped into the column, samples were taken from the even numbered ports to confirm the initial solids concentration of the slurry. After that, samples were taken from the six ports above the solid-water interface for the remainder of the test. During each sampling period, 120 milliliter (mL) sample was extracted from the column and placed in labeled bottles. The sampling was performed after 1 hour, 2 hour, 4 hour, 6 hour, 12 hour, 1 day, 2 days, 3 days, 4 days, 7 days, 11 days, and 15 days. During each sampling time, the water height, slurry height, and temperature were recorded before the samples were extracted from the column. A photograph of the entire column was also taken at each sampling time, which is included in Appendix B of this thesis.

Figure 4.9- Sampling Protocol: Solid water interface (left) and sample extraction using needle (right)

4.4.3 Total Suspended Solids (TSS) and Turbidity

Total suspended solids (TSS) and turbidity analyses were run to determine the amount of suspended solids in the water column. These tests were performed on the samples collected from the settling column ports during the course of the experiment (15 days). The TSS analysis (Figure 4.10) was performed in general accordance with Environmental Protection Agency (EPA) Environmental Sciences Section (ESS) Method 340.2. The test included pouring a sample through a 0.47 micron pore size filter and weighing the dried solids on the filter. A vacuum pump was used to extract the water through the filter and distilled water was used to rinse the sample. TSS was calculated using the following equation:

$$TSS = \frac{W_p}{V_t} * 10^6 \qquad (4.6)$$

where TSS is the total suspended solids in grams per liter (g/L), W_p is the weight of dried particles in grams and V_t is the volume of the sample in liters.

Figure 4.10- TSS (left) and Turbidity (right) Apparatus

The turbidity test was performed as an additional check to measure the amount of solids present in suspension. This test includes placing the sample in a vial and in a turbidimeter apparatus. The vial must be cleaned with a microfiber cloth and inverted twice to ensure no bubbles disturb the sample reading. The value displayed on the machine was recorded in NTUs. Figure 4.10 shows the apparatus used to determine the TSS and turbidity. The TSS and turbidity test results for each sample is included in Appendix B of this report.

5 Results and Discussion

5.1 Introduction

The results from the previously described tests are presented in this chapter. These series of tests were run to evaluate the effects of salinity, grain size distribution, and initial solids concentration on sedimentation time. The master list shown in Table 5.1 has each of the 15 tests run for this research with the variables listed.

Table 5.1-Master List of Sample Variables

Test Number	Sample Source	Salinity (ppt)	Grain Size Distribution		Initial Solids Concentration (g/L)
			% Fines	% Coarse	
2014-5	Grand Isle and Plaquemines Parish, LA	0.34	64.4	35.6	109.33
2014-6	Grand Isle and Plaquemines Parish, LA	0.24	77.7	22.3	99.4
2014-7	False River, LA	0.29	95	5	96.5
2014-8	False River, LA	0.20	95	5	98
2014-9	Terrebonne Parish, LA	0.30	91	9	98.6
2014-10	Terrebonne Parish, LA	2.5	91	9	97.7
2014-11	Terrebonne Parish, LA	1	91	9	98.4
2014-12	Terrebonne Parish, LA	2	91	9	95.6
2014-13	Terrebonne Parish, LA	3.2	91	9	102.5
2014-14	Terrebonne Parish, LA	5.2	91	9	100
2015-1	Lake Borgne, LA	1.12	85	15	100.7
2015-2	Lake Borgne, LA	1.09	89	11	106.31
2015-3	Terrebonne Parish, LA	2	59	41	97.7
2015-4	Terrebonne Parish, LA	32	91	9	95.6
2015-5	Terrebonne Parish, LA	4	91	9	99.4

The height of the solid-water interface is recorded to capture approximately 2.5 inches of settlement of the slurry, producing a settling curve for each test. Typically, the sedimentation curve mimics a logarithmic curve, where the asymptote is the final settled height. The curve has is a steep linear portion, where most of the settlement occurs, and plateaus as the settlement slows down. Figure 5.1 shows a typical settling curve. The x-axis is the settling time in days and the y-axis is H/H_0, where H is the height of the interface at a certain time and H_0 is the initial slurry height.

The linear portion of the settling curve is the zone-settling portion where the slurry settles due to various sedimentation characteristics. The slope of this portion of the curve varies depending on the solids concentration and other factors. The portion of the curve that has plateaus is called compression-settling. At this point, most the settlement has already occurred and the slurry is settling under its own weight.

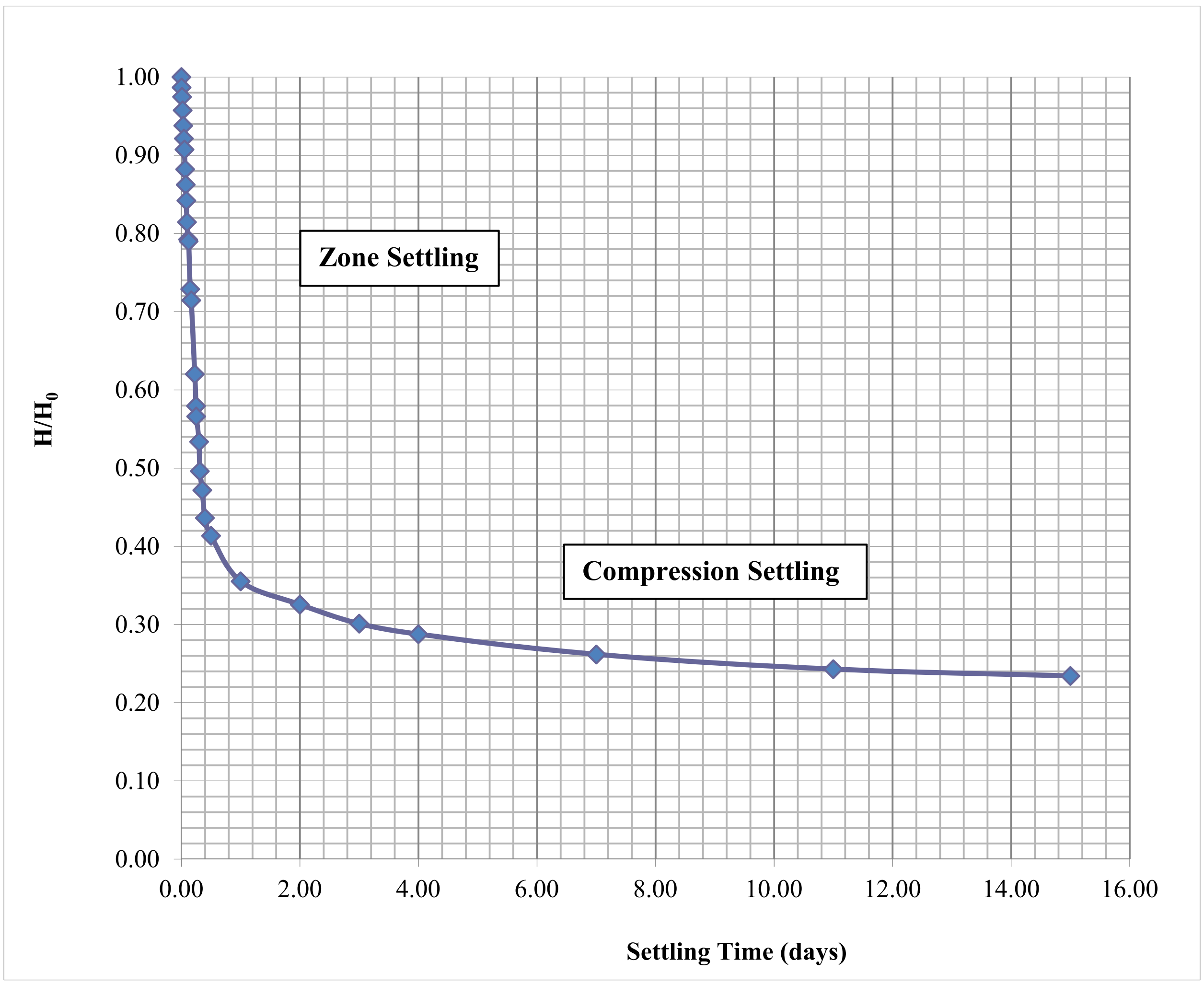

Figure 5.1-Typical Settling Curve

5.2 Effects of Grain Size Distribution on Sedimentation of Dredged Sediments

The effects of grain size distribution on sedimentation were analyzed using samples from various locations. A series of seven tests were completed to analyze the effects of grain size on sedimentation. Four of the samples came from different locations. Three samples were created in the laboratory at UNO using material taken from two locations, varying the percentage of sand and fines. The tests were run with tap water and had an initial particles concentration of approximately 100 g/L. The percent fines for this series of tests varied from 98% fines to 45% fines. Table 5.2 summarizes the characteristics of each of the nine samples and the grain size distribution curves for each of these samples are shown in Figure 5.2.

Table 5.2- Characteristics of samples used to analyze effects of grain size

Test ID	Sample Source	% Fines	% Coarse	Organic Content, %	Specific Gravity	Liquid Limit, %	Plastic Limit, %	Initial Solids Concentration, g/L
2013-7	Plaquemines Parish, LA	98	2	8.3	2.71	58	30	101.6
2014-7	False River, LA	95	5	3.8	2.64	45	15	96.5
2014-9	Terrebonne Parish, LA	91	9	3.1	2.65	49	23	98.6
2015-2	Terrebonne Parish, LA	89	11	3.3	2.58	37	21	106.3
2015-1	Lake Borgne, LA	85	15	10.4	2.59	38	26	100.7
2014-6	Composite Sample	78	22	6.9	2.79	77	40	99.4
2014-5	Composite Sample	64	36	5.8	2.68	73	48	109.3
2015-3	Terrebonne Parish, LA	55	45	5.5	2.70	35	19	95.6
2014-4	Composite Sample	45	55	3.2	2.68	27	13	104.9

Based off the settling curves in Figure 5.3, the samples with the highest percent of coarse grained material (2014-4 with 65% coarse) had the highest settling rate and had the lowest critical point of sedimentation. The samples the higher percent of fine grained material had slower settling rates and higher critical points of sedimentation. The critical point of sedimentation is the point where the curve transitions from zone settling to compression settling.

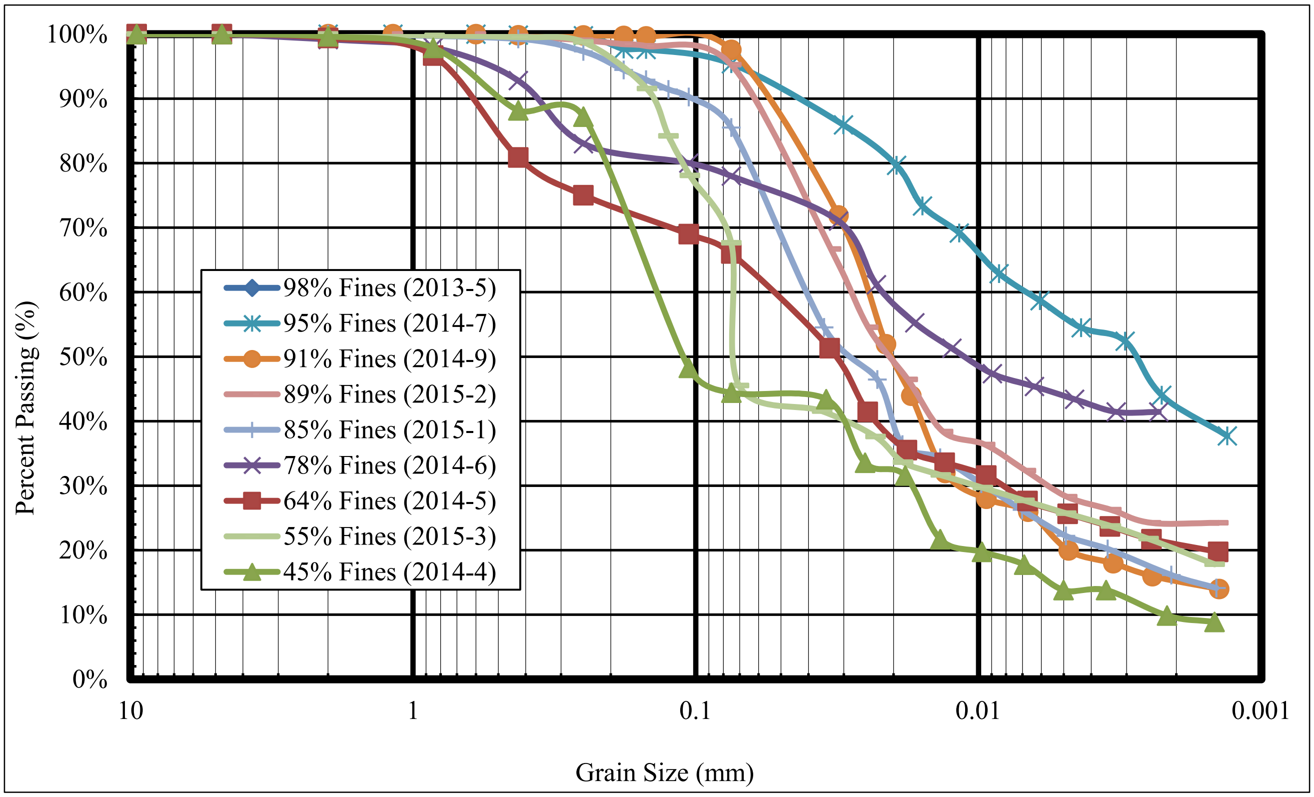

Figure 5.2-Grain size distribution curves for effects of grain size on sedimentation of dredged sediments

To further analyze the effects of grain size distribution, the graph was zoomed into to focus on the linear portion of the curve. This portion is called zone settling. Test number 2013-5 with the highest percent fines, 98%, had the slowest settling rate and test number 2014-4 with the lowest percent fines, 45%, had quickest settling rate.

The samples with 95% to 85% fines had very similar settling rates. Test 2015-2, with 89% fines, did not have the most percentage fine grained material of those four samples, it seem to have smaller particles, causing a slower settling rate.

The samples were 78% to 55% fines also had similar settling rates. The sample with 78% fine grains had a slower settling rate, with the sample with 64% having the next slowest, and the sample with 55% the fastest rate of those three samples.

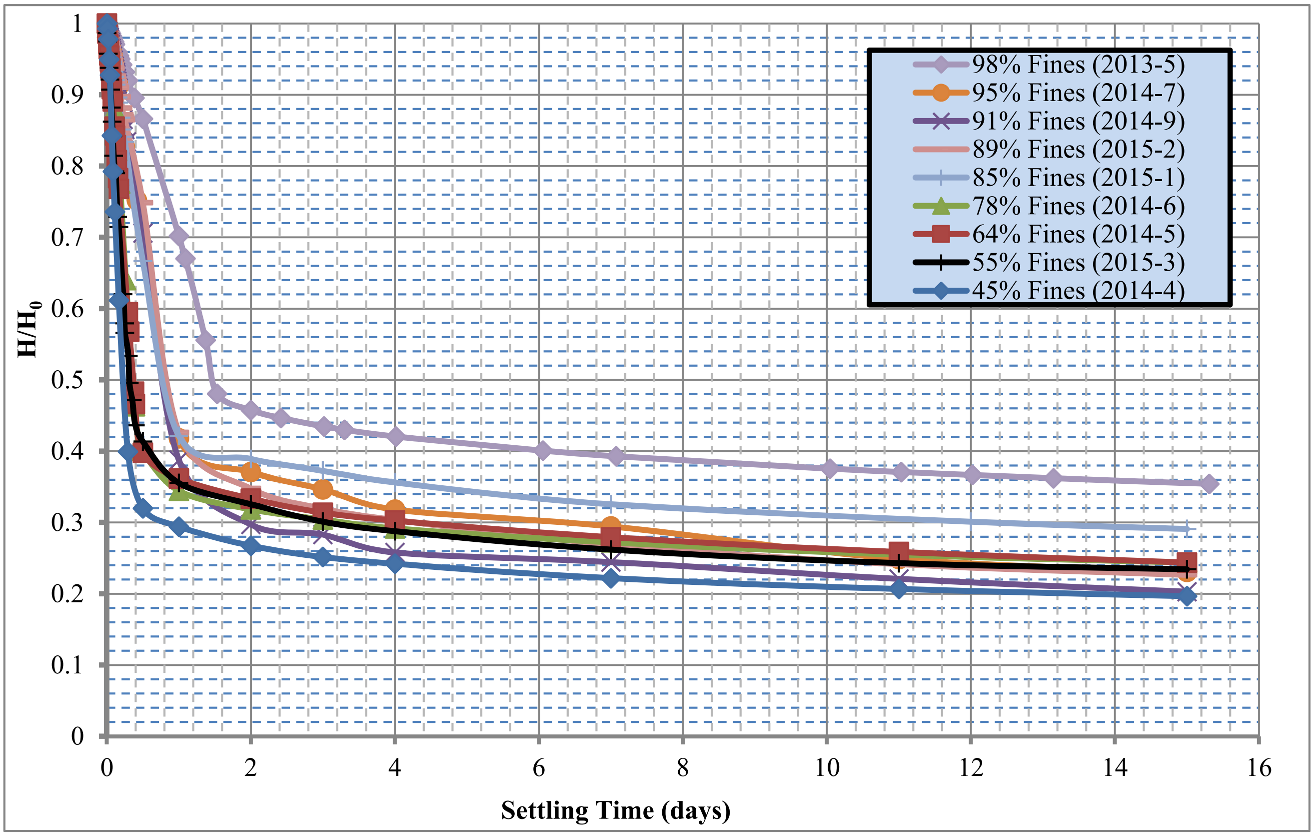

Figure 5.3-Settling curves for effects of grain size on sedimentation of dredged sediments

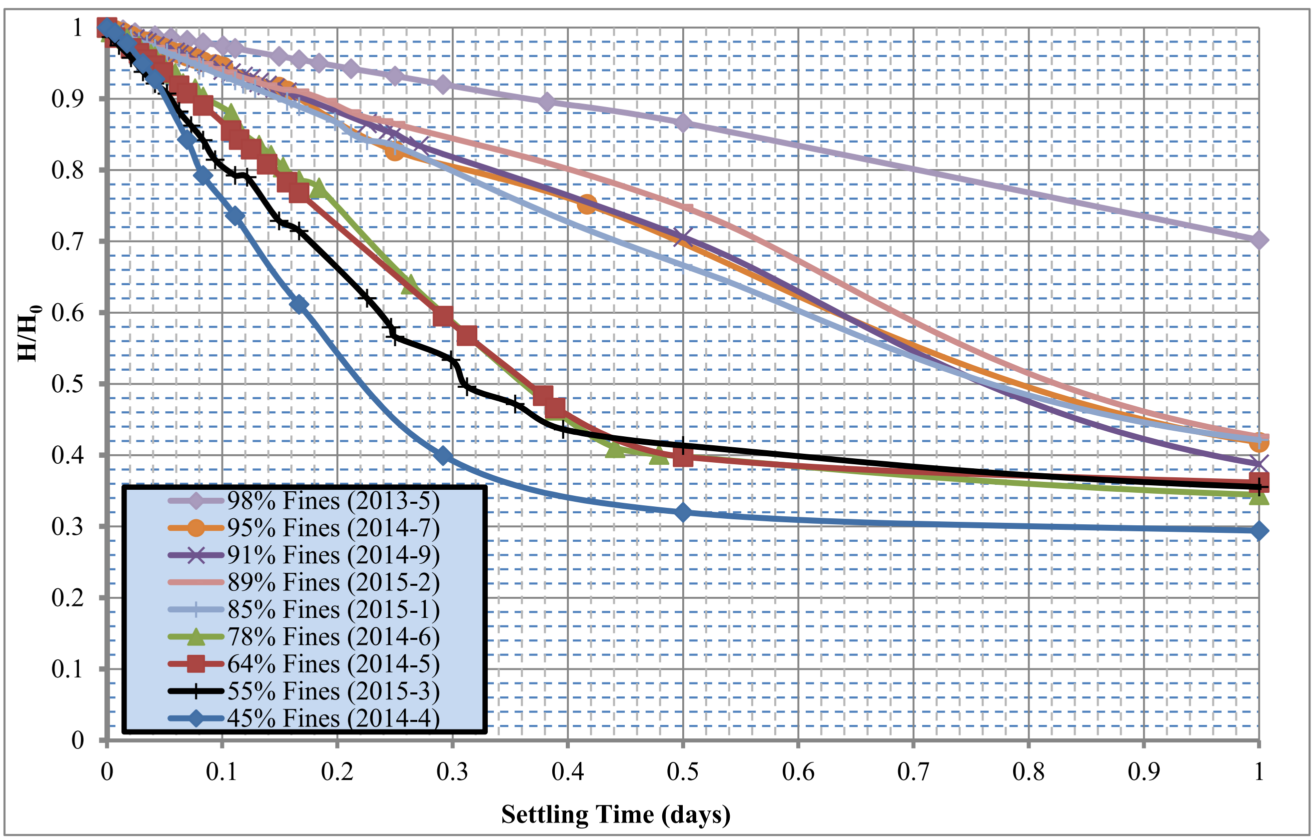

Figure 5.4-Zone settling portion of settling curve

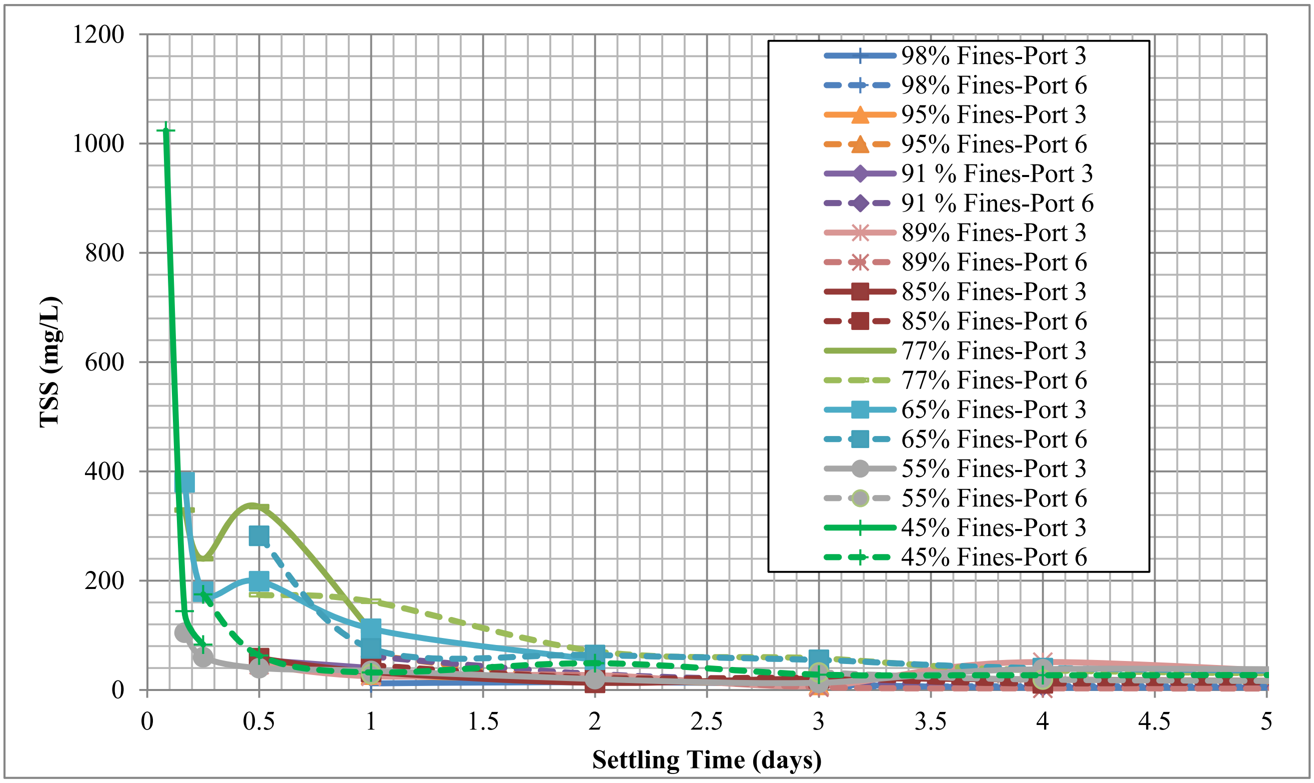

Figure 5.5-TSS vs. sedimentation time for the effects of grain size distribution on sedimentation

Based on the TSS testing for the tests varying the grain size, the samples with the lower percent of fine grained material had higher TSS values (Figure 5.5). In those samples with less fine grain material, there are not as many flocs and there is more individual particle settlement, leading to a more turbid water column. The samples with higher percent fines have more flocs and less individual particles left in the water column.

5.3 Effects of Salinity on Sedimentation of Dredged Sediments

The effects of salinity of sedimentation were analyzed using the same homogenous sample for a series of eight tests. The concentration for each of the eight tests was approximately 100 grams per liter (g/L) and the geotechnical properties were kept constant by using the same homogenous sample. The salinity varied from 0.3 parts per thousand (ppt) to 32 ppt. Table 5.3 and 5.4 summarize the characteristics of the samples used to evaluate the effects of salinity.

Table 5.3- Geotechnical Characteristics

Sample Source	% Fines	% Coarse	Organic Content, %	Specific Gravity	Liquid Limit, %	Plastic Limit, %
Terrebonne Parish, LA	91	9	3.1	2.65	49	26

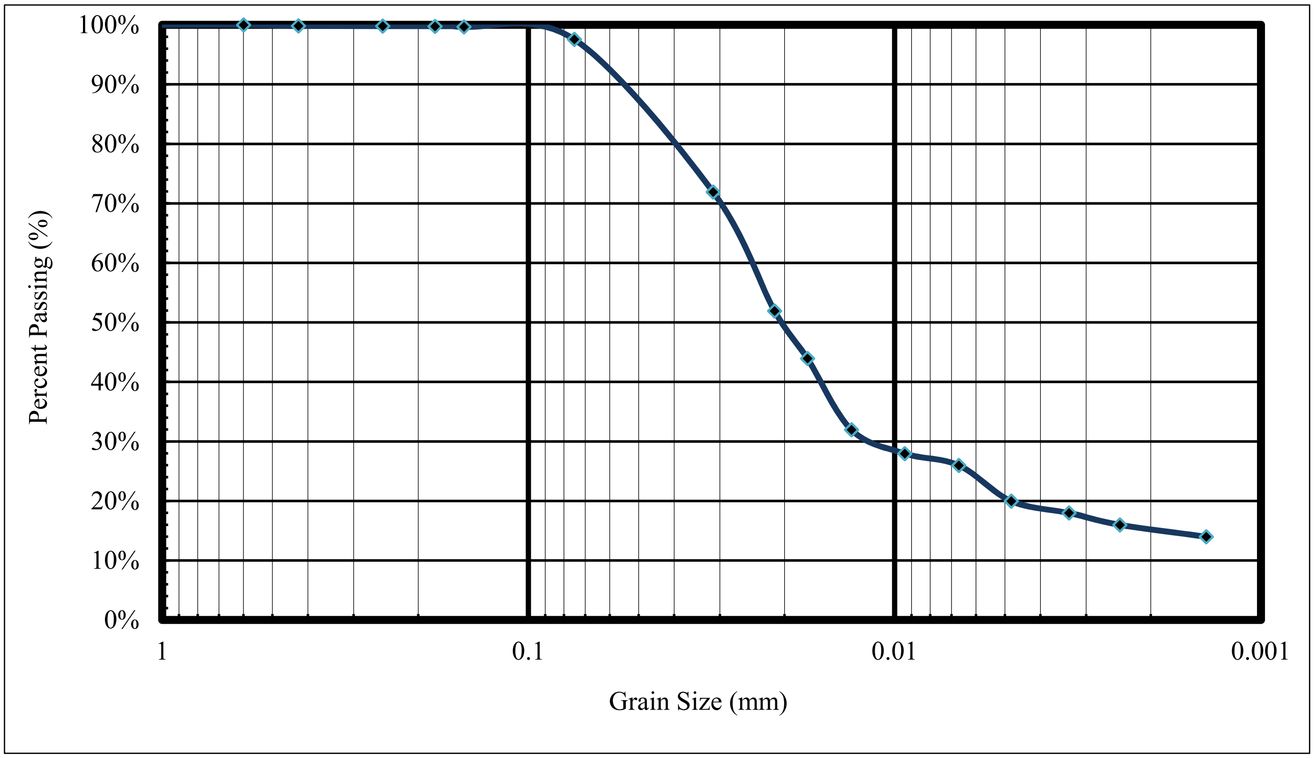

Figure 5.6-Grain size distribution curve for effects of salinity on sedimentation

Table 5.4- Salinity variations between each test

Test ID	Salinity, ppt	Concentration, g/L	Bulk Density, g/L
2014-9	0.3	98.6	436
2014-10	0.5	97.7	462
2014-11	1	98.4	381
2014-12	2	96.5	327
2014-13	3.2	102.5	354
2014-14	5.2	100	462
2015-4	32	95.6	355
2015-5	4	99.40	532

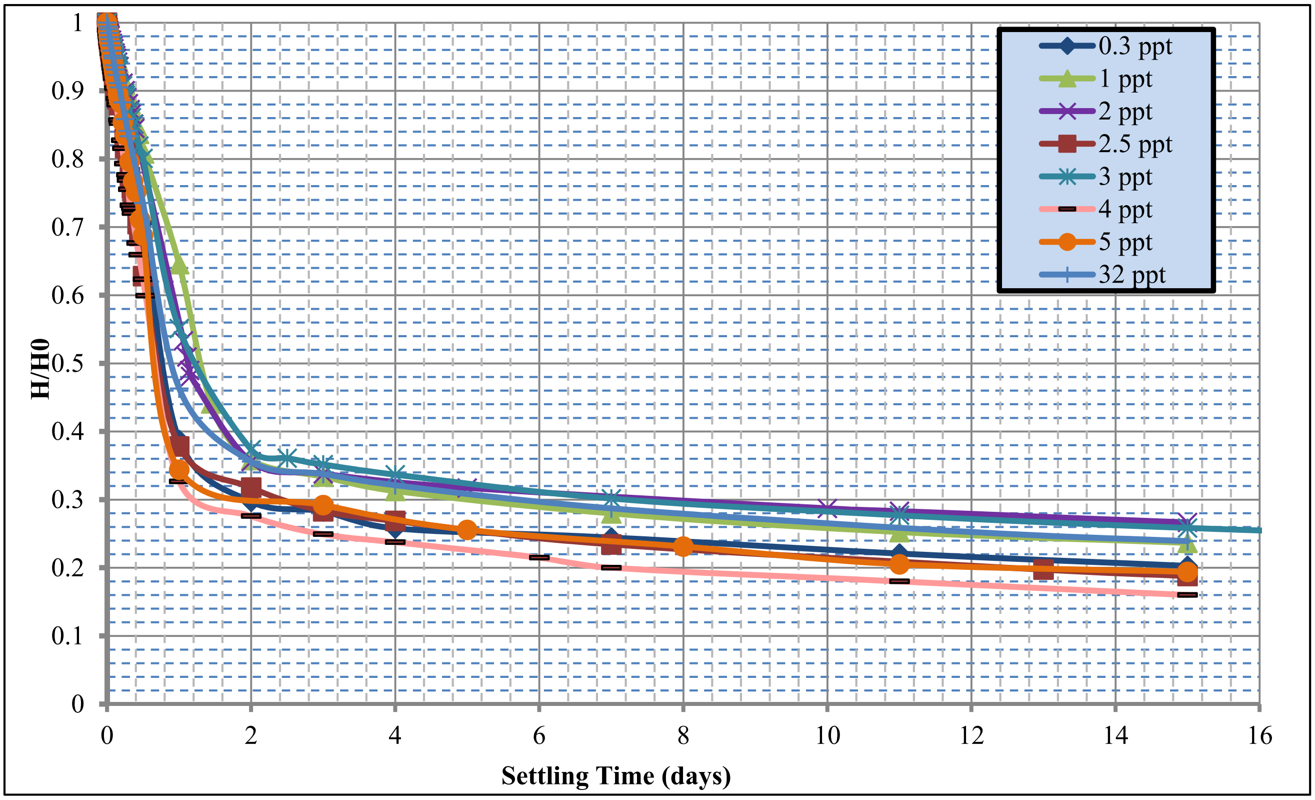

Figure 5.7-Settling curves for effects of salinity on sedimentation of dredged sediments

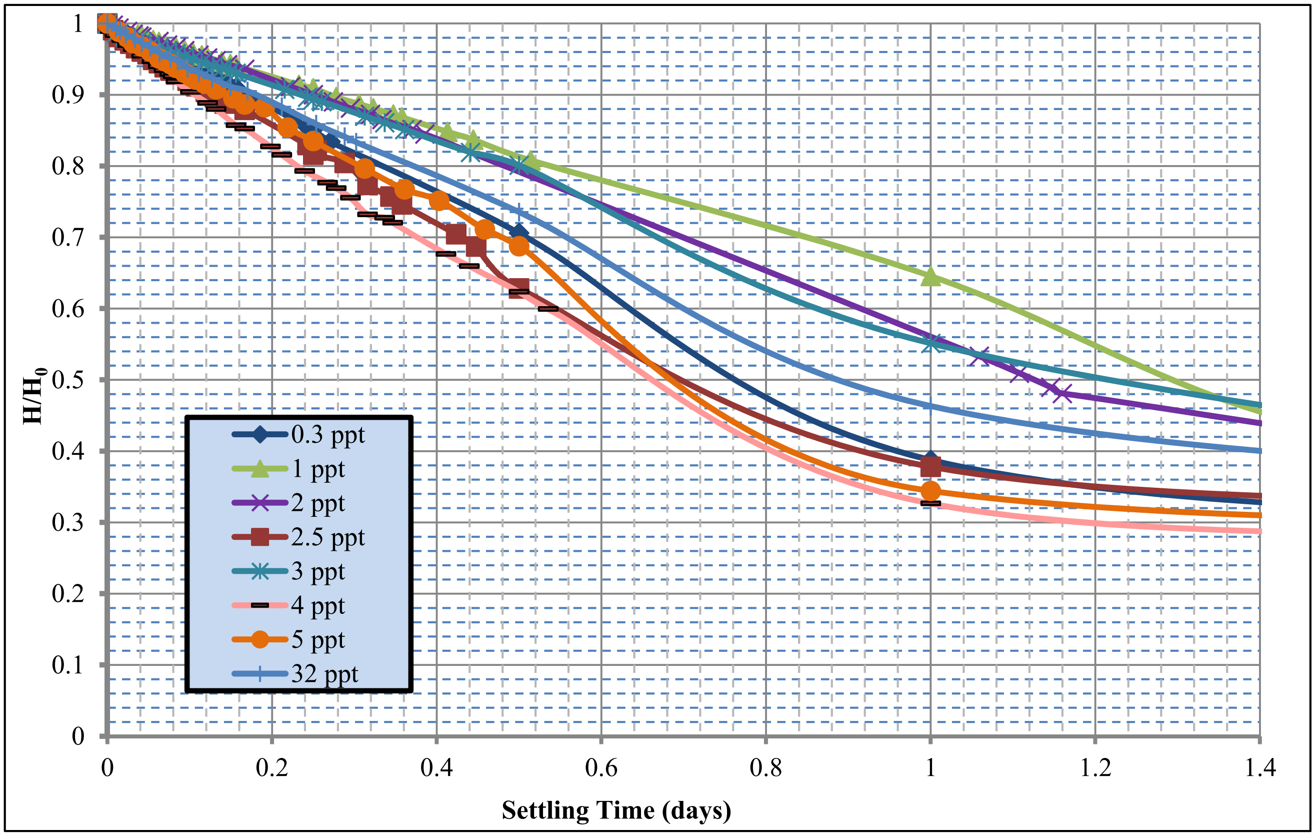

Figure 5.8- Zone settling portion of curve

Based on the settling curves (Figure 5.7), there was no obvious trend with varying salinity. Figure 5.8 shows that the gentler slopes were seen in the 1, 2, and 3 ppt samples. The steeper slopes, the faster settling rates, where seen in the 2.5, 4, and 5 ppt samples. The highest salinity sample at 32 ppt had a settling in the middle of all the other samples. There are many different ions in fine grain sediment and salt water and this could be impacting the variable results. Additional analysis should be conducted on the ionic composition on the sediments and water to further examine the effects of salinity on sedimentation of dredged material.

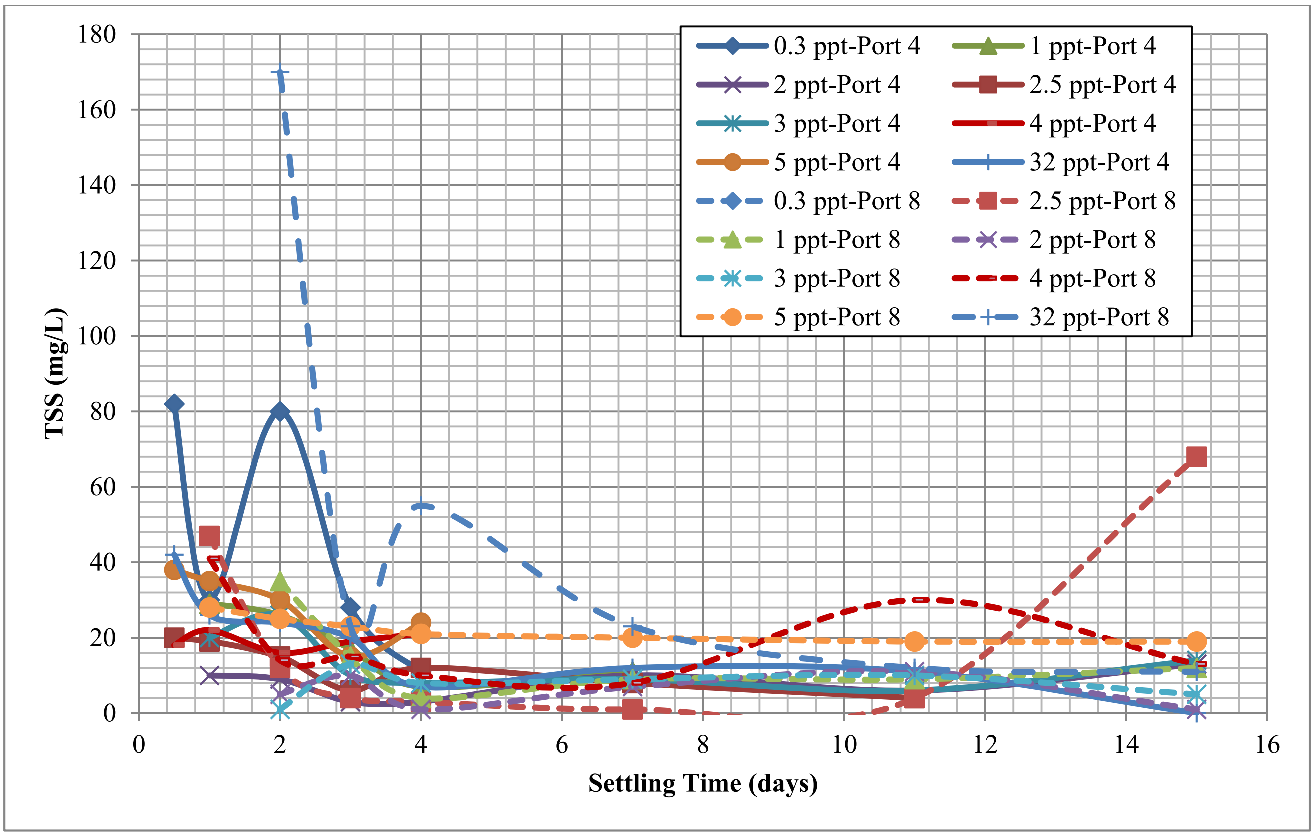

Figure 5.9-Settling Time vs TSS

After analyzing the settling time verse TSS graph for each port sampled throughout the effects of salinity tests it was difficult to determine a definite trend with the salinity changing. As expected, the TSS values were typically greater at the start of the test and decreased with time. However, there was not a trending sample that always had the highest or lowest TSS value. In Ports 1 through 4, the lowest salinity sample, 0.3 ppt, tended to have the highest TSS. However, in Ports 4 through 9, the highest TSS values where seen typically in the sample with 32 ppt.

5.4 Effects of Initial Solids Concentration on Sedimentation of Dredged Sediments

In order to analyze the effects of initial solids concentration, a series of mini column tests were run in 2000 mL columns. There were 12 tests run with concentrations varying from 130 g/L to 2 g/L. The same sample source was used for each of these 12 tests and the sample characteristics are shown below in Table 5.5 and Table 5.6.

Table 5.5-Mini Column Test Sample Concentrations

Mini Column Test Number	Initial Solids Concentration, g/L
1	130
2	100
3	75
4	50
5	40
6	25
7	20
8	15
9	10
10	5
11	3
12	2

Table 5.6-Sample Characteristics

Sample Source	% Fines	% Coarse	Organic Content, %	Specific Gravity
Terrebonne Parish	91	9	3.1	2.65

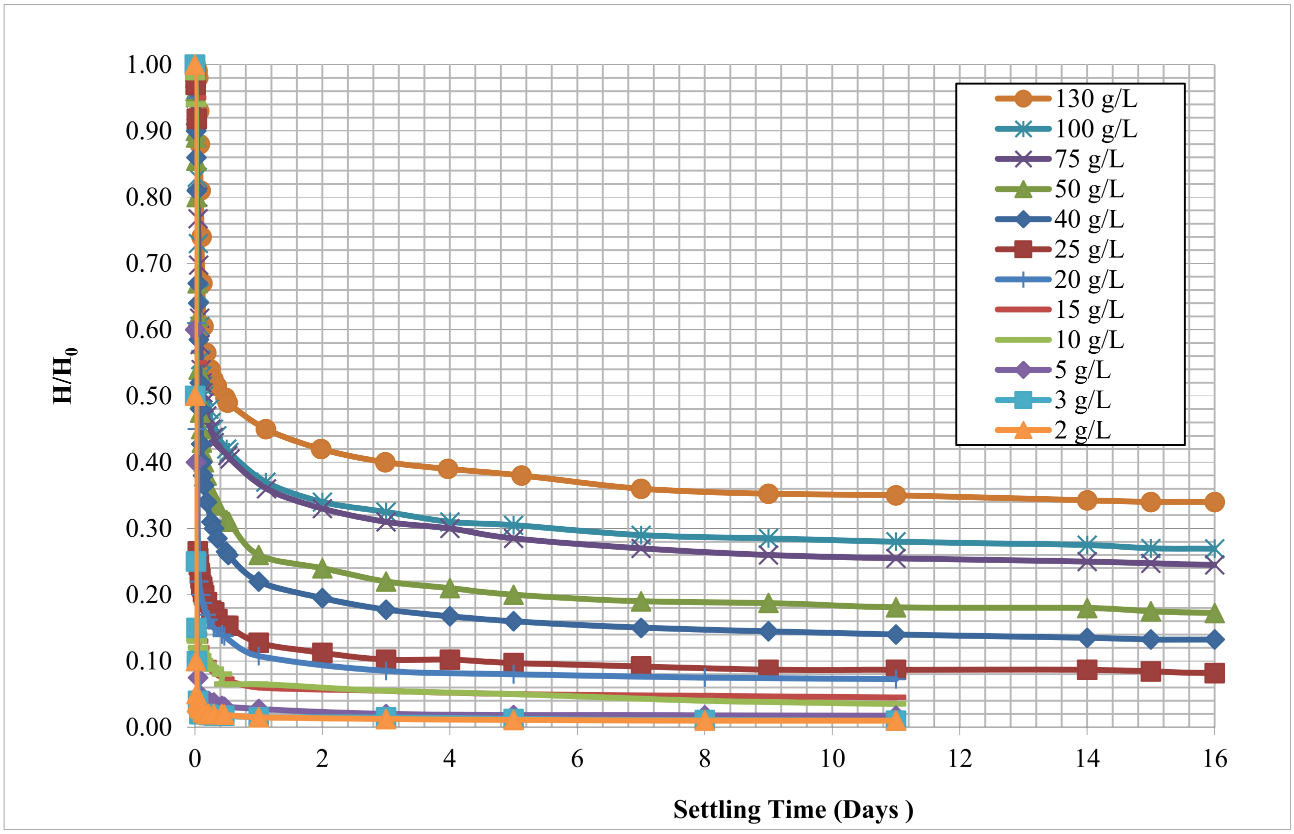

Figure 5.10-Settling curve of tests analyzing the effects of initial solids concentration on sedimentation

Based on the results shown in Figure 5.10, the slurry with the lowest initial solid concentration had the settled the fastest. As the initial solids concentration increased, the height of the critical sedimentation point increased and the sedimentation rate decreased, with a gentler slope.

Since there was no full column settling test run on these samples, there were no testing done on TSS and turbidity.

5.5 Evaluation of Settling Velocity

The settling curves were developed by running a series of mini column settling tests in 2000 mL columns. Twelve mini column tests were run with concentrations varying from 130 g/L to 2 g/L. The same sample source was used for all 12 tests and the sample characteristics are shown below in Table 5.7. Tap water was used in all 12 of these tests. The slope of each settling curve in the zone settling portion is shown in Figure 5.9.

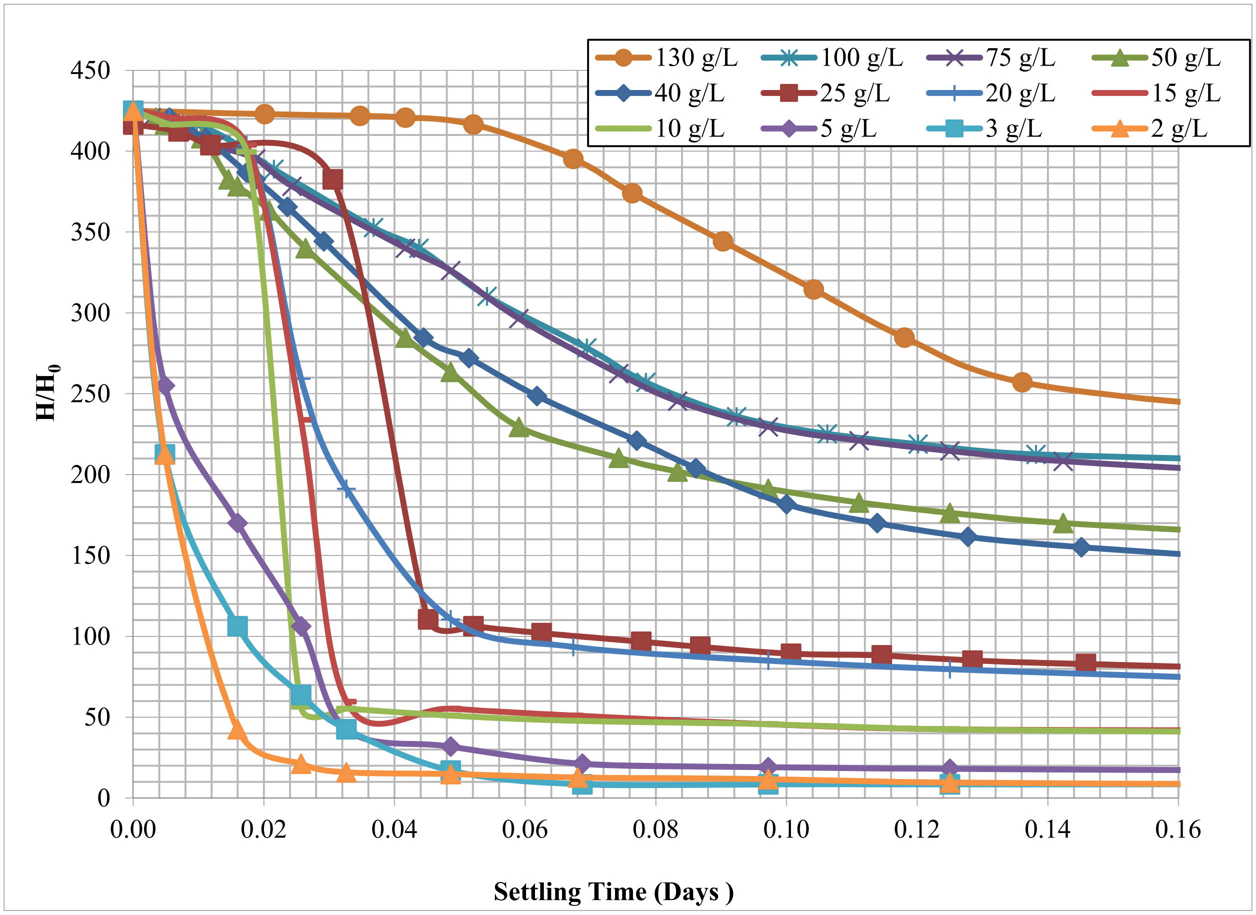

Figure 5.11-Zone settling portion of settling curves

The slope of the linear portion of the settling curve was plotted on a semi-log graph with respect to initial solids concentration. In order to estimate the settling velocity of the individual particles of the slurry, the points on the graph were interpolated back to the y-axis (Figure 5.12). Based on the results from the series of tests run, three different particle settling velocities can be determined for this sample. The upper portion of the graph represents the discrete settling with a particle settling velocity of approximately 3500 feet per day. The middle portion of the graph represents constant compression settling with a particle settling velocity on the order of 200 feet per day. The lowest portion of the graph represents a higher compression settling with the lowest settling velocity of about 15 feet per day. The equation from Vesilind (1968) can be used to determine the settling velocity. the equation is shown below:

$$V_s = V_o * e^{-kc} \tag{5.1}$$

where, V_s is the settling velocity, V_o is the initial velocity, k is the slope of the settling curve, and c is the initial solids concentration.

Table 5.7- Characteristics of samples used to determine settling velocity

Sample Location	% Fines	% Coarse	Organic Content, %	Specific Gravity	Liquid Limit, %	Plastic Limit, %	pH
Terrebonne Parish, LA	91	9	3.1	2.65	49	23	7.11

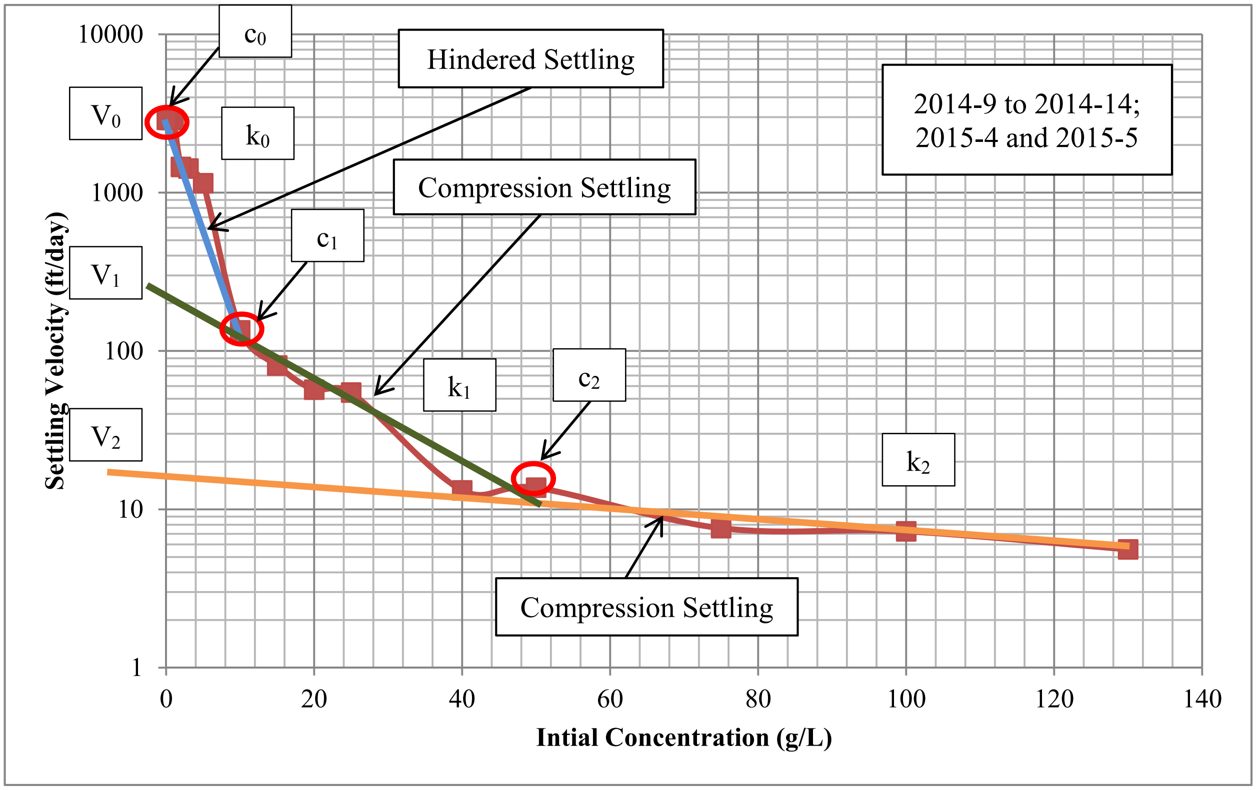

Figure 5.12-Intial solids concentration verses settling velocity

Table 5.8-Settling Velocity Summary Table

Hindered Settling Characteristics			Compression Settling 1 Characteristics			Compression Settling 2 Characteristics		
V_o (ft/day)	k_o	C_o (g/L)	V_1 (ft/day)	k_1	C_1 (g/L)	V_2 (ft/day)	k_2	C_2 (g/L)
3500	-277.88	0.1	200	-3.03	10	15	-0.10	50

5.6 Correlations between TSS and Turbidity

For each of the 15-day column settling test, turbidity and TSS tests were performed on the samples extracted from the water column during the sampling schedule. TSS verses turbidity values were plotted for each of the 15 tests performed for this research and are included in Appendix B of this thesis. A general equation was developed by plotting TSS verses turbidity for all 15 tests (Figure 5.13)

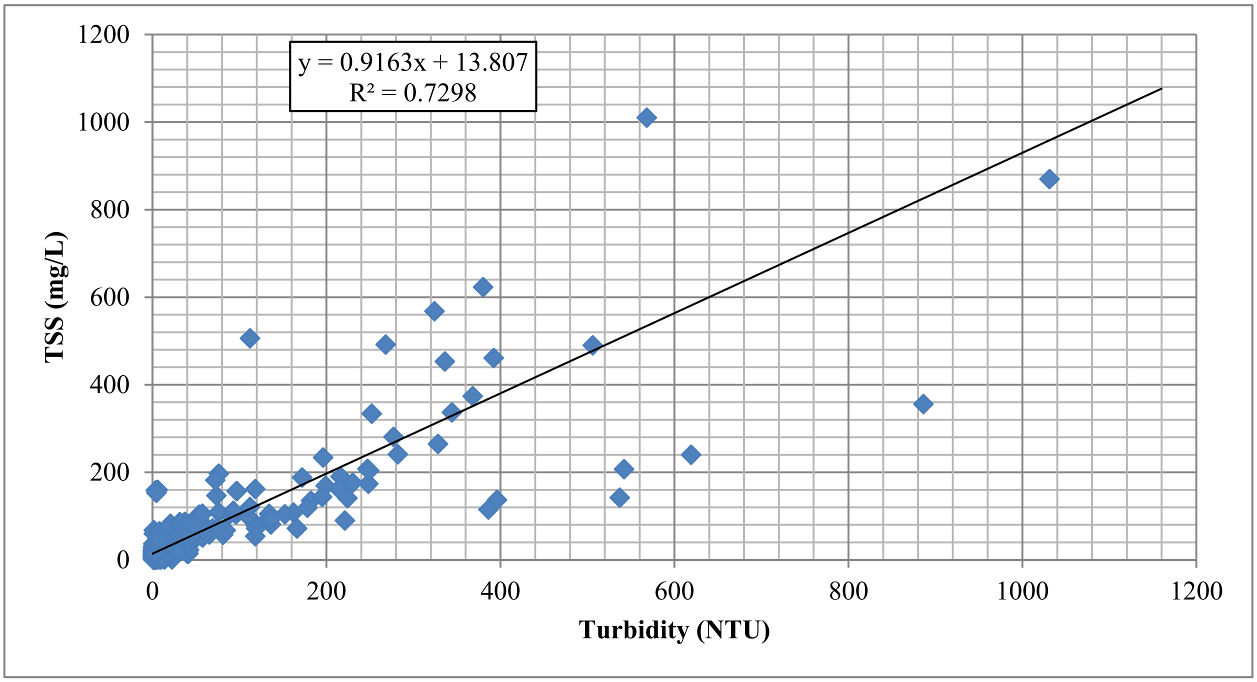

Figure 5.13-Turbidity verses TSS for all 15 tests

A linear regression produced a coefficient of determination (R^2) of 0.7298 and the general equation is as follows:

$$TSS = 0.9163(turbidity) + 13.807 \tag{5.2}$$

where, TSS is in mg/L and turbidity is in NTU. This equation can be helpful in determining TSS values from turbidity, since the TSS procedure is time consuming.

5.7 Bulk Dry Density

During each test, the initial solids particle concentration, the volume of the sample in the column, the volume of the settled slurry in the column, and the average total suspended solid concentration at a specified time. The bulk density of the slurry sediments is factor in design for marsh creation projects and more research is necessary for the models used in design. The mass of the settled slurry was determined by the following equation:

$$M_{ss} = [C_0(V_t)] - [C_s(V_t - V_{ss})] \tag{5.3}$$

where, M_{ss} is the mass of the settled slurry, C_0 is the initial solids particle concentration, C_s is the average concentration of the suspended solids, V_t is the volume of the total sample and V_{ss} is the volume of the settled slurry. Using this information the dry bulk density can be determined by the following equation:

$$\rho_b = \frac{M_{ss}}{V_{ss}} \tag{5.4}$$

where, ρ_b is the bulk dry density, M_{ss} is the mass of settled slurry, and V_{ss} is the volume of the settled slurry.   Figure 5.14 shows a schematic of the bulk dry density calculation.

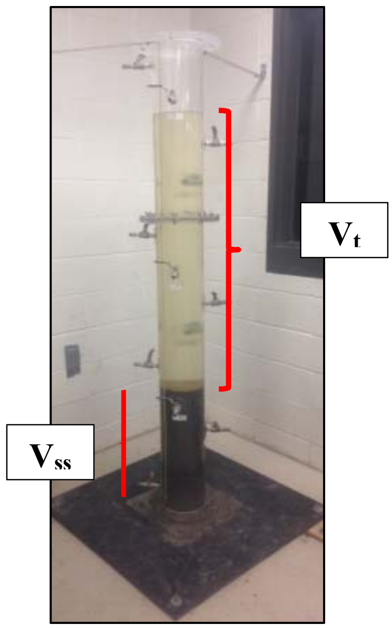

Figure 5.9-Schematic of bulk dry density

5.7.1 Correlation between Bulk Dry Density and Initial Solids Concentration

In order to develop a correlation between bulk dry density and initial solids concentration on the 2000 mL column settling tests, equation 5.2 had to be adjusted since no testing was done one suspended solids in these columns. In order to determine the mass of the settled slurry for the 2000 mL columns, the following equation was used:

$$M_{ss} = [C_0(V_t)] - [(V_t - V_{ss})] \tag{5.5}$$

This equation is the same as equation 5.2, but does not include the average suspended solid concentration (C_s). The bulk density equation remains the same as equation 5.3.

5.7.1.1 15-Day Bulk Dry Density

This section presents equations for the 15-day bulk dry density. These equations are only applicable to the range of initial solid concentrations that were tested in this thesis. Figure 5.15 is initial solids concentration verses 15-day dry bulk density for the mini column tests, since those were the only tests where initial solids concentration was varied.

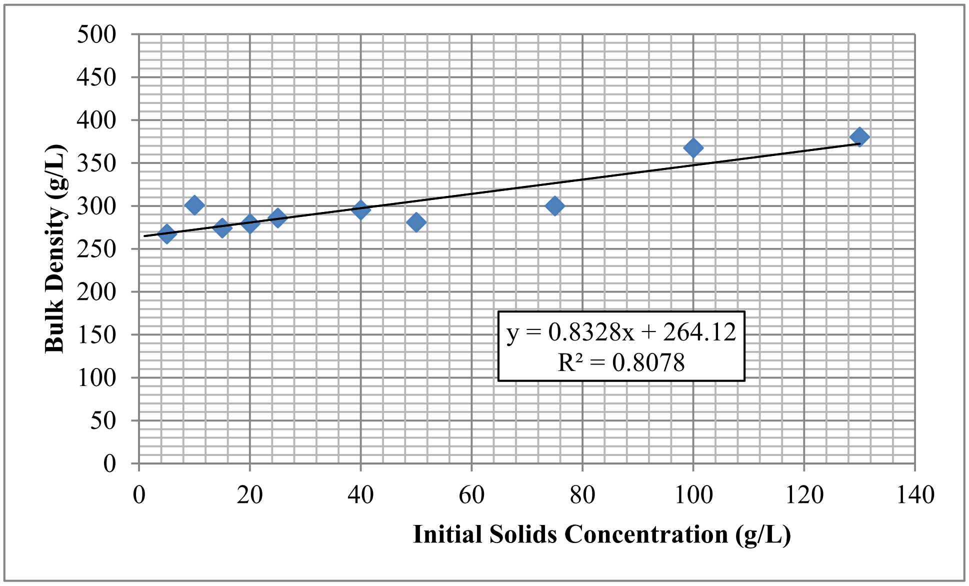

Figure 5.15-Initial solids concentration verses 15-day bulk dry density

A linear regression produced a coefficient of determination (R^2) of 0.8078 and the general equation is as follows:

$$\rho_b = 0.8328(C_0) + 264.12 \tag{5.6}$$

where, ρ_b is the bulk dry density and C_0 is the initial solids concentration. This equation could be used to determine the 15-day bulk dry density for these concentrations tested.

5.7.1.2 Inflection Point Bulk Dry Density

This section presents equations for the bulk dry density at the inflection points during the column settling test. The inflection point is the time where the settling transitions from zone settling to compression settling. Figure 5.16 is initial solids concentration verses dry bulk density at inflection points for the mini column tests

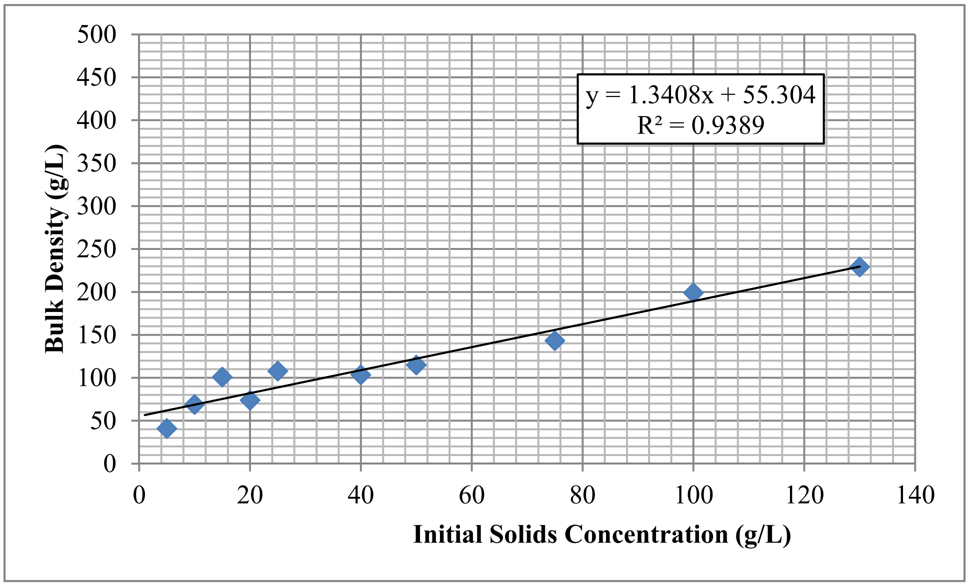

Figure 5.16-Initial solids concentration verses bulk dry density at inflection points

A linear regression produced a coefficient of determination (R^2) of 0.9389 and the general equation is as follows:

$$\rho_b = 1.3408(C_0) + 55.304 \tag{5.7}$$

where, ρ_b is the bulk dry density and C_0 is the initial solids concentration. This equation could be used to determine the 15-day bulk dry density for these concentrations tested.

5.8 Soil Resistivity

Soil resistivity testing was performed for each of the tests run during this research. This test is primarily determined by the soil's electrolyte content. Electrolytes consist of moisture, minerals, and dissolved salts. Typically, soil resistivity decreases (improves) as electrolytes increase. Soil resistivity decreases as the moisture content increases from very little moisture to roughly 20 percent moisture (Soil Resistivity Measure).

Salt content an impact the results of soil resistivity testing, causing the measurements to decrease with an increase in salt content (Why Measure Soil Resistivity?). When the salinity of the water used during the column settling test was plotted against the soil resistivity, there was a general trend of the soil resistivity decreasing with an increase in salinity (Figure 5.17).

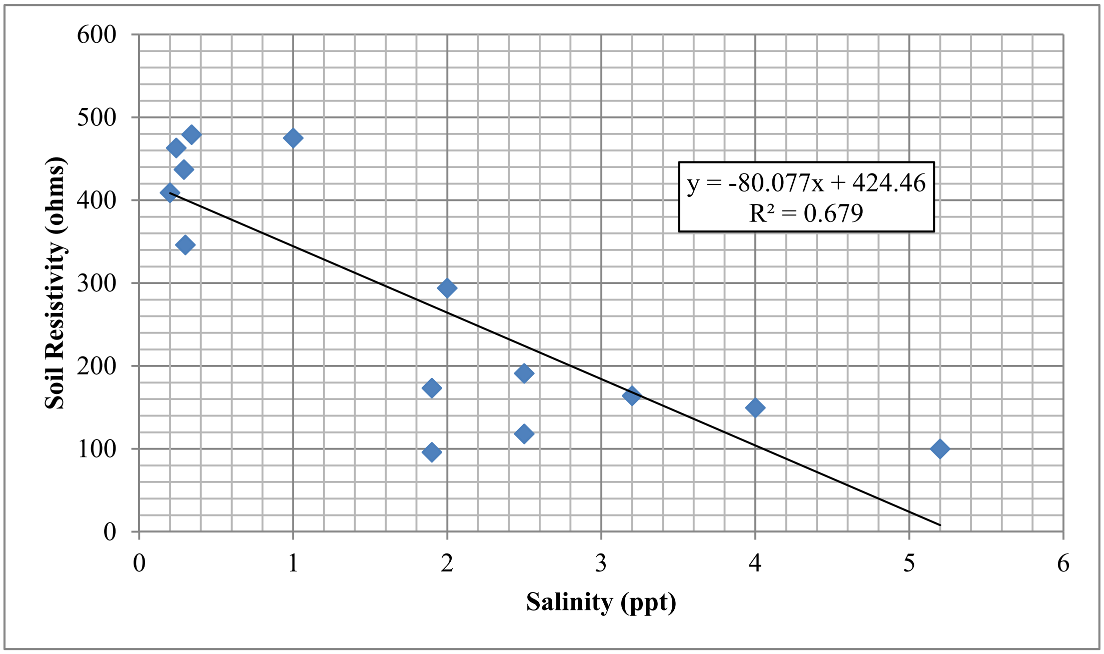

Figure 5.17-Salinity vs. Soil Resistivity

5.9 Soil Electrical Conductivity

Once the dredge material has been used in marsh creation site, it is important for this material to be able to sustain plant life. This is critical for the stabilization of the newly placed material and can reduce the re-suspension and erosion of the sediment. The conductivity measurement can help determine the type of plants that can sustain life in the dredge material used for the project. As expected, there was a correlation between the conductivity and salinity. There was increase with conductivity with the increase in salinity of the slurry (Figure 5.18)

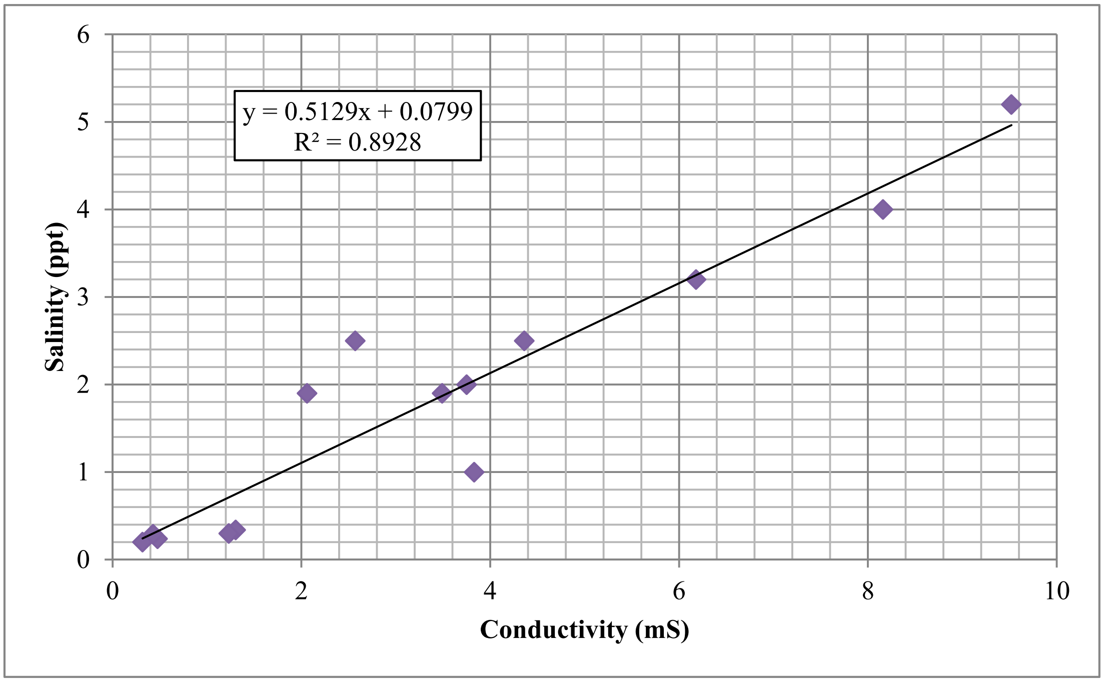

Figure 5.18-Conductivity vs. salinity

5.10 Geographic Information Systems (GIS) Database

Another large portion of this thesis was to compile all of the data developed in this research into a geographic information systems (GIS) file. A county boundary file was imported for Louisiana and Texas and a file with water features was imported into the GIS program, Arc Map. The data was imported with the GPS coordinates of all of the sample sources to create a shapefile. Within the program once the shapefile has been uploaded, each data point represents a sample source and there is a table with all of the data from this research (Figure 5.19). In addition to the data, the settling curve is also in the file (Figure 5.20). The map in GIS is shown in Figure 5.21. This file can be helpful for design engineers to use in future coastal restoration projects in coastal Louisiana.

Field	Value
Shape	Point
Sample ID	2014-9
Project Location	Terrebonne Parish
Latitude DMS	29°13'12.15"
Latitude DD	29.220042
Longitude DMS	91° 4'46.26"
Longitude DD	-91.079517
Easting	686675.9
Northing	3233892.4
Zone	15
CST Start Date	9/4/2010
CST End Date	9/19/2010
Sample Type	Shelby Tubes
Sample Source	PSI
Water Type	Tap
Initial Solids Concentration (g/L)	98.6
Salinity (ppt)	0.3
pH	7.11
Specific Gravity	2.65
Organic Content (%)	3.1
Liquid Limit (%)	49
Plastic Limit (%)	23
Plasticity Index (%)	26
% Coarse	9
% Fines	91
Resistivity (ohms)	346
Bulk Density (g/L)	436
Conductivity (mS)	1.23

Figure 5.19-Data table for 2014-9 in ArcMap

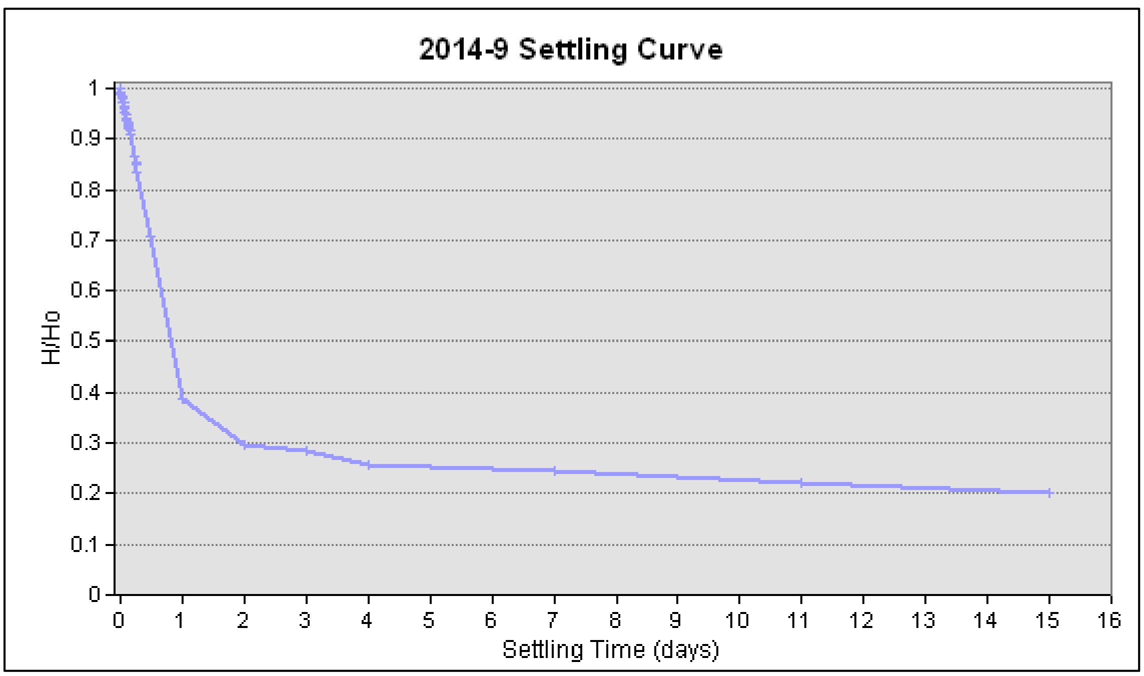

Figure 5.20-Settling curve for 2014-9 in ArcMap

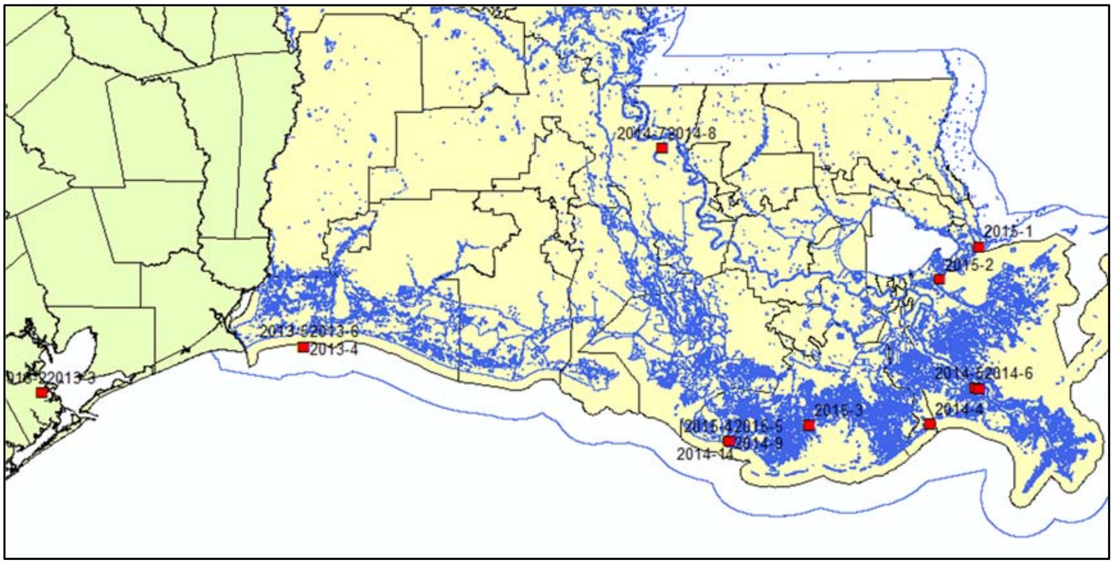

Figure 5.21-All data points in ArcMap

6. Summary and Conclusions

All sample sources came from on-going marsh restoration and land creation projects or areas where these projects could take place. The samples were successfully characterized using the methods presented herein. The conclusions conducted from this research are provided below.

1. Based on this research, there was no conclusive trend with the increase in salinity for the settling curve and TSS values. There should be additional testing performed to determine the effects of salinity on sedimentation of dredged sediments
2. Samples with higher percentages of fine material had the slowest settling rates. Thus, fine grained material stays in suspension longer than coarse material. The TSS and turbidity values in the water column were highest in samples were lower percentage of fine material. When as the percentage of fine grained material increases, the more flocs will occur and less material will be left in suspension.
3. As the initial solids concentrations of the samples increased, the settling rate of the sediments decreased. The samples with higher concentrations have increased contact between the particles in the slurry causing hindered settling and slower settling rates.
4. Based on the research performed, a relationship between TSS and turbidity was developed. This equation can be used to easily predict TSS values using the turbidity testing procedure which is a simpler and quicker test to run.

   $$TSS=0.9163(turbidity) + 13.807 \tag{5.2}$$

   Additional testing should be conducted to verify the validity of the equation.

5. The settling velocity of the solid particles in dredged material was estimated. Three settling velocities were determined for the sediment analyzed: for discrete settling 3500 feet per day, for constant compression settling 200 feet per day, and higher compression settling 15 feet per day.
6. The relationship between the dry bulk density and initial solids particle concentration (C_o) was derived based off the samples tested for this research. The relationship between the dry bulk density at 15 days and the dry bulk density at inflection points for each test to the initial solids particle concentration was estimated.

   $$\rho_b = 0.8328(C_0) + 264.12 \tag{5.6}$$

   $$\rho_b = 1.3408(C_0) + 55.304 \tag{5.7}$$

These equations can be used to estimate the bulk dry density of the dredged material based on its initial solids concentration that is being used for the marsh creation project.

The conclusions presented herein are only applicable to slurry samples with initial concentrations on the order of 100 grams per liter.

The results from this research can be used to assist in the design of marsh creation and land restoration projects. Additional testing should be conducted to better evaluate the material properties and engineering characteristics and confirm the derived equations.

7. Recommendations for Future Research

Following are some recommendations to advance the research findings presented in this thesis.

- Additional testing should be conducted on the effects of salinity on sedimentation of dredged sediments. There should be tested done on the ionic exchange between the particles and determine if there are trends.
- There should be some testing done on the zeta potential of the material and how that impacts the flocculation that occurs during sedimentation.
- The results found in this research have been compiled into a GIS database containing the engineering properties of dredged sediments obtained from and used in Louisiana coastal restoration projects. Additional research conducted on dredged sediments for marsh creation and land restoration should be added to this database.
- The equations derived in this research relating (i) TSS and (ii) turbidity, and dry bulk density and initial solids concentration indicated high R^2 values. Additional testing should be conducted to verify the validity of these equations.
- The self-weight consolidation of dredged sediments that occurs during the compression settling stage should be further analyzed. The effects of salinity, grain size distribution, and initial solids concentration on self-weight compression should be evaluated.
- Once the new marsh area has been created, it is important to analyze and understand the re-suspension characteristics of the dredge material. Wave actions can cause the sediments to re-suspend and potentially erode the placed dredge material. Laboratory tests should be conducted on the dredge material to evaluate these characteristics and the critical bed shear stress of the sediments used in marsh creation projects.
- The chemical composition of the dredged sediments can also impact the success of a marsh creation project. Once the material has been placed in an open water area to create land, it is important for that area to support marsh vegetation growth. The vegetation prevents erosion by keeping the sediments in place. If a soil contains unfavorable chemical composition, it inhibits the marsh vegetation growth and allows erosion to occur on the newly created marsh area. Research should be done to determine if the dredge sediment can foster vegetation growth.

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APPENDIX A

Site Vicinity Plan for Sample Sources

Summary of Engineering Properties of Dredged Sediments

Sample ID	Project Location	GPS Coordinates	Column Settling Test Initiation	Column Settling Test Finish Date	Sample Type	Sample Source	Type of water	Initial Solids Concentration (g/L)	Salinity (ppt)	pH	Specific Gravity	Organic Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Coarse (%)	Fines (%)	Resistivity (ohms)	Bulk Density (g/L)	Conductivity (mS)
2014-5	Lab Composite	N/A	4/1/2014	4/16/2014	UNO Lab Composite	N/A	Tap	109.33	0.34	6.8	2.68	5.8	73	48	25	35.6	64.4	479	393	1.304
2014-6	Lab Composite	N/A	4/23/2014	5/8/2014	UNO Lab Composite	N/A	Tap	99.4	0.24	7.07	2.79	6.9	77	40	37	22.3	77.7	463	360	0.476
2014-7	False River, LA	30°41'11.47"N 91°26'13.29"W	7/14/2014	7/29/2014	Grab	Eustis	Tap	96.5	0.29	6.94	2.64	3.8	45	15	35	5	95	437	376	0.428
2014-8	False River, LA	30°41'11.47"N 91°26'13.29"W	8/20/2014	9/4/2014	Grab	Eustis	Site	98	0.2	6.8	2.64	3.8	45	15	35	5	95	409	370	0.317
2014-9	Terrebonne Parish, LA	29°13'12.15"N 91° 4'46.26"W	9/5/2014	9/20/2014	Shelby Tubes	PSI	Tap	98.6	0.3	7.11	2.65	3.1	49	23	26	9	91	346	436	1.23
2014-10	Terrebonne Parish, LA	29°13'12.15"N 91° 4'46.26"W	9/22/2014	10/7/2014	Shelby Tubes	PSI	Site	97.7	2.5	7.46	2.65	3.1	49	23	26	9	91	118	462	4.36
2014-11	Terrebonne Parish, LA	29°13'12.15"N 91° 4'46.26"W	10/8/2014	10/23/2014	Shelby Tubes	PSI	Composite	98.4	1	7.56	2.65	3.1	49	23	26	9	91	475	381	3.83
2014-12	Terrebonne Parish, LA	29°13'12.15"N 91° 4'46.26"W	10/24/2014	11/7/2014	Shelby Tubes	PSI	Composite	95.6	2	6.94	2.65	3.1	49	23	26	9	91	294	327	3.75
2014-13	Terrebonne Parish, LA	29°13'12.15"N 91° 4'46.26"W	11/10/2014	11/25/2014	Shelby Tubes	PSI	Composite	102.5	3.2	7.47	2.65	3.1	49	23	26	9	91	164	354	6.18
2014-14	Terrebonne Parish, LA	29°13'12.15"N 91° 4'46.26"W	12/2/2014	12/17/2014	Shelby Tubes	PSI	Composite	100	5.2	6.85	2.65	3.1	49	23	26	9	91	348	462	9.52
2015-1	Lake Borgne, LA	30.156073 N 89.6214 W	12/31/2014	1/15/2015	Grab	UNO	Site	100.7	1.12	6.65	2.59	10.4	38	26	12	15	85	95.9	262	3.49
2015-2	Lake Borgne, LA	,30.001541 N 89.8599 W	1/16/2015	1/31/2015	Grab	UNO	Site	106.31	1.09	6.77	2.58	3.3	37	21	16	89	11	173.4	415	2.06

2015-3	Terrebonne Parish, LA	29.288882 N 90.622262 W	2/2/2015	2/1720/15	Grab	UNO	Site	97.7	2	6.66	2.70	5.5	34	19	16	55	45	191	367	2.57
2015-4	Terrebonne Parish, LA	29°13'12.15"N 91° 4'46.26"W	2/18/15	3/5/15	Shelby Tubes	PSI	Grand Isle, LA	95.6	32	6.5	2.65	3.1	49	23	26	9	91	216	355	8.83
2015-5	Terrebonne Parish, LA	29°13'12.15"N 91° 4'46.26"W	3/6/15	3/21/15	Shelby Tubes	PSI	Fifi Island, LA	99.4	4	7.18	2.65	3.1	49	23	26	9	91	149.5	532	8.16

APPENDIX B

2014-5

2014-5 | Engineering Properties

Sample ID	Project Location	GPS Coordinates	Test Start	Sample Type	Sample Source
2014-5	Plaquemines Parish and Grand Isle, LA	N/A	4/1/14	UNO Lab Composite	N/A

Concentration (g/L)	Water Type	Salinity (ppt)	pH	Specific Gravity	Organic Content (%)
109.33	Tap	0.34	6.8	2.68	5.8

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Grain Size Distribution		Bulk Density (g/L)	Resistivity (ohms)	Conductivity (mS)
			Fines (%)	Coarse (%)			
73	41	33	64	36	393	393	1.30

Site Vicinity Plan for 2014-5

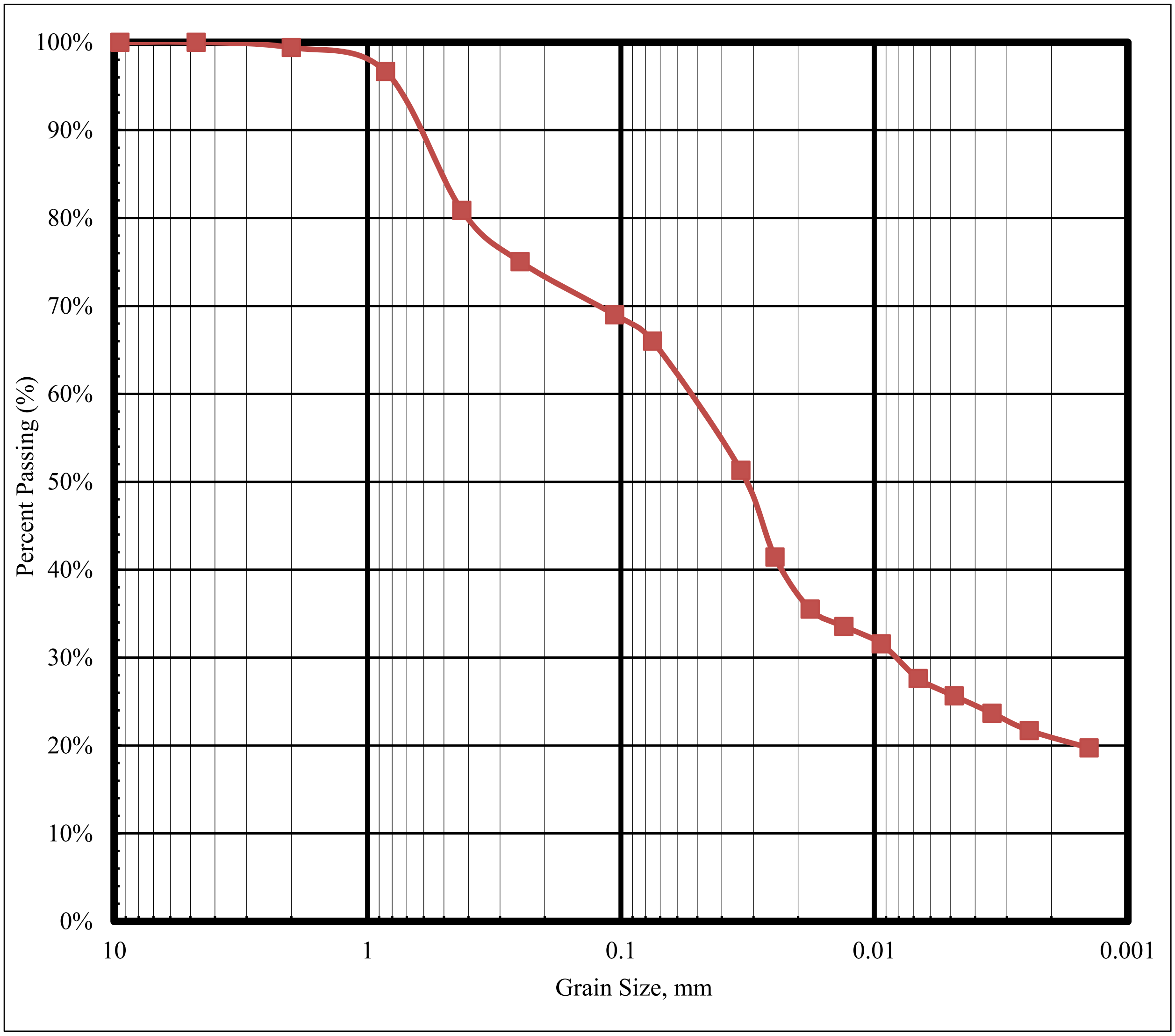
2014-5 | Hydrometer

Elapsed Time (min)	Temp Reading (C)	Composite Correction	Hydrometer Reading	Corrected Hydrometer Reading	Effective Depth (L, cm)	Value of K	Diameter of Particle Size (mm)	Percent Finer (%)
0.25	22.6	9	41	32	11.1	0.01374	0.0916	63.15%
2	22.6	9	35	26	12	0.01374	0.0337	51.31%
4	22.2	9	30	21	12.9	0.01374	0.0247	41.44%
8	21.9	9	27	18	13.3	0.01391	0.0179	35.52%
15	21.4	9	26	17	13.5	0.01391	0.0132	33.55%
30	21.3	9	25	16	13.7	0.01391	0.0094	31.57%
60	21.2	9	23	14	14	0.01391	0.0067	27.63%
120	20.7	9	22	13	14.2	0.01408	0.0048	25.65%
240	20.7	9	21	12	14.3	0.01408	0.0034	23.68%
480	20.9	9	20	11	14.5	0.01408	0.0024	21.71%
1440	20	9	19	10	14.7	0.01408	0.0014	19.73%

2014-5 | Sieve Analysis

Sieve Size	Particle Size (mm)	Cumulative Weight Retained (g)	Percent Retained	Percent Passing
3/8"	9.5000	0	0.00%	100.00%
#4	4.7500	0	0.00%	100.00%
#10	2.0000	0.3	0.60%	99.40%
#20	0.8500	1.66	3.32%	96.68%
#40	0.4250	9.56	19.12%	80.88%
#60	0.2500	12.48	24.96%	75.04%
#140	0.1060	15.50	31.00%	69.00%
#200	0.075	17	34.00%	33.00%
Pan		17.5	35%	65%

2014-5 | Grain Size Curve



% Fines	% Coarse
64	36

2014-5 | Atterberg Limits

	LL	LL	PL	PL
Container No.	L14	L3	L2	L6
Number of Blows	26	24	-	-
Weight of Can (g)	13.93	13.68	13.81	13.72
Weight of Wet Soil + Can (g)	19.13	20.65	20.02	19.99
Weight of Dry Soil + Can (g)	16.94	17.70	18.24	18.15
Weight of Dry Soil (g)	3.01	4.02	4.43	4.43
Water Weight (g)	2.19	2.95	1.78	1.84
Moisture Content (%)	72.76	73.38	40.18	41.53
Correction Factor	1.005	0.995		
Corrected Percent	72.82	72.98		

Liquid Limit	Plastic Limit	Plasticity Index
73	41	33

2014-5 | Organic Content

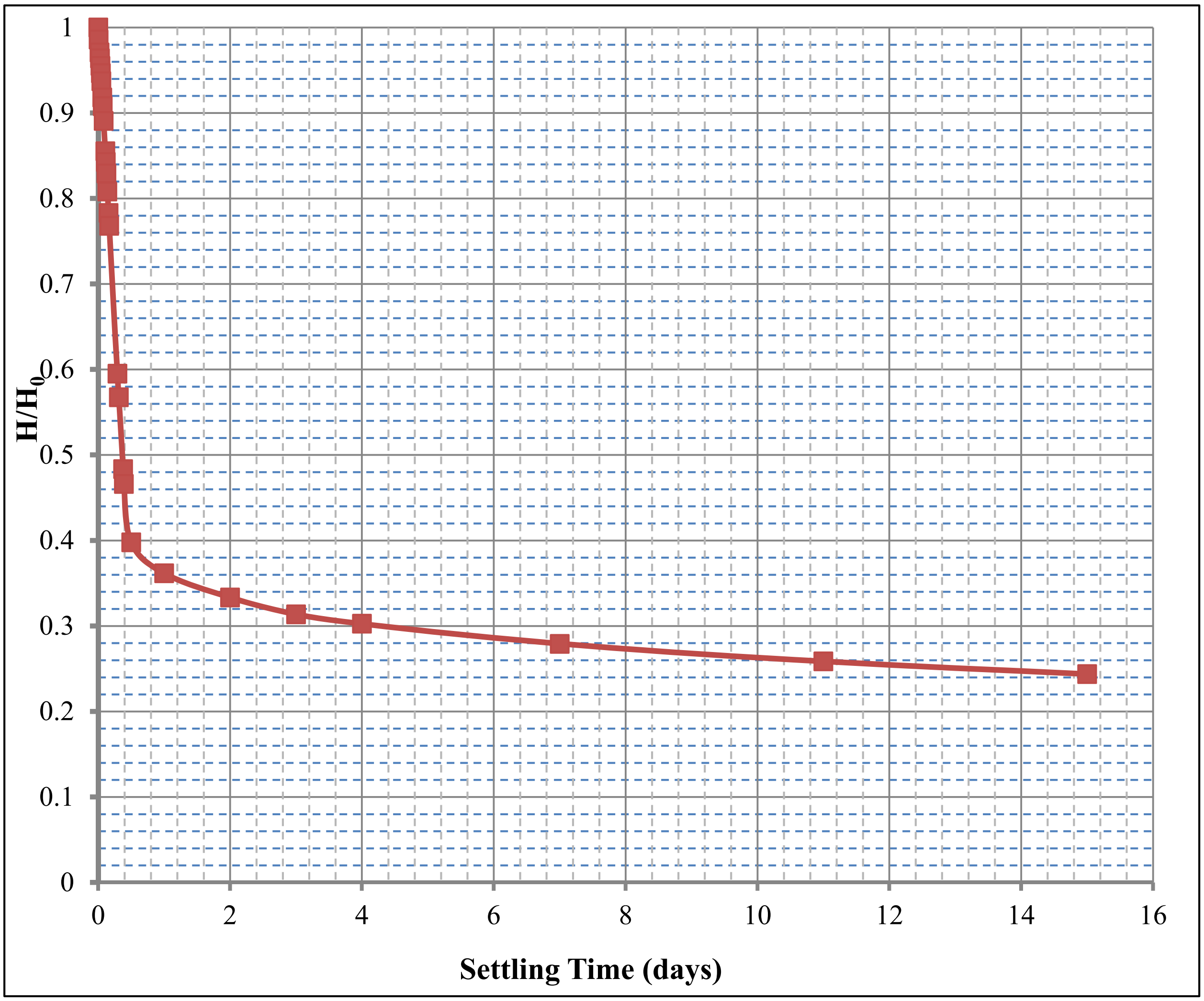
Dish Number	2
Weight of Dish with Cover (g)	346.23
Weight of Dish with Cover + Soil (g)	6.57.28
Weight of Dish with Cover + Ash (g)	639.12
Weight of Ash (g)	292.89
Weight of Soil (g)	311.05
Ash Content (%)	94.16%
Organic Content (%)	5.8%

2014-5 | Specific Gravity

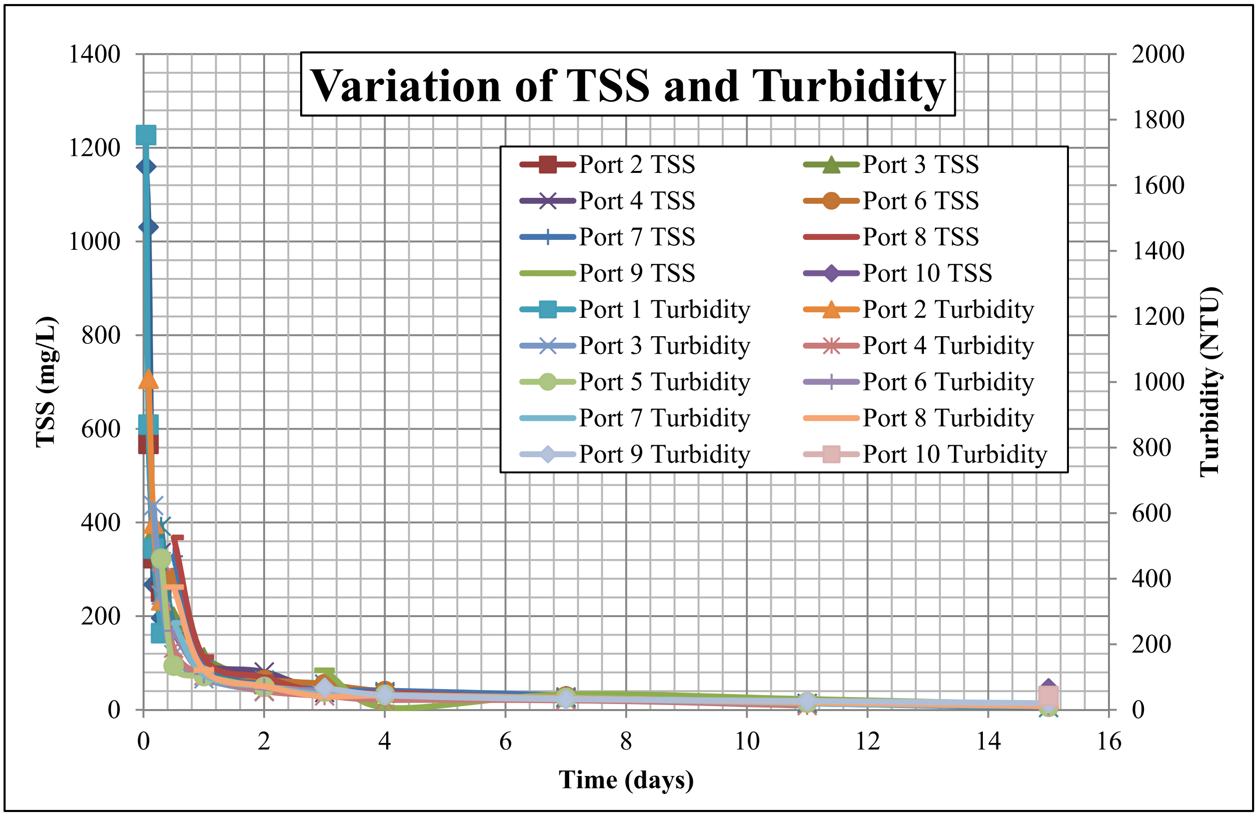
Flask Number	1
Temperature, T (˚C)	25
Weight of Flask, M_f (g)	203.89
Weight of Dry Soil, M_s (g)	37.03
Weight of Flask + Soil + Water, M_{fsw} (g)	724.75
Weight of Flask + Water, M_{fw} (g)	701.5
$M_{fw} – M_{fws} + M_s$ (g)	13.78
G_s (at T)	2.69
Correction Factor	0.9991
G_s (at 20˚C)	2.68

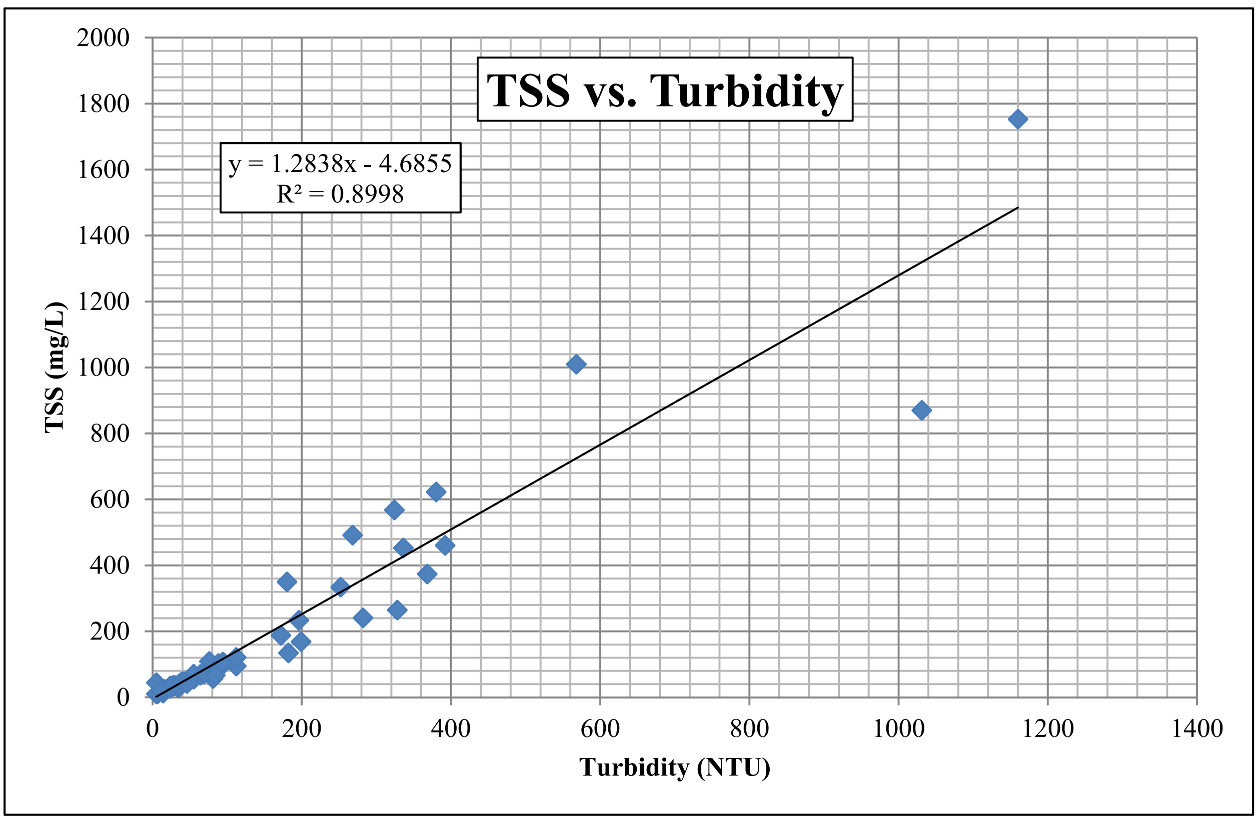
Temperature (˚C)	Correction Factor
17	1.0006
18	1.0004
19	1.0002
20	1
21	0.9998
22	0.9996
23	0.9993
24	0.9991
25	0.9988
26	0.9986
27	0.9983
28	0.998

2014-5 | Settling Curve



2014-5 | TSS and Turbidity





2014-5 | Bulk Density

Initial Concentration (g/L)=	109.33		Column Volume (in^3)=	15984.42		1 liter=	61.02 in^3
Specific Gravity=	2.68		Column Diameter (in)=	8		Column Height (in)=	79.5

Date	Test Time	C_s Avg (g/L)	Water Height (in)	Slurry Height (in)	V_t (in^3)	V_s (in^3)	V_t (L)	V_s (L)	Mass Settled (g)	Bulk Density (g/L)
4/1/2014	1h	1.16	79.1875	75.25	15922	15130	971594	923283	106218666	115.04
	2h	0.80	79	70.8125	15884	14238	969294	868837	105942745	121.94
	4h	0.32	78.6875	61.0625	15821	12277	965460	749209	105533610	140.86
	7h	0.27	78.125	47.3125	15708	9513	958558	580503	104746235	180.44
	12h	0.26	77.25	31.625	15532	6359	947822	388024	103531616	266.82
4/2/2014	1d	0.10	75.5625	28.75	15193	5781	927117	352749	101354394	287.33
4/3/2014	2d	0.06	74.6875	26.5	15017	5328	916381	325143	100197175	308.16
4/4/2014	3d	0.05	73.75	24.9375	14828	5014	904879	305972	98946389	323.38
4/5/2014	4d	0.04	72.625	24.0625	14602	4838	891076	295236	97443379	330.05
4/8/2014	7d	0.03	71.6875	22.1875	14414	4461	879573	272230	96192018	353.35
4/12/2014	11d	0.02	70.75	20.5625	14225	4134	868070	252292	94940880	376.31
4/16/2014	15d	0.01	69.5625	19.375	13986	3896	853500	237722	93349026	392.68

2014-5 | Testing Photos

START

1 HOUR

2 HOUR

6 HOUR

1 DAY

2 DAY

3 DAY

4 DAY

7 DAY

11 DAY

2014-6

2014-5 | Engineering Properties

Sample ID	Project Location	GPS Coordinates	Test Start	Sample Type	Sample Source
2014-6	Plaquemines Parish and Grand Isle, LA	N/A	4/23/14	UNO Lab Composite	N/A

Concentration (g/L)	Water Type	Salinity (ppt)	pH	Specific Gravity	Organic Content (%)
99.4	Tap	0.24	7.07	2.79	6.9

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Grain Size Distribution		Bulk Density (g/L)	Resistivity (ohms)	Conductivity (mS)
			Fines (%)	Coarse (%)			
78	37	41	78	22	360	463	0.48

Site Vicinity Plan for 2014-6

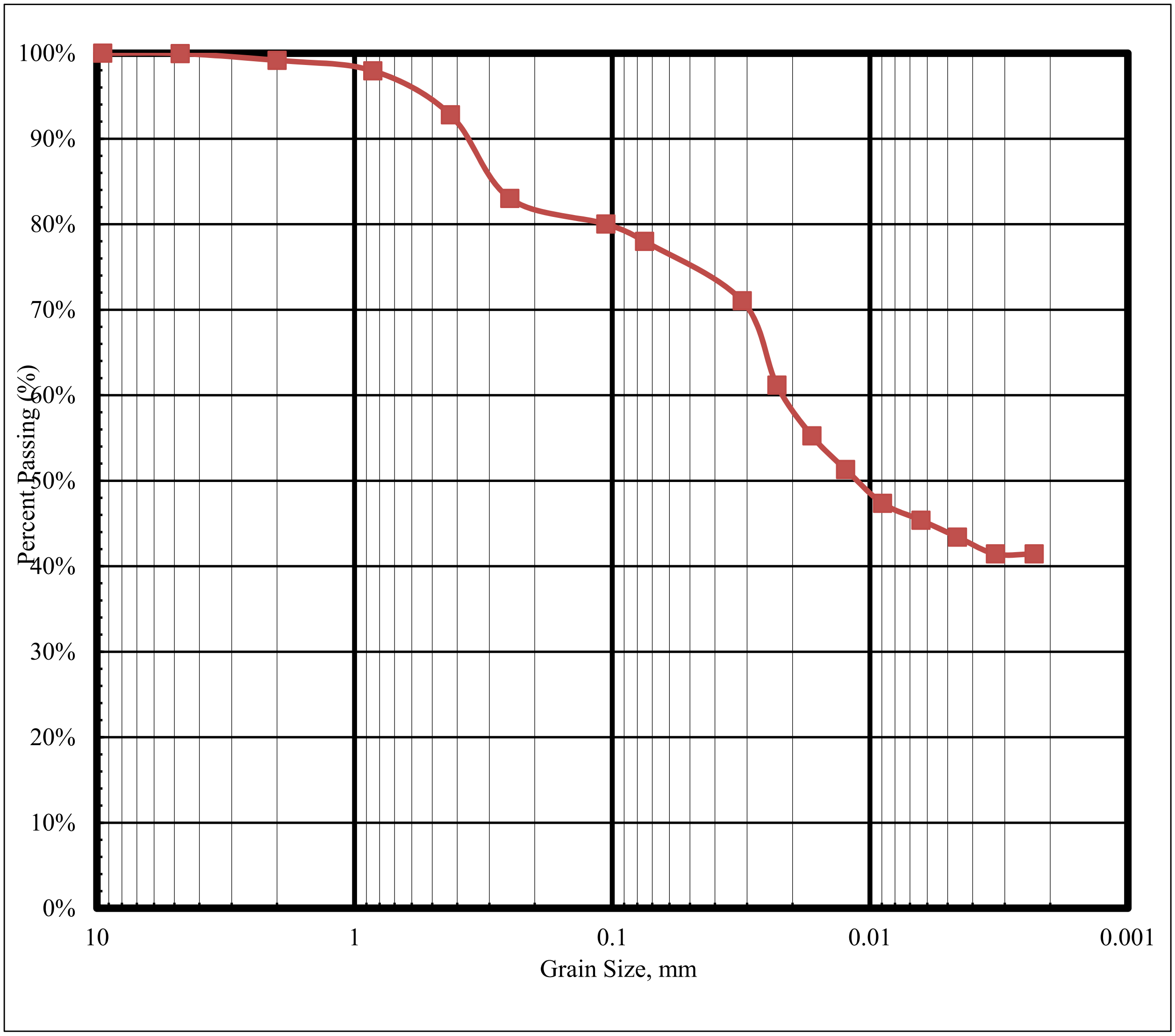
2014-6 | Hydrometer

Elapsed Time (min)	Temp Reading (C)	Composite Correction	Hydrometer Reading	Corrected Hydrometer Reading	Effective Depth (L, cm)	Value of K	Diameter of Particle Size (mm)	Percent Finer (%)
0.25	22.6							
2	22.6	9	45	36	10.4	0.01374	0.0313	71.04%
4	22.2	9	40	31	11.2	0.01374	0.0230	61.18%
8	21.9	9	37	28	11.7	0.01391	0.0168	55.26%
15	21.4	9	35	26	12	0.01391	0.0124	51.31%
30	21.3	9	33	24	12.4	0.01391	0.0089	47.36%
60	21.2	9	32	23	12.5	0.01391	0.0063	45.39%
120	20.7	9	31	22	12.7	0.01408	0.0046	43.41%
240	20.7	9	30	21	12.9	0.01408	0.0033	41.44%
480	20.9	9	30	21	12.9	0.01408	0.0023	41.44%
1440	20	9	29	20	13	0.01408	0.0013	39.47%

2014-6 | Sieve Analysis

Sieve Size	Particle Size (mm)	Cumulative Weight Retained (g)	Percent Retained	Percent Passing
3/8"	9.5000	0	0.00%	100.00%
#4	4.7500	0.02	0.04%	99.96%
#10	2.0000	0.42	0.84%	99.16%
#20	0.8500	1.03	2.06%	97.94%
#40	0.4250	3.6	7.20%	92.80%
#60	0.2500	8.49	16.98%	83.02%
#140	0.1060	9.99	19.98%	80.02%
#200	0.075	11.00	22.00%	78.00%
Pan		11.15	22.30%	77.70%

2014-6 | Grain Size Curve



% Fines	% Coarse
78	22

2014-6 | Atterberg Limits

	LL	LL	PL	PL
Container No.	L14	L3	L2	L6
Number of Blows	29	27	-	-
Weight of Can (g)	13.94	13.72	13.90	13.80
Weight of Wet Soil + Can (g)	19.70	20.6	20.17	20.13
Weight of Dry Soil + Can (g)	17.20	17.61	18.50	18.40
Weight of Dry Soil (g)	3.26	3.89	4.60	4.60
Water Weight (g)	2.50	2.99	1.67	1.73
Moisture Content (%)	76.69	78.86	36.30	37.61
Correction Factor	1.018	1.009		
Corrected Percent	78.07	77.56		

Liquid Limit	Plastic Limit	Plasticity Index
78	37	41

2014-6 | Organic Content

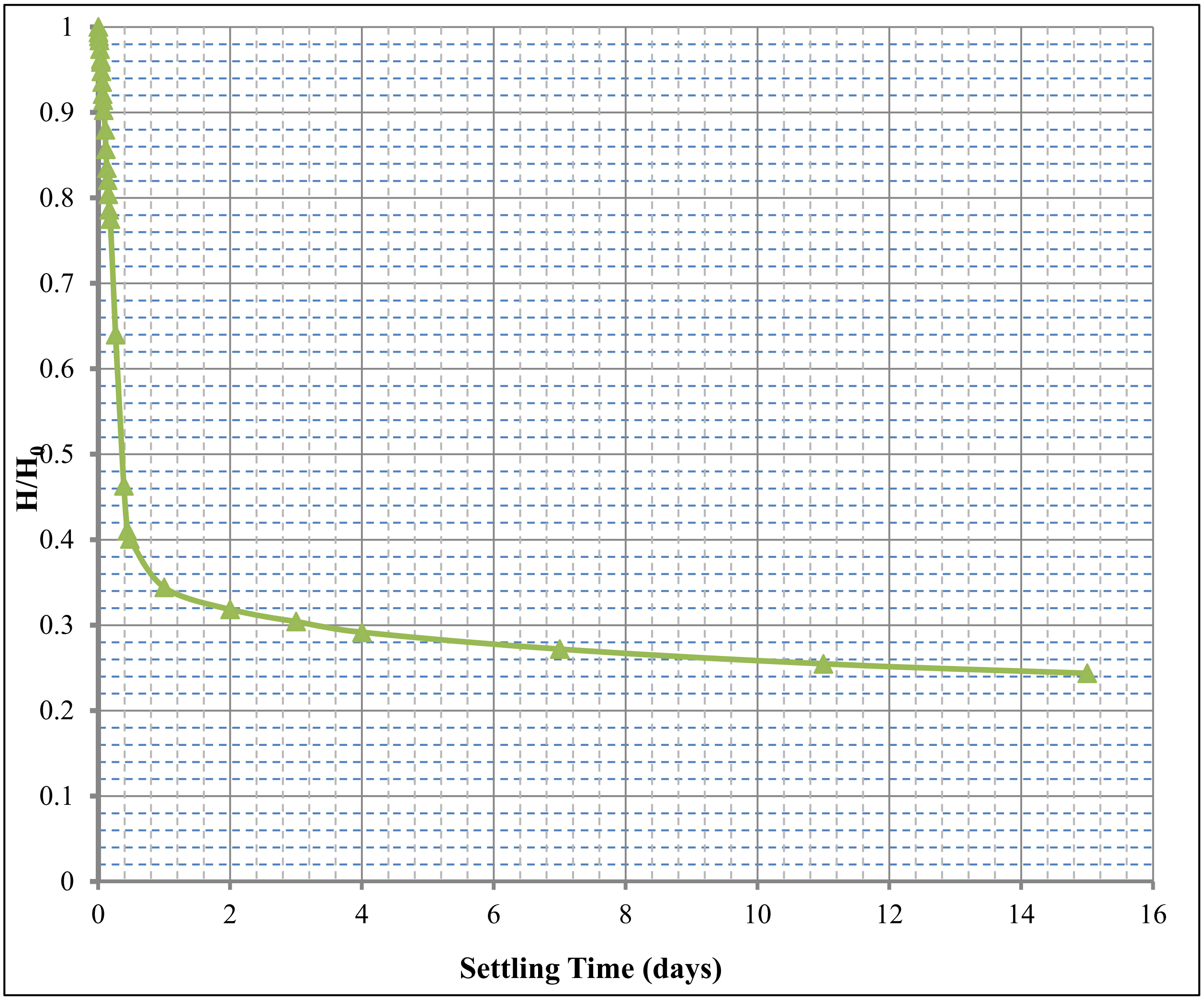
Dish Number	2
Weight of Dish with Cover (g)	348.51
Weight of Dish with Cover + Soil (g)	579.31
Weight of Dish with Cover + Ash (g)	563.50
Weight of Ash (g)	214.99
Weight of Soil (g)	230.80
Ash Content (%)	93.1
Organic Content (%)	6.9

2014-6 | Specific Gravity

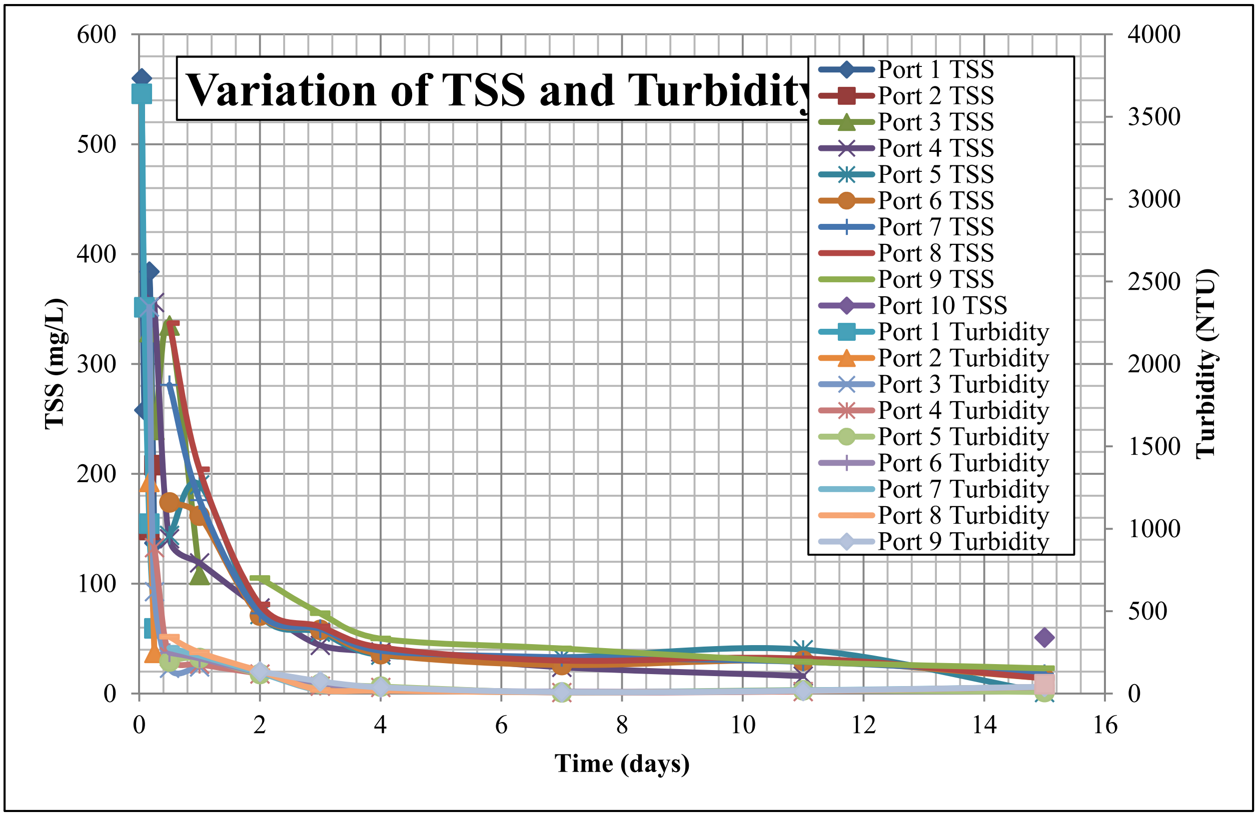
Flask Number	1
Temperature, T (˚C)	24
Weight of Flask, M_f (g)	203.87
Weight of Dry Soil, M_s (g)	36.88
Weight of Flask + Soil + Water, M_{fsw} (g)	724.90
Weight of Flask + Water, M_{fw} (g)	701.23
$M_{fw} - M_{fws} + M_s$ (g)	13.21
G_s (at T)	2.79
Correction Factor	0.9991
G_s (at 20˚C)	2.79

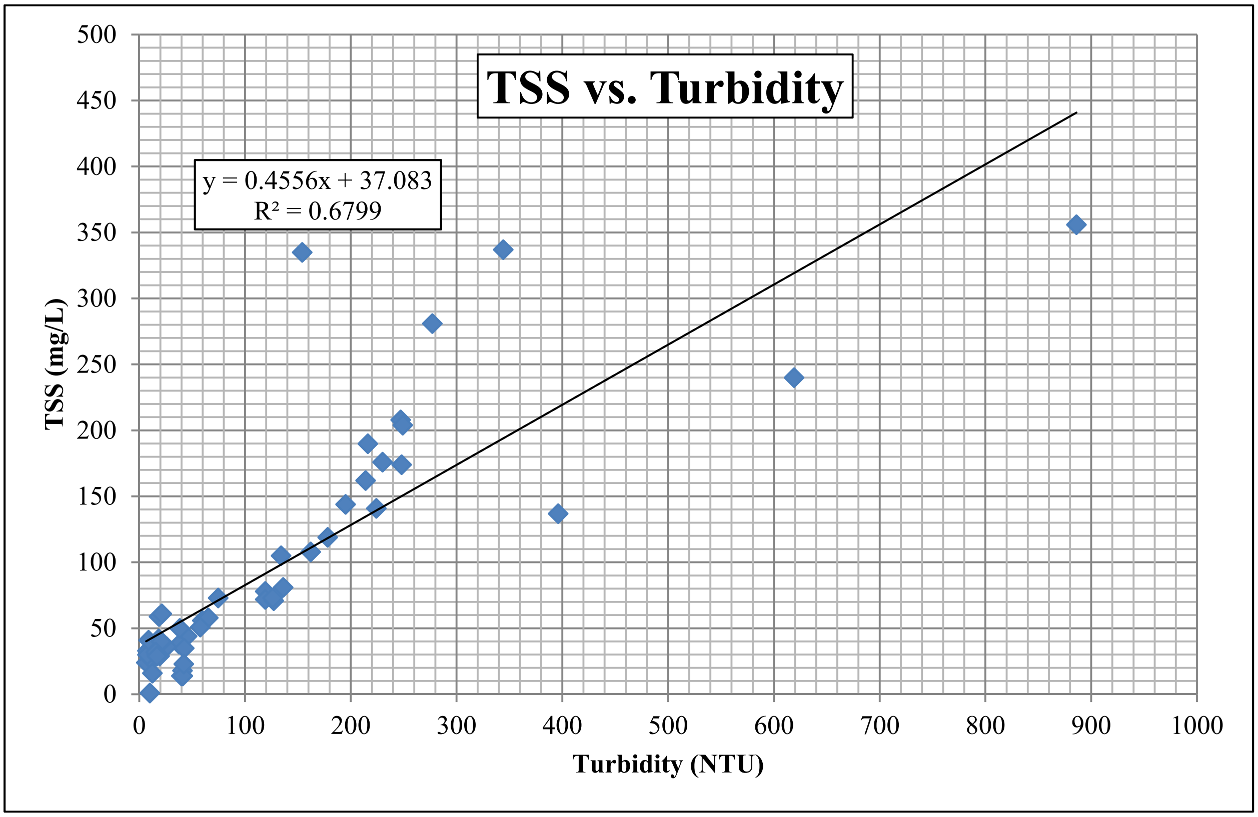
Temperature (˚C)	Correction Factor
17	1.0006
18	1.0004
19	1.0002
20	1
21	0.9998
22	0.9996
23	0.9993
24	0.9991
25	0.9988
26	0.9986
27	0.9983
28	0.998

2014-6 | Settling Curve



2014-6 | TSS and Turbidity





2014-6 | Bulk Density

Initial Concentration (g/L)=	99.4		Column Volume (in^3)=	15984.42		1 liter=	61.02 in^3
Specific Gravity=	2.79		Column Diameter (in)=	8		Column Height (in)=	79.5

Date	Test Time	C_s Avg (g/L)	Water Height (in)	Slurry Height (in)	V_t (in^3)	V_s (in^3)	V_t (L)	V_s (L)	Mass Settled (g)	Bulk Density (g/L)
4/23/2014	1h	0.5600	79	76.25	15884	15331	969294	935553	96287859	102.92
	2h	0.2580	78.8125	71.75	15846	14426	966993	880340	96055821	109.11
	4h	0.2873	78.6875	62.5	15821	12566	965460	766846	95868725	125.02
	6h	0.0000	78	50.875	15683	10229	957024	624213	95009387	152.21
	12h	0.0000	77.375	31.875	15557	6409	949356	391092	94194382	240.85
4/24/2014	1d	0.0000	76.1875	27.375	15318	5504	934786	335879	92782386	276.24
4/25/2014	2d	0.0000	75.0625	25.3125	15092	5089	920983	310573	91457822	294.48
4/26/2014	3d	0.0000	74	24.1875	14879	4863	907946	296770	90175636	303.86
4/27/2014	4d	0.0400	73	23.1875	14678	4662	895677	284500	88967870	312.72
4/30/2014	7d	0.0312	72	21.625	14476	4348	883407	265329	87753981	330.74
5/4/2014	11d	0.0293	71.0625	20.25	14288	4072	871904	248458	86612076	348.60
5/8/2014	15d	0.0202	70.1875	19.375	14112	3896	861169	237722	85551102	359.88

2014-6 | Testing Photos

START

1 HOUR

4 HOUR

6 HOUR

12 HOUR

1 DAY

2 DAY

3 DAY

11 DAY

2014-7

2014-7 | Engineering Properties

Sample ID	Project Location	GPS Coordinates	Test Start	Sample Type	Sample Source
2014-7	False River, LA	30˚41'11.47" N 91˚26'13.29" W	7/14/14	Grab	Eustis

Concentration (g/L)	Water Type	Salinity (ppt)	pH	Specific Gravity	Organic Content (%)
96.5	Tap	0.29	6.94	2.64	3.8

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Grain Size Distribution		Bulk Density (g/L)	Resistivity (ohms)	Conductivity (mS)
			Fines (%)	Coarse (%)			
45	15	35	95	5	437	437	0.43

Site Vicinity Plan for 2014-7

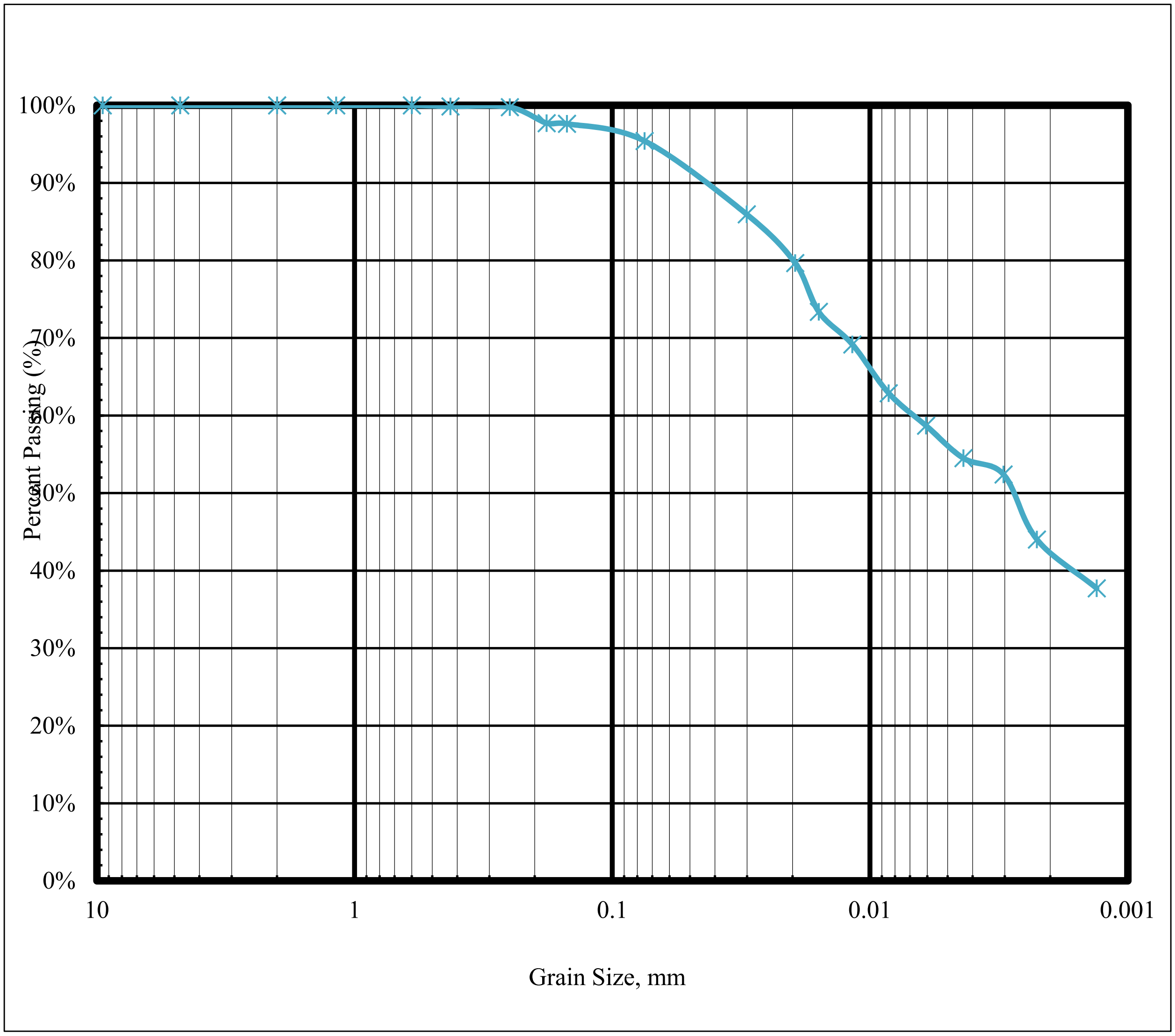
2014-7 | Hydrometer

Elapsed Time (min)	Temp Reading (C)	Composite Correction	Hydrometer Reading	Corrected Hydrometer Reading	Effective Depth (L, cm)	Value of K	Diameter of Particle Size (mm)	Percent Finer (%)
0.25	22.1	4	45					
2	22.2	4	44	40	9.7	0.01374	0.0303	83.85%
4	22.2	4	42	38	10.1	0.01374	0.0195	79.66%
8	22.2	4	39	35	10.6	0.01374	0.0158	73.37%
15	22.2	4	37	33	10.9	0.01374	0.0117	69.18%
30	22.1	4	34	30	11.4	0.01374	0.0085	62.89%
60	22.1	4	32	28	11.7	0.01374	0.0061	58.69%
120	22.2	4	30	26	12	0.01374	0.0043	54.50%
240	22.3	4	29	25	12.2	0.01374	0.0030	52.41%
480	22.2	4	25	21	12.9	0.01374	0.0023	44.02%
1440	22.3	4	22	18	13.3	0.01374	0.0013	37.73%

2014-7 | Sieve Analysis

Sieve Size	Particle Size (mm)	Cumulative Weight Retained (g)	Percent Retained	Percent Passing
3/8"	9.5000	0	0.00%	100.00%
#4	4.7500	0	0.00%	100.00%
#10	2.0000	0	0.00%	100.00%
#20	1.1800	0	0.00%	100.00%
#40	0.6000	0.07	0.14%	99.86%
#60	0.4250	0.12	0.24%	99.76%
#80	0.2500	0.15	0.30%	99.70%
#100	0.1800	0.19	0.38%	99.62%
#200	0.1500	0.65	1.30%	98.70%
Pan	0.0750	0.74	1.48%	98.52%

2014-7 | Grain Size Curve



% Fines	% Coarse
95	5

2014-7 | Atterberg Limits

	LL	LL	PL	PL
Container No.	A1	A2	A3	A4
Number of Blows	29	28		
Weight of Can (g)	13.70	13.70	13.69	13.86
Weight of Wet Soil + Can (g)	32.44	33.42	20.49	20.46
Weight of Dry Soil + Can (g)	26.71	27.36	19.60	19.56
Weight of Dry Soil (g)	13.01	13.66	5.91	5.70
Water Weight (g)	5.73	6.06	0.89	0.90
Moisture Content (%)	44.04	44.36	15.06	15.79
Correction Factor	1.02	1.014		
Corrected Percent	45	45		

Liquid Limit	Plastic Limit	Plasticity Index
45	15	30

2014-7 | Organic Content

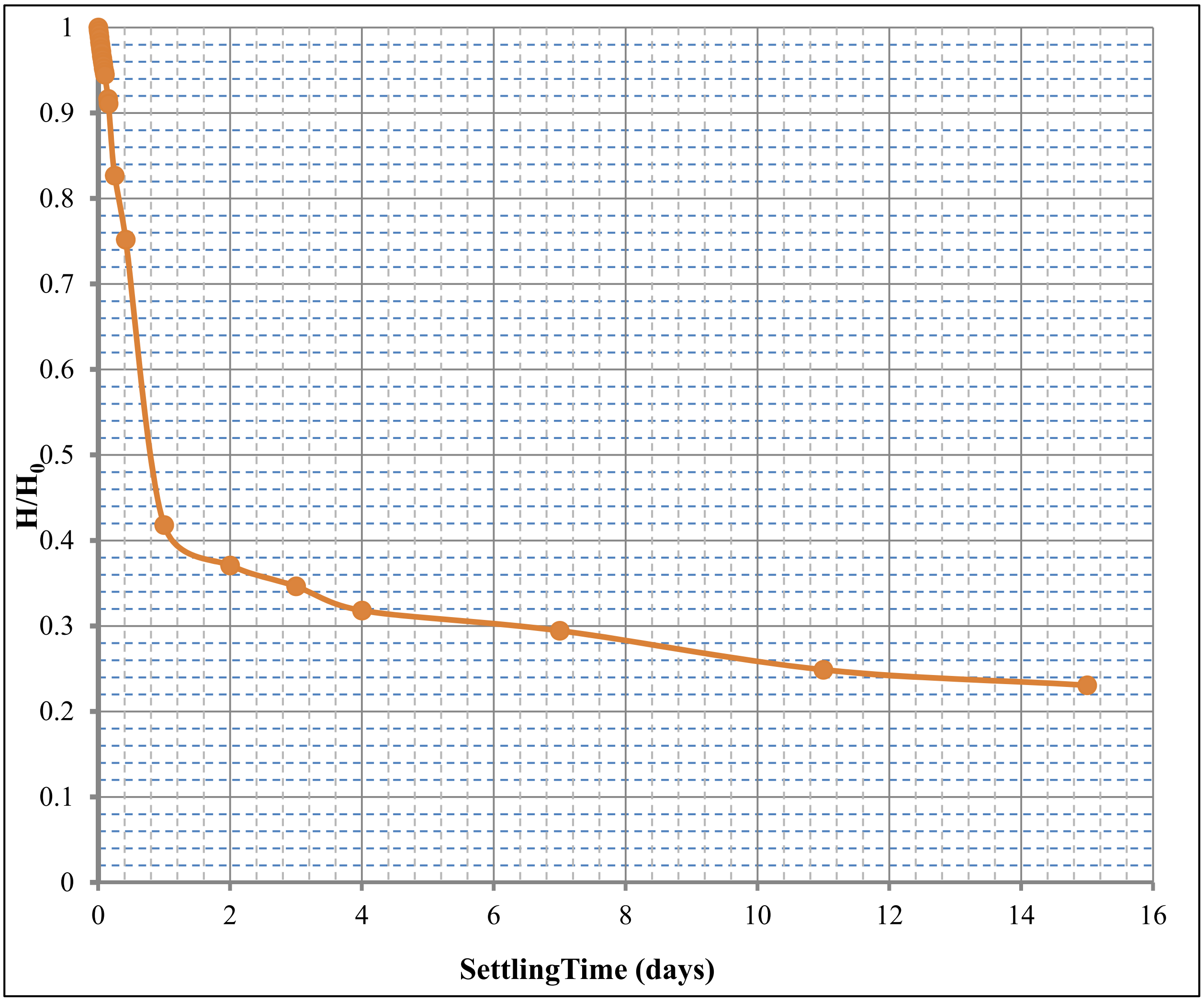
Dish Number	8
Weight of Dish with Cover (g)	126.97
Weight of Dish with Cover + Soil (g)	224.90
Weight of Dish with Cover + Ash (g)	221.16
Weight of Ash (g)	94.19
Weight of Soil (g)	97.93
Ash Content (%)	96.18
Organic Content (%)	3.8

2014-7 | Specific Gravity

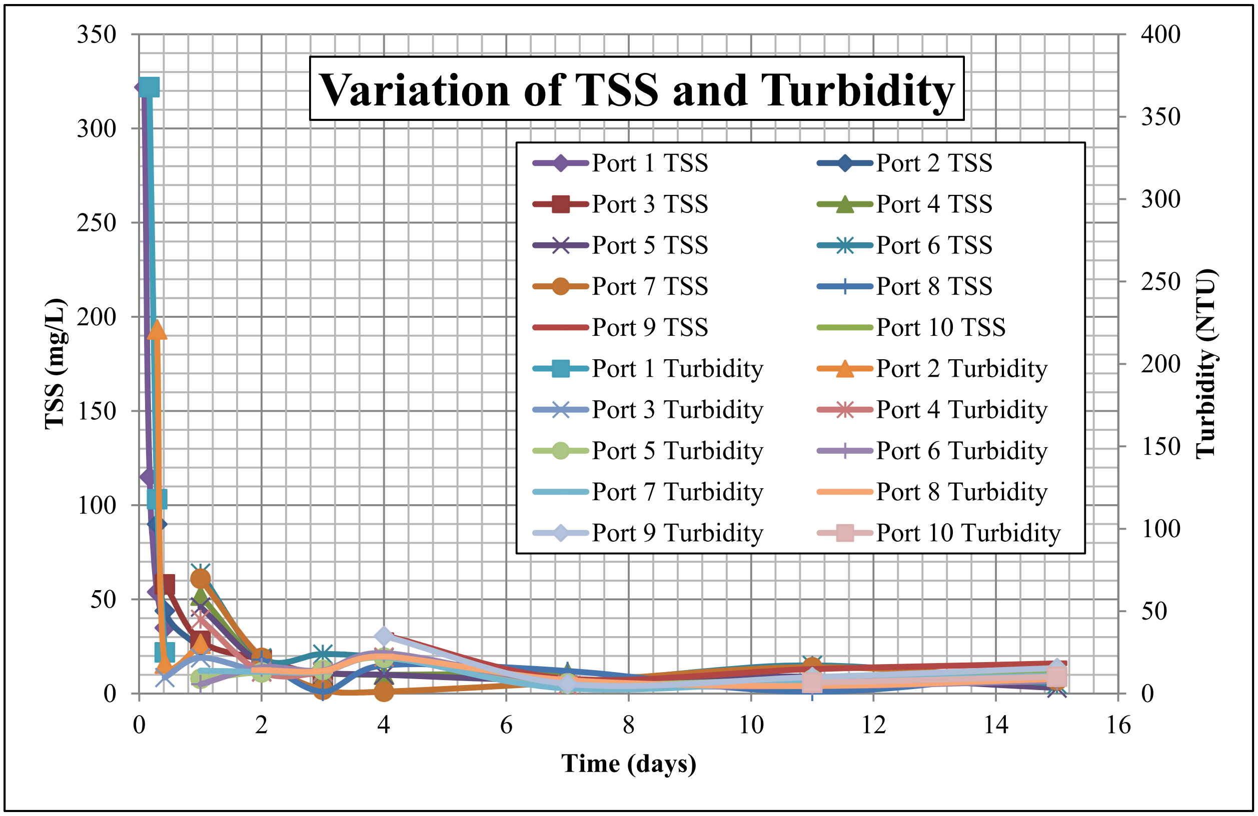
Flask Number	1
Temperature, T (˚C)	22
Weight of Flask, M_f (g)	203.89
Weight of Dry Soil, M_s (g)	56.46
Weight of Flask + Soil + Water, M_{fsw} (g)	736.29
Weight of Flask + Water, M_{fw} (g)	701.23
$M_{fw} – M_{fws} + M_s$ (g)	21.40
G_s (at T)	2.64
Correction Factor	0.9996
G_s (at 20˚C)	2.64

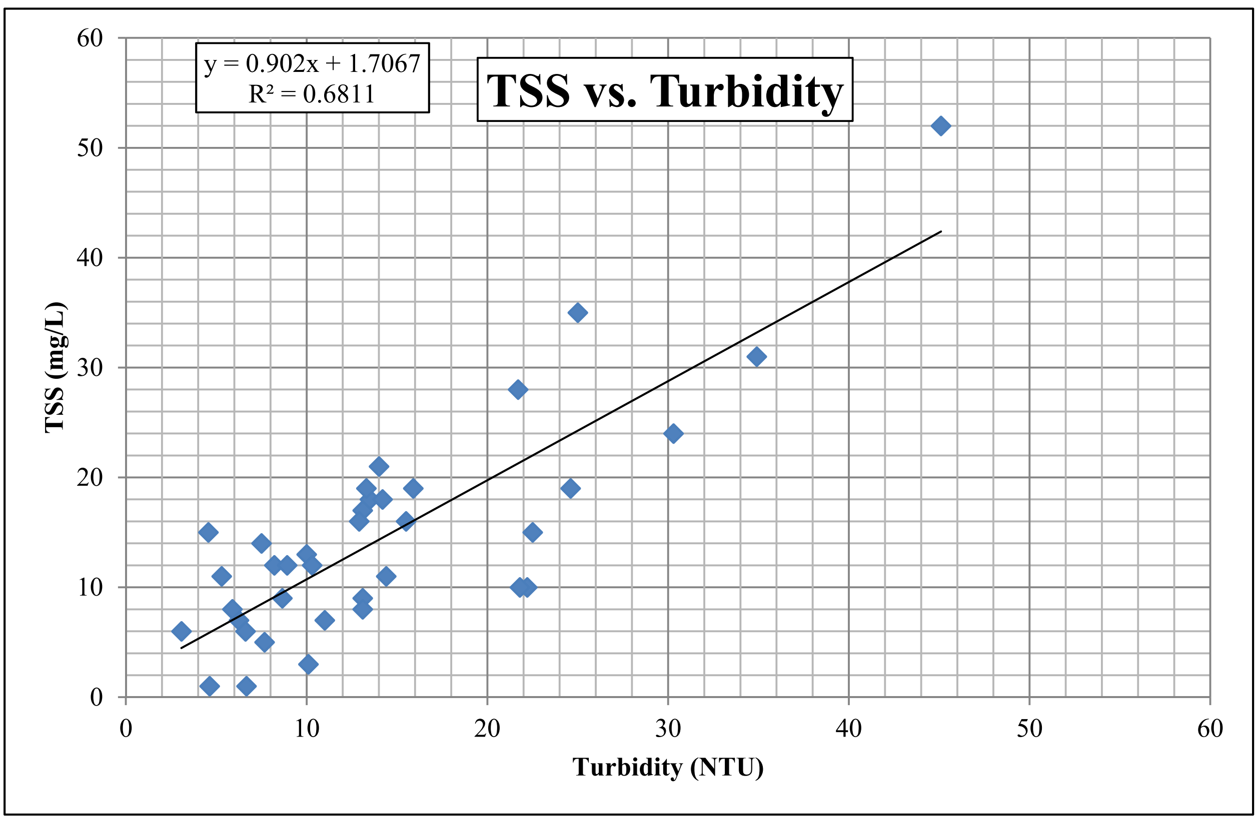
Temperature (˚C)	Correction Factor
17	1.0006
18	1.0004
19	1.0002
20	1
21	0.9998
22	0.9996
23	0.9993
24	0.9991
25	0.9988
26	0.9986
27	0.9983
28	0.998

2014-7 | Settling Curve



2014-7 | TSS and Turbidity





2014-7 | Bulk Density

Initial Concentration (g/L)=	96.5		Column Volume (in^3)=	15984.42		1 liter=	61.02 in^3
Specific Gravity=	2.64		Column Diameter (in)=	8		Column Height (in)=	79.5

Date	Test Time	C_s Avg (g/L)	Water Height (in)	Slurry Height (in)	V_t (in^3)	V_s (in^3)	V_t (L)	V_s (L)	Mass Settled (g)	Bulk Density (g/L)
7/14/2014	1h	0.00	79.375	77.375	15959	15557	973895	949356	93980864	98.99
	2h	0.32	79.375	75.5625	15959	15193	973895	927117	93965802	101.35
	4h	0.12	79.0625	72.3125	15896	14539	970061	887241	93601337	105.50
	6h	0.07	78.9375	65.625	15871	13195	968527	805189	93451099	116.06
	12h	0.05	78.5	59.6875	15783	12001	963159	732338	92934314	126.90
7/15/2014	1d	0.05	77.875	33.1875	15658	6673	955491	407195	92179718	226.38
7/16/2014	2d	0.02	76.5625	29.4375	15394	5919	939387	361185	90640522	250.95
7/17/2014	3d	0.01	75.5625	27.5	15193	5529	927117	337412	89461712	265.14
7/18/2014	4d	0.01	74.625	25.25	15004	5077	915615	309806	88348129	285.17
7/21/2014	7d	0.02	73.5	23.375	14778	4700	901811	286801	87009938	303.38
7/25/2014	11d	0.01	72.25	19.75	14527	3971	886474	242323	85538560	352.99
7/29/2014	15d	0.01	71.3125	18.3125	14338	3682	874972	224686	84428816	375.76

2014-7 | Testing Photos

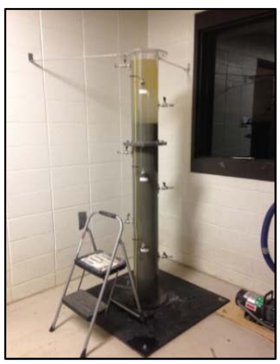
START

1 HOUR

2 HOUR

4 HOUR

6 HOUR



12 HOUR

1 DAY

2 DAY

3 DAY

7 DAY

11 DAY

15 DAY

2014-8

2014-8 | Engineering Properties

Sample ID	Project Location	GPS Coordinates	Test Start	Sample Type	Sample Source
2014-8	False River, LA	30°41'11.47" N 91°26'13.29" W	8/20/14	Grab	Eustis

Concentration (g/L)	Water Type	Salinity (ppt)	pH	Specific Gravity	Organic Content (%)
98	Site	0.20	6.90	2.64	3.8

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Grain Size Distribution		Bulk Density (g/L)	Resistivity (ohms)	Conductivity (mS)
			Fines (%)	Coarse (%)			
45	15	35	95	5	437	437	0.43

Site Vicinity Plan for 2014-8

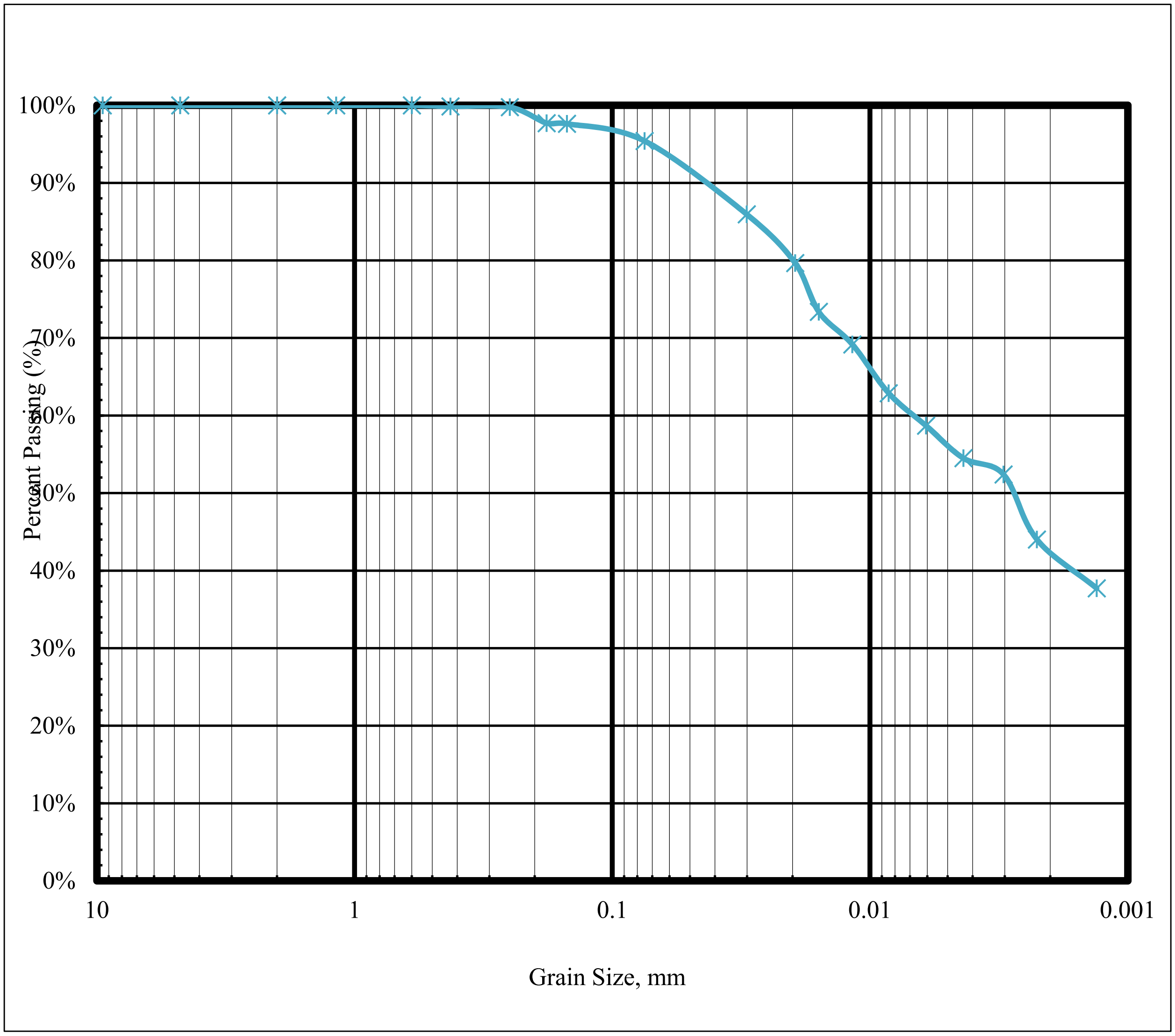
2014-8 | Hydrometer

Elapsed Time (min)	Temp Reading (C)	Composite Correction	Hydrometer Reading	Corrected Hydrometer Reading	Effective Depth (L, cm)	Value of K	Diameter of Particle Size (mm)	Percent Finer (%)
0.25	22.1	4	45					
2	22.2	4	44	40	9.7	0.01374	0.0303	83.85%
4	22.2	4	42	38	10.1	0.01374	0.0195	79.66%
8	22.2	4	39	35	10.6	0.01374	0.0158	73.37%
15	22.2	4	37	33	10.9	0.01374	0.0117	69.18%
30	22.1	4	34	30	11.4	0.01374	0.0085	62.89%
60	22.1	4	32	28	11.7	0.01374	0.0061	58.69%
120	22.2	4	30	26	12	0.01374	0.0043	54.50%
240	22.3	4	29	25	12.2	0.01374	0.0030	52.41%
480	22.2	4	25	21	12.9	0.01374	0.0023	44.02%
1440	22.3	4	22	18	13.3	0.01374	0.0013	37.73%

2014-8 | Sieve Analysis

Sieve Size	Particle Size (mm)	Cumulative Weight Retained (g)	Percent Retained	Percent Passing
3/8"	9.5000	0	0.00%	100.00%
#4	4.7500	0	0.00%	100.00%
#10	2.0000	0	0.00%	100.00%
#20	1.1800	0	0.00%	100.00%
#40	0.6000	0.07	0.14%	99.86%
#60	0.4250	0.12	0.24%	99.76%
#80	0.2500	0.15	0.30%	99.70%
#100	0.1800	0.19	0.38%	99.62%
#200	0.1500	0.65	1.30%	98.70%
Pan	0.0750	0.74	1.48%	98.52%

2014-8 | Grain Size Curve



% Fines	% Coarse
95	5

2014-8 | Atterberg Limits

	LL	LL	PL	PL
Container No.	A1	A2	A3	A4
Number of Blows	29	28		
Weight of Can (g)	13.70	13.70	13.69	13.86
Weight of Wet Soil + Can (g)	32.44	33.42	20.49	20.46
Weight of Dry Soil + Can (g)	26.71	27.36	19.60	19.56
Weight of Dry Soil (g)	13.01	13.66	5.91	5.70
Water Weight (g)	5.73	6.06	0.89	0.90
Moisture Content (%)	44.04	44.36	15.06	15.79
Correction Factor	1.02	1.014		
Corrected Percent	45	45		

Liquid Limit	Plastic Limit	Plasticity Index
45	15	30

2014-8 | Organic Content

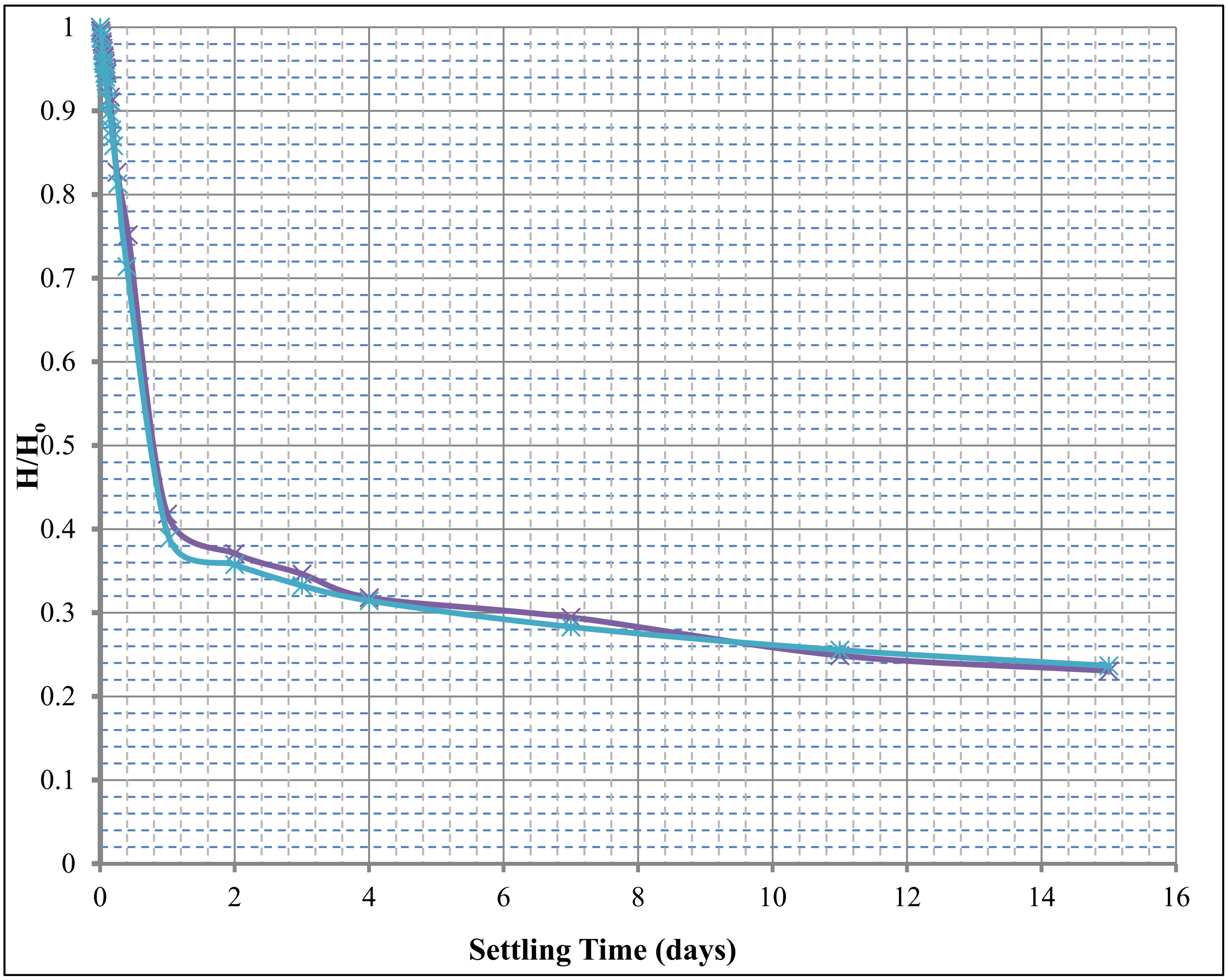
Dish Number	8
Weight of Dish with Cover (g)	126.97
Weight of Dish with Cover + Soil (g)	224.90
Weight of Dish with Cover + Ash (g)	221.16
Weight of Ash (g)	94.19
Weight of Soil (g)	97.93
Ash Content (%)	96.18
Organic Content (%)	3.8

2014-8 | Specific Gravity

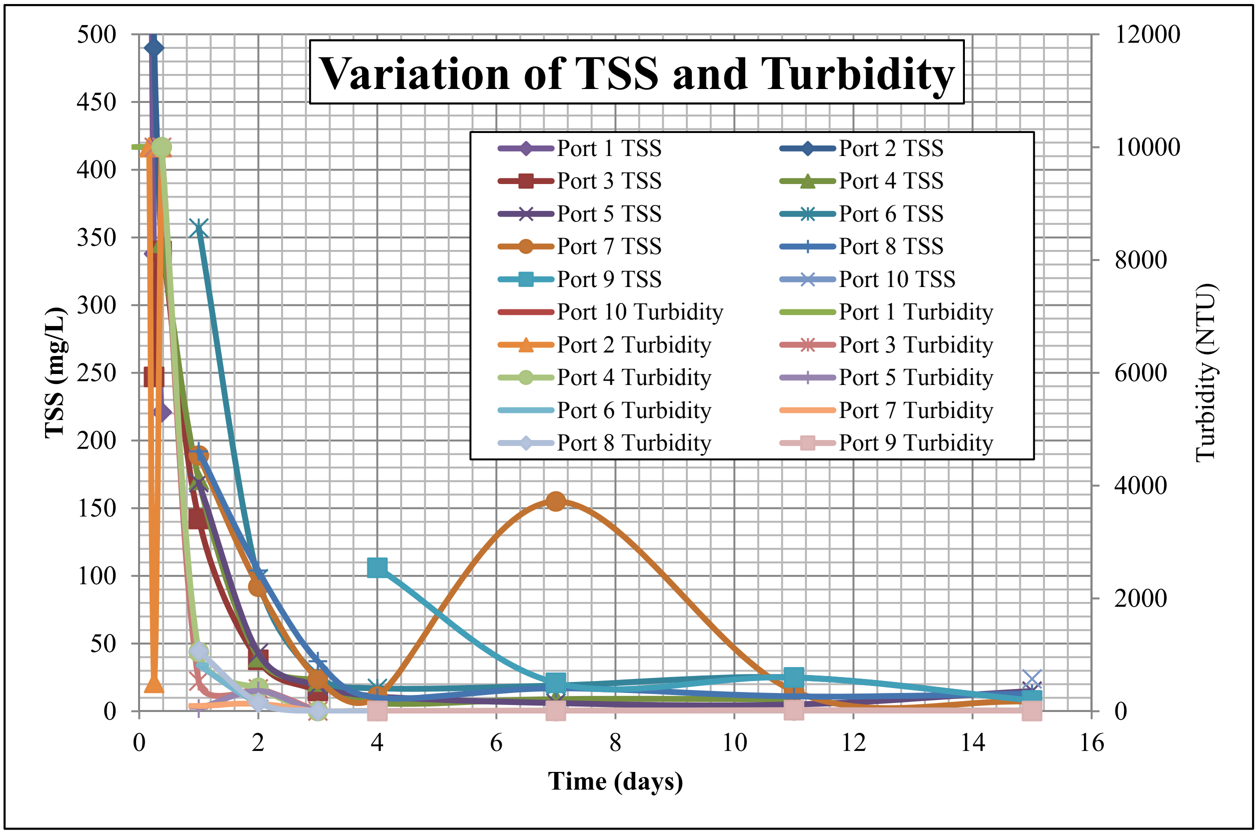
Flask Number	1
Temperature, T (˚C)	22
Weight of Flask, M_f (g)	203.89
Weight of Dry Soil, M_s (g)	56.46
Weight of Flask + Soil + Water, M_{fsw} (g)	736.29
Weight of Flask + Water, M_{fw} (g)	701.23
$M_{fw} – M_{fws} + M_s$ (g)	21.40
G_s (at T)	2.64
Correction Factor	0.9996
G_s (at 20˚C)	2.64

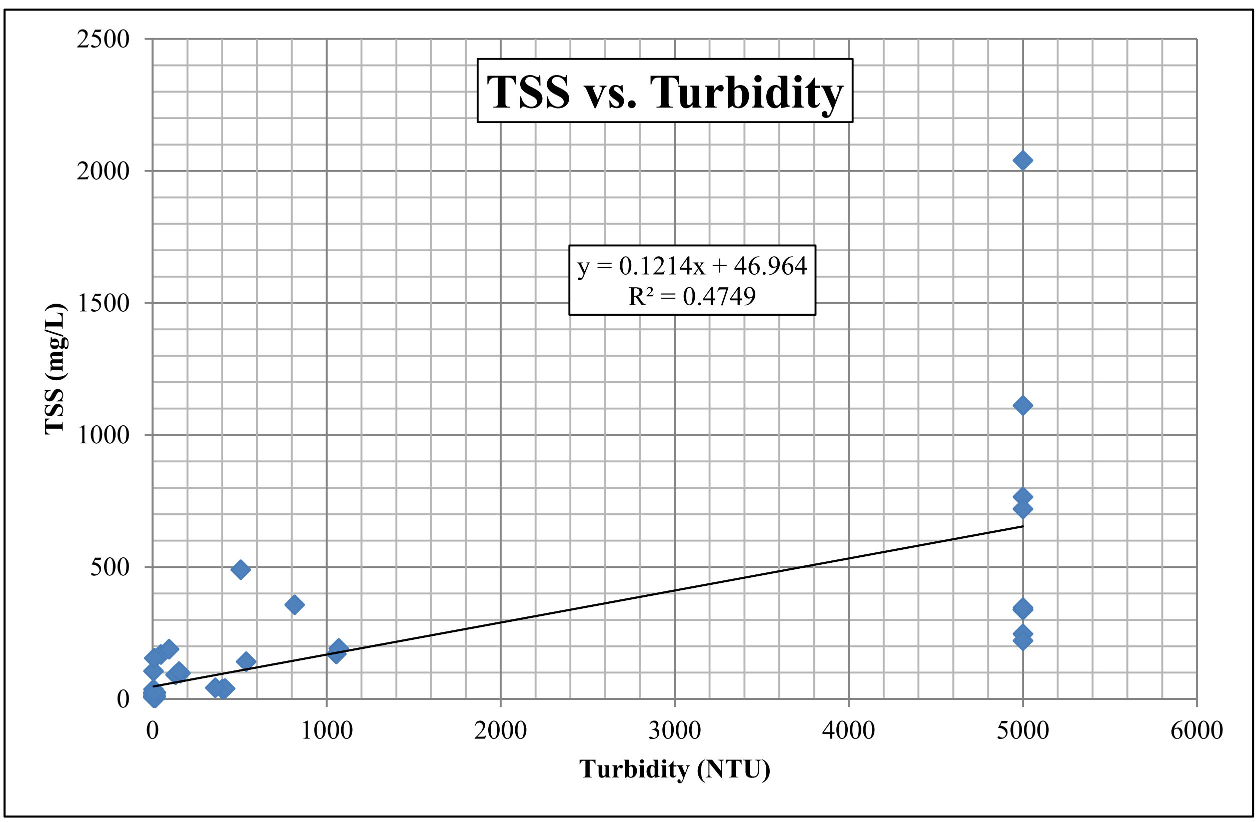
Temperature (˚C)	Correction Factor
17	1.0006
18	1.0004
19	1.0002
20	1
21	0.9998
22	0.9996
23	0.9993
24	0.9991
25	0.9988
26	0.9986
27	0.9983
28	0.998

2014-8 | Settling Curve



2014-8 | TSS and Turbidity





2014-8 | Bulk Density

Initial Concentration (g/L)=	98		Column Volume (in^3)=	15984.42		1 liter=	61.02 in^3
Specific Gravity=	2.64		Column Diameter (in)=	8		Column Height (in)=	79.5

Date	Test Time	C_s Avg (g/L)	Water Height (in)	Slurry Height (in)	V_t (in^3)	V_s (in^3)	V_t (L)	V_s (L)	Mass Settled (g)	Bulk Density (g/L)
8/20/2014	1h	2.0400	78.9375	76.3125	15871	15344	968527	936319	94849947	101.30
	2h	1.1120	78.75	74.375	15834	14954	966227	912547	94630506	103.70
	4h	0.7430	78.5625	69.75	15796	14024	963926	855801	94384407	110.29
	6h	0.3583	78.5625	64.625	15796	12994	963926	792919	94403467	119.06
	12h	0.3113	77.625	56.75	15607	11410	952423	696297	93257761	133.93
8/21/2014	1d	0.2033	76.875	30.9375	15457	6220	943221	379589	92321064	243.21
8/22/2014	2d	0.0692	75.625	28.4375	15205	5718	927884	348915	90892604	260.50
8/23/2014	3d	0.0238	74.75	26.4375	15029	5316	917148	324376	89866409	277.04
8/24/2014	4d	0.0268	73.8125	25	14841	5027	905646	306739	88737201	289.29
8/27/2014	7d	0.0378	72.8125	22.5	14640	4524	893376	276065	87527502	317.05
8/31/2014	11d	0.0148	71.875	20.3125	14451	4084	881873	249225	86414208	346.73
9/4/2014	15d	0.0122	70.9375	18.8125	14263	3782	870371	230821	85288547	369.50

2014-8 | Testing Photos

2 HOUR

4 HOUR

6 HOUR

12 HOUR

1 DAY

2 DAY

3 DAY

4 DAY

11 DAY

15 DAY

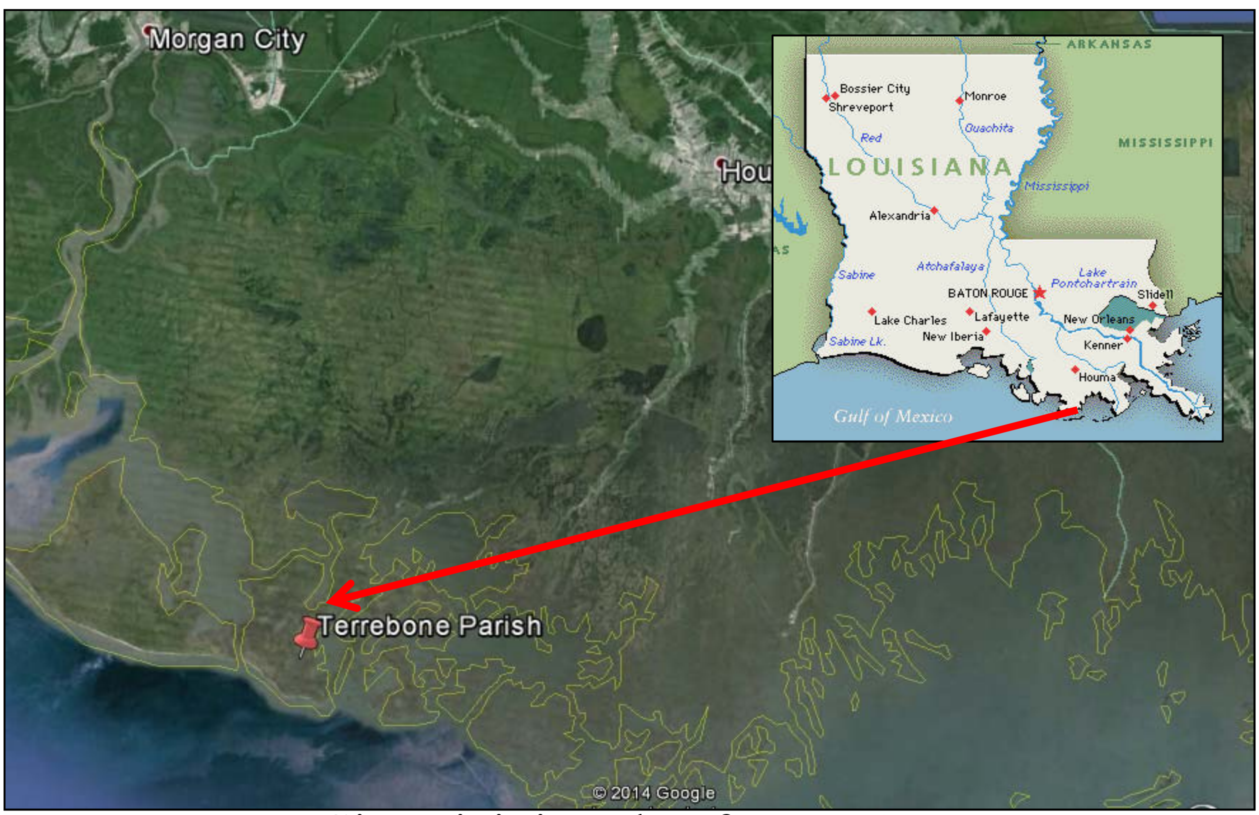
2014-9

2014-9 | Engineering Properties

Sample ID	Project Location	GPS Coordinates	Test Start	Sample Type	Sample Source
2014-9	Terrebonne Parish, LA	29°13'12.15"N 91° 4'46.26"W	9/5/14	Shelby Tubes	PSI

Concentration (g/L)	Water Type	Salinity (ppt)	pH	Specific Gravity	Organic Content (%)
98.6	Tap	0.30	7.11	2.65	3.1

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Grain Size Distribution		Bulk Density (g/L)	Resistivity (ohms)	Conductivity (mS)
			Fines (%)	Coarse (%)			
49	23	26	91	9	436	346	1.23



Site Vicinity Plan for 2014-9

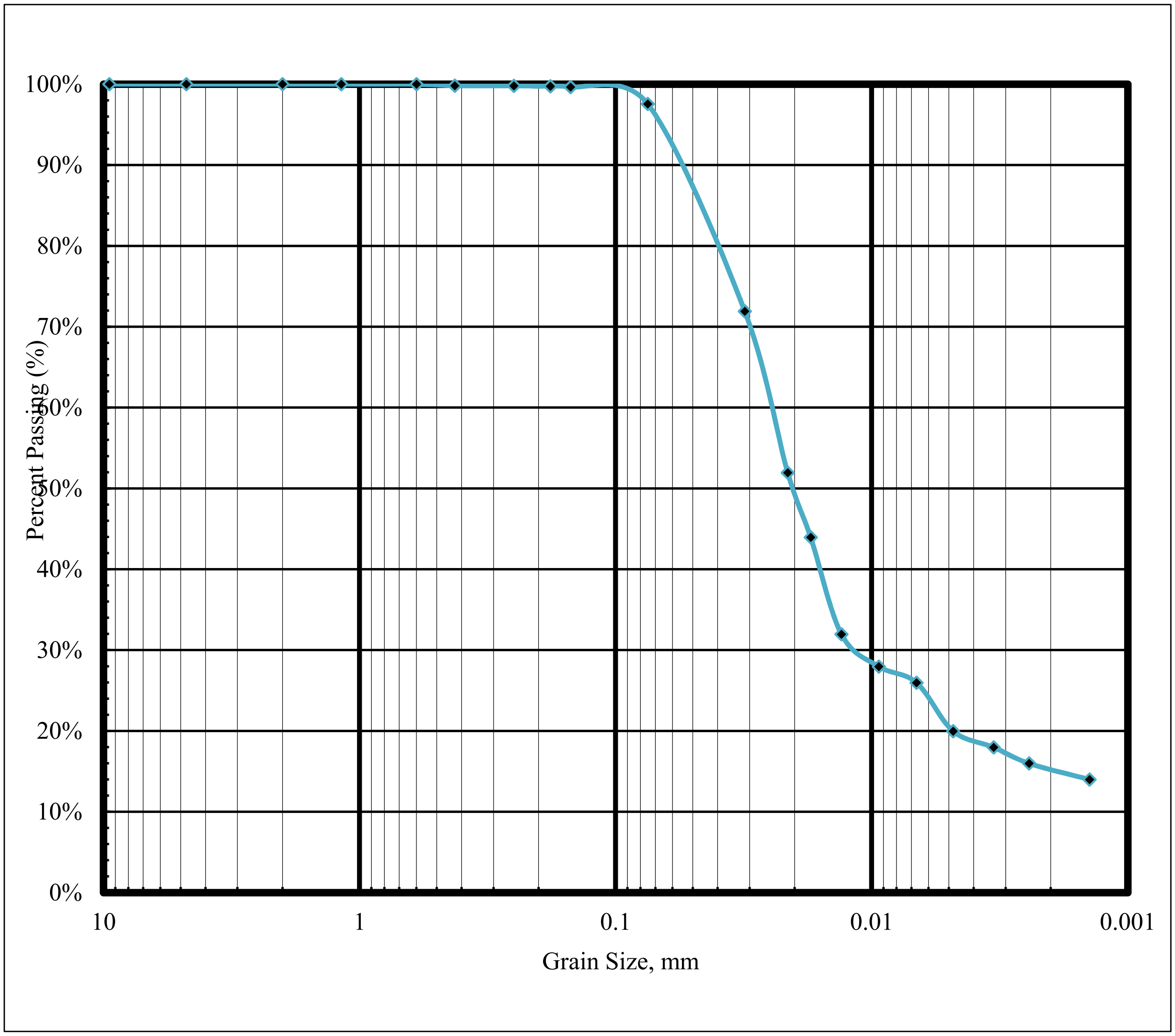
2014-9 | Hydrometer

Elapsed Time (min)	Temp Reading (C)	Composite Correction	Hydrometer Reading	Corrected Hydrometer Reading	Effective Depth (L, cm)	Value of K	Diameter of Particle Size (mm)	Percent Finer (%)
0.25	22.1	4	48	44	9.1	0.01374	0.0829	87.89%
2	22.1	4	40	36	10.4	0.01374	0.0313	71.91%
4	22.2	4	30	26	12	0.01374	0.0213	51.94%
8	22.2	4	26	22	12.7	0.01374	0.0173	43.95%
15	22.2	4	20	16	13.7	0.01374	0.0131	31.96%
30	22.2	4	18	14	14	0.01374	0.0094	27.97%
60	22.2	4	17	13	14.2	0.01374	0.0067	25.97%
120	22.3	4	14	10	14.7	0.01374	0.0048	19.98%
240	22.3	4	13	9	14.8	0.01374	0.0033	17.98%
480	22.2	4	12	8	15	0.01374	0.0024	15.98%
1440	22.2	4	11	7	15.2	0.01374	0.0014	13.98%

2014-9 | Sieve Analysis

Sieve Size	Particle Size (mm)	Cumulative Weight Retained (g)	Percent Retained	Percent Passing
3/8"	9.5000	0	0.00%	100.00%
#4	4.7500	0	0.00%	100.00%
#10	2.0000	0	0.00%	100.00%
#20	0.850	0	0.00%	100.00%
#40	0.4250	0.09	0.18%	99.82%
#60	0.25000	0.10	0.20%	99.80%
#80	0.1800	0.13	0.26%	99.74%
#100	0.1500	0.17	0.34%	99.66%
#200	0.0750	1.22	2.44%	97.56%
Pan		1.61	3.22%	96.78%

2014-9 | Grain Size Curve



% Fines	% Coarse
91	9

2014-9 | Atterberg Limits

	LL	LL	PL	PL
Container No.	A4	A3	L19	A1
Number of Blows	22	23		
Weight of Can (g)	13.86	13.69	13.79	13.81
Weight of Wet Soil + Can (g)	31.77	35.16	21.58	20.77
Weight of Dry Soil + Can (g)	25.78	28.08	20.16	19.48
Weight of Dry Soil (g)	11.92	11.39	6.37	5.67
Water Weight (g)	5.99	7.08	1.42	1.29
Moisture Content (%)	50.25	49.20	22.29	22.75
Correction Factor	0.985	0.990		
Corrected Percent	49	49		

Liquid Limit	Plastic Limit	Plasticity Index
49	23	26

2014-9 | Organic Content

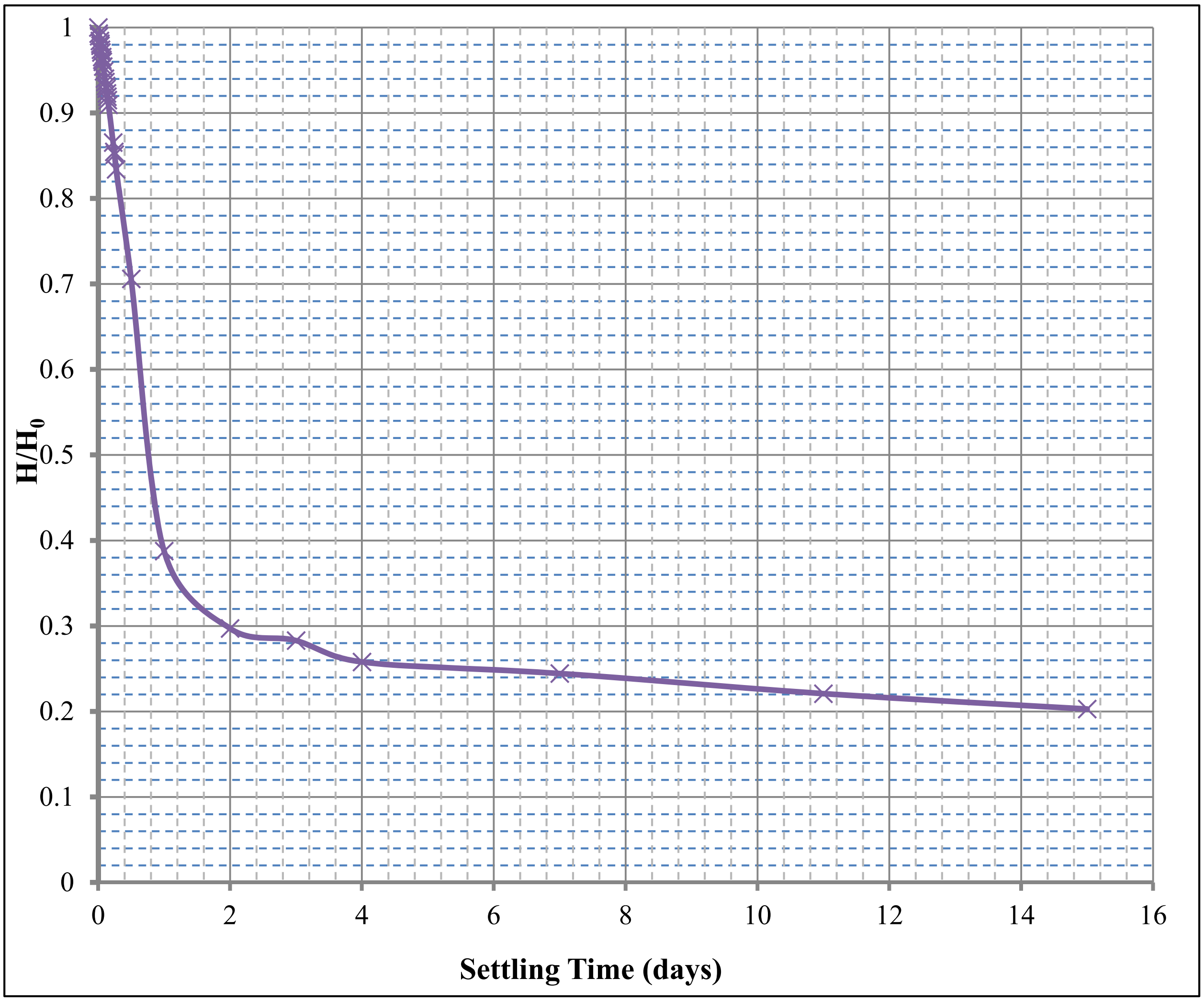
Dish Number	3
Weight of Dish with Cover (g)	340.82
Weight of Dish with Cover + Soil (g)	510.81
Weight of Dish with Cover + Ash (g)	505.52
Weight of Ash (g)	164.70
Weight of Soil (g)	169.99
Ash Content (%)	96.89
Organic Content (%)	3.1

2014-9 | Specific Gravity

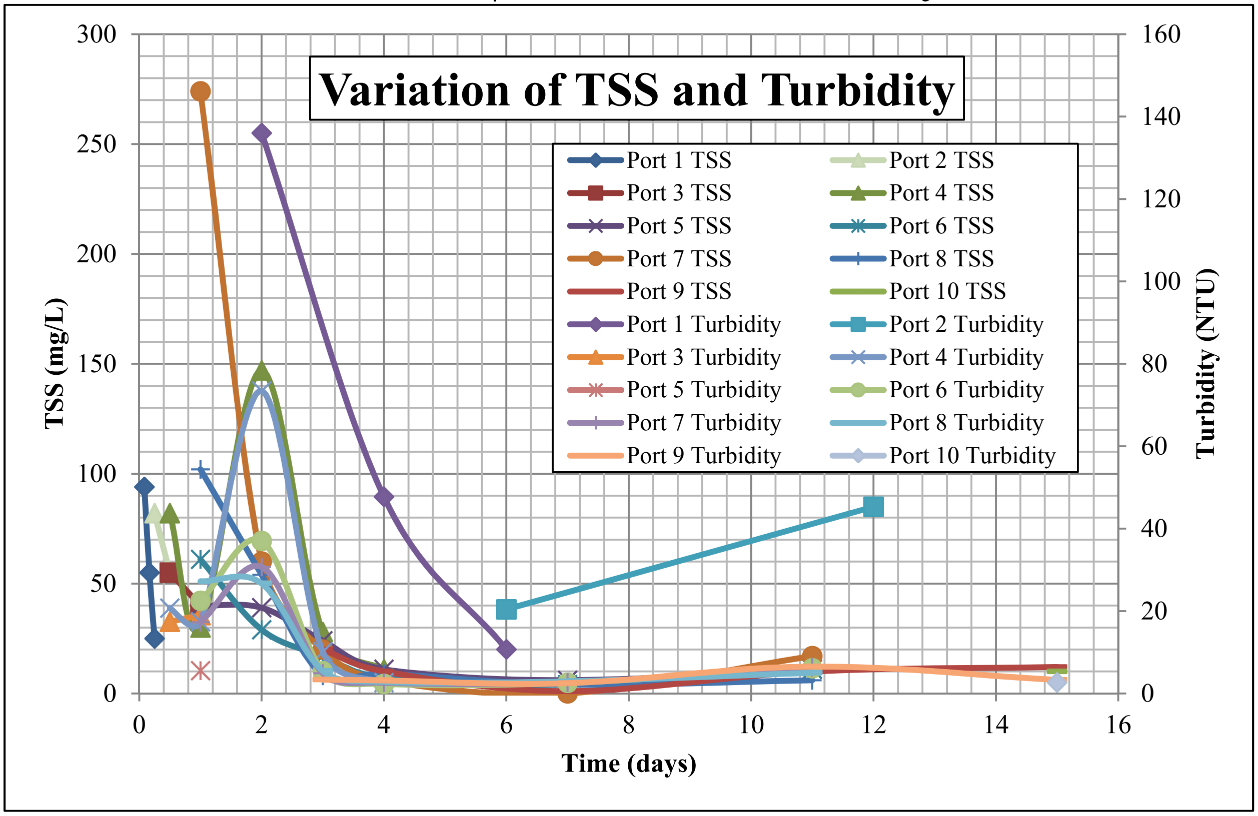
Flask Number	2
Temperature, T (˚C)	22.3
Weight of Flask, M_f (g)	203.89
Weight of Dry Soil, M_s (g)	59.49
Weight of Flask + Soil + Water, M_{fsw} (g)	738.40
Weight of Flask + Water, M_{fw} (g)	701.32
$M_{fw} – M_{fws} + M_s$ (g)	22.41
G_s (at T)	2.66
Correction Factor	0.9996
G_s (at 20˚C)	2.65

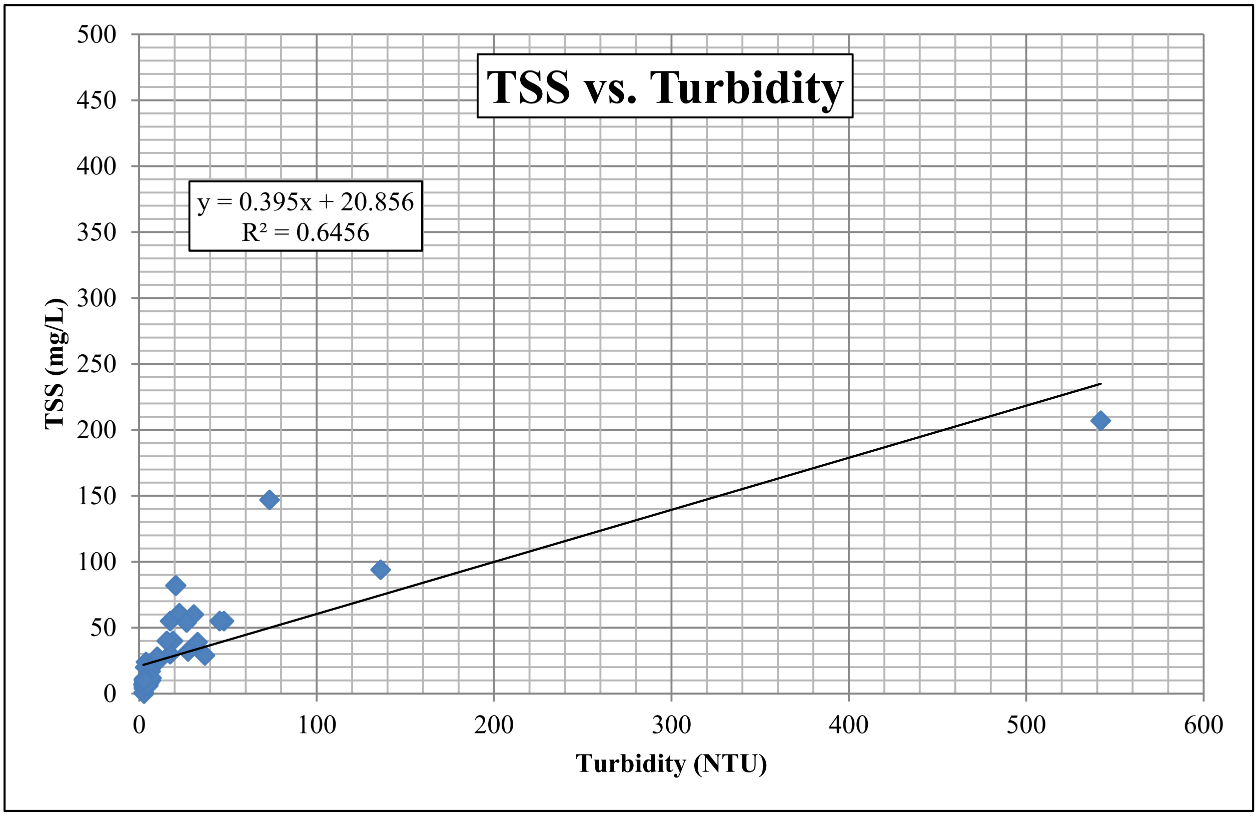
Temperature (˚C)	Correction Factor
17	1.0006
18	1.0004
19	1.0002
20	1
21	0.9998
22	0.9996
23	0.9993
24	0.9991
25	0.9988
26	0.9986
27	0.9983
28	0.998

2014-9 | Settling Curve



2014-9 | TSS and Turbidity





2014-9 | Bulk Density

Initial Concentration (g/L)=	98.6		Column Volume (in^3)=	15984.42		1 liter=	61.02 in^3
Specific Gravity=	2.65		Column Diameter (in)=	8		Column Height (in)=	79.5

Date	Test Time	C_s Avg (g/L)	Water Height (in)	Slurry Height (in)	V_t (in^3)	V_s (in^3)	V_t (L)	V_s (L)	Mass Settled (g)	Bulk Density (g/L)
9/5/2014	1h	0.00	79.125	77.4375	15909	15570	970828	950123	95971565	101.01
	2h	0.21	79.125	75.4375	15909	15168	970828	925584	95962200	103.68
	4h	0.09	78.8125	72.3125	15846	14539	966993	887241	95585034	107.73
	6h	0.07	78.4375	67.6875	15771	13609	962392	830495	95128654	114.54
	12h	0.05	78.25	56.125	15733	11285	960092	688628	94895541	137.80
9/6/2014	1d	0.09	77.5	30.8125	15582	6195	950890	378055	93948362	248.50
9/7/2014	2d	0.06	76	23.625	15281	4750	932485	289868	92142555	317.88
9/8/2014	3d	0.02	74.9375	22.5	15067	4524	919449	276065	90879955	329.20
9/9/2014	4d	0.01	74	20.5	14879	4122	907946	251526	89749490	356.82
9/12/2014	7d	0.00	76.125	19.4375	15306	3908	934019	238489	92329935	387.15
9/16/2014	11d	0.01	72	17.5625	14476	3531	883407	215484	87322117	405.24
9/20/2014	15d	0.01	71.0625	16.125	14288	3242	871904	197846	86186855	435.63

2014-9 | Testing Photos


START


1 HOUR


2 HOUR


4 HOUR


6 HOUR


1 DAY


2 DAY


3 DAY


4 DAY


7 DAY


11 DAY

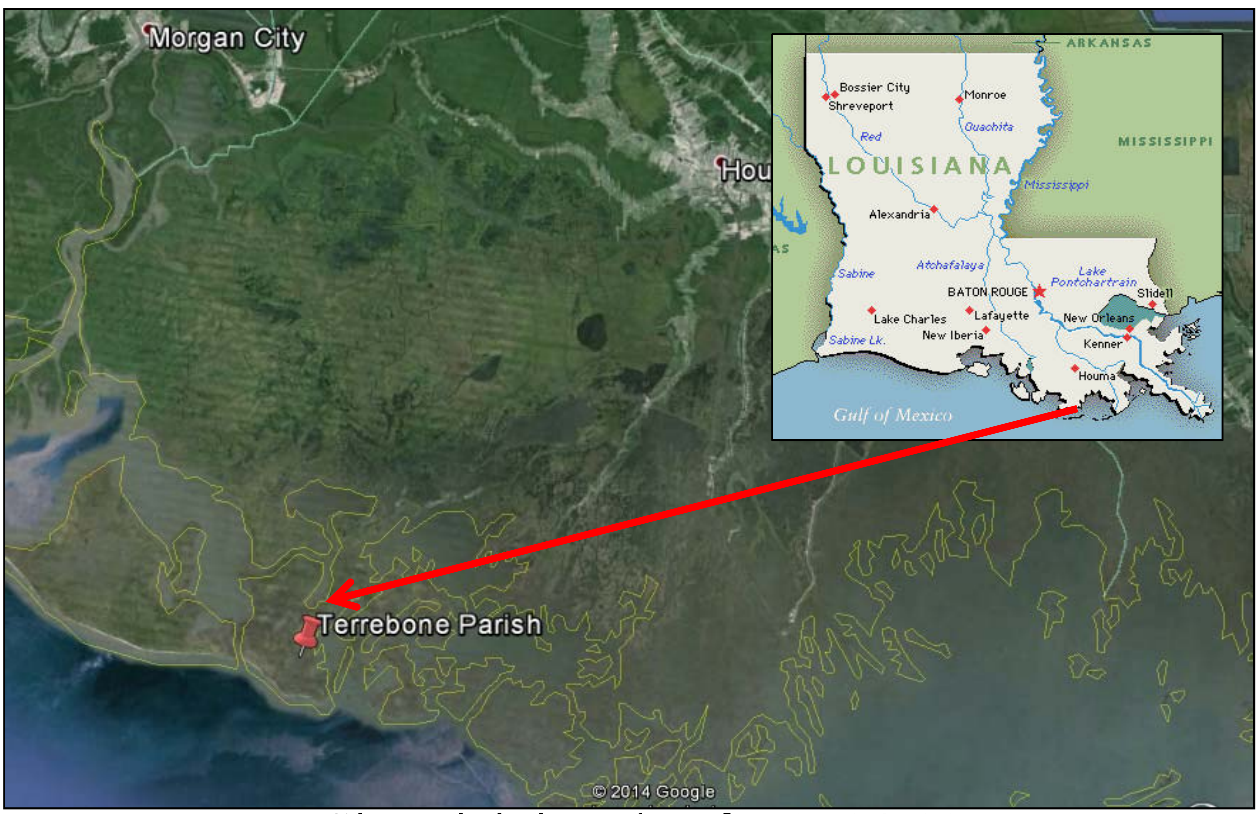
2014-10

2014-10 | Engineering Properties

Sample ID	Project Location	GPS Coordinates	Test Start	Sample Type	Sample Source
2014-10	Terrebonne Parish, LA	29°13'12.15"N 91° 4'46.26"W	9/22/14	Shelby Tubes	PSI

Concentration (g/L)	Water Type	Salinity (ppt)	pH	Specific Gravity	Organic Content (%)
97.7	Site	2.5	7.46	2.65	3.1

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Grain Size Distribution		Bulk Density (g/L)	Resistivity (ohms)	Conductivity (mS)
			Fines (%)	Coarse (%)			
49	23	26	91	9	462	118	4.36



Site Vicinity Plan for 2014-10

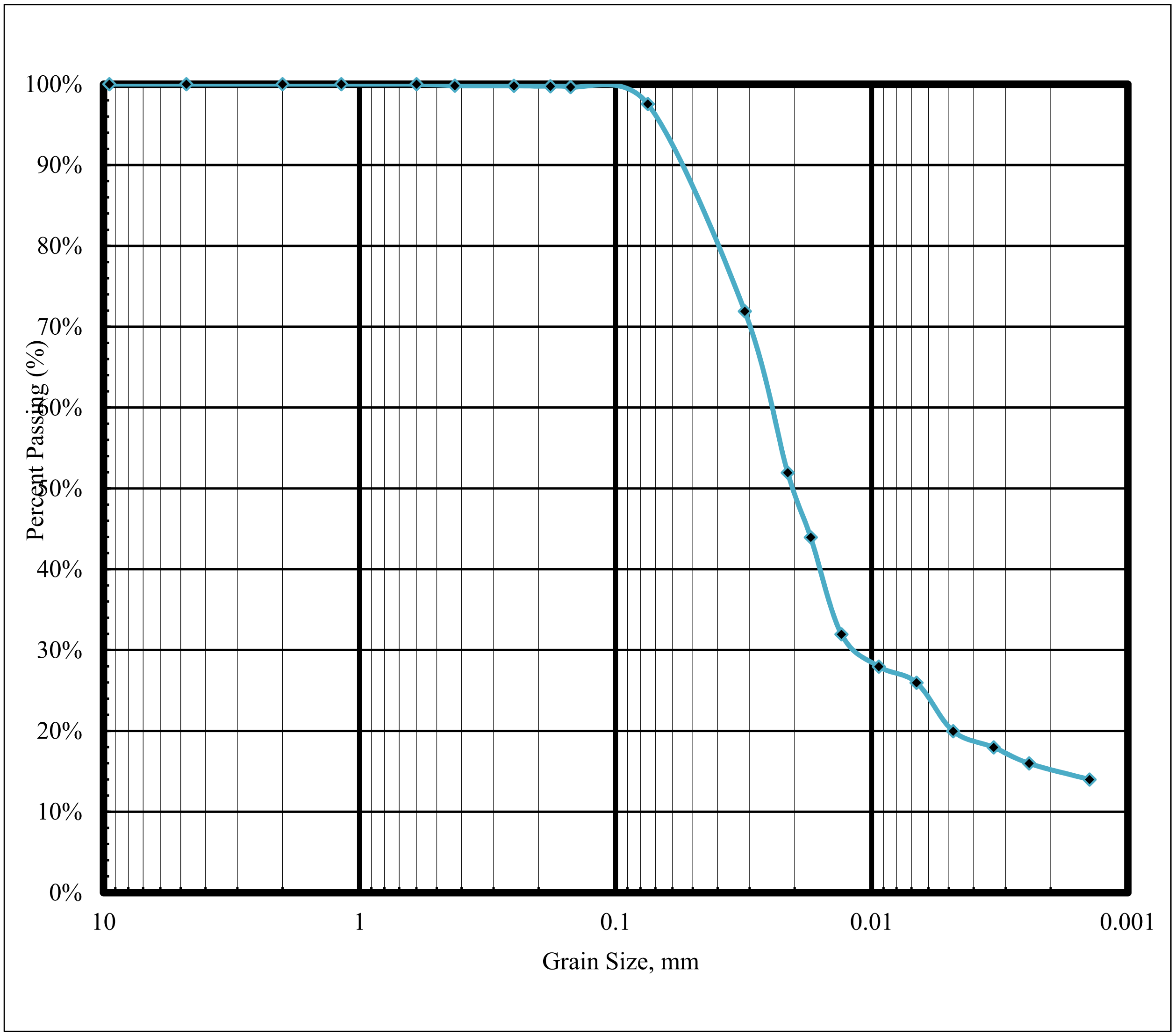
2014-10 | Hydrometer

Elapsed Time (min)	Temp Reading (C)	Composite Correction	Hydrometer Reading	Corrected Hydrometer Reading	Effective Depth (L, cm)	Value of K	Diameter of Particle Size (mm)	Percent Finer (%)
0.25	22.1	4	48	44	9.1	0.01374	0.0829	87.89%
2	22.1	4	40	36	10.4	0.01374	0.0313	71.91%
4	22.2	4	30	26	12	0.01374	0.0213	51.94%
8	22.2	4	26	22	12.7	0.01374	0.0173	43.95%
15	22.2	4	20	16	13.7	0.01374	0.0131	31.96%
30	22.2	4	18	14	14	0.01374	0.0094	27.97%
60	22.2	4	17	13	14.2	0.01374	0.0067	25.97%
120	22.3	4	14	10	14.7	0.01374	0.0048	19.98%
240	22.3	4	13	9	14.8	0.01374	0.0033	17.98%
480	22.2	4	12	8	15	0.01374	0.0024	15.98%
1440	22.2	4	11	7	15.2	0.01374	0.0014	13.98%

2014-10 | Sieve Analysis

Sieve Size	Particle Size (mm)	Cumulative Weight Retained (g)	Percent Retained	Percent Passing
3/8"	9.5000	0	0.00%	100.00%
#4	4.7500	0	0.00%	100.00%
#10	2.0000	0	0.00%	100.00%
#20	0.850	0	0.00%	100.00%
#40	0.4250	0.09	0.18%	99.82%
#60	0.25000	0.10	0.20%	99.80%
#80	0.1800	0.13	0.26%	99.74%
#100	0.1500	0.17	0.34%	99.66%
#200	0.0750	1.22	2.44%	97.56%
Pan		1.61	3.22%	96.78%

2014-10 | Grain Size Curve



% Fines	% Coarse
91	9

2014-10 | Atterberg Limits

	LL	LL	PL	PL
Container No.	A4	A3	L19	A1
Number of Blows	22	23		
Weight of Can (g)	13.86	13.69	13.79	13.81
Weight of Wet Soil + Can (g)	31.77	35.16	21.58	20.77
Weight of Dry Soil + Can (g)	25.78	28.08	20.16	19.48
Weight of Dry Soil (g)	11.92	11.39	6.37	5.67
Water Weight (g)	5.99	7.08	1.42	1.29
Moisture Content (%)	50.25	49.20	22.29	22.75
Correction Factor	0.985	0.990		
Corrected Percent	49	49		

Liquid Limit	Plastic Limit	Plasticity Index
49	23	26

2014-10 | Organic Content

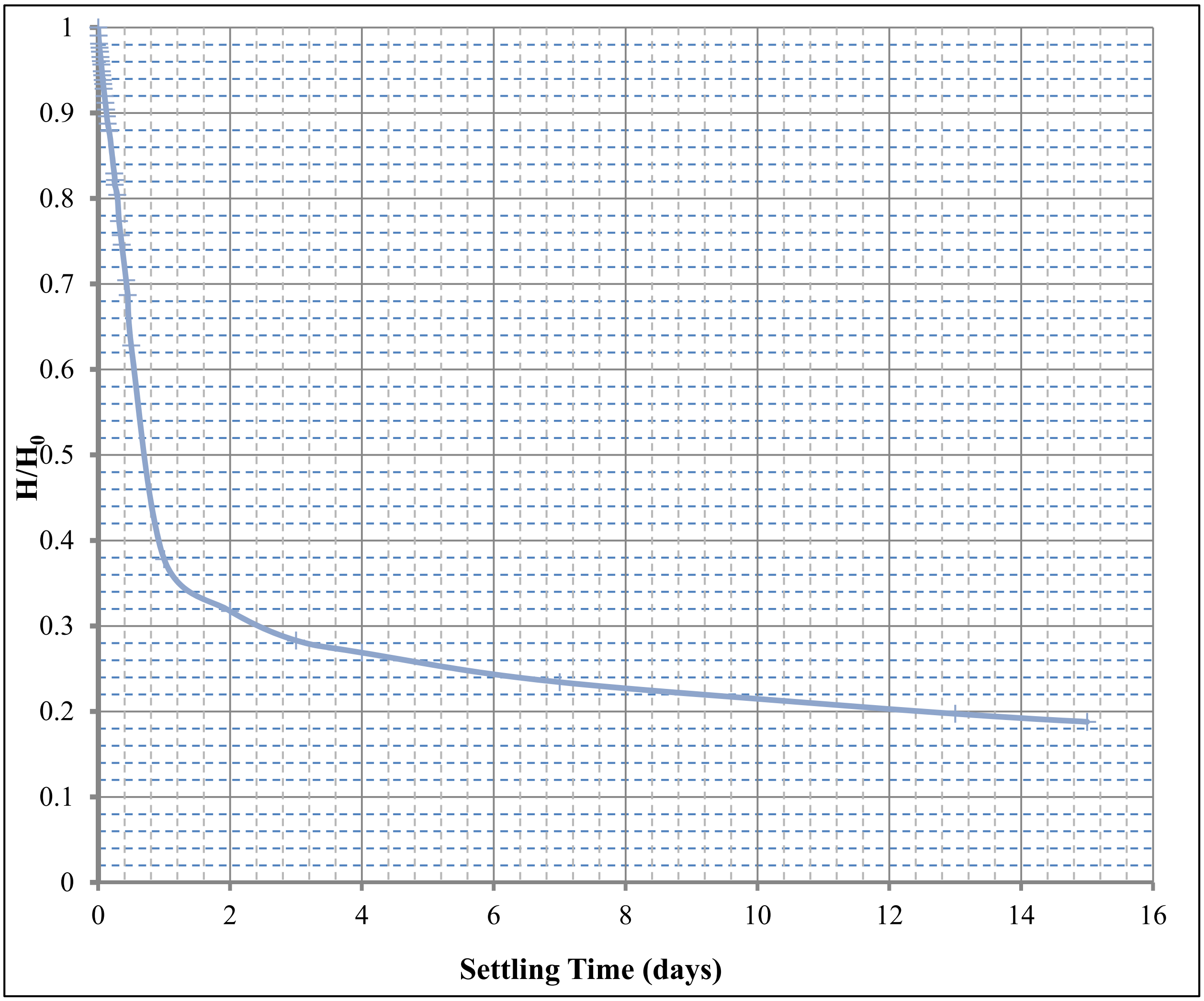
Dish Number	3
Weight of Dish with Cover (g)	340.82
Weight of Dish with Cover + Soil (g)	510.81
Weight of Dish with Cover + Ash (g)	505.52
Weight of Ash (g)	164.70
Weight of Soil (g)	169.99
Ash Content (%)	96.89
Organic Content (%)	3.1

2014-10 | Specific Gravity

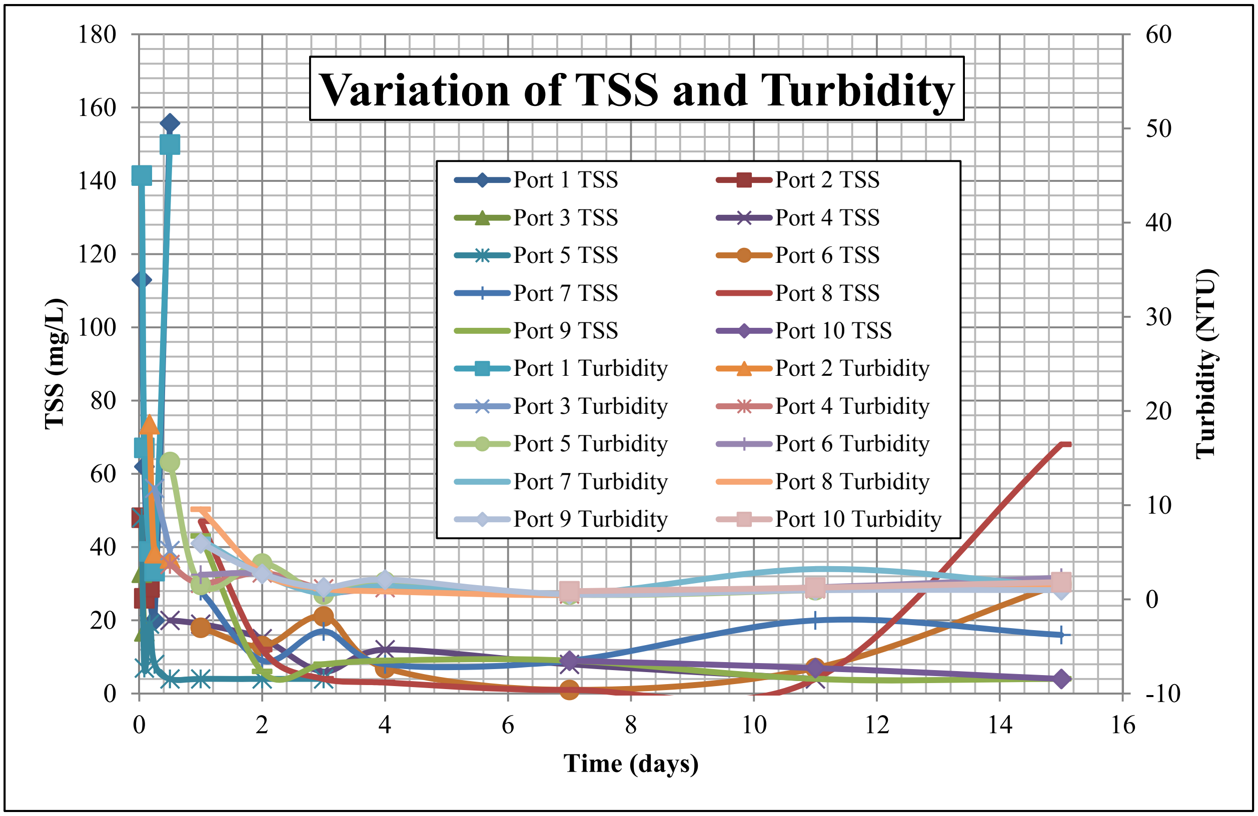
Flask Number	2
Temperature, T (˚C)	22.3
Weight of Flask, M_f (g)	203.89
Weight of Dry Soil, M_s (g)	59.49
Weight of Flask + Soil + Water, M_{fsw} (g)	738.40
Weight of Flask + Water, M_{fw} (g)	701.32
$M_{fw} – M_{fws} + M_s$ (g)	22.41
G_s (at T)	2.66
Correction Factor	0.9996
G_s (at 20˚C)	2.65

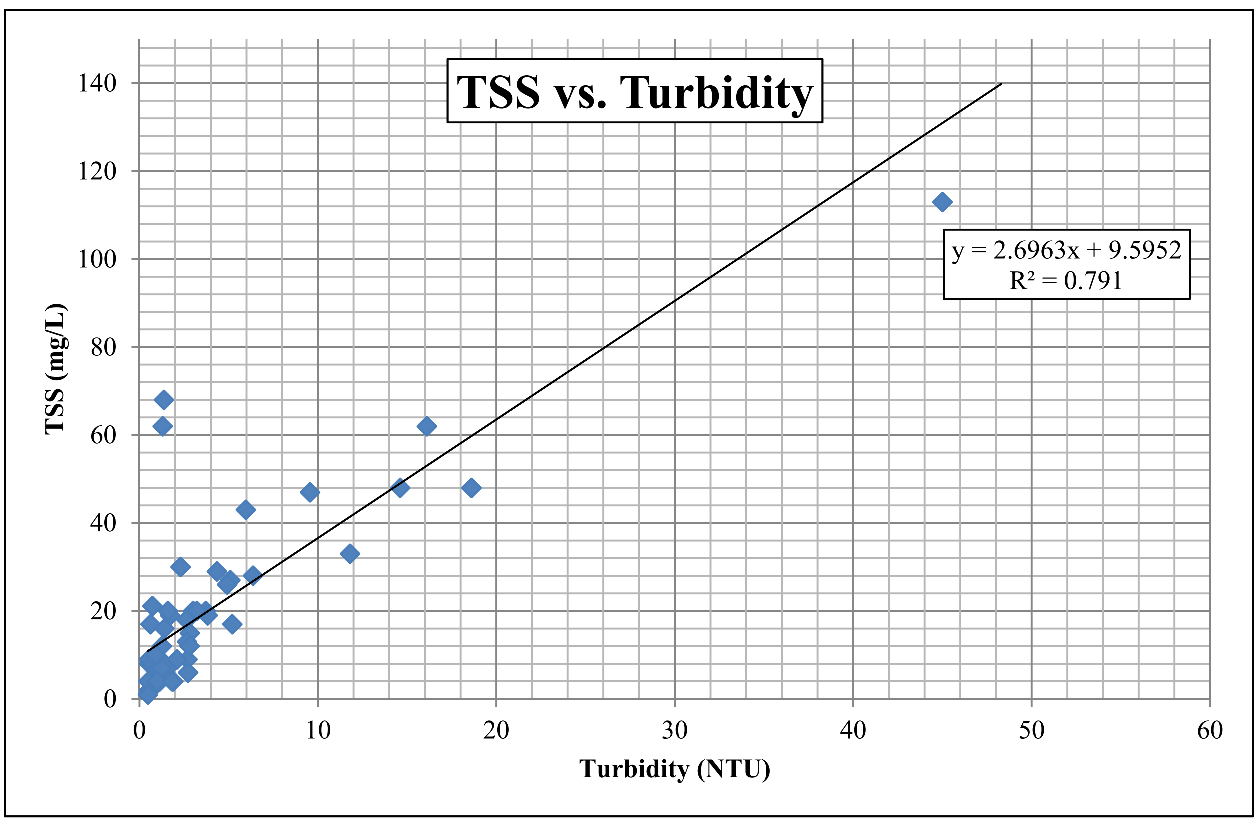
Temperature (˚C)	Correction Factor
17	1.0006
18	1.0004
19	1.0002
20	1
21	0.9998
22	0.9996
23	0.9993
24	0.9991
25	0.9988
26	0.9986
27	0.9983
28	0.998

2014-10 | Settling Curve



2014-10 | TSS and Turbidity





2014-10 | Bulk Density

Initial Concentration (g/L)=	97.7		Column Volume (in^3)=	15984.42		1 liter=	61.02 in^3
Specific Gravity=	2.65		Column Diameter (in)=	8		Column Height (in)=	79.5

Date	Test Time	C_s Avg (g/L)	Water Height (in)	Slurry Height (in)	V_t (in^3)	V_s (in^3)	V_t (L)	V_s (L)	Mass Settled (g)	Bulk Density (g/L)
9/21/2014	1h	0.11	79.0625	76.375	15896	15356	970061	937086	94965220	101.34
	2h	0.06	78.75	73.8125	15834	14841	966227	905646	94589819	104.44
	4h	0.04	78.625	69.875	15808	14049	964693	857334	94439400	110.15
	6h	0.03	78.1875	64.875	15721	13044	959325	795987	93913605	117.98
	12h	0.05	77.5	49.9375	15582	10041	950890	612710	93073847	151.91
9/22/2014	1d	0.03	76.5625	30.0625	15394	6044	939387	368853	91950571	249.29
9/23/2014	2d	0.01	75.5	25.25	15180	5077	926350	309806	90682109	292.71
9/24/2014	3d	0.01	74.5	22.5	14979	4524	914081	276065	89481708	324.13
9/25/2014	4d	0.01	73.5625	21.375	14791	4298	902578	262261	88357822	336.91
9/28/2014	7d	0.01	72.5625	18.625	14590	3745	890309	228520	87157582	381.40
10/2/2014	11d	0.02	71.8125	15.6875	14439	3154	881107	192478	86248051	448.09
10/6/2014	15d	0.02	70.5	14.9375	14175	3003	865003	183276	84667637	461.97

2014-10 | Testing Photos


1 HOUR


2 HOUR


4 HOUR


6 HOUR


12 HOUR


2 DAY


3 DAY


4 DAY


7 DAY


11 DAY


15 DAY

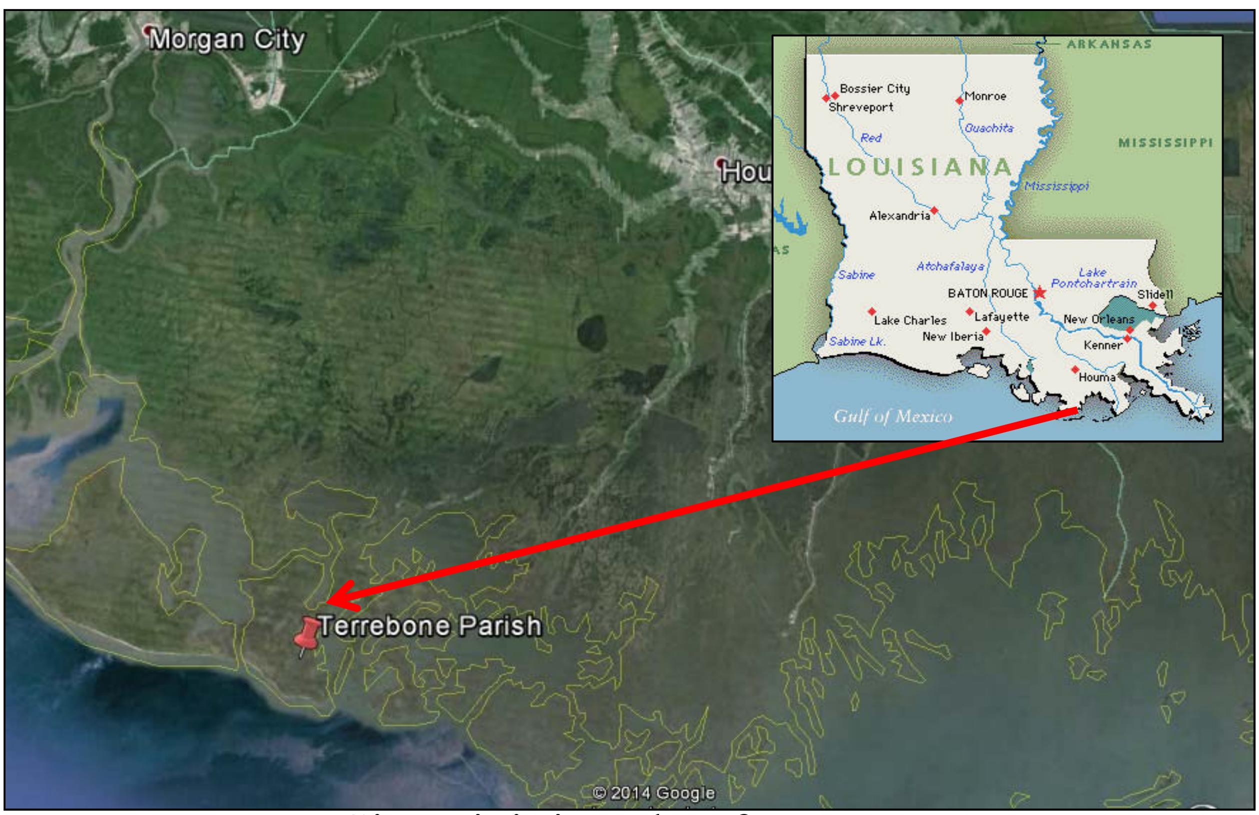
2014-11

2014-11 | Engineering Properties

Sample ID	Project Location	GPS Coordinates	Test Start	Sample Type	Sample Source
2014-11	Terrebonne Parish, LA	29°13'12.15"N 91° 4'46.26"W	10/8/14	Shelby Tubes	PSI

Concentration (g/L)	Water Type	Salinity (ppt)	pH	Specific Gravity	Organic Content (%)
98.4	Com-posite	1 ppt	7.56	2.65	3.1

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Grain Size Distribution		Bulk Density (g/L)	Resistivity (ohms)	Conductivity (mS)
			Fines (%)	Coarse (%)			
49	23	26	91	9	381	475	3.83



Site Vicinity Plan for 2014-11

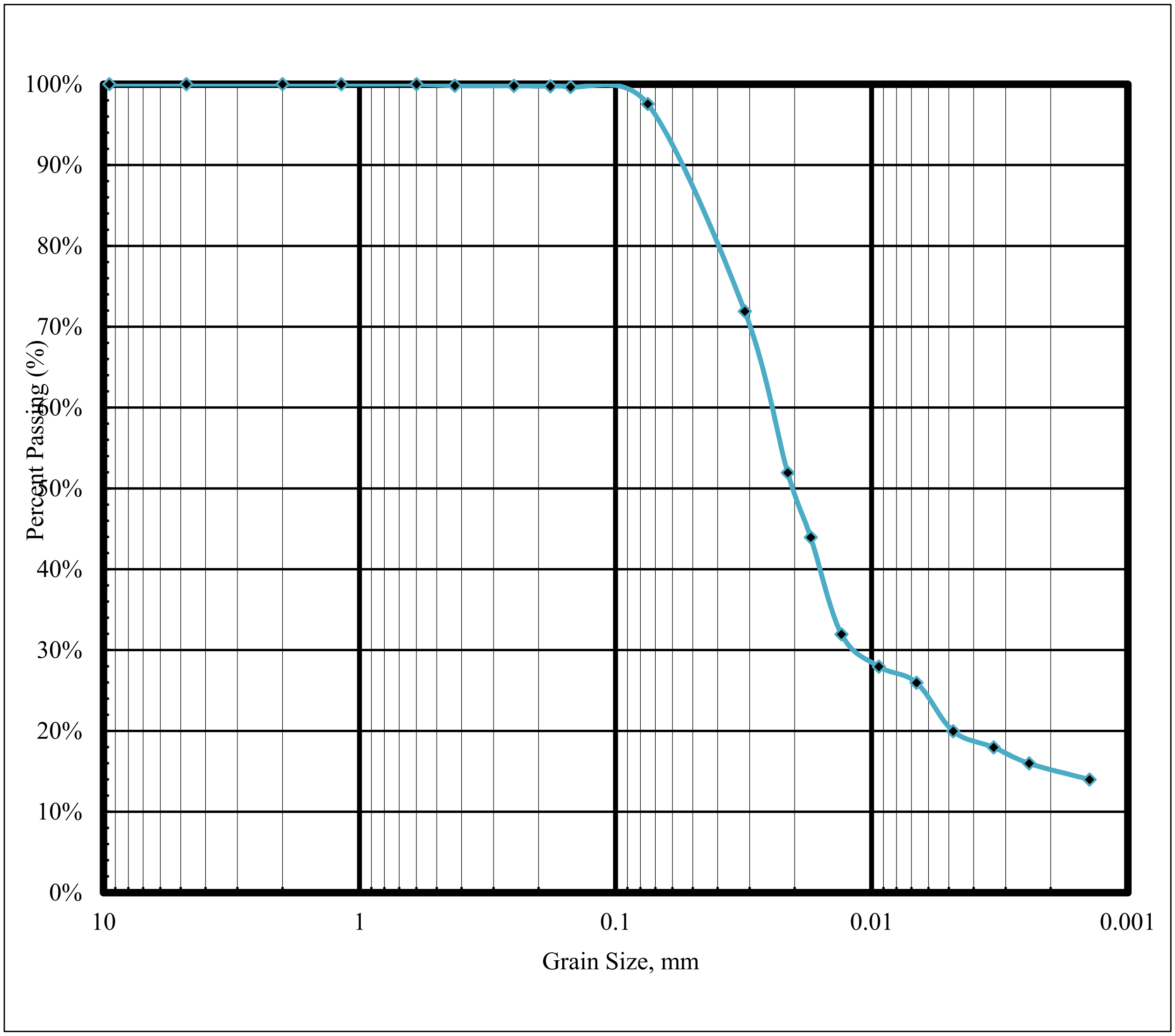
2014-11 | Hydrometer

Elapsed Time (min)	Temp Reading (C)	Composite Correction	Hydrometer Reading	Corrected Hydrometer Reading	Effective Depth (L, cm)	Value of K	Diameter of Particle Size (mm)	Percent Finer (%)
0.25	22.1	4	48	44	9.1	0.01374	0.0829	87.89%
2	22.1	4	40	36	10.4	0.01374	0.0313	71.91%
4	22.2	4	30	26	12	0.01374	0.0213	51.94%
8	22.2	4	26	22	12.7	0.01374	0.0173	43.95%
15	22.2	4	20	16	13.7	0.01374	0.0131	31.96%
30	22.2	4	18	14	14	0.01374	0.0094	27.97%
60	22.2	4	17	13	14.2	0.01374	0.0067	25.97%
120	22.3	4	14	10	14.7	0.01374	0.0048	19.98%
240	22.3	4	13	9	14.8	0.01374	0.0033	17.98%
480	22.2	4	12	8	15	0.01374	0.0024	15.98%
1440	22.2	4	11	7	15.2	0.01374	0.0014	13.98%

2014-11 | Sieve Analysis

Sieve Size	Particle Size (mm)	Cumulative Weight Retained (g)	Percent Retained	Percent Passing
3/8"	9.5000	0	0.00%	100.00%
#4	4.7500	0	0.00%	100.00%
#10	2.0000	0	0.00%	100.00%
#20	0.850	0	0.00%	100.00%
#40	0.4250	0.09	0.18%	99.82%
#60	0.25000	0.10	0.20%	99.80%
#80	0.1800	0.13	0.26%	99.74%
#100	0.1500	0.17	0.34%	99.66%
#200	0.0750	1.22	2.44%	97.56%
Pan		1.61	3.22%	96.78%

2014-11 | Grain Size Curve



% Fines	% Coarse
91	9

2014-11 | Atterberg Limits

	LL	LL	PL	PL
Container No.	A4	A3	L19	A1
Number of Blows	22	23		
Weight of Can (g)	13.86	13.69	13.79	13.81
Weight of Wet Soil + Can (g)	31.77	35.16	21.58	20.77
Weight of Dry Soil + Can (g)	25.78	28.08	20.16	19.48
Weight of Dry Soil (g)	11.92	11.39	6.37	5.67
Water Weight (g)	5.99	7.08	1.42	1.29
Moisture Content (%)	50.25	49.20	22.29	22.75
Correction Factor	0.985	0.990		
Corrected Percent	49	49		

Liquid Limit	Plastic Limit	Plasticity Index
49	23	26

2014-11 | Organic Content

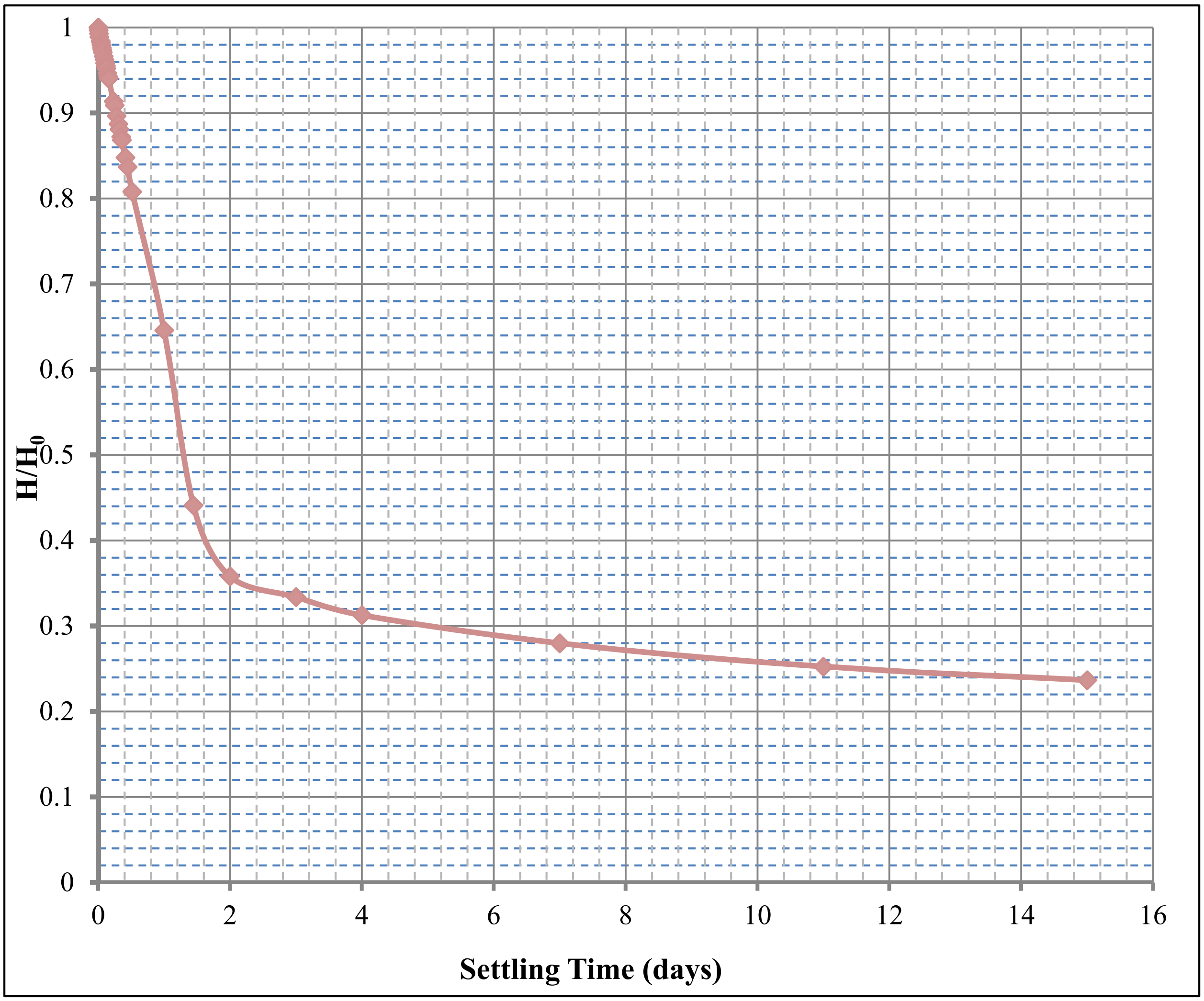
Dish Number	3
Weight of Dish with Cover (g)	340.82
Weight of Dish with Cover + Soil (g)	510.81
Weight of Dish with Cover + Ash (g)	505.52
Weight of Ash (g)	164.70
Weight of Soil (g)	169.99
Ash Content (%)	96.89
Organic Content (%)	3.1

2014-11 | Specific Gravity

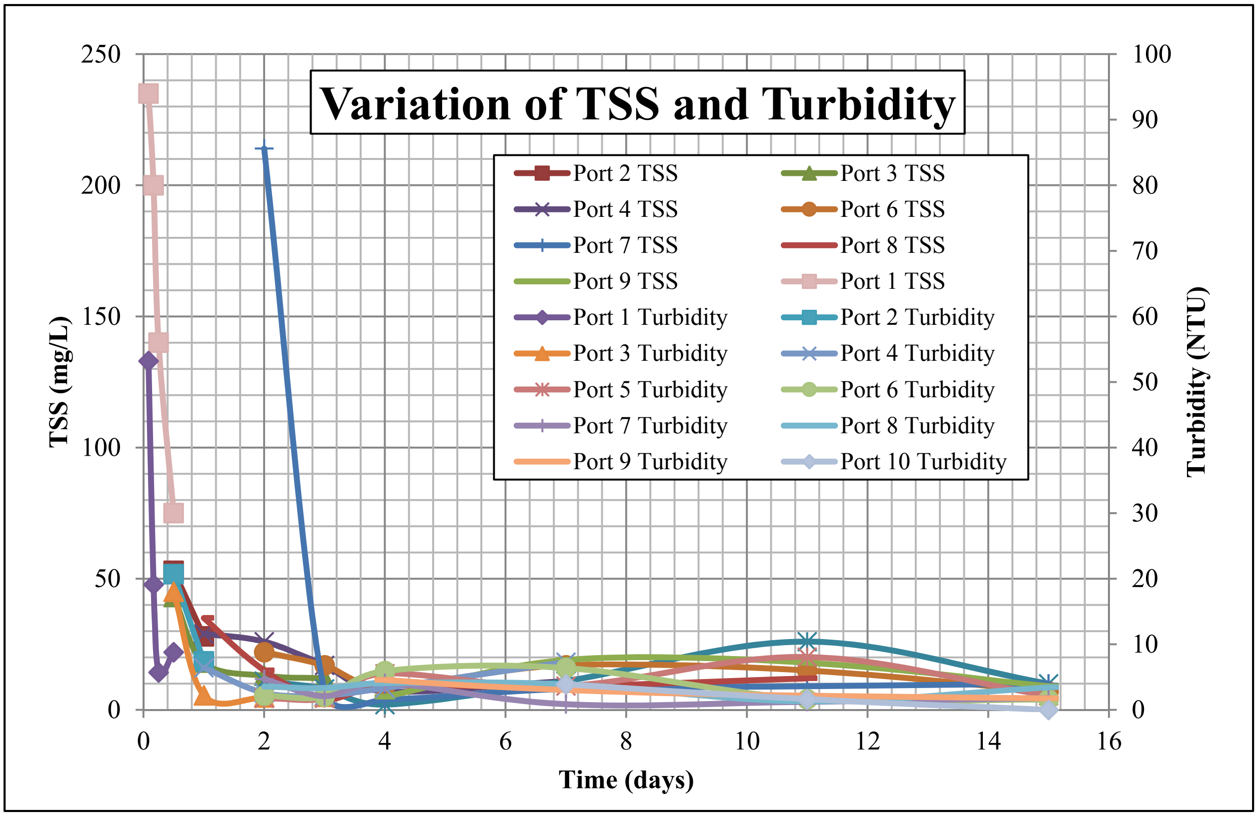
Flask Number	2
Temperature, T (˚C)	22.3
Weight of Flask, M_f (g)	203.89
Weight of Dry Soil, M_s (g)	59.49
Weight of Flask + Soil + Water, M_{fsw} (g)	738.40
Weight of Flask + Water, M_{fw} (g)	701.32
$M_{fw} – M_{fws} + M_s$ (g)	22.41
G_s (at T)	2.66
Correction Factor	0.9996
G_s (at 20˚C)	2.65

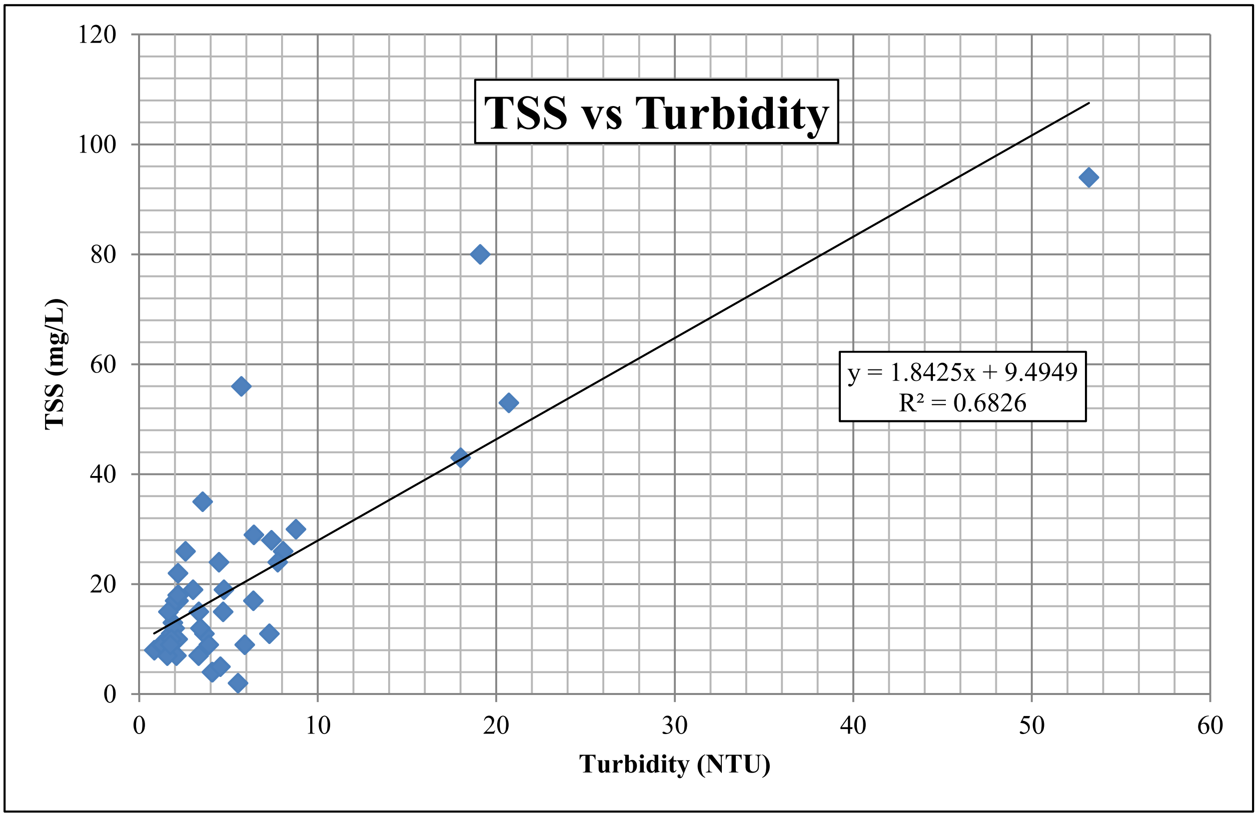
Temperature (˚C)	Correction Factor
17	1.0006
18	1.0004
19	1.0002
20	1
21	0.9998
22	0.9996
23	0.9993
24	0.9991
25	0.9988
26	0.9986
27	0.9983
28	0.998

2014-11 | Settling Curve



2014-11 | TSS and Turbidity





2014-11 | Bulk Density

Initial Concentration (g/L)=	98.8		Column Volume (in^3)=	15984.42		1 liter=	61.02 in^3
Specific Gravity=	2.65		Column Diameter (in)=	8		Column Height (in)=	79.5

Date	Test Time	C_s Avg (g/L)	Water Height (in)	Slurry Height (in)	V_t (in^3)	V_s (in^3)	V_t (L)	V_s (L)	Mass Settled (g)	Bulk Density (g/L)
10/8/2014	1h	0.00	79.75	76.375	16035	15356	978496	937086	96675409	103.17
	2h	0.09	79.75	77.0625	16035	15494	978496	945522	96672310	102.24
	4h	0.08	79.4375	75	15972	15080	974662	920216	96292231	104.64
	6h	0.06	79.25	72.5	15934	14577	972361	889542	96064656	107.99
	12h	0.04	79.1875	64.4375	15922	12956	971594	790619	95985928	121.41
10/9/2014	1d	0.02	78.5	51.5	15783	10355	963159	631881	95151922	150.59
10/10/2014	2d	0.05	77.875	28.375	15658	5705	955491	348148	94369984	271.06
10/11/2014	3d	0.01	76.625	26.625	15406	5353	940154	326677	92879417	284.32
10/12/2014	4d	0.01	75.75	24.9375	15230	5014	929418	305972	91823265	300.10
10/15/2014	7d	0.01	74.75	22.3125	15029	4486	917148	273764	90606213	330.96
10/19/2014	11d	0.02	73.8125	20.125	14841	4046	905646	246925	89466700	362.32
10/23/2014	15d	0.01	72.75	18.875	14627	3795	892609	231588	88182412	380.77

2014-11 | Testing Photos

START

1 HOUR

2 HOUR

4 HOUR

6 HOUR

12 HOUR

1 DAY

2 DAY

4 DAY

7 DAY

11 DAY

15 DAY

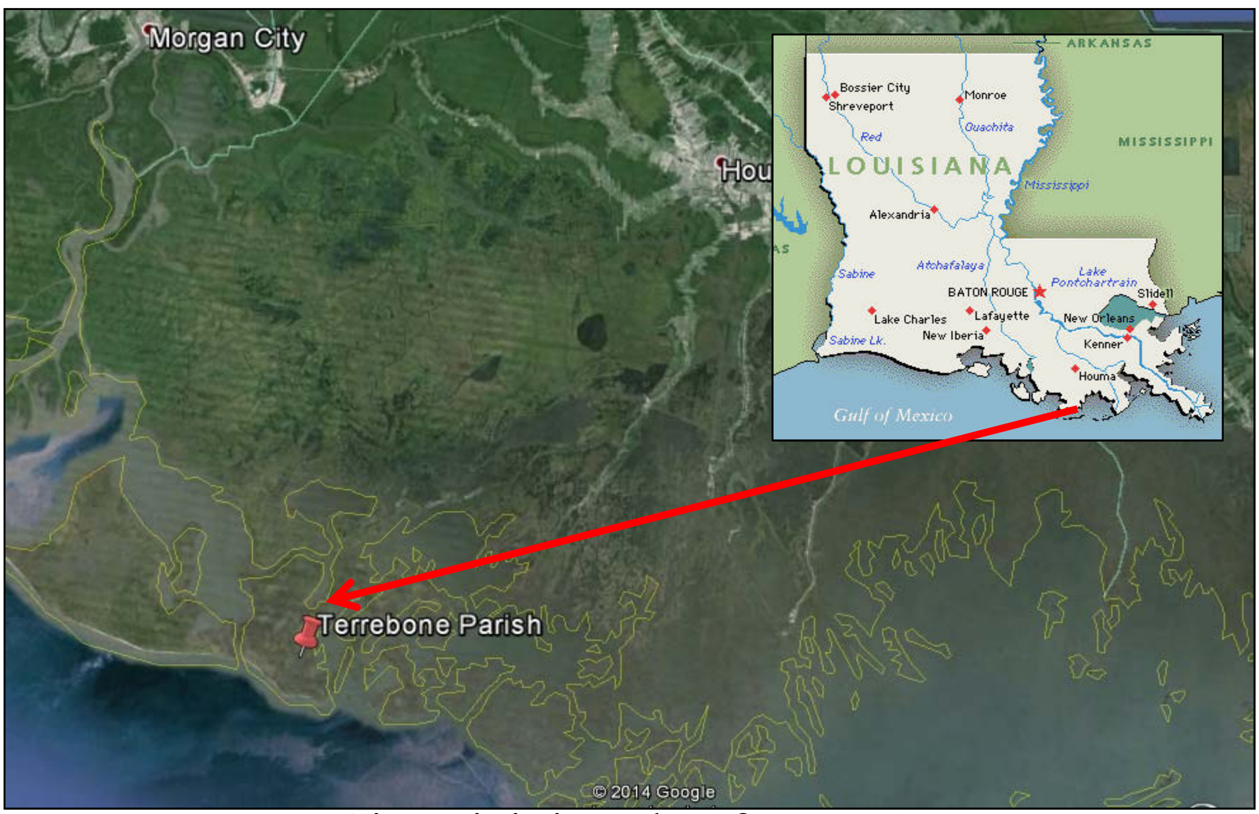
2014-12

2014-12 | Engineering Properties

Sample ID	Project Location	GPS Coordinates	Test Start	Sample Type	Sample Source
2014-12	Terrebonne Parish, LA	29°13'12.15"N 91° 4'46.26"W	10/24/14	Shelby Tubes	PSI

Concentration (g/L)	Water Type	Salinity (ppt)	pH	Specific Gravity	Organic Content (%)
95.6	Composite	2	6.94	2.65	3.1

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Grain Size Distribution		Bulk Density (g/L)	Resistivity (ohms)	Conductivity (mS)
			Fines (%)	Coarse (%)			
49	23	26	91	9	327	294	3.75



Site Vicinity Plan for 2014-12

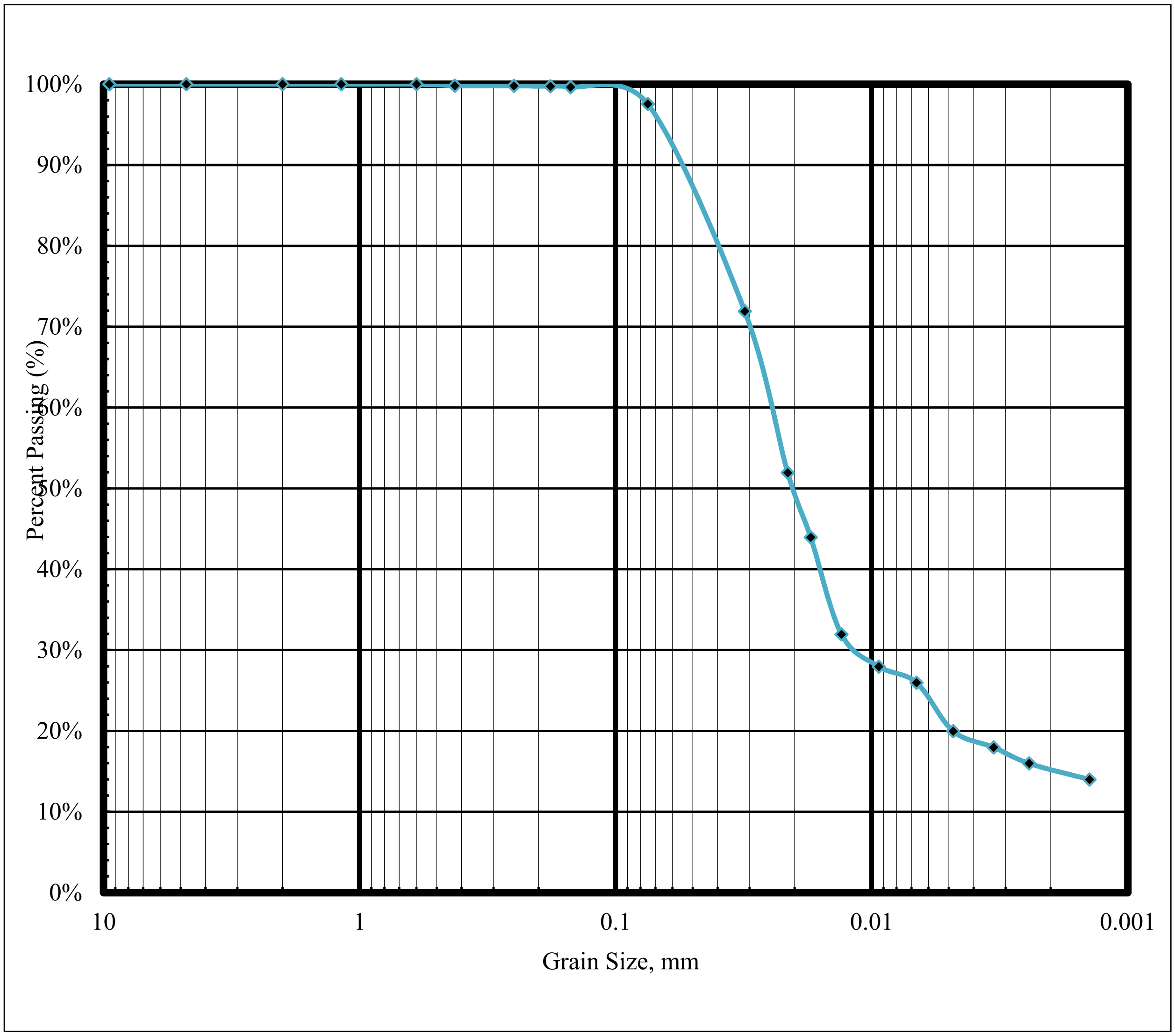
2014-12 | Hydrometer

Elapsed Time (min)	Temp Reading (C)	Composite Correction	Hydrometer Reading	Corrected Hydrometer Reading	Effective Depth (L, cm)	Value of K	Diameter of Particle Size (mm)	Percent Finer (%)
0.25	22.1	4	48	44	9.1	0.01374	0.0829	87.89%
2	22.1	4	40	36	10.4	0.01374	0.0313	71.91%
4	22.2	4	30	26	12	0.01374	0.0213	51.94%
8	22.2	4	26	22	12.7	0.01374	0.0173	43.95%
15	22.2	4	20	16	13.7	0.01374	0.0131	31.96%
30	22.2	4	18	14	14	0.01374	0.0094	27.97%
60	22.2	4	17	13	14.2	0.01374	0.0067	25.97%
120	22.3	4	14	10	14.7	0.01374	0.0048	19.98%
240	22.3	4	13	9	14.8	0.01374	0.0033	17.98%
480	22.2	4	12	8	15	0.01374	0.0024	15.98%
1440	22.2	4	11	7	15.2	0.01374	0.0014	13.98%

2014-12 | Sieve Analysis

Sieve Size	Particle Size (mm)	Cumulative Weight Retained (g)	Percent Retained	Percent Passing
3/8"	9.5000	0	0.00%	100.00%
#4	4.7500	0	0.00%	100.00%
#10	2.0000	0	0.00%	100.00%
#20	0.850	0	0.00%	100.00%
#40	0.4250	0.09	0.18%	99.82%
#60	0.25000	0.10	0.20%	99.80%
#80	0.1800	0.13	0.26%	99.74%
#100	0.1500	0.17	0.34%	99.66%
#200	0.0750	1.22	2.44%	97.56%
Pan		1.61	3.22%	96.78%

2014-12 | Grain Size Curve



% Fines	% Coarse
91	9

2014-12 | Atterberg Limits

	LL	LL	PL	PL
Container No.	A4	A3	L19	A1
Number of Blows	22	23		
Weight of Can (g)	13.86	13.69	13.79	13.81
Weight of Wet Soil + Can (g)	31.77	35.16	21.58	20.77
Weight of Dry Soil + Can (g)	25.78	28.08	20.16	19.48
Weight of Dry Soil (g)	11.92	11.39	6.37	5.67
Water Weight (g)	5.99	7.08	1.42	1.29
Moisture Content (%)	50.25	49.20	22.29	22.75
Correction Factor	0.985	0.990		
Corrected Percent	49	49		

Liquid Limit	Plastic Limit	Plasticity Index
49	23	26

2014-12 | Organic Content

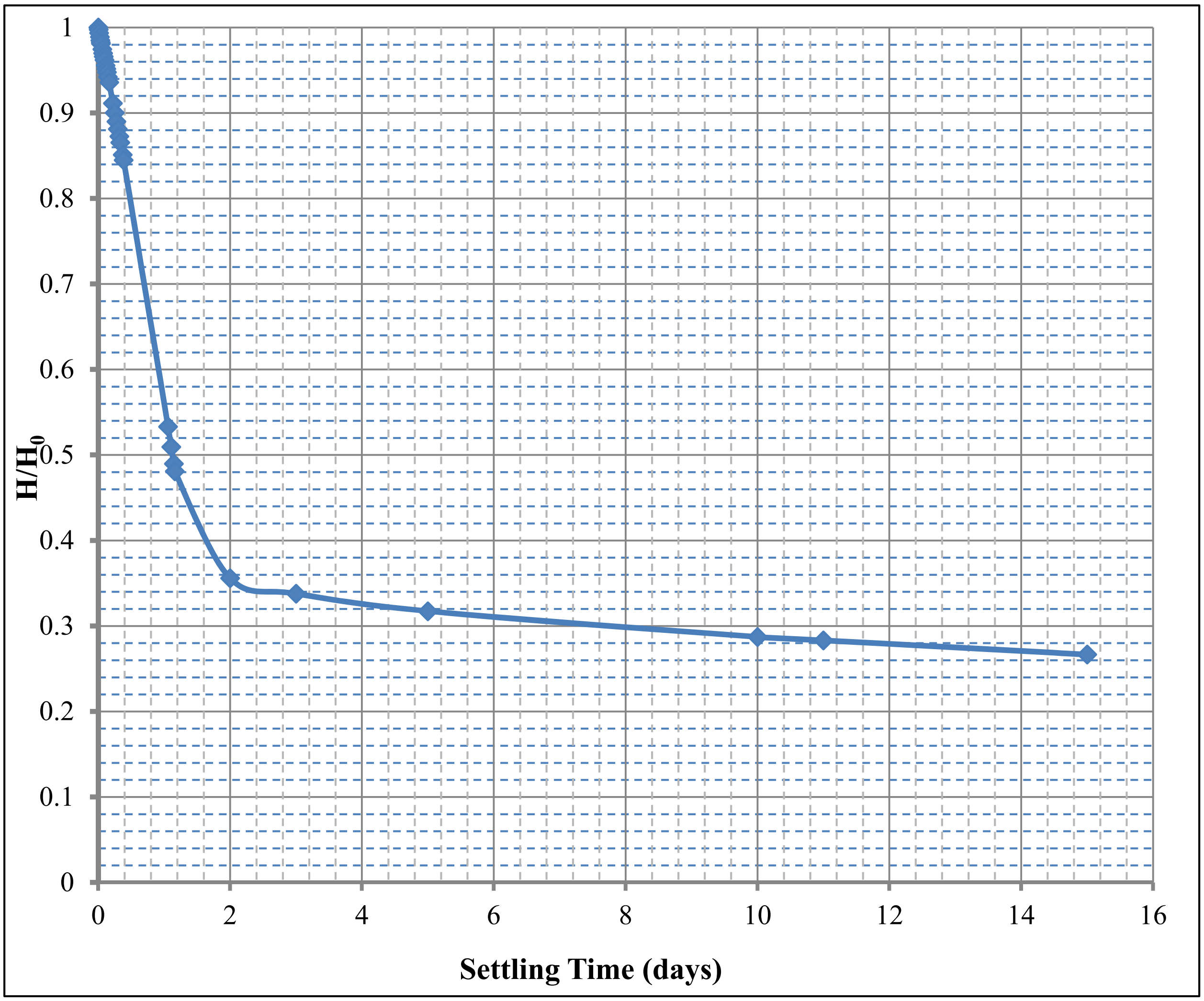
Dish Number	3
Weight of Dish with Cover (g)	340.82
Weight of Dish with Cover + Soil (g)	510.81
Weight of Dish with Cover + Ash (g)	505.52
Weight of Ash (g)	164.70
Weight of Soil (g)	169.99
Ash Content (%)	96.89
Organic Content (%)	3.1

2014-12 | Specific Gravity

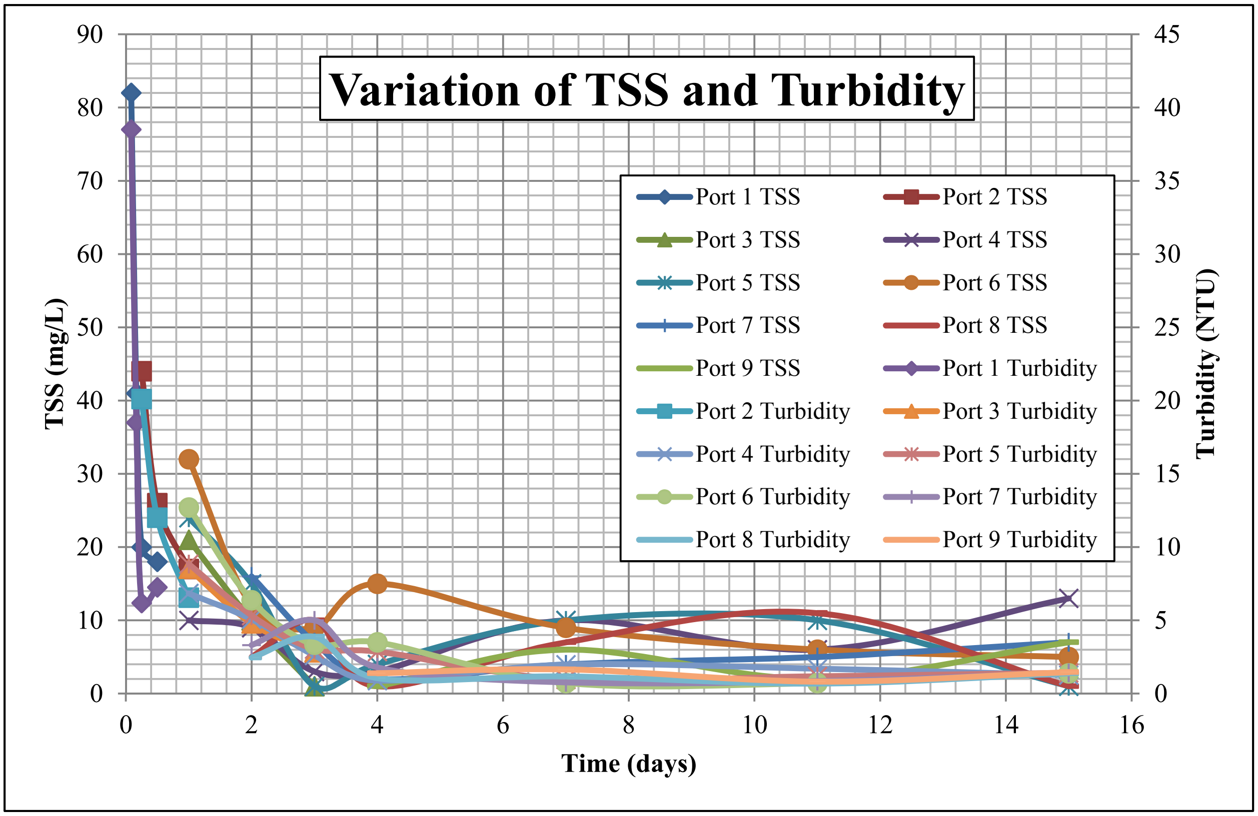
Flask Number	2
Temperature, T (˚C)	22.3
Weight of Flask, M_f (g)	203.89
Weight of Dry Soil, M_s (g)	59.49
Weight of Flask + Soil + Water, M_{fsw} (g)	738.40
Weight of Flask + Water, M_{fw} (g)	701.32
$M_{fw} – M_{fws} + M_s$ (g)	22.41
G_s (at T)	2.66
Correction Factor	0.9996
G_s (at 20˚C)	2.65

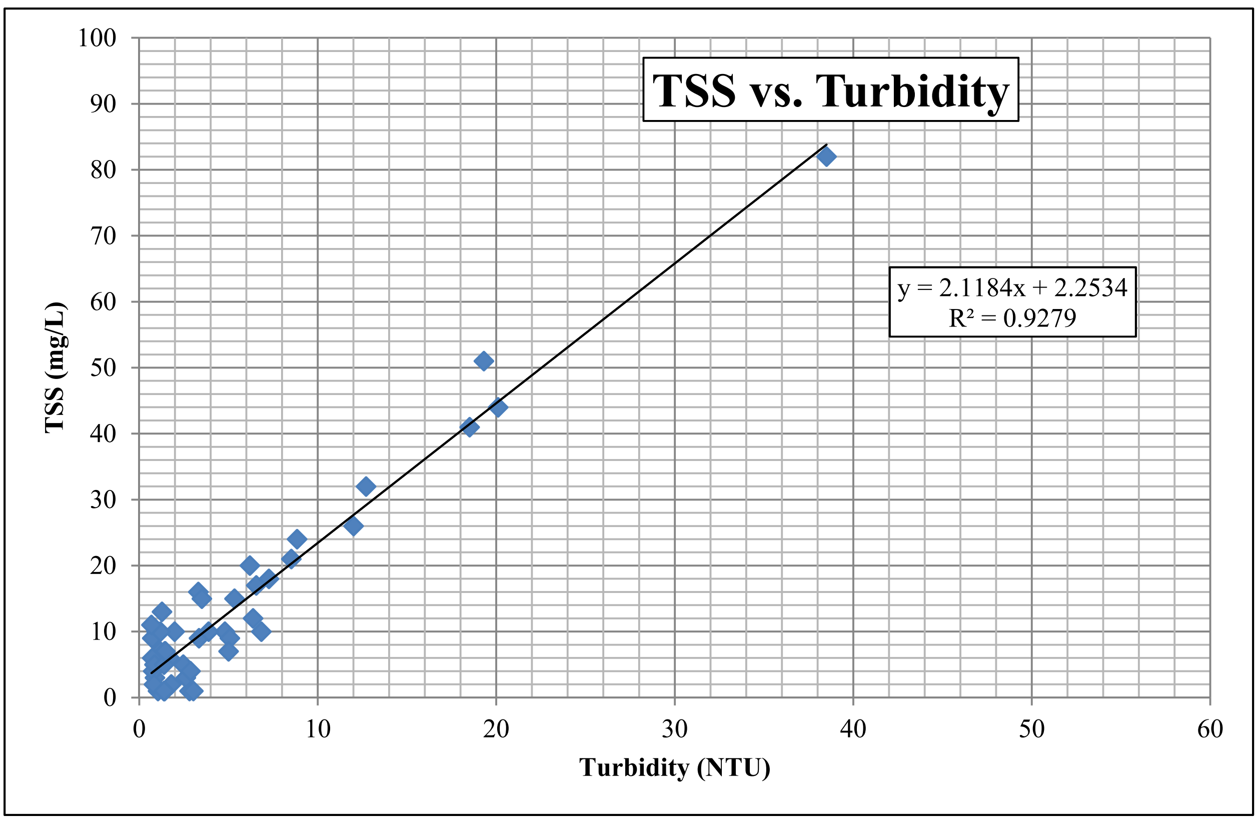
Temperature (˚C)	Correction Factor
17	1.0006
18	1.0004
19	1.0002
20	1
21	0.9998
22	0.9996
23	0.9993
24	0.9991
25	0.9988
26	0.9986
27	0.9983
28	0.998

2014-12 | Settling Curve



2014-12 | TSS and Turbidity



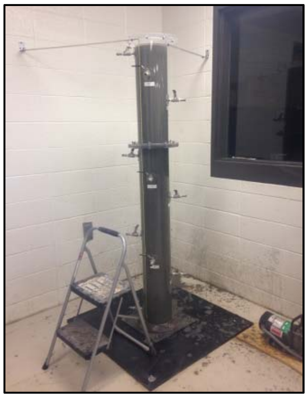


2014-12 | Bulk Density

Initial Concentration (g/L)=	95.6		Column Volume (in^3)=	15984.42		1 liter=	61.02 in^3
Specific Gravity=	2.65		Column Diameter (in)=	8		Column Height (in)=	79.5

Date	Test Time	C_s Avg (g/L)	Water Height (in)	Slurry Height (in)	V_t (in^3)	V_s (in^3)	V_t (L)	V_s (L)	Mass Settled (g)	Bulk Density (g/L)
10/24/2014	1h	0.00	79	77.5	15884	15582	969294	950890	92664496	97.45
	2h	0.08	79	76.3125	15884	15344	969294	936319	92661792	98.96
	4h	0.04	78.75	73.9375	15834	14866	966227	907179	92368833	101.82
	6h	0.03	78.5625	71.125	15796	14301	963926	872671	92148402	105.59
	12h	0.02	78.5625	66.75	15796	13421	963926	818992	92148134	112.51
10/25/2014	1d	0.02	78.375	42.125	15758	8470	961625	516854	91922273	177.85
10/26/2014	2d	0.01	76.625	28.3125	15406	5693	940154	347381	89872077	258.71
10/27/2014	3d	0.01	75.625	26.6875	15205	5366	927884	327443	88702625	270.89
10/28/2014	4d	0.00	74.75	25.0625	15029	5039	917148	307505	87676739	285.12
10/31/2014	7d	0.01	73.6875	22.6875	14816	4562	904112	278365	86428304	310.49
11/4/2014	11d	0.01	72.75	22.375	14627	4499	892609	274531	85329323	310.82
11/8/2014	15d	0.01	71.9375	21.0625	14464	4235	882640	258427	84376870	326.50

2014-12 | Testing Photos


START


1 HOUR


2 HOUR


4 HOUR


12 HOUR


1 DAY


2 DAY


3 DAY


4 DAY


7 DAY


11 DAY


15 DAY

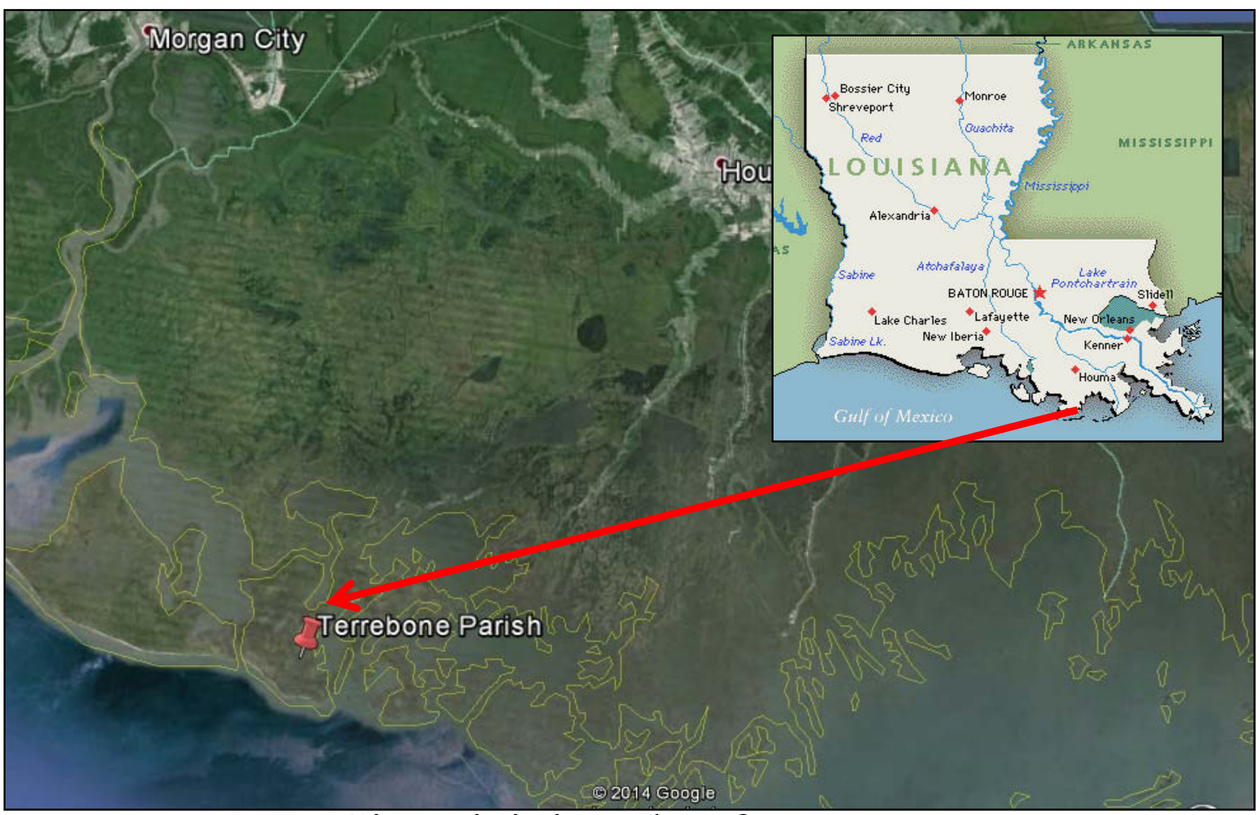
2014-13

2014-13 | Engineering Properties

Sample ID	Project Location	GPS Coordinates	Test Start	Sample Type	Sample Source
2014-13	Terrebonne Parish, LA	29°13'12.15"N 91° 4'46.26"W	11/10/14	Shelby Tubes	PSI

Concentration (g/L)	Water Type	Salinity (ppt)	pH	Specific Gravity	Organic Content (%)
102.5	Composite	3.2	7.47	2.65	3.1

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Grain Size Distribution		Bulk Density (g/L)	Resistivity (ohms)	Conductivity (mS)
			Fines (%)	Coarse (%)			
49	23	26	91	9	345	164	6.18



Site Vicinity Plan for 2014-13

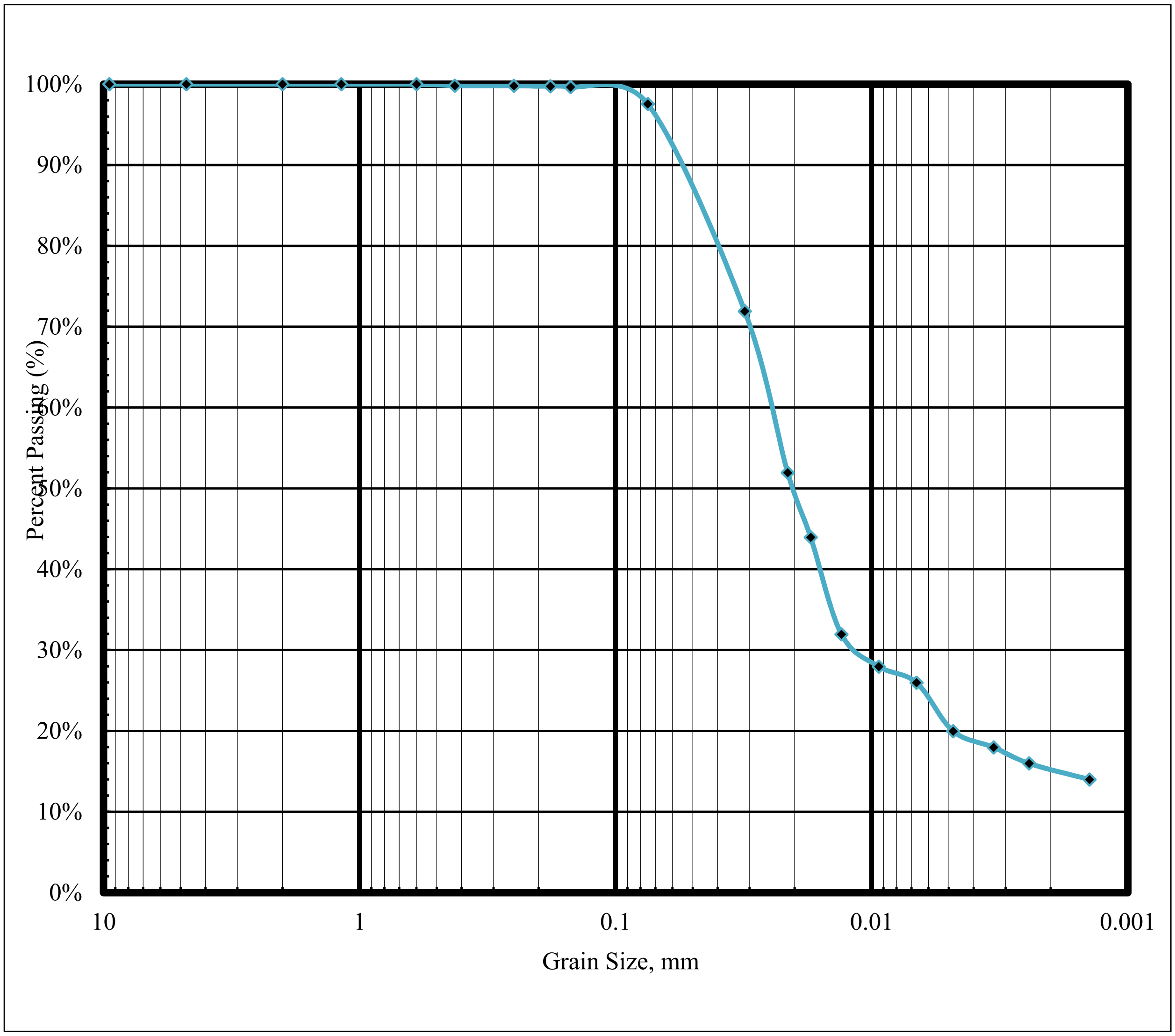
2014-13 | Hydrometer

Elapsed Time (min)	Temp Reading (C)	Composite Correction	Hydrometer Reading	Corrected Hydrometer Reading	Effective Depth (L, cm)	Value of K	Diameter of Particle Size (mm)	Percent Finer (%)
0.25	22.1	4	48	44	9.1	0.01374	0.0829	87.89%
2	22.1	4	40	36	10.4	0.01374	0.0313	71.91%
4	22.2	4	30	26	12	0.01374	0.0213	51.94%
8	22.2	4	26	22	12.7	0.01374	0.0173	43.95%
15	22.2	4	20	16	13.7	0.01374	0.0131	31.96%
30	22.2	4	18	14	14	0.01374	0.0094	27.97%
60	22.2	4	17	13	14.2	0.01374	0.0067	25.97%
120	22.3	4	14	10	14.7	0.01374	0.0048	19.98%
240	22.3	4	13	9	14.8	0.01374	0.0033	17.98%
480	22.2	4	12	8	15	0.01374	0.0024	15.98%
1440	22.2	4	11	7	15.2	0.01374	0.0014	13.98%

2014-13 | Sieve Analysis

Sieve Size	Particle Size (mm)	Cumulative Weight Retained (g)	Percent Retained	Percent Passing
3/8"	9.5000	0	0.00%	100.00%
#4	4.7500	0	0.00%	100.00%
#10	2.0000	0	0.00%	100.00%
#20	0.850	0	0.00%	100.00%
#40	0.4250	0.09	0.18%	99.82%
#60	0.25000	0.10	0.20%	99.80%
#80	0.1800	0.13	0.26%	99.74%
#100	0.1500	0.17	0.34%	99.66%
#200	0.0750	1.22	2.44%	97.56%
Pan		1.61	3.22%	96.78%

2014-13 | Grain Size Curve



% Fines	% Coarse
91	9

2014-13 | Atterberg Limits

	LL	LL	PL	PL
Container No.	A4	A3	L19	A1
Number of Blows	22	23		
Weight of Can (g)	13.86	13.69	13.79	13.81
Weight of Wet Soil + Can (g)	31.77	35.16	21.58	20.77
Weight of Dry Soil + Can (g)	25.78	28.08	20.16	19.48
Weight of Dry Soil (g)	11.92	11.39	6.37	5.67
Water Weight (g)	5.99	7.08	1.42	1.29
Moisture Content (%)	50.25	49.20	22.29	22.75
Correction Factor	0.985	0.990		
Corrected Percent	49	49		

Liquid Limit	Plastic Limit	Plasticity Index
49	23	26

2014-13 | Organic Content

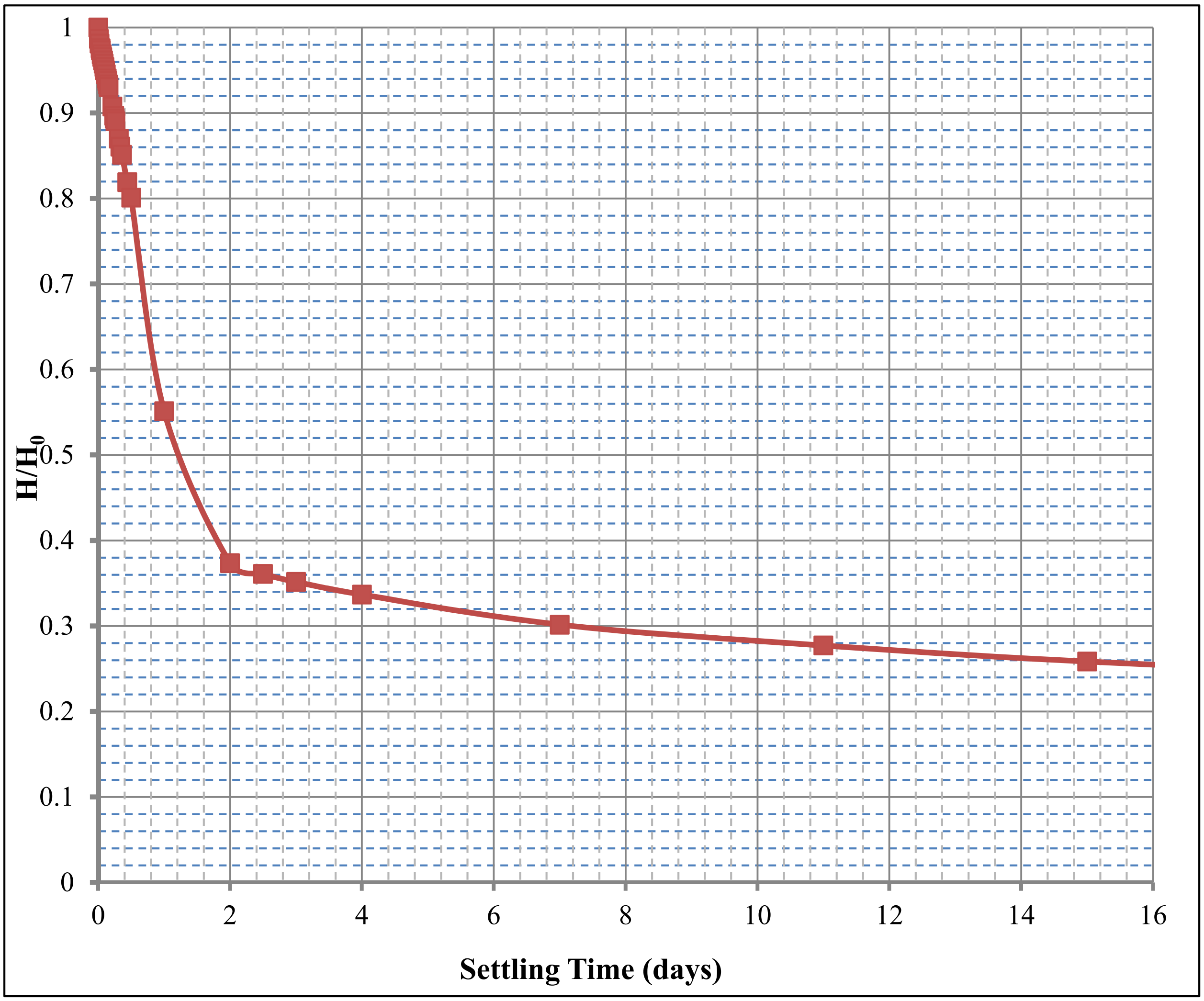
Dish Number	3
Weight of Dish with Cover (g)	340.82
Weight of Dish with Cover + Soil (g)	510.81
Weight of Dish with Cover + Ash (g)	505.52
Weight of Ash (g)	164.70
Weight of Soil (g)	169.99
Ash Content (%)	96.89
Organic Content (%)	3.1

2014-13 | Specific Gravity

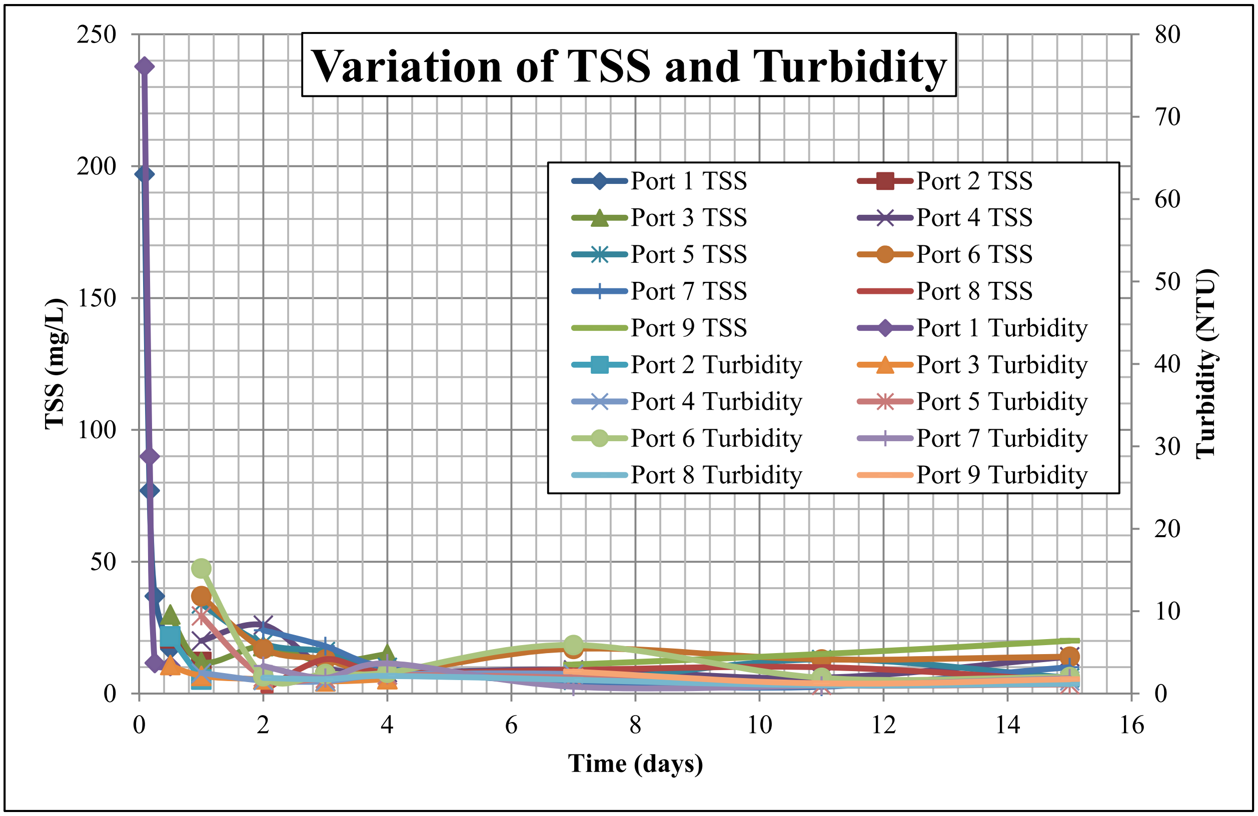
Flask Number	2
Temperature, T (˚C)	22.3
Weight of Flask, M_f (g)	203.89
Weight of Dry Soil, M_s (g)	59.49
Weight of Flask + Soil + Water, M_{fsw} (g)	738.40
Weight of Flask + Water, M_{fw} (g)	701.32
$M_{fw} – M_{fws} + M_s$ (g)	22.41
G_s (at T)	2.66
Correction Factor	0.9996
G_s (at 20˚C)	2.65

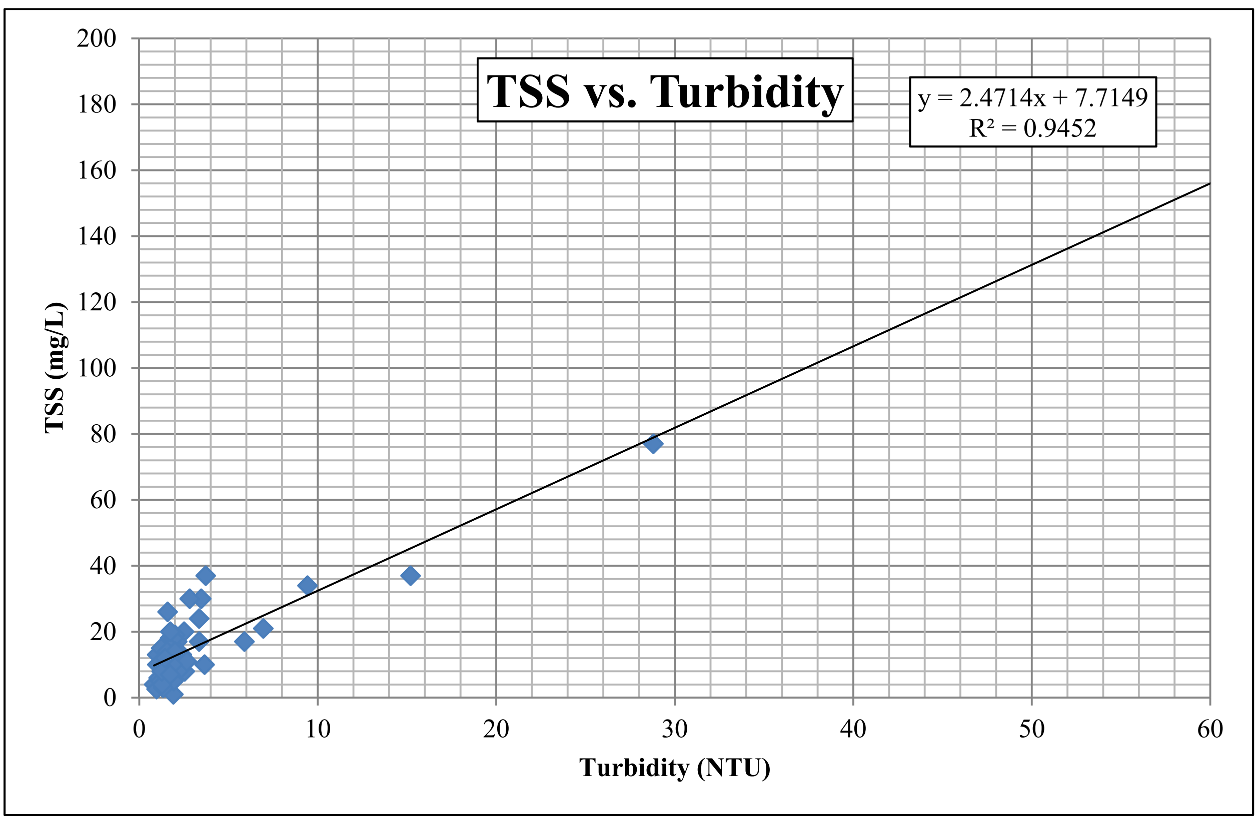
Temperature (˚C)	Correction Factor
17	1.0006
18	1.0004
19	1.0002
20	1
21	0.9998
22	0.9996
23	0.9993
24	0.9991
25	0.9988
26	0.9986
27	0.9983
28	0.998

2014-13 | Settling Curve



2014-13 | TSS and Turbidity





2014-13 | Bulk Density

Initial Concentration (g/L)=	102.5		Column Volume (in^3)=	15984.42		1 liter=	61.02 in^3
Specific Gravity=	2.65		Column Diameter (in)=	8		Column Height (in)=	79.5

Date	Test Time	C_s Avg (g/L)	Water Height (in)	Slurry Height (in)	V_t (in^3)	V_s (in^3)	V_t (L)	V_s (L)	Mass Settled (g)	Bulk Density (g/L)
11/10/2014	1h									
	2h	0.1970	79.16	76.44	15916	15369	971231	937853	99239956	105.82
	4h	0.0770	79	74.25	15884	14929	969294	911014	99044079	108.72
	6h	0.0370	78.8125	71.31	15846	14338	966993	874972	98810078	112.93
	12h	0.0227	78.625	63.94	15808	12855	964693	784484	98574314	125.65
11/11/2014	1d	0.0242	78	44	15683	8847	957024	539860	97784705	181.13
11/12/2014	2d	0.0175	76.875	29.81	15457	5994	943221	365786	96374180	263.47
11/13/2014	3d	0.0137	75.8125	28.06	15243	5642	930185	344314	95044138	276.04
11/14/2014	4d	0.0098	74.875	26.88	15055	5404	918682	329744	93870935	284.68
11/17/2014	7d	0.0092	74	24.06	14879	4838	907946	295236	92774053	314.24
11/21/2014	11d	0.0099	72.9375	22.125	14665	4448	894910	271464	91441336	336.85
11/25/2014	15d	0.0115	71.5	20.625	14376	4147	877272	253059	89638043	354.22

2014-13 | Testing Photos


START


1 HOUR


2 HOUR


4 HOUR


6 HOUR


12 HOUR


1 DAY


2 DAY


3 DAY


7 DAY


11 DAY


15 DAY

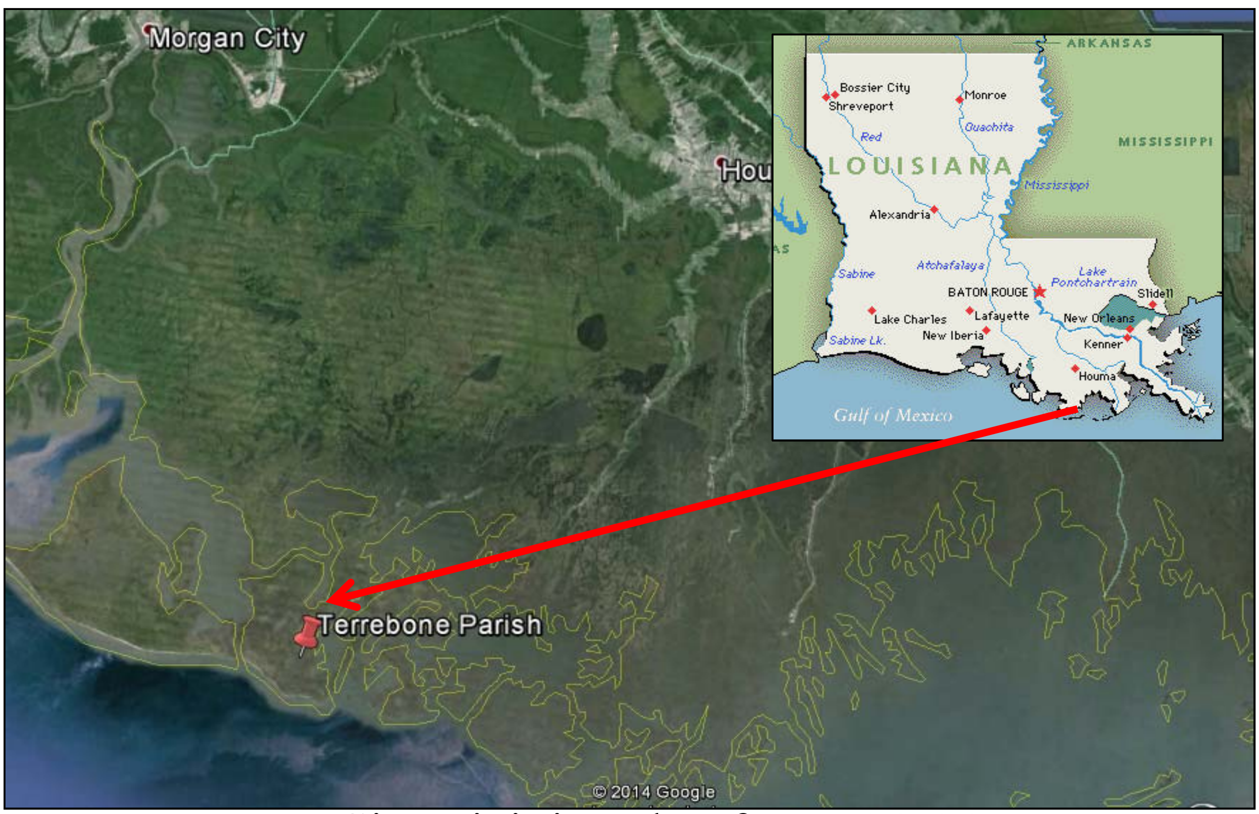
2014-14

2014-14 | Engineering Properties

Sample ID	Project Location	GPS Coordinates	Test Start	Sample Type	Sample Source
2014-14	Terrebonne Parish, LA	29°13'12.15"N 91° 4'46.26"W	12/2/14	Shelby Tubes	PSI

Concentration (g/L)	Water Type	Salinity (ppt)	pH	Specific Gravity	Organic Content (%)
100	Composite	5.2	6.85	2.65	3.1

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Grain Size Distribution		Bulk Density (g/L)	Resistivity (ohms)	Conductivity (mS)
			Fines (%)	Coarse (%)			
49	23	26	91	9	462	384	9.52



Site Vicinity Plan for 2014-14

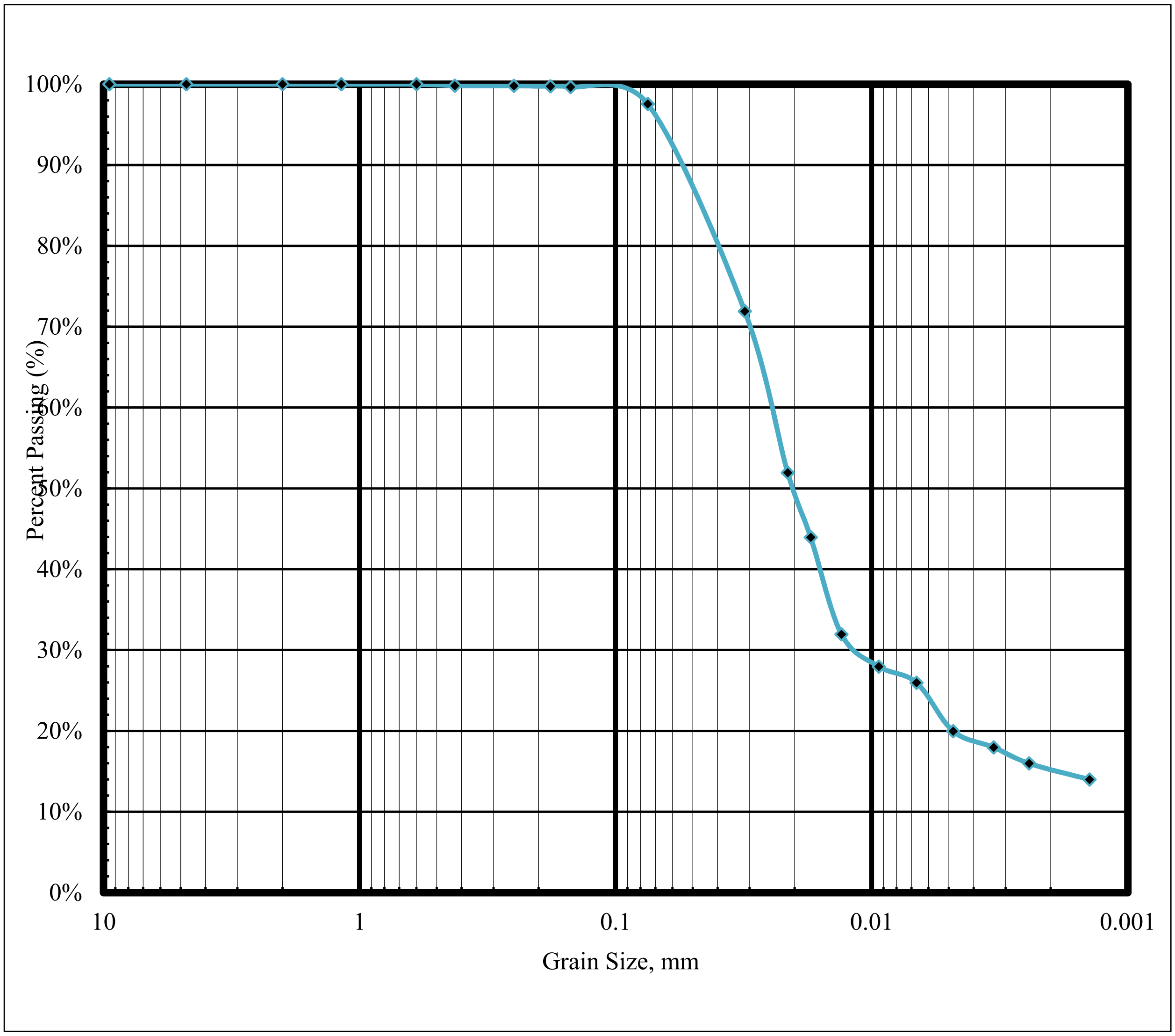
2014-14 | Hydrometer

Elapsed Time (min)	Temp Reading (C)	Composite Correction	Hydrometer Reading	Corrected Hydrometer Reading	Effective Depth (L, cm)	Value of K	Diameter of Particle Size (mm)	Percent Finer (%)
0.25	22.1	4	48	44	9.1	0.01374	0.0829	87.89%
2	22.1	4	40	36	10.4	0.01374	0.0313	71.91%
4	22.2	4	30	26	12	0.01374	0.0213	51.94%
8	22.2	4	26	22	12.7	0.01374	0.0173	43.95%
15	22.2	4	20	16	13.7	0.01374	0.0131	31.96%
30	22.2	4	18	14	14	0.01374	0.0094	27.97%
60	22.2	4	17	13	14.2	0.01374	0.0067	25.97%
120	22.3	4	14	10	14.7	0.01374	0.0048	19.98%
240	22.3	4	13	9	14.8	0.01374	0.0033	17.98%
480	22.2	4	12	8	15	0.01374	0.0024	15.98%
1440	22.2	4	11	7	15.2	0.01374	0.0014	13.98%

2014-14 | Sieve Analysis

Sieve Size	Particle Size (mm)	Cumulative Weight Retained (g)	Percent Retained	Percent Passing
3/8"	9.5000	0	0.00%	100.00%
#4	4.7500	0	0.00%	100.00%
#10	2.0000	0	0.00%	100.00%
#20	0.850	0	0.00%	100.00%
#40	0.4250	0.09	0.18%	99.82%
#60	0.25000	0.10	0.20%	99.80%
#80	0.1800	0.13	0.26%	99.74%
#100	0.1500	0.17	0.34%	99.66%
#200	0.0750	1.22	2.44%	97.56%
Pan		1.61	3.22%	96.78%

2014-14 | Grain Size Curve



% Fines	% Coarse
91	9

2014-14 | Atterberg Limits

	LL	LL	PL	PL
Container No.	A4	A3	L19	A1
Number of Blows	22	23		
Weight of Can (g)	13.86	13.69	13.79	13.81
Weight of Wet Soil + Can (g)	31.77	35.16	21.58	20.77
Weight of Dry Soil + Can (g)	25.78	28.08	20.16	19.48
Weight of Dry Soil (g)	11.92	11.39	6.37	5.67
Water Weight (g)	5.99	7.08	1.42	1.29
Moisture Content (%)	50.25	49.20	22.29	22.75
Correction Factor	0.985	0.990		
Corrected Percent	49	49		

Liquid Limit	Plastic Limit	Plasticity Index
49	23	26

2014-14 | Organic Content

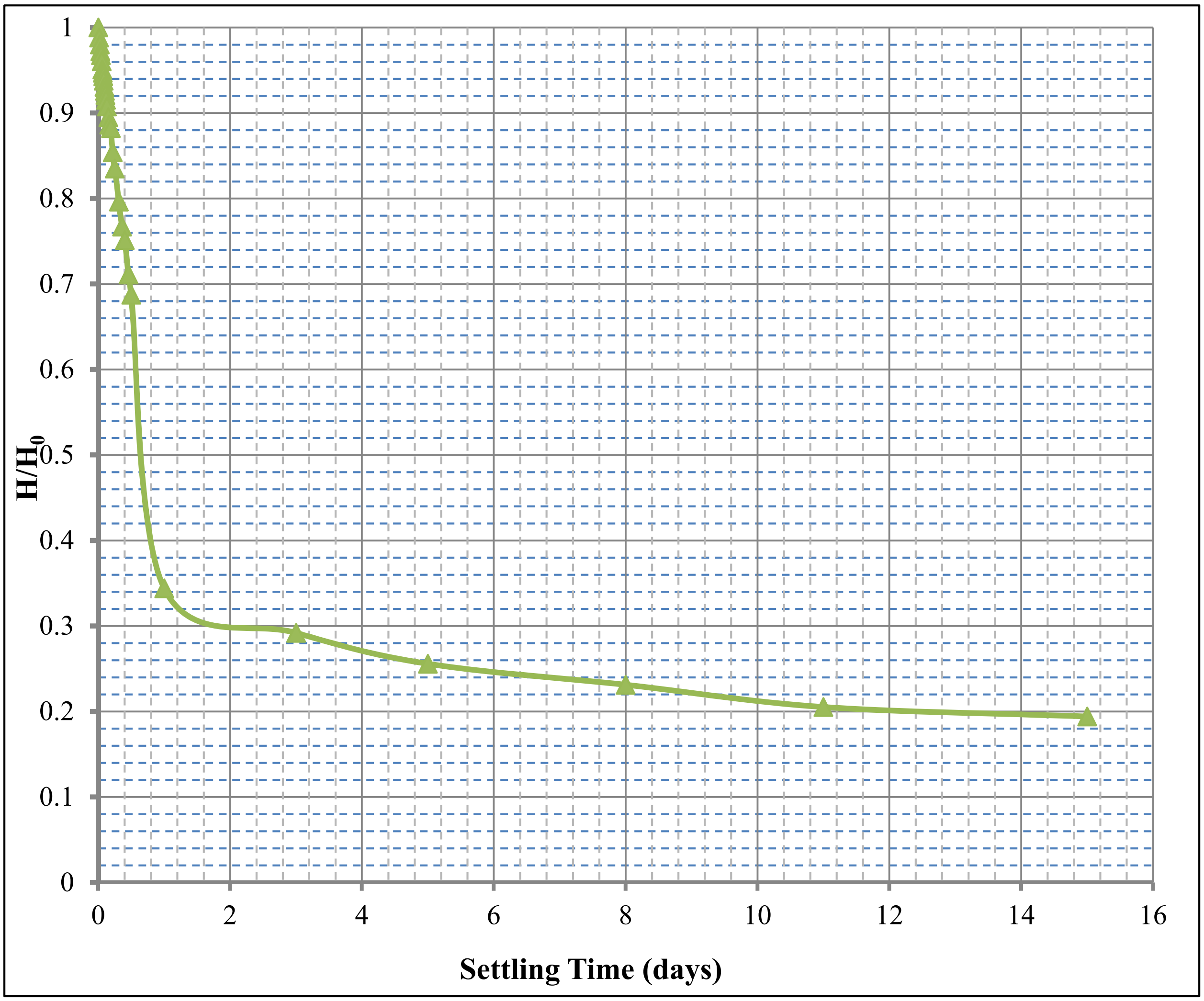
Dish Number	3
Weight of Dish with Cover (g)	340.82
Weight of Dish with Cover + Soil (g)	510.81
Weight of Dish with Cover + Ash (g)	505.52
Weight of Ash (g)	164.70
Weight of Soil (g)	169.99
Ash Content (%)	96.89
Organic Content (%)	3.1

2014-14 | Specific Gravity

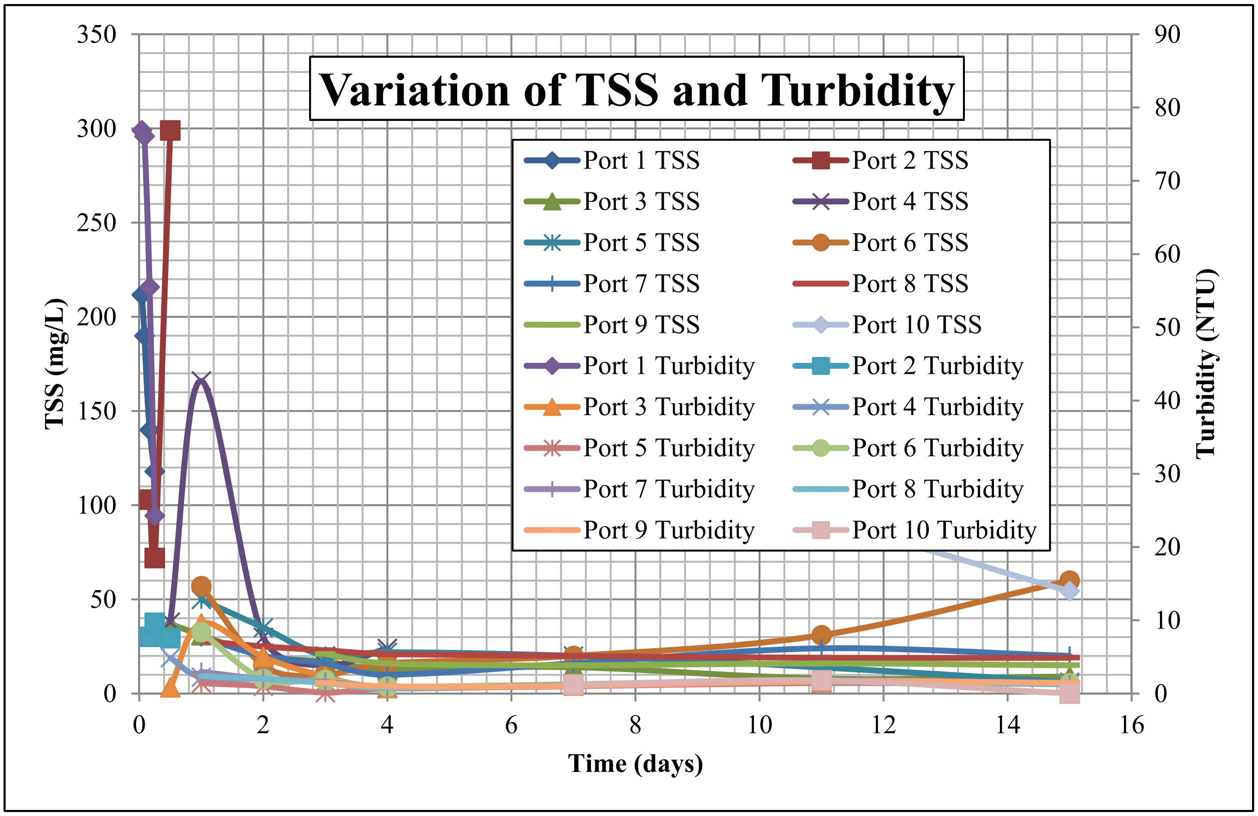
Flask Number	2
Temperature, T (˚C)	22.3
Weight of Flask, M_f (g)	203.89
Weight of Dry Soil, M_s (g)	59.49
Weight of Flask + Soil + Water, M_{fsw} (g)	738.40
Weight of Flask + Water, M_{fw} (g)	701.32
$M_{fw} – M_{fws} + M_s$ (g)	22.41
G_s (at T)	2.66
Correction Factor	0.9996
G_s (at 20˚C)	2.65

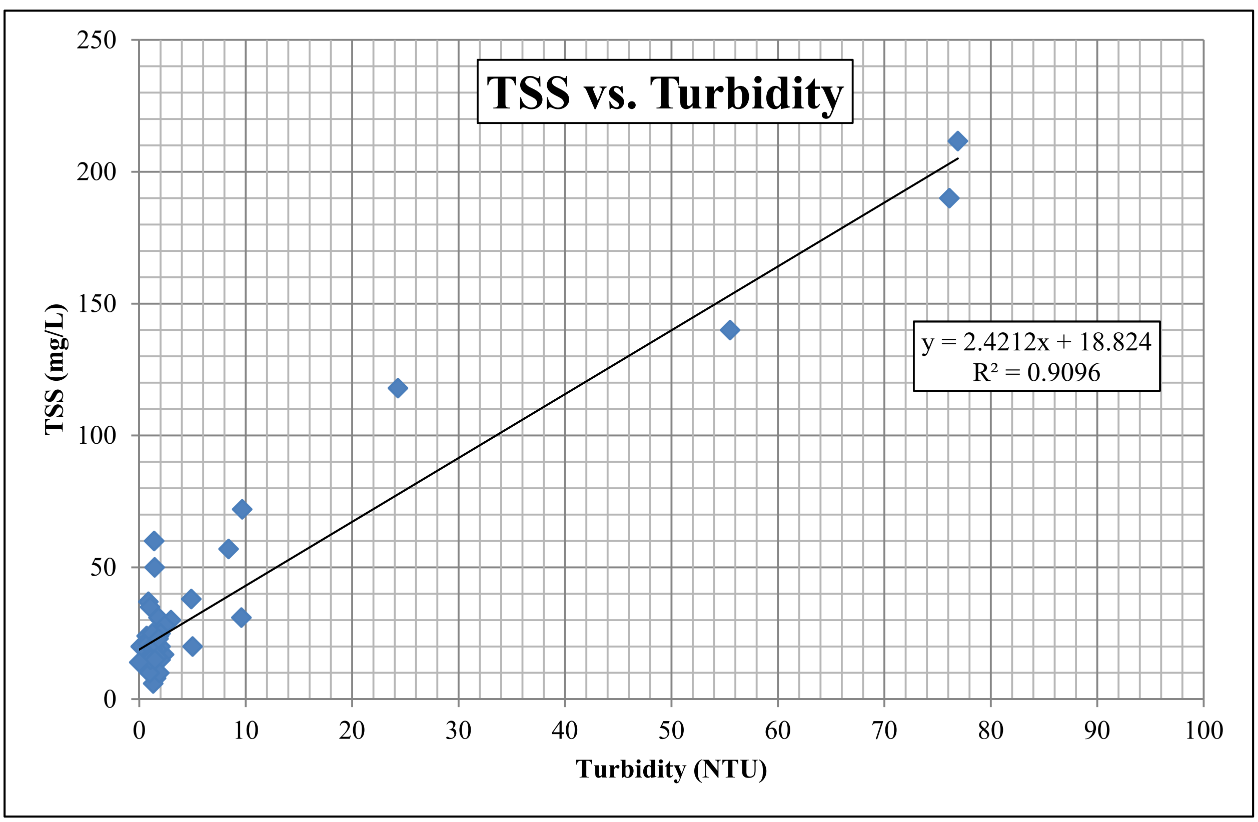
Temperature (˚C)	Correction Factor
17	1.0006
18	1.0004
19	1.0002
20	1
21	0.9998
22	0.9996
23	0.9993
24	0.9991
25	0.9988
26	0.9986
27	0.9983
28	0.998

2014-14 | Settling Curve



2014-14 | TSS and Turbidity





2014-14 | Bulk Density

Initial Concentration (g/L)=	100		Column Volume (in^3)=	15984.42		1 liter=	61.02 in^3
Specific Gravity=	2.65		Column Diameter (in)=	8		Column Height (in)=	79.5

Date	Test Time	C_s Avg (g/L)	Water Height (in)	Slurry Height (in)	V_t (in^3)	V_s (in^3)	V_t (L)	V_s (L)	Mass Settled (g)	Bulk Density (g/L)
12/2/2014	1h	0.21	78.6875	76.625	15821	15406	965460	940154	96540609	102.69
	2h	0.19	78.375	74.25	15758	14929	961625	911014	96152926	105.55
	4h	0.12	78.125	70.1875	15708	14112	958558	861169	95843971	111.30
	6h	0.09	77.6875	66.125	15620	13295	953190	811324	95305534	117.47
	12h	0.12	77.25	54.4375	15532	10945	947822	667923	94747325	141.85
12/3/2014	1d	0.08	76.375	27.25	15356	5479	937086	334345	93659309	280.13
12/5/2014	3d	0.03	75.375	23.125	15155	4650	924817	283733	92459883	325.87
12/6/2014	4d	0.04	74.3125	20.25	14941	4072	911780	248458	91152455	366.87
12/9/2014	7d	0.10	73.25	18.3125	14728	3682	898744	224686	89804492	399.69
12/13/2014	11d	0.04	72.0625	16.25	14489	3267	884174	199380	88390197	443.33
12/17/2014	15d	0.07	71.0625	15.375	14288	3091	871904	188644	87145149	461.96

2014-14 | Testing Photos


START


1 HOUR


2 HOUR


4 HOUR


6 HOUR


12 HOUR


1 DAY


3 DAY


4 DAY


7 DAY


11 DAY


15 DAY

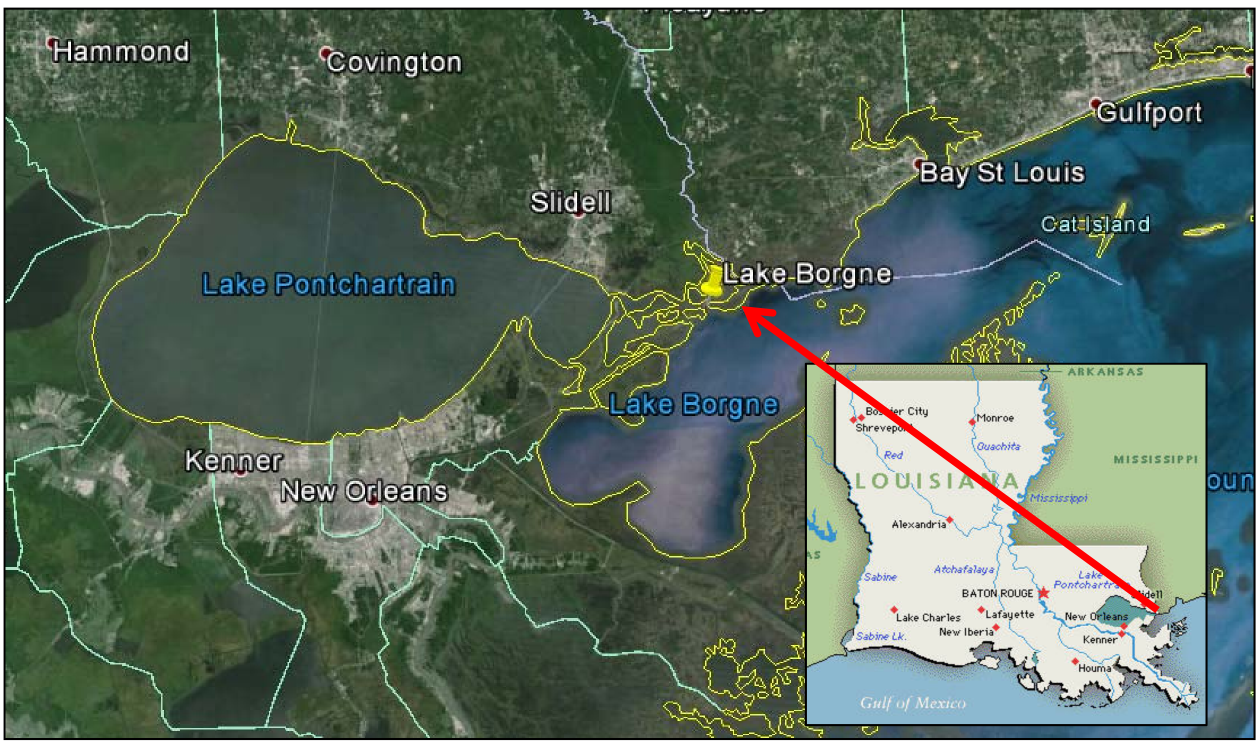
2015-1

2015-1 | Engineering Properties

Sample ID	Project Location	GPS Coordinates	Test Start	Sample Type	Sample Source
2015-1	Lake Borgne, LA	30.156073 N 89.6214 W	12/31/14	Grab	UNO

Concentration (g/L)	Water Type	Salinity (ppt)	pH	Specific Gravity	Organic Content (%)
100.7	Site	1.12	6.65	2.59	10.4

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Grain Size Distribution		Bulk Density (g/L)	Resistivity (ohms)	Conductivity (mS)
			Fines (%)	Coarse (%)			
38	26	12	85	15	262	95.9	3.49



Site Vicinity Plan for 2015-1

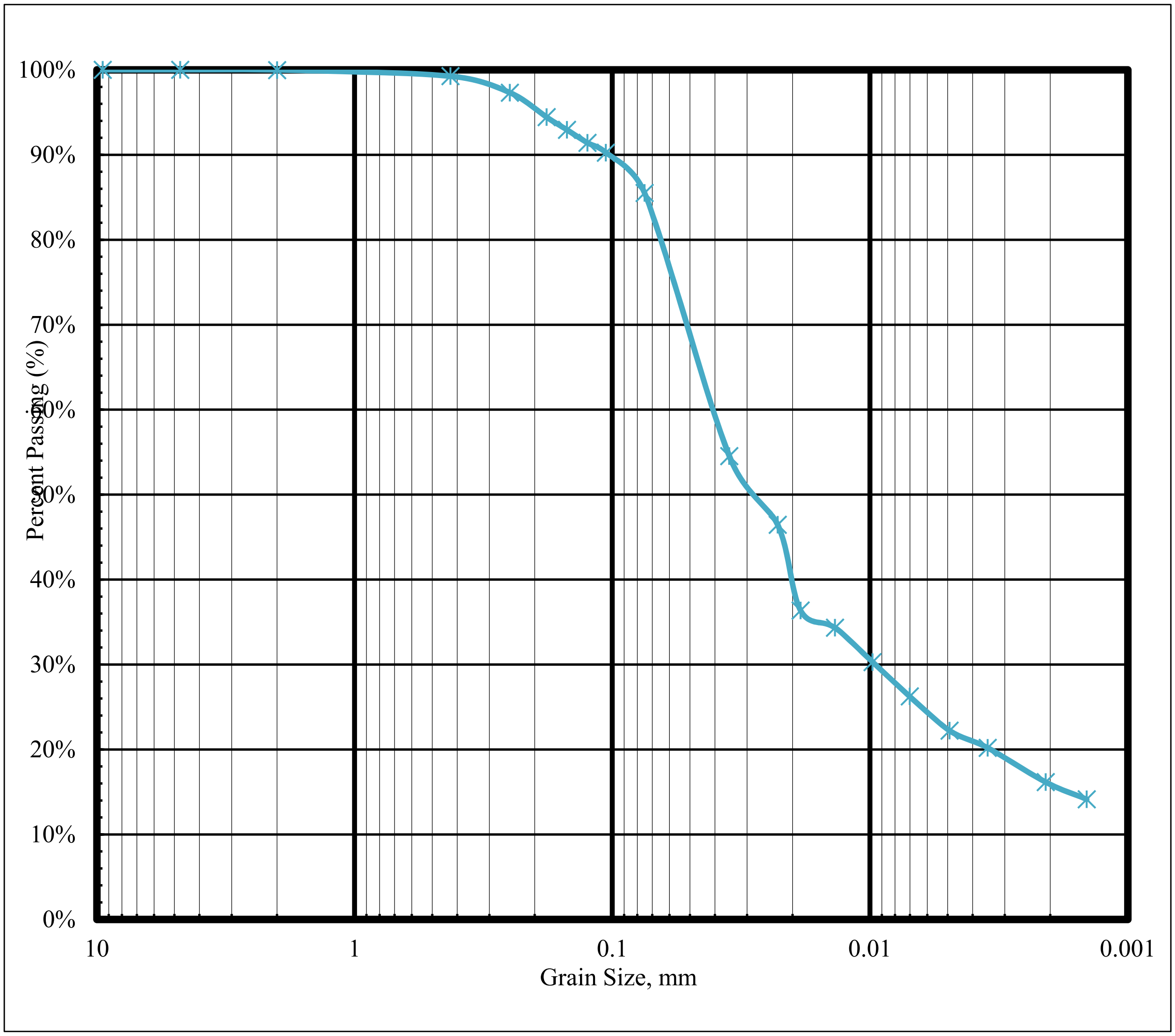
2015-1 | Hydrometer

Elapsed Time (min)	Temp Reading (C)	Composite Correction	Hydrometer Reading	Corrected Hydrometer Reading	Effective Depth (L, cm)	Value of K	Diameter of Particle Size (mm)	Percent Finer (%)
0.25	18.8	9	41	41	32	0.01443	0.0962	64.64%
2	18.8	9	36	27	11.9	0.01443	0.0352	54.54%
5	18.8	9	32	23	12.5	0.01443	0.0228	46.46%
8	18.6	9	27	18	13.3	0.01443	0.0186	36.36%
15	18.6	9	26	17	13.5	0.01443	0.0137	34.34%
30	18.6	9	24	15	13.8	0.01443	0.0098	30.30%
60	18.6	9	22	13	14.2	0.01443	0.0070	26.26%
125	18.7	9	20	11	14.5	0.01443	0.0049	22.22%
250	18.7	9	19	10	14.7	0.01443	0.0035	20.20%
720	18.3	9	17	8	15	0.01443	0.0021	16.16%
1560	17.8	9	16	7	15.2	0.01462	0.0014	14.14%

2015-1 | Sieve Analysis

Sieve Size	Particle Size (mm)	Cumulative Weight Retained (g)	Percent Retained	Percent Passing
3/8"	9.5000	0	0.00%	100.00%
#4	4.7500	0	0.00%	100.00%
#10	2.0000	0	0.00%	100.00%
#20	0.850	0	0.00%	100.00%
#40	0.4250	0.09	0.18%	99.82%
#60	0.25000	0.10	0.20%	99.80%
#80	0.1800	0.13	0.26%	99.74%
#100	0.1500	0.17	0.34%	99.66%
#200	0.0750	1.22	2.44%	97.56%
Pan		1.61	3.22%	96.78%

2015-1 | Grain Size Curve



% Fines	% Coarse
85	15

2015-1 | Atterberg Limits

	LL	LL	PL	PL
Container No.	A1	L32	L19	L22
Number of Blows	29	28		
Weight of Can (g)	13.74	13.57	13.81	13.78
Weight of Wet Soil + Can (g)	25.55	27.62	21.04	20.47
Weight of Dry Soil + Can (g)	22.35	23.77	19.55	19.10
Weight of Dry Soil (g)	8.61	10.20	5.74	5.32
Water Weight (g)	3.20	3.85	1.49	1.37
Moisture Content (%)	37.17	37.75	25.96	25.75
Correction Factor	1.018	1.014		
Corrected Percent	38	38		

Liquid Limit	Plastic Limit	Plasticity Index
38	26	12

2015-1 | Organic Content

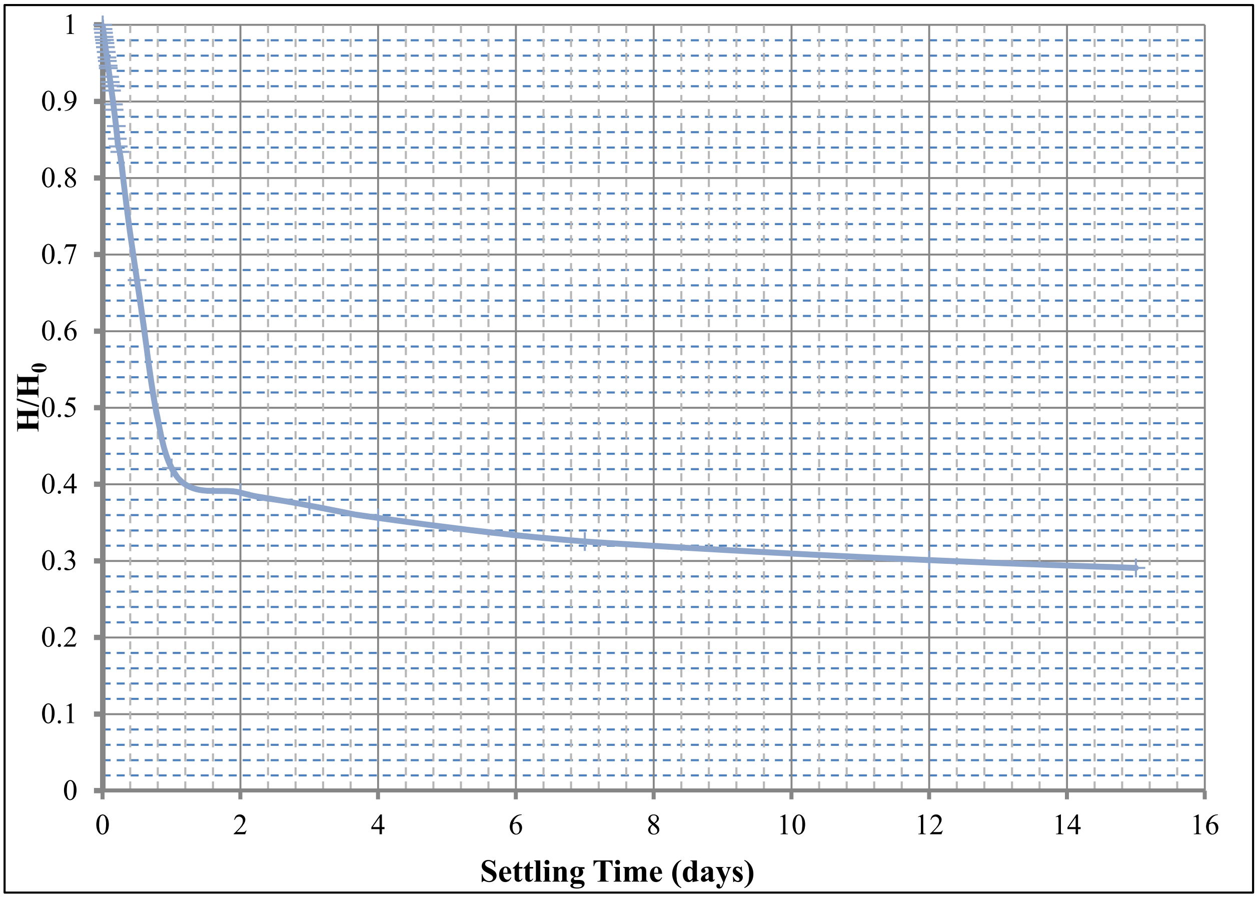
Dish Number	5c
Weight of Dish with Cover (g)	109.84
Weight of Dish with Cover + Soil (g)	215.33
Weight of Dish with Cover + Ash (g)	204.35
Weight of Ash (g)	94.51
Weight of Soil (g)	105.49
Ash Content (%)	89.59
Organic Content (%)	10.4

2015-1 | Specific Gravity

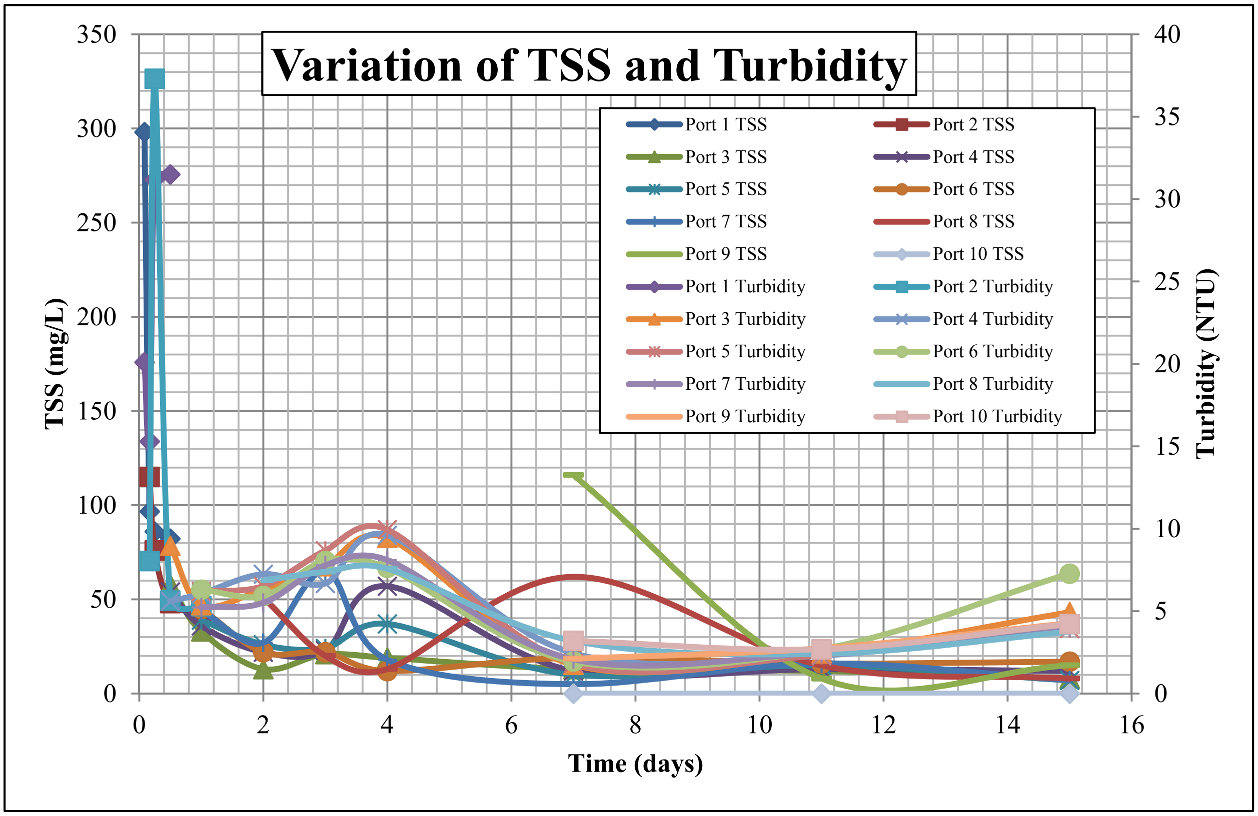
Flask Number	1
Temperature, T (˚C)	20.3
Weight of Flask, M_f (g)	203.87
Weight of Dry Soil, M_s (g)	50.28
Weight of Flask + Soil + Water, M_{fsw} (g)	732.04
Weight of Flask + Water, M_{fw} (g)	701.18
$M_{fw} – M_{fws} + M_s$ (g)	19.42
G_s (at T)	2.59
Correction Factor	1
G_s (at 20˚C)	2.59

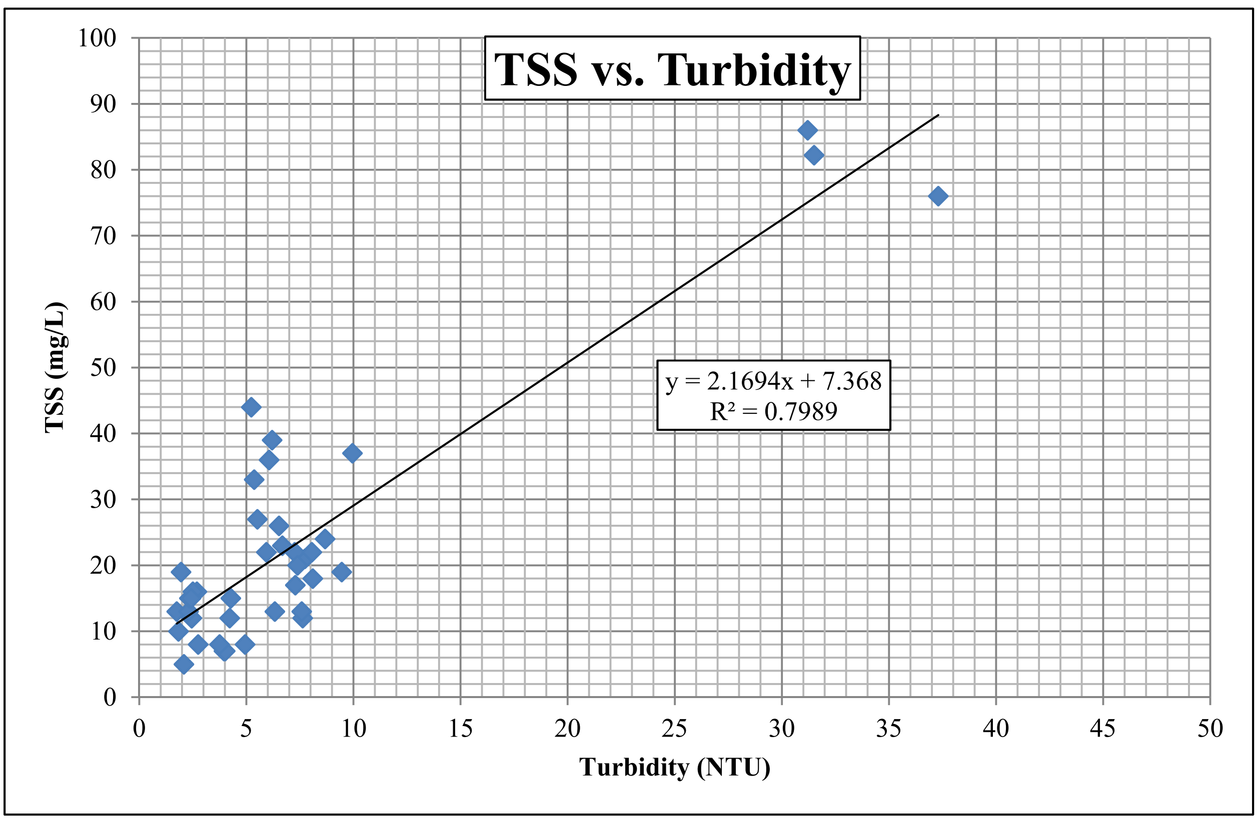
Temperature (˚C)	Correction Factor
17	1.0006
18	1.0004
19	1.0002
20	1
21	0.9998
22	0.9996
23	0.9993
24	0.9991
25	0.9988
26	0.9986
27	0.9983
28	0.998

2015-1 | Settling Curve



2015-1 | TSS and Turbidity





2015-1 | Bulk Density

Initial Concentration (g/L)=	100.7		Column Volume (in^3)=	15984.42		1 liter=	61.02 in^3
Specific Gravity=	2.59		Column Diameter (in)=	8		Column Height (in)=	79.5

Date	Test Time	C_s Avg (g/L)	Water Height (in)	Slurry Height (in)	V_t (in^3)	V_s (in^3)	V_t (L)	V_s (L)	Mass Settled (g)	Bulk Density (g/L)
12/31/2014	1h		79.5	77.19	15984	15519	975429	947055	98225666	103.72
	2h	0.30	78.9375	75	15871	15080	968527	920216	97516276	105.97
	4h	0.11	78.5	70.69	15783	14213	963159	867303	96979978	111.82
	6h	0.08	78	66.31	15683	13333	957024	813624	96360736	118.43
	12h	0.06	77.5	53	15582	10656	950890	650286	95736377	147.22
1/1/2015	1d	0.04	76.4375	33.5	15369	6736	937853	411030	94420743	229.72
1/2/2015	2d	0.03	75.3125	30.94	15142	6220	924050	379589	93037220	245.10
1/3/2015	3d	0.03	74.25	29.63	14929	5956	911014	363485	91723096	252.34
1/4/2015	4d	0.03	73.25	28.31	14728	5693	898744	347381	90489187	260.49
1/7/2015	7d	0.03	72.25	25.25	14527	5077	886474	309806	89248455	288.08
1/11/2015	11d	0.01	71.25	23.94	14326	4813	874205	293702	88024558	299.71

2015-1 | Testing Photos

START

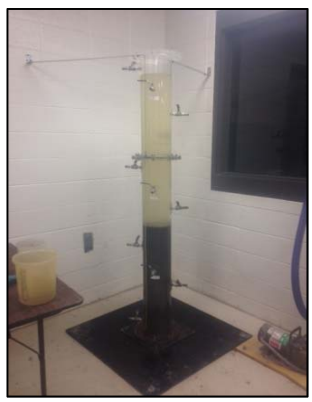
1 HOUR

2 HOUR

4 HOUR

6 HOUR

12 HOUR



1 DAY

2 DAY

3 DAY

7 DAY

11 DAY

15 DAY

2015-2

2015-2 | Engineering Properties

Sample ID	Project Location	GPS Coordinates	Test Start	Sample Type	Sample Source
2015-2	Lake Borgne, LA	30.001541 N 89.8599 W	1/16/15	Grab	UNO

Concentration (g/L)	Water Type	Salinity (ppt)	pH	Specific Gravity	Organic Content (%)
106.9	Site	1.09	6.77	2.58	3.3

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Grain Size Distribution		Bulk Density (g/L)	Resistivity (ohms)	Conductivity (mS)
			Fines (%)	Coarse (%)			
37	21	16	89	11	415	173	2.06

Site Vicinity Plan for 2015-2

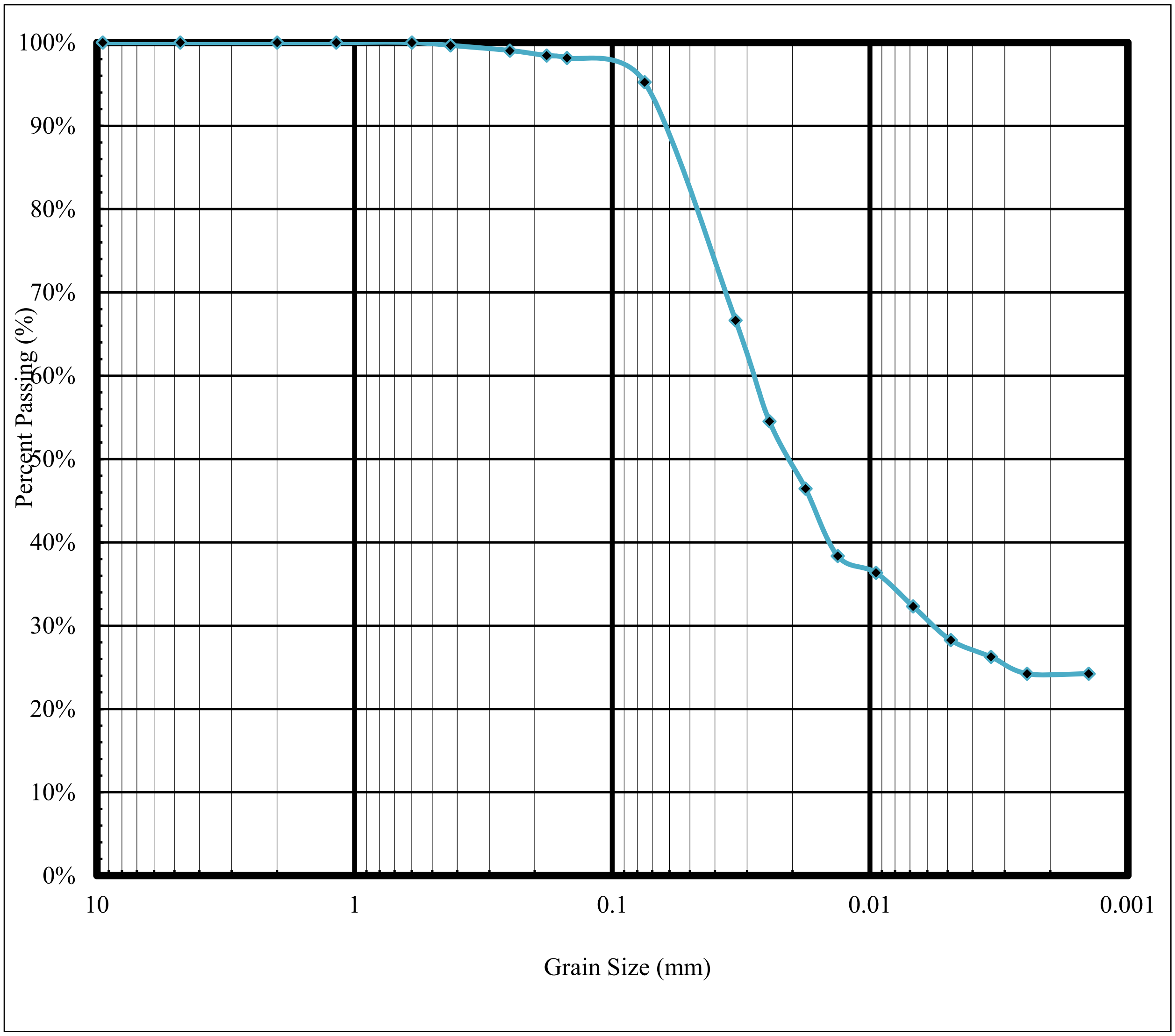
2015-2 | Hydrometer

Elapsed Time (min)	Temp Reading (C)	Composite Correction	Hydrometer Reading	Corrected Hydrometer Reading	Effective Depth (L, cm)	Value of K	Diameter of Particle Size (mm)	Percent Finer (%)
0.3	19.9	6	44	38	10.1	0.01425	0.0640	76.76%
2	19.9	6	39	33	10.9	0.01425	0.0333	66.66%
4	19.9	6	33	27	11.9	0.01425	0.0246	54.54%
8	19.8	6	29	23	12.5	0.01425	0.0178	46.46%
15	19.7	6	25	19	13.2	0.01425	0.0134	38.38%
30	19.6	6	24	18	13.3	0.01425	0.0095	36.36%
60	19.3	6	22	16	13.7	0.01425	0.0068	32.32%
120	19.2	6	20	14	14	0.01425	0.0049	28.28%
250	19.1	6	19	13	14.2	0.01425	0.0034	26.26%
480	19.1	6	18	12	14.3	0.01425	0.0025	24.24%
1440	19.2	6	18	12	14.3	0.01425	0.0014	24.24%

2015-2 | Sieve Analysis

Sieve Size	Particle Size (mm)	Cumulative Weight Retained (g)	Percent Retained	Percent Passing
3/8"	9.5000	0	0.00%	100.00%
#4	4.7500	0	0.00%	100.00%
#10	2.0000	0	0.00%	100.00%
#20	0.850	0	0.00%	100.00%
#40	0.4250	0.17	0.34%	99.66%
#60	0.25000	0.48	0.96%	99.04%
#80	0.1800	0.78	1.56%	98.44%
#100	0.1500	0.92	1.84%	98.16%
#200	0.0750	2.38	4.76%	95.24%
Pan		3.05	6.10%	93.90%

2015-2 | Grain Size Curve



% Fines	% Coarse
89	11

2015-2 | Atterberg Limits

	LL	LL	PL	PL
Container No.	A4	L27	L26	L31
Number of Blows	28	26		
Weight of Can (g)	13.95	13.96	13.58	13.61
Weight of Wet Soil + Can (g)	28.54	30.45	20.38	20.86
Weight of Dry Soil + Can (g)	24.73	26.04	19.18	19.60
Weight of Dry Soil (g)	10.78	12.08	5.60	5.90
Water Weight (g)	3.81	4.41	1.20	1.26
Moisture Content (%)	35.34	36.51	21.43	21.04
Correction Factor	1.014	1.005		
Corrected Percent	36	37		

Liquid Limit	Plastic Limit	Plasticity Index
37	21	16

2015-2 | Organic Content

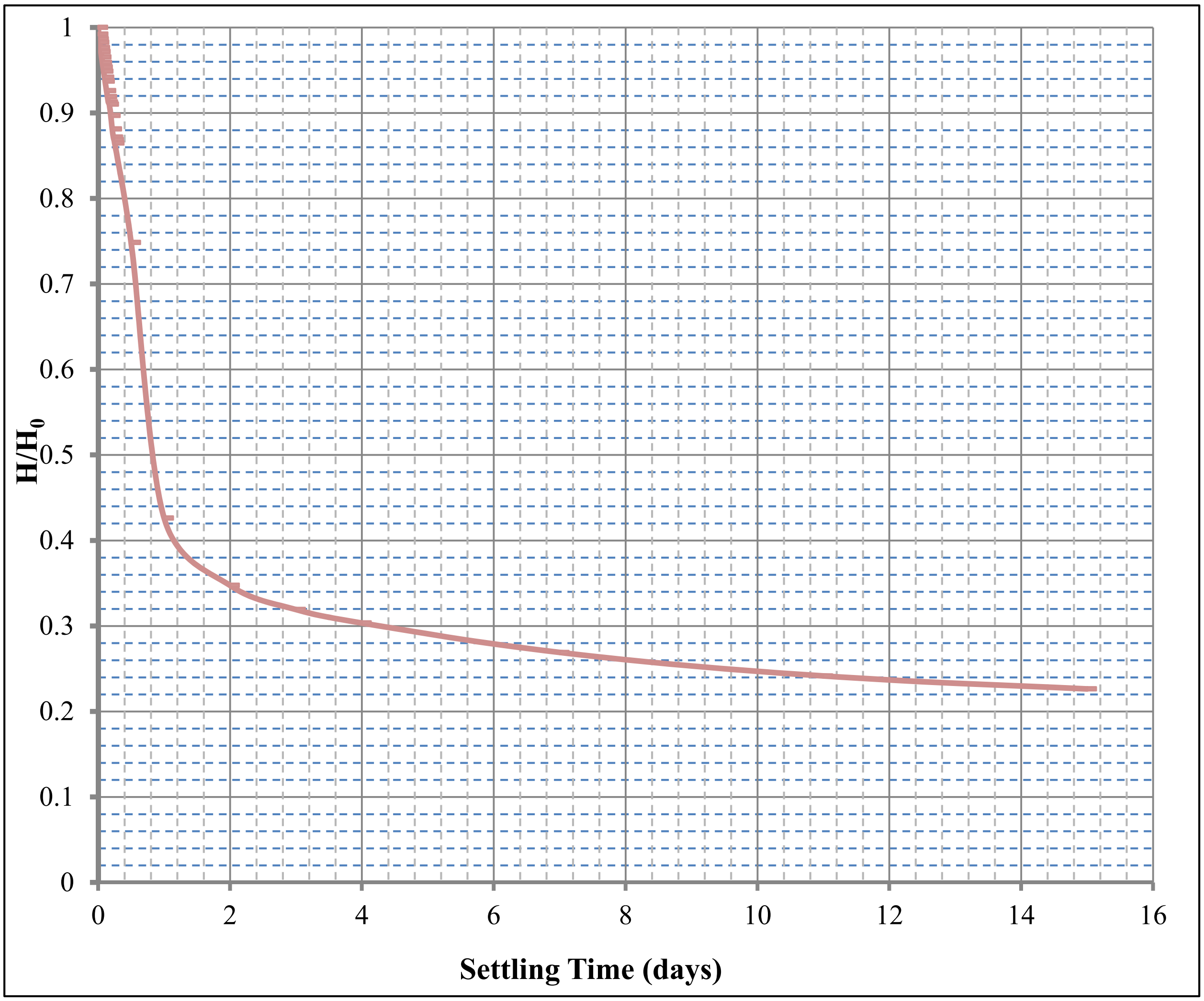
Dish Number	C
Weight of Dish with Cover (g)	117.38
Weight of Dish with Cover + Soil (g)	274.58
Weight of Dish with Cover + Ash (g)	269.44
Weight of Ash (g)	152.06
Weight of Soil (g)	157.20
Ash Content (%)	93.73
Organic Content (%)	3.3

2015-2 | Specific Gravity

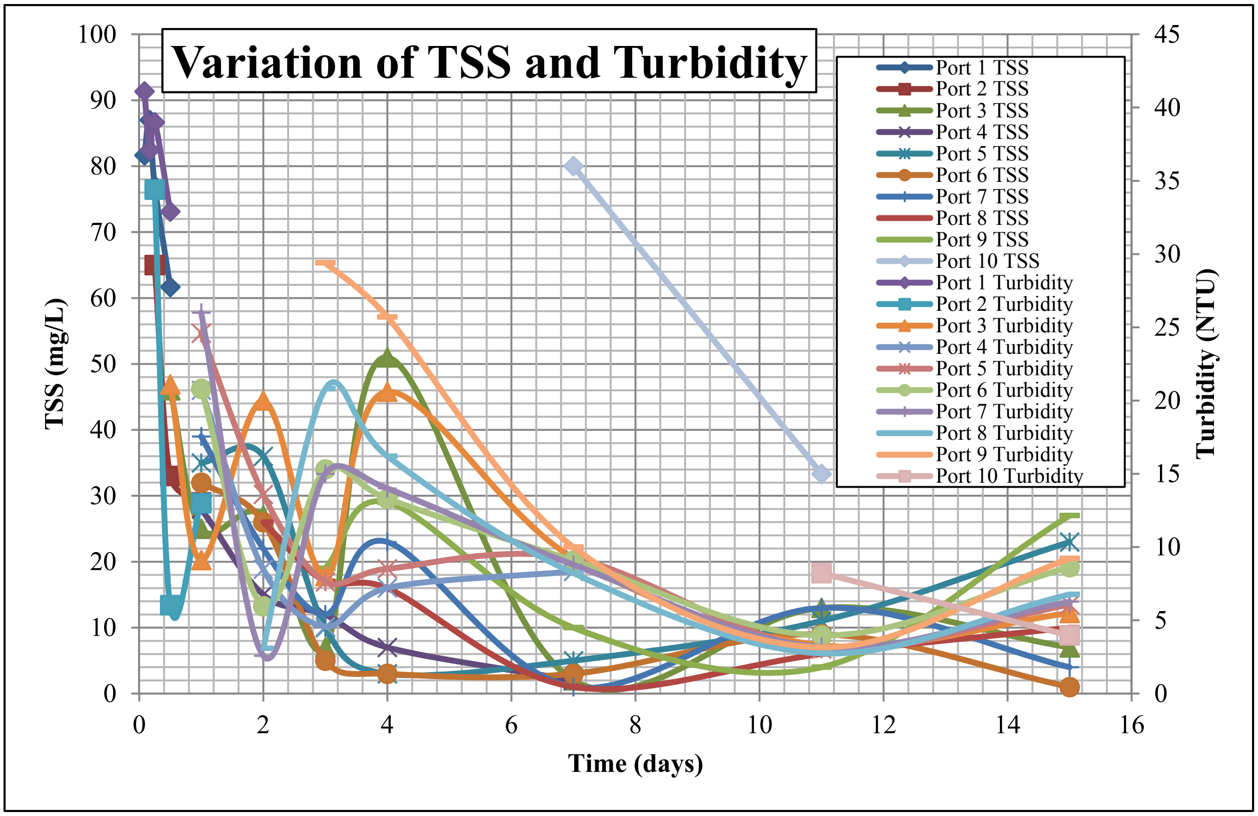
Flask Number	2
Temperature, T (˚C)	18.5
Weight of Flask, M_f (g)	179.50
Weight of Dry Soil, M_s (g)	54.43
Weight of Flask + Soil + Water, M_{fsw} (g)	710.44
Weight of Flask + Water, M_{fw} (g)	677.11
$M_{fw} – M_{fws} + M_s$ (g)	21.1
G_s (at T)	2.5796
Correction Factor	1.004
G_s (at 20˚C)	2.5806

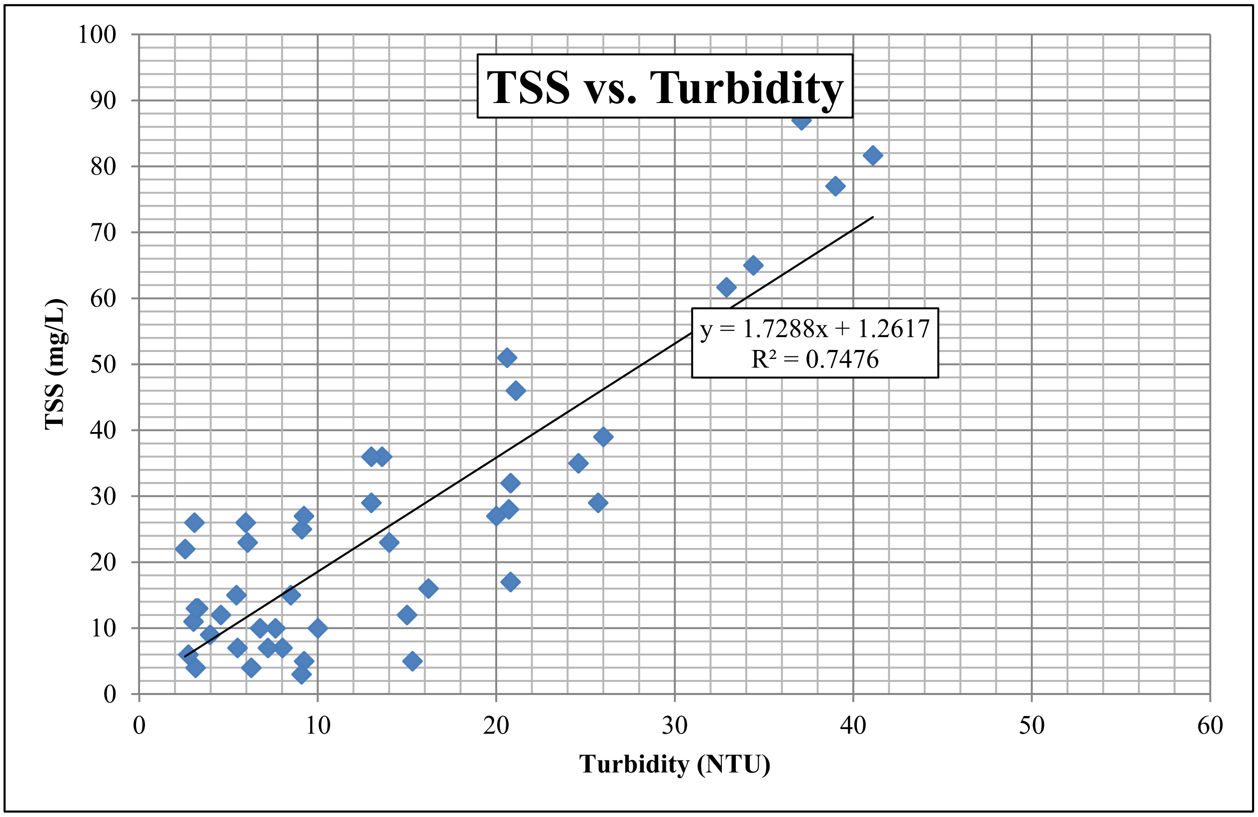
Temperature (˚C)	Correction Factor
17	1.0006
18	1.0004
19	1.0002
20	1
21	0.9998
22	0.9996
23	0.9993
24	0.9991
25	0.9988
26	0.9986
27	0.9983
28	0.998

2015-2 | Settling Curve



2015-2 | TSS and Turbidity





2015-2 | Bulk Density

Initial Concentration (g/L)=	106.31		Column Volume (in^3)=	15984.42		1 liter=	61.02 in^3
Specific Gravity=	2.58		Column Diameter (in)=	8		Column Height (in)=	79.5

Date	Test Time	C_s Avg (g/L)	Water Height (in)	Slurry Height (in)	V_t (in^3)	V_s (in^3)	V_t (L)	V_s (L)	Mass Settled (g)	Bulk Density (g/L)
1/16/2015	1h	0.0000	79.3125	77.25	15947	15532	973128	947822	103452048	109.15
	2h	0.0817	79	75.4375	15884	15168	969294	925584	103040866	111.33
	4h	0.0870	78.625	72.375	15808	14552	964693	888008	102548629	115.48
	6h	0.0710	78.3125	68.75	15746	13823	960859	843531	102139358	121.09
	12h	0.0469	77.75	59.5	15633	11963	953957	730038	101403486	138.90
1/17/2015	1d	0.0313	76.25	33.875	15331	6811	935553	415631	99441155	239.25
1/18/2015	2d	0.0253	75.9375	27.625	15268	5554	931718	338946	99034816	292.18
1/19/2015	3d	0.0117	74.9375	25.375	15067	5102	919449	311340	97738349	313.93
1/20/2015	4d	0.0189	73.8125	24.375	14841	4901	905646	299070	96266630	321.89
1/23/2015	7d	0.0034	72.375	21.375	14552	4298	888008	262261	94400905	359.95
1/27/2015	11d	0.0101	71.375	19.1875	14351	3858	875739	235422	93092196	395.43

2015-2 | Testing Photos


1 HOUR


2 HOUR


4 HOUR


6 HOUR


12 HOUR


1 DAY


2 DAY


3 DAY


4 DAY


7 DAY


11 DAY


15 DAY

2015-3

2015-3 | Engineering Properties

Sample ID	Project Location	GPS Coordinates	Test Start	Sample Type	Sample Source
2015-3	Terrebonne Parish	29.288882 N 90.622262 W	2/2/15	Grab	UNO

Concentration (g/L)	Water Type	Salinity (ppt)	pH	Specific Gravity	Organic Content (%)
97.7	Site	2	6.66	2.70	5.5

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Grain Size Distribution		Bulk Density (g/L)	Resistivity (ohms)	Conductivity (mS)
			Fines (%)	Coarse (%)			
35	19	16	55	45	367	191	2.57

Site Vicinity Plan for 2015-3

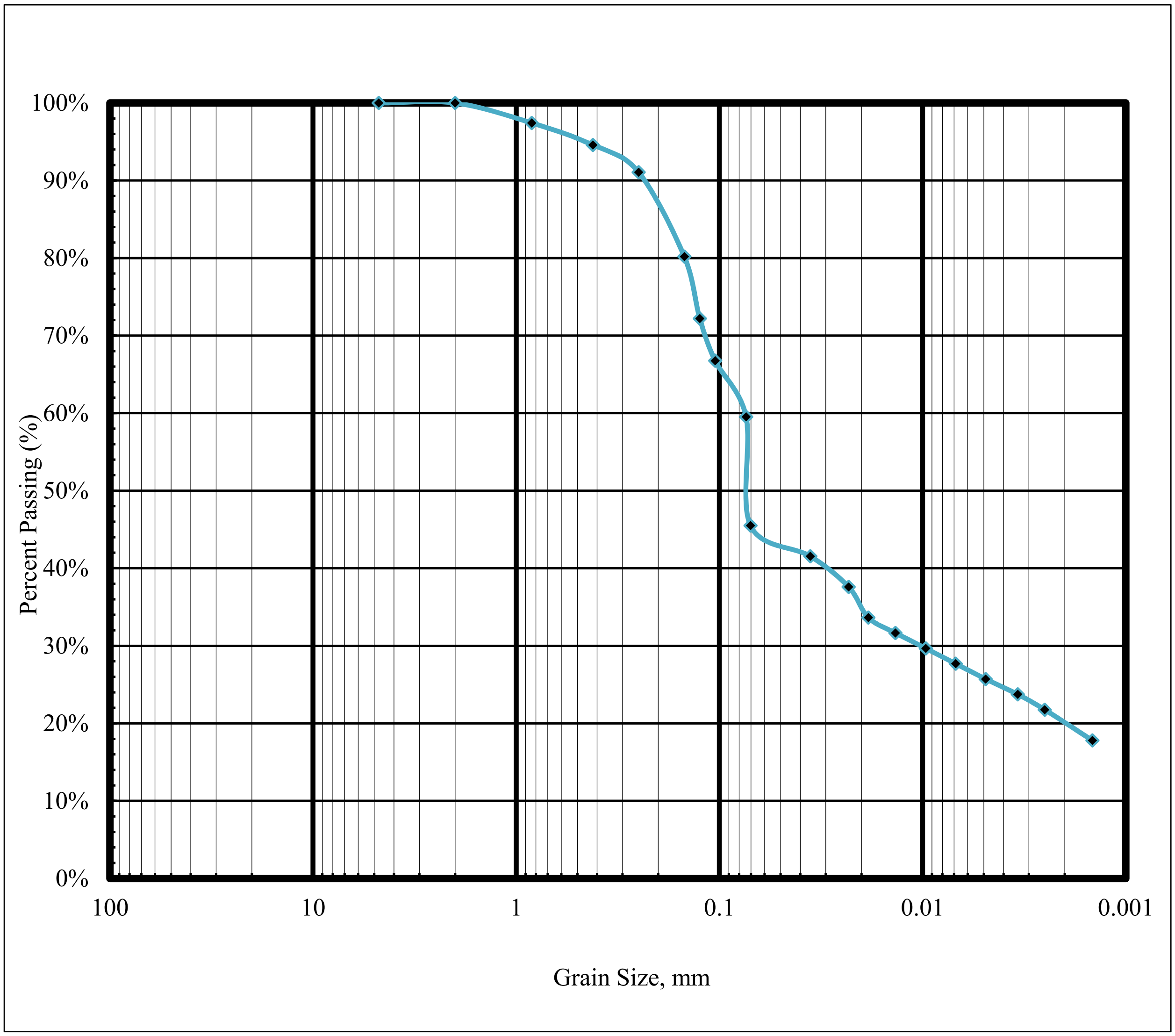
2015-3 | Hydrometer

Elapsed Time (min)	Temp Reading (C)	Composite Correction	Hydrometer Reading	Corrected Hydrometer Reading	Effective Depth (L, cm)	Value of K	Diameter of Particle Size (mm)	Percent Finer (%)
0.5	20.1	7	30	23	12.5	0.01408	0.0704	45.51%
2	20.1	7	28	21	12.9	0.01408	0.0358	41.56%
5	19.9	7	26	19	13.2	0.01425	0.0232	37.60%
8	19.8	7	24	17	13.5	0.01425	0.0185	33.64%
15	19.8	7	23	16	13.7	0.01425	0.0136	31.66%
30	19.6	7	22	15	13.8	0.01425	0.0097	29.68%
60	19.3	7	21	14	14	0.01425	0.0069	27.70%
120	19.2	7	20	13	14.2	0.01425	0.0049	25.72%
250	19.2	7	19	12	14.3	0.01425	0.0034	23.75%
480	18.9	7	18	11	14.5	0.01443	0.0025	21.77%
1440	18.8	7	16	9	14.8	0.01443	0.0015	17.81%

2015-3 | Sieve Analysis

Sieve Size	Particle Size (mm)	Cumulative Weight Retained (g)	Percent Retained	Percent Passing
No.4	4.760	0.00	0.00%	100.00%
No.10	2.000	0.00	0.00%	100.00%
No.20	0.840	3.35	2.57%	97.43%
No. 40	0.420	7.03	5.40%	94.60%
No. 60	0.250	11.62	8.93%	91.07%
No. 100	0.149	25.77	19.80%	80.20%
No. 120	0.125	36.16	27.79%	72.21%
No. 140	0.105	43.25	33.24%	66.76%
No. 200	0.074	52.64	40.45%	59.55%
Pan		63.12	48.52%	51.48%

2015-3 | Grain Size Curve



% Fines	% Coarse
55	45

2015-3 | Atterberg Limits

	LL	LL	PL	PL
Container No.	A1	A4	L23	L49
Number of Blows	24	26		
Weight of Can (g)	13.59	14.01	13.78	13.90
Weight of Wet Soil + Can (g)	29.52	30.02	20.01	20.78
Weight of Dry Soil + Can (g)	25.44	25.90	19.02	19.70
Weight of Dry Soil (g)	11.85	11.89	5.26	5.80
Water Weight (g)	4.08	4.12	0.99	1.08
Moisture Content (%)	34.43	34.65	18.89	18.62
Correction Factor	.0995	1.005		
Corrected Percent	34	35		

Liquid Limit	Plastic Limit	Plasticity Index
35	19	16

2015-3 | Organic Content

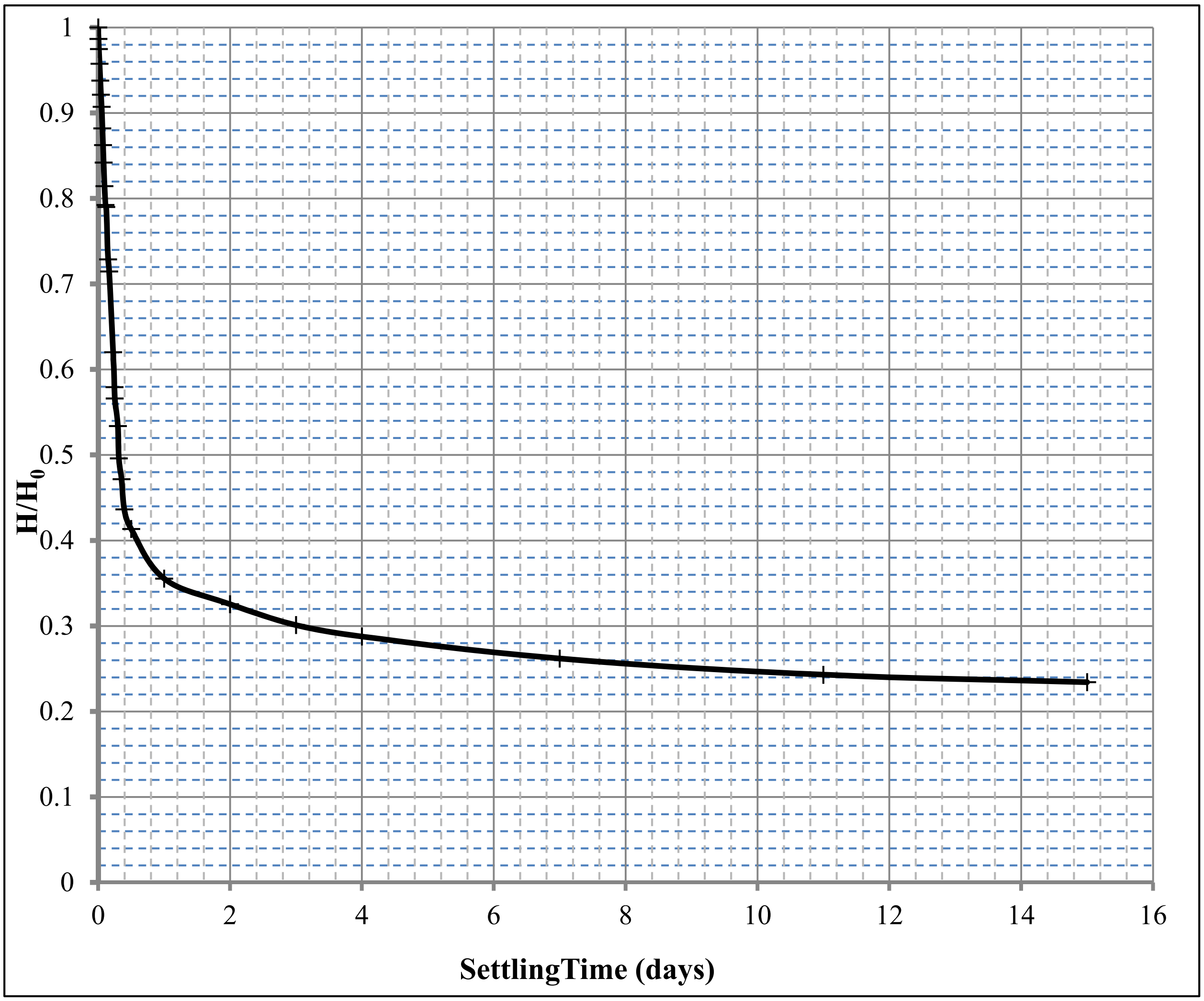
Dish Number	B
Weight of Dish with Cover (g)	127.00
Weight of Dish with Cover + Soil (g)	288.30
Weight of Dish with Cover + Ash (g)	279.50
Weight of Ash (g)	152.50
Weight of Soil (g)	161.30
Ash Content (%)	94.54
Organic Content (%)	5.5

2015-3 | Specific Gravity

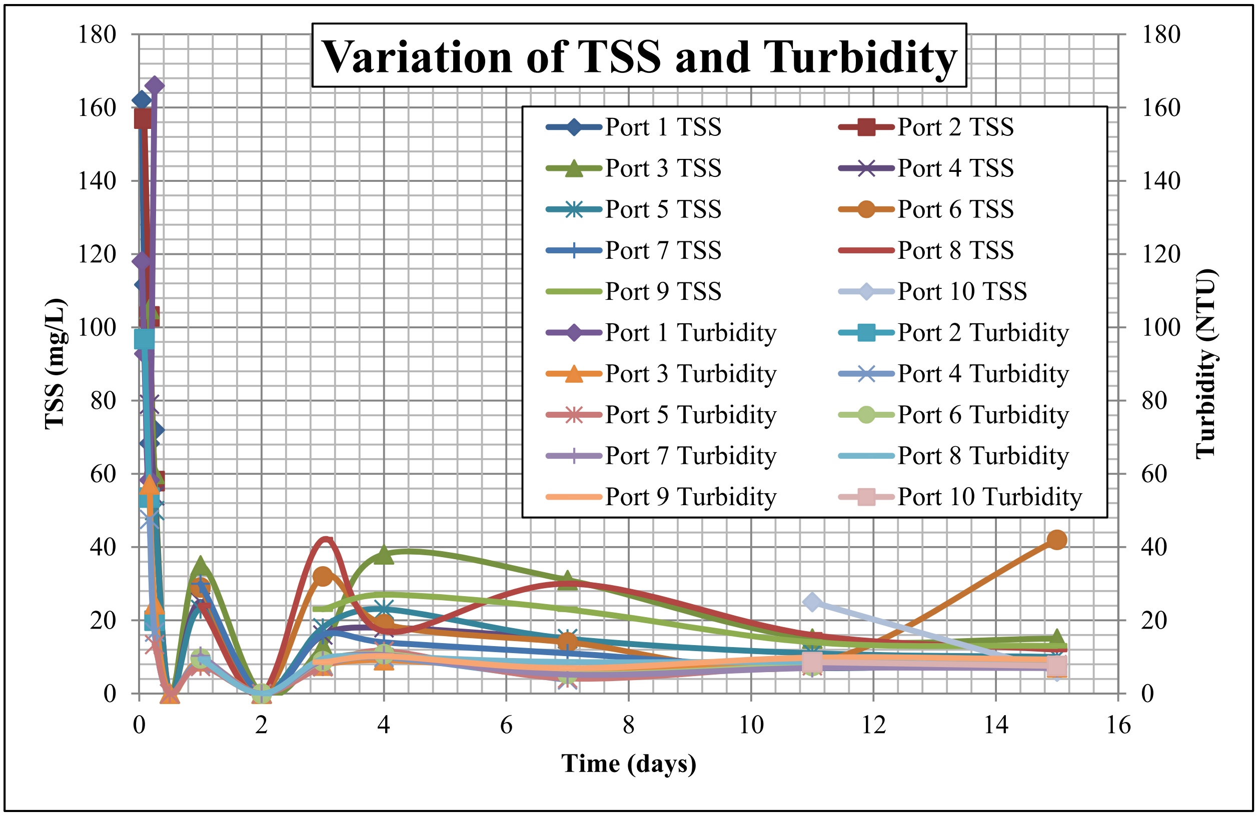
Flask Number	1
Temperature, T (˚C)	19.9
Weight of Flask, M_f (g)	203.87
Weight of Dry Soil, M_s (g)	50.18
Weight of Flask + Soil + Water, M_{fsw} (g)	732.78
Weight of Flask + Water, M_{fw} (g)	701.18
$M_{fw} – M_{fws} + M_s$ (g)	18.58
G_s (at T)	2.700
Correction Factor	1.0002
G_s (at 20˚C)	2.701

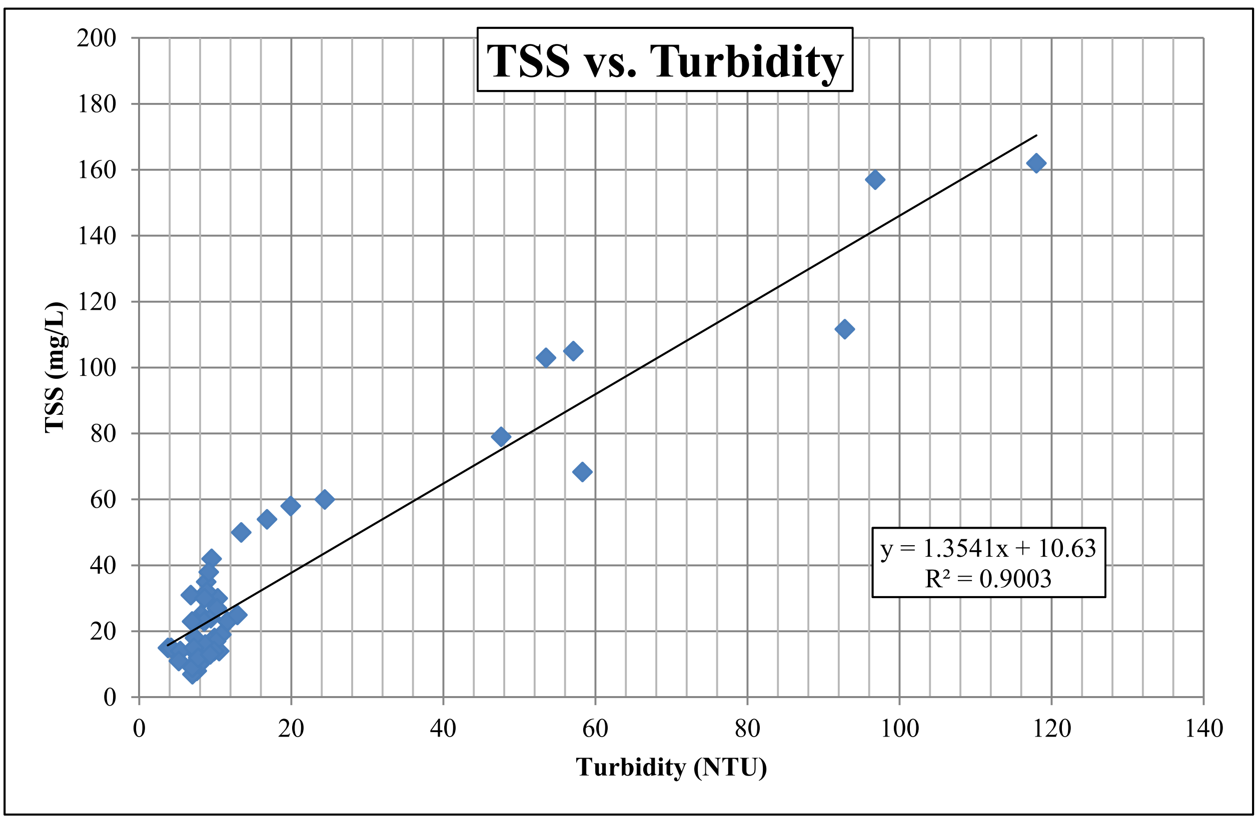
Temperature (˚C)	Correction Factor
17	1.0006
18	1.0004
19	1.0002
20	1
21	0.9998
22	0.9996
23	0.9993
24	0.9991
25	0.9988
26	0.9986
27	0.9983
28	0.998

2015-3 | Settling Curve



2015-3 | TSS and Turbidity





2015-3 | Bulk Density

Initial Concentration (g/L)=	97.07		Column Volume (in^3)=	15984.42		1 liter=	61.02 in^3
Specific Gravity=	2.70		Column Diameter (in)=	8		Column Height (in)=	79.5

Date	Test Time	C_s Avg (g/L)	Water Height (in)	Slurry Height (in)	V_t (in^3)	V_s (in^3)	V_t (L)	V_s (L)	Mass Settled (g)	Bulk Density (g/L)
2/2/2015	1h	0.16	79.1875	73.25	15922	14728	971594	898744	94300869	104.93
	2h	0.13	78.8125	66.9375	15846	13459	966993	821293	93846472	114.27
	4h	0.09	78.25	56.8125	15733	11423	960092	697063	93172739	133.66
	6h	0.06	77.4375	45	15570	9048	950123	552129	92205011	167.00
	12h		76.9375	32.875	15469	6610	943988	403361	91632911	227.17
2/3/2015	1d	0.03	76.5	28.25	15381	5680	938620	346615	91095468	262.81
2/4/2015	2d		76	25.875	15281	5202	932485	317474	90516344	285.11
2/5/2015	3d	0.02	75.25	23.9375	15130	4813	923283	293702	89608700	305.10
2/6/2015	4d	0.02	74.25	22.875	14929	4599	911014	280666	88417678	315.03
2/9/2015	7d	0.02	72.9375	20.8125	14665	4185	894910	255360	86856193	340.13
2/13/2015	11d	0.01	71.5	19.3125	14376	3883	877272	236956	85148042	359.34

2015-3 | Testing Photos


START


1 HOUR


2 HOUR


4 HOUR


6 HOUR


1 DAY


4 DAY


11 DAY


11 DAY

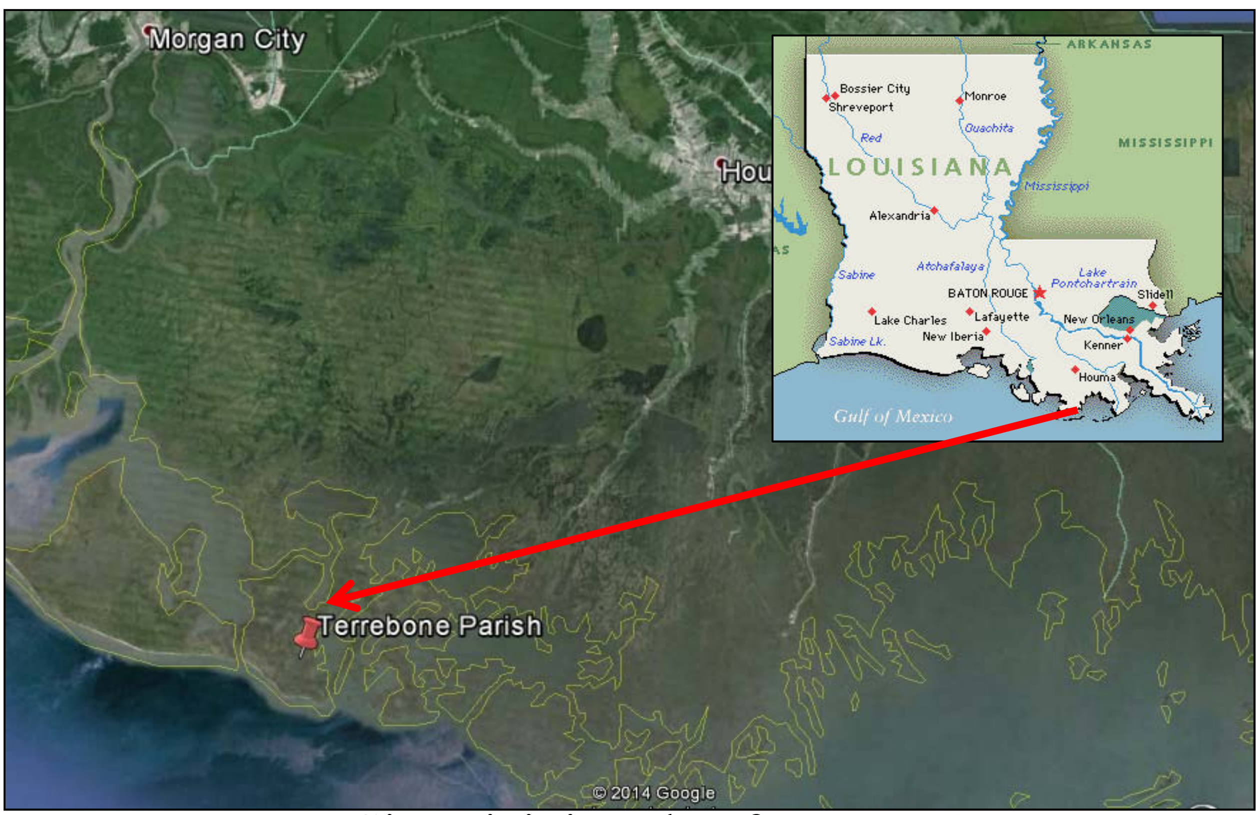
2015-4

2015-4 | Engineering Properties

Sample ID	Project Location	GPS Coordinates	Test Start	Sample Type	Sample Source
2015-4	Terrebonne Parish, LA	29°13'12.15"N 91° 4'46.26"W	2/18/15	Shelby Tubes	PSI

Concentration (g/L)	Water Type	Salinity (ppt)	pH	Specific Gravity	Organic Content (%)
95.5	Salt	32	6.5	2.65	3.1

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Grain Size Distribution		Bulk Density (g/L)	Resistivity (ohms)	Conductivity (mS)
			Fines (%)	Coarse (%)			
49	23	26	91	9	355	216	8.83



Site Vicinity Plan for 2015-4

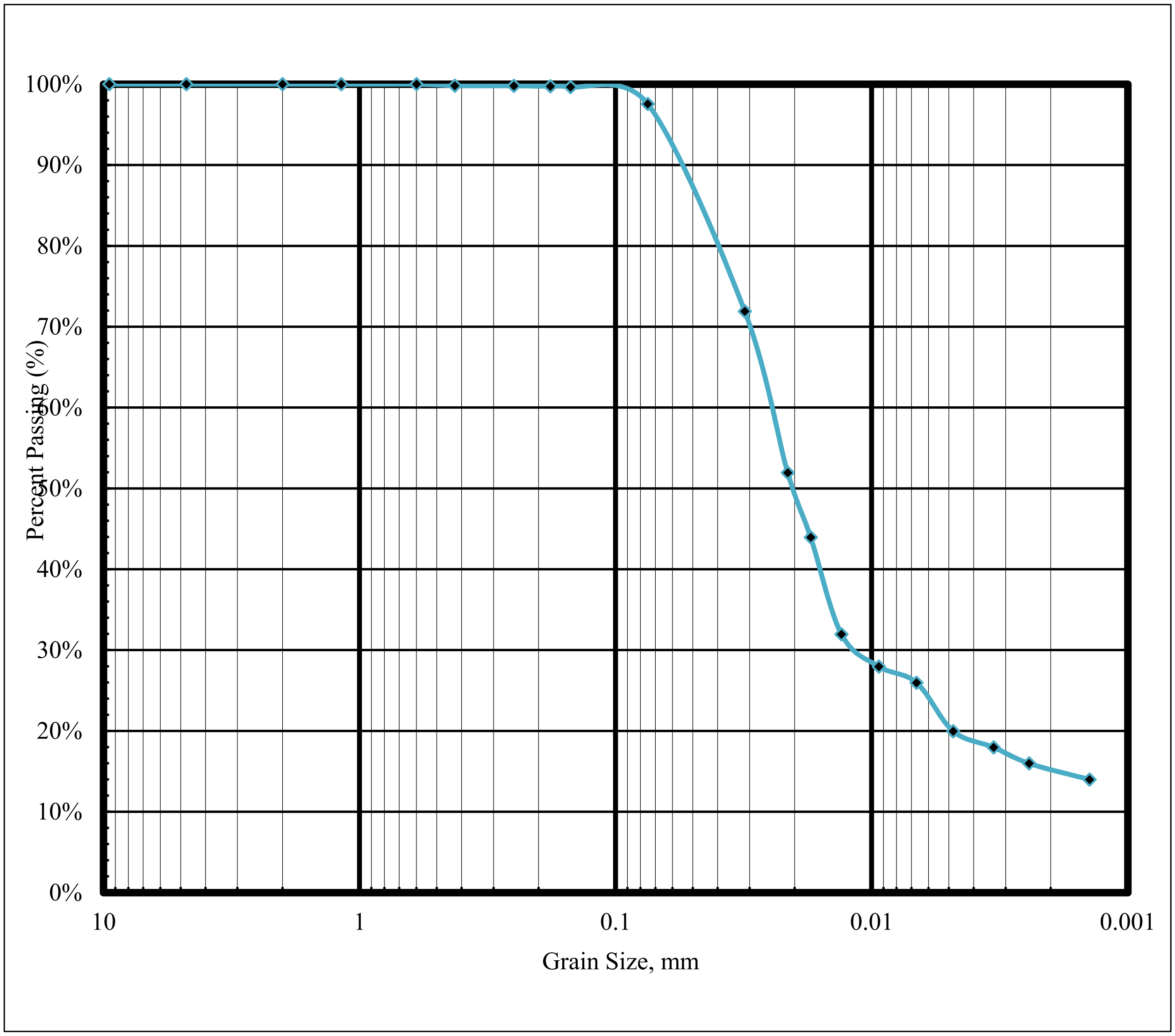
2015-4 | Hydrometer

Elapsed Time (min)	Temp Reading (C)	Composite Correction	Hydrometer Reading	Corrected Hydrometer Reading	Effective Depth (L, cm)	Value of K	Diameter of Particle Size (mm)	Percent Finer (%)
0.25	22.1	4	48	44	9.1	0.01374	0.0829	87.89%
2	22.1	4	40	36	10.4	0.01374	0.0313	71.91%
4	22.2	4	30	26	12	0.01374	0.0213	51.94%
8	22.2	4	26	22	12.7	0.01374	0.0173	43.95%
15	22.2	4	20	16	13.7	0.01374	0.0131	31.96%
30	22.2	4	18	14	14	0.01374	0.0094	27.97%
60	22.2	4	17	13	14.2	0.01374	0.0067	25.97%
120	22.3	4	14	10	14.7	0.01374	0.0048	19.98%
240	22.3	4	13	9	14.8	0.01374	0.0033	17.98%
480	22.2	4	12	8	15	0.01374	0.0024	15.98%
1440	22.2	4	11	7	15.2	0.01374	0.0014	13.98%

2015-4 | Sieve Analysis

Sieve Size	Particle Size (mm)	Cumulative Weight Retained (g)	Percent Retained	Percent Passing
3/8"	9.5000	0	0.00%	100.00%
#4	4.7500	0	0.00%	100.00%
#10	2.0000	0	0.00%	100.00%
#20	0.850	0	0.00%	100.00%
#40	0.4250	0.09	0.18%	99.82%
#60	0.25000	0.10	0.20%	99.80%
#80	0.1800	0.13	0.26%	99.74%
#100	0.1500	0.17	0.34%	99.66%
#200	0.0750	1.22	2.44%	97.56%
Pan		1.61	3.22%	96.78%

2015-4 | Grain Size Curve



% Fines	% Coarse
91	9

2015-4 | Atterberg Limits

	LL	LL	PL	PL
Container No.	A4	A3	L19	A1
Number of Blows	22	23		
Weight of Can (g)	13.86	13.69	13.79	13.81
Weight of Wet Soil + Can (g)	31.77	35.16	21.58	20.77
Weight of Dry Soil + Can (g)	25.78	28.08	20.16	19.48
Weight of Dry Soil (g)	11.92	11.39	6.37	5.67
Water Weight (g)	5.99	7.08	1.42	1.29
Moisture Content (%)	50.25	49.20	22.29	22.75
Correction Factor	0.985	0.990		
Corrected Percent	49	49		

Liquid Limit	Plastic Limit	Plasticity Index
49	23	26

2015-4 | Organic Content

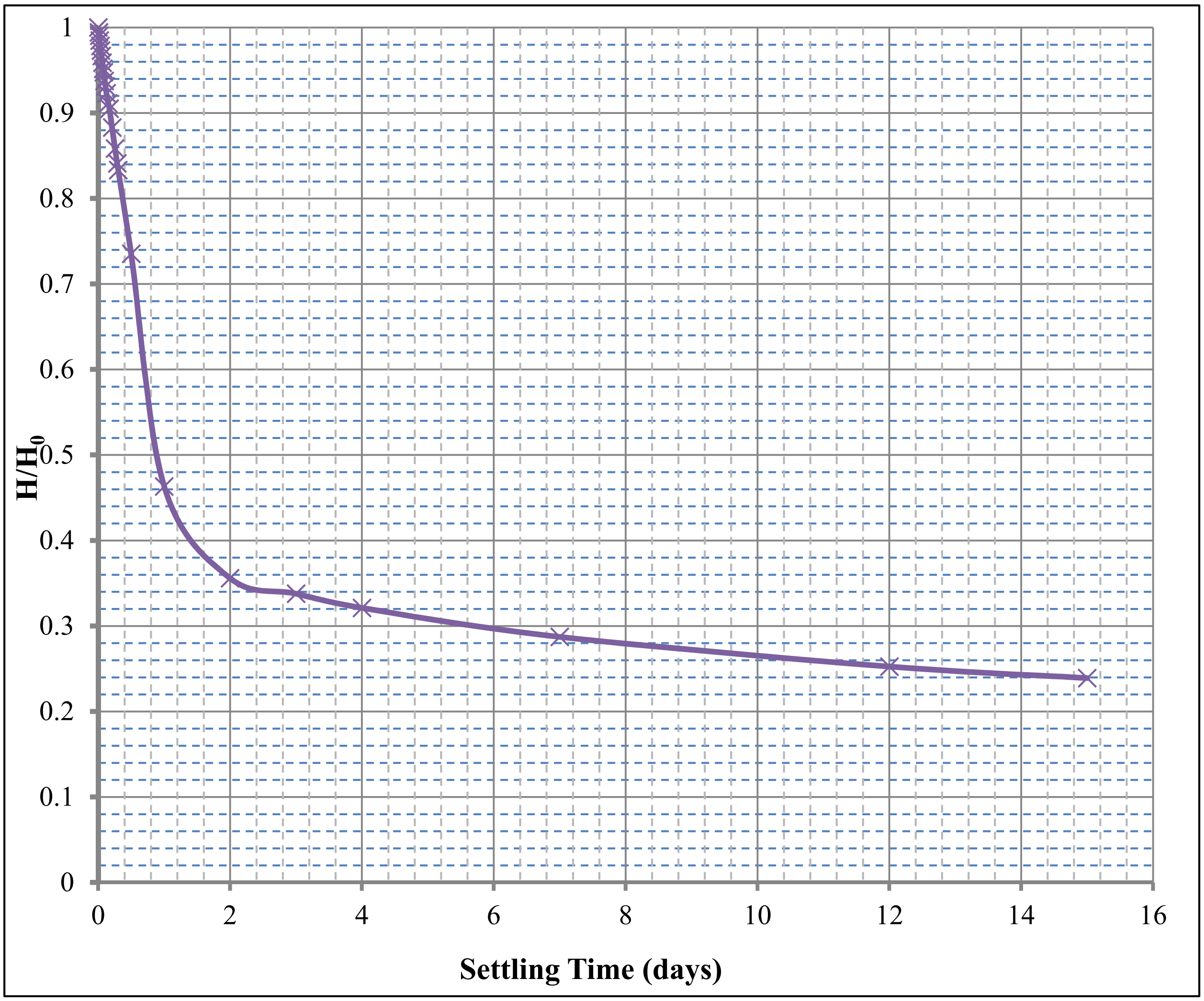
Dish Number	3
Weight of Dish with Cover (g)	340.82
Weight of Dish with Cover + Soil (g)	510.81
Weight of Dish with Cover + Ash (g)	505.52
Weight of Ash (g)	164.70
Weight of Soil (g)	169.99
Ash Content (%)	96.89
Organic Content (%)	3.1

2015-4 | Specific Gravity

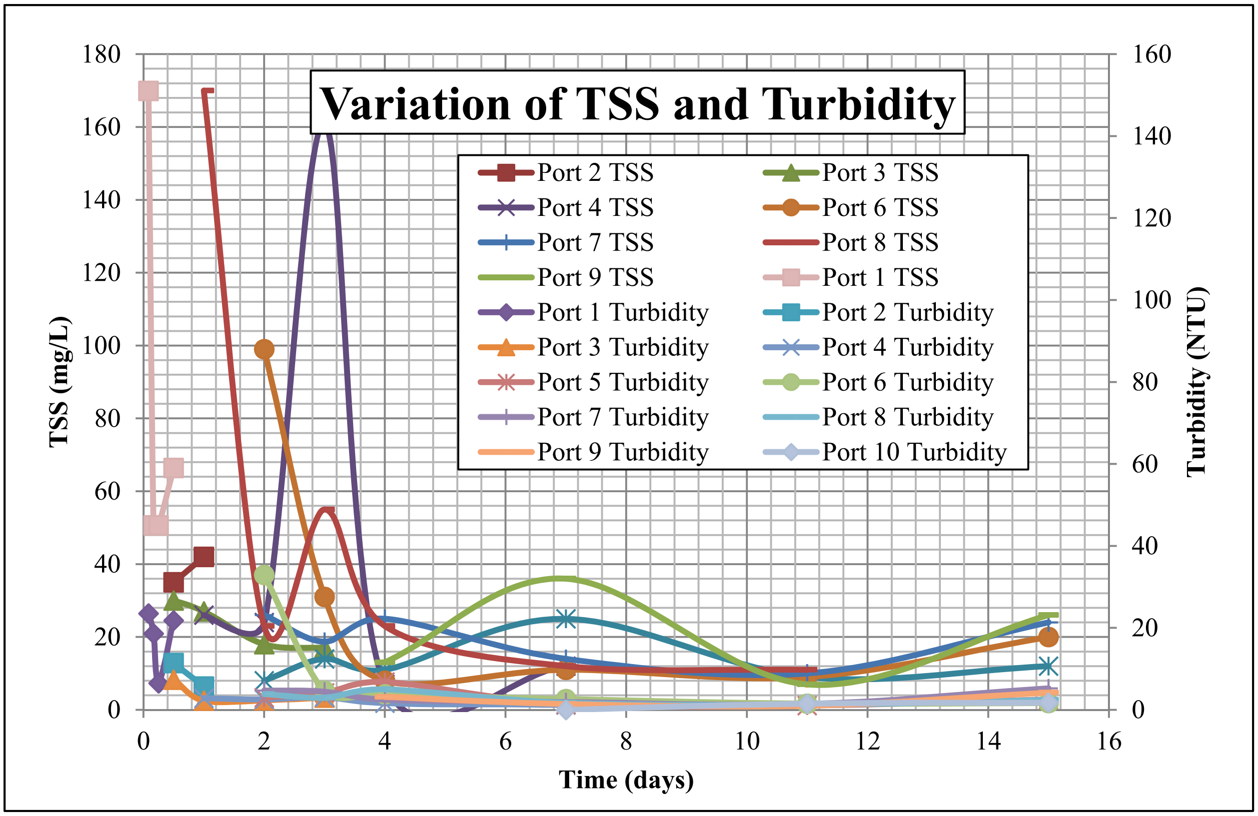
Flask Number	2
Temperature, T (˚C)	22.3
Weight of Flask, M_f (g)	203.89
Weight of Dry Soil, M_s (g)	59.49
Weight of Flask + Soil + Water, M_{fsw} (g)	738.40
Weight of Flask + Water, M_{fw} (g)	701.32
$M_{fw} – M_{fws} + M_s$ (g)	22.41
G_s (at T)	2.66
Correction Factor	0.9996
G_s (at 20˚C)	2.65

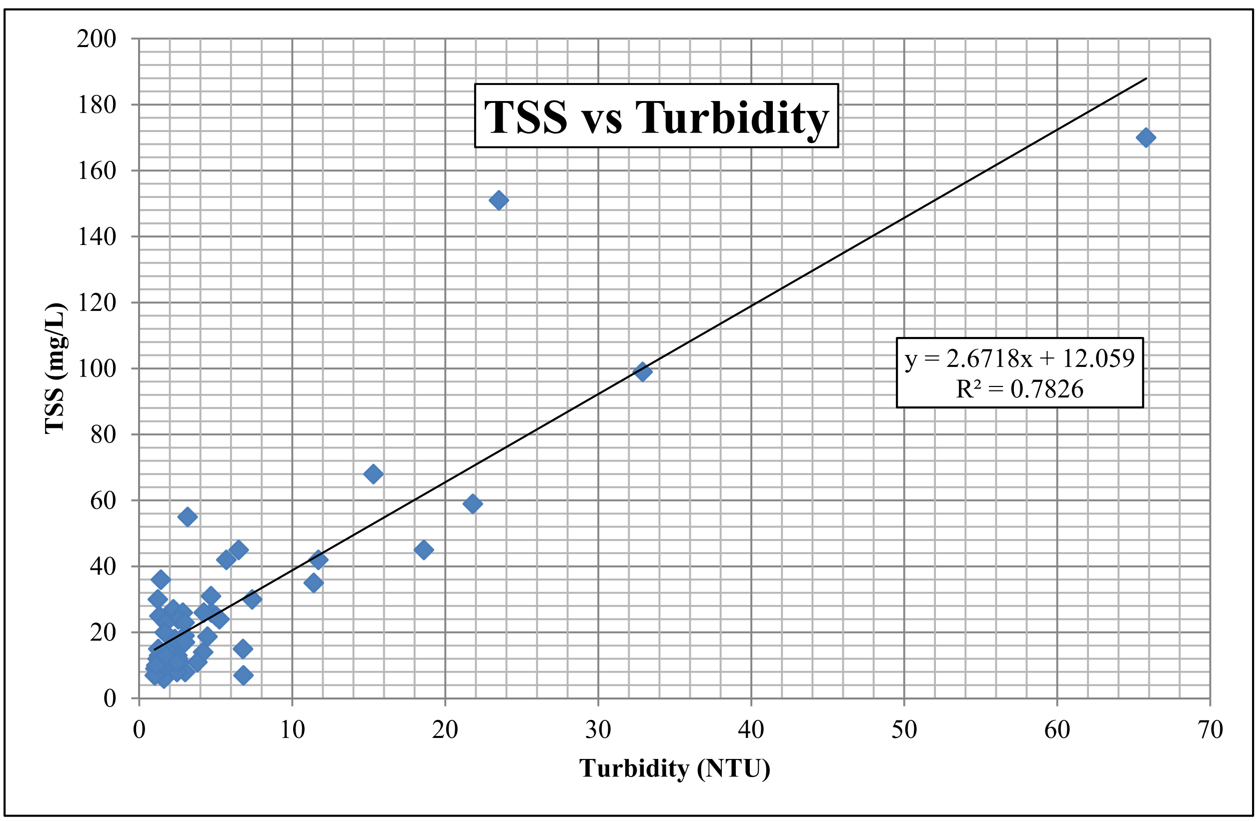
Temperature (˚C)	Correction Factor
17	1.0006
18	1.0004
19	1.0002
20	1
21	0.9998
22	0.9996
23	0.9993
24	0.9991
25	0.9988
26	0.9986
27	0.9983
28	0.998

2015-4 | Settling Curve



2015-4 | TSS and Turbidity





2015-4 | Bulk Density

Initial Concentration (g/L)=	95.5		Column Volume (in^3)=	15984.42		1 liter=	61.02 in^3
Specific Gravity=	2.65		Column Diameter (in)=	8		Column Height (in)=	79.5

Date	Test Time	C_s Avg (g/L)	Water Height (in)	Slurry Height (in)	V_t (in^3)	V_s (in^3)	V_t (L)	V_s (L)	Mass Settled (g)	Bulk Density (g/L)
2/18/2015	1h	0.17	79	77.0625	15884	15494	969294	945522	92839118	98.19
	2h	0.15	78.625	75.0625	15808	15092	964693	920983	92395848	100.32
	4h	0.05	78.4375	71.6875	15771	14414	962392	879573	92178366	104.80
	6h	0.06	77.9375	68	15670	13672	956257	834329	91587589	109.77
	12h	0.04	77.5	58.25	15582	11712	950890	714701	91070513	127.42
2/19/2015	1d	0.06	76.9375	36.6875	15469	7376	943988	450139	90387230	200.80
2/20/2015	2d	0.06	75.875	28.1875	15256	5667	930952	345848	89136923	257.73
2/21/2015	3d	0.04	74.875	26.75	15055	5378	918682	328210	87969287	268.03
2/22/2015	4d	0.02	73.9375	25.4375	14866	5115	907179	312106	86881756	278.37
2/25/2015	7d	0.02	72.75	22.75	14627	4574	892609	279132	85486547	306.26
3/1/2015	11d	0.01	71.5	20	14376	4021	877272	245391	84020800	342.40

2015-4 | Testing Photos


START


1 HOUR


2 HOUR


4 HOUR


6 HOUR


12 HOUR


2 DAY


3 DAY


4 DAY


7 DAY


11 DAY


15 DAY

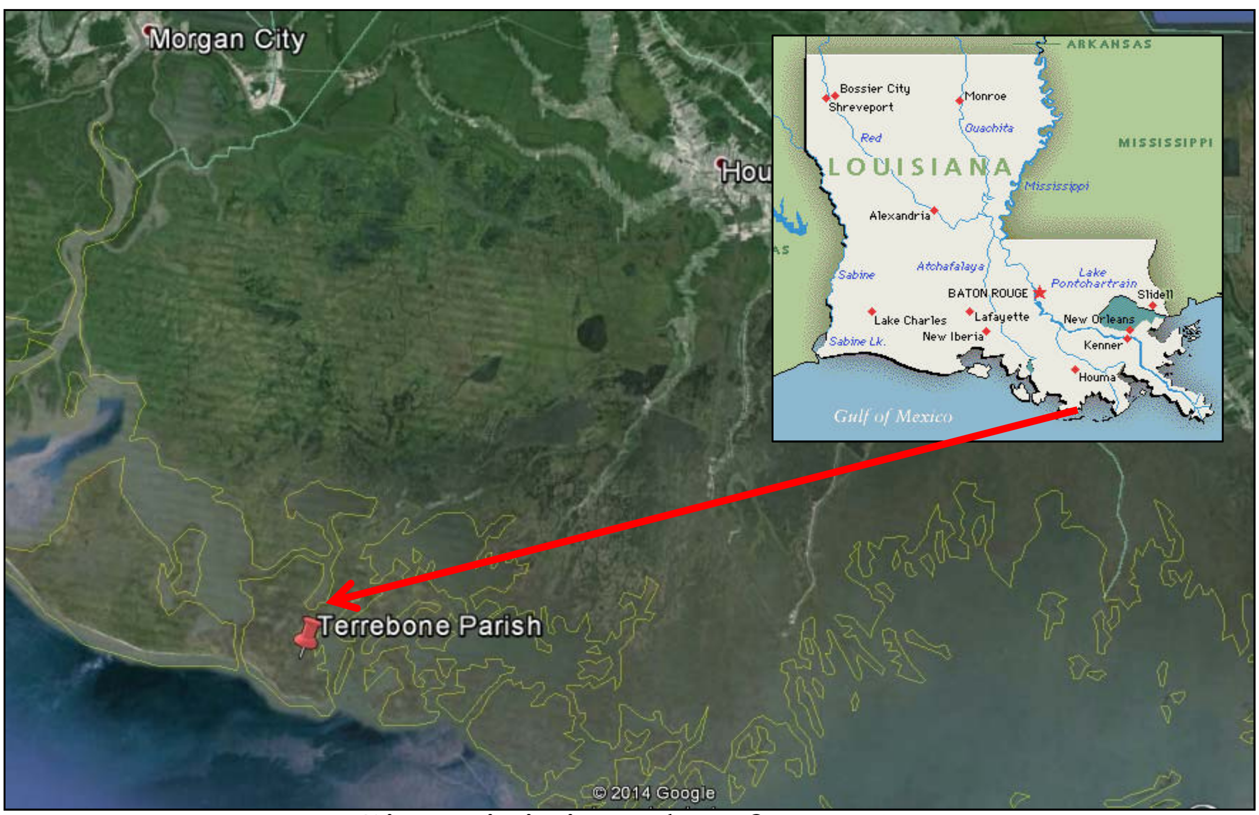
2015-5

2015-5 | Engineering Properties

Sample ID	Project Location	GPS Coordinates	Test Start	Sample Type	Sample Source
2015-5	Terrebonne Parish, LA	29°13'12.15"N 91° 4'46.26"W	3/6/15	Shelby Tubes	PSI

Concentration (g/L)	Water Type	Salinity (ppt)	pH	Specific Gravity	Organic Content (%)
100	Site	4	7.18	2.65	3.1

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Grain Size Distribution		Bulk Density (g/L)	Resistivity (ohms)	Conductivity (mS)
			Fines (%)	Coarse (%)			
49	23	26	91	9	532	149.5	8.16



Site Vicinity Plan for 2015-5

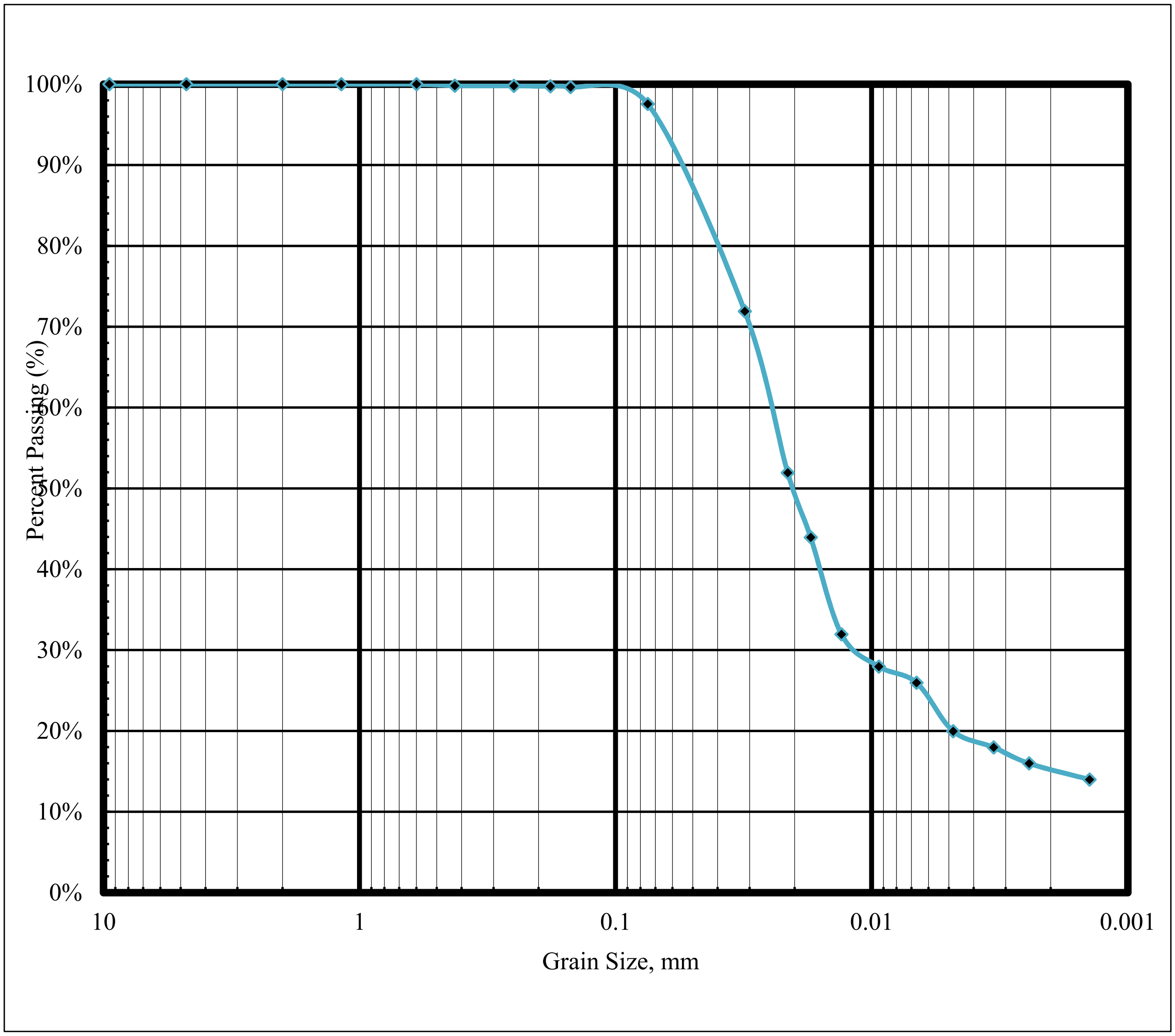
2015-5 | Hydrometer

Elapsed Time (min)	Temp Reading (C)	Composite Correction	Hydrometer Reading	Corrected Hydrometer Reading	Effective Depth (L, cm)	Value of K	Diameter of Particle Size (mm)	Percent Finer (%)
0.25	22.1	4	48	44	9.1	0.01374	0.0829	87.89%
2	22.1	4	40	36	10.4	0.01374	0.0313	71.91%
4	22.2	4	30	26	12	0.01374	0.0213	51.94%
8	22.2	4	26	22	12.7	0.01374	0.0173	43.95%
15	22.2	4	20	16	13.7	0.01374	0.0131	31.96%
30	22.2	4	18	14	14	0.01374	0.0094	27.97%
60	22.2	4	17	13	14.2	0.01374	0.0067	25.97%
120	22.3	4	14	10	14.7	0.01374	0.0048	19.98%
240	22.3	4	13	9	14.8	0.01374	0.0033	17.98%
480	22.2	4	12	8	15	0.01374	0.0024	15.98%
1440	22.2	4	11	7	15.2	0.01374	0.0014	13.98%

2015-5 | Sieve Analysis

Sieve Size	Particle Size (mm)	Cumulative Weight Retained (g)	Percent Retained	Percent Passing
3/8"	9.5000	0	0.00%	100.00%
#4	4.7500	0	0.00%	100.00%
#10	2.0000	0	0.00%	100.00%
#20	0.850	0	0.00%	100.00%
#40	0.4250	0.09	0.18%	99.82%
#60	0.25000	0.10	0.20%	99.80%
#80	0.1800	0.13	0.26%	99.74%
#100	0.1500	0.17	0.34%	99.66%
#200	0.0750	1.22	2.44%	97.56%
Pan		1.61	3.22%	96.78%

2015-5 | Grain Size Curve



% Fines	% Coarse
91	9

2015-3 | Atterberg Limits

	LL	LL	PL	PL
Container No.	A4	A3	L19	A1
Number of Blows	22	23		
Weight of Can (g)	13.86	13.69	13.79	13.81
Weight of Wet Soil + Can (g)	31.77	35.16	21.58	20.77
Weight of Dry Soil + Can (g)	25.78	28.08	20.16	19.48
Weight of Dry Soil (g)	11.92	11.39	6.37	5.67
Water Weight (g)	5.99	7.08	1.42	1.29
Moisture Content (%)	50.25	49.20	22.29	22.75
Correction Factor	0.985	0.990		
Corrected Percent	49	49		

Liquid Limit	Plastic Limit	Plasticity Index
49	23	26

2015-3 | Organic Content

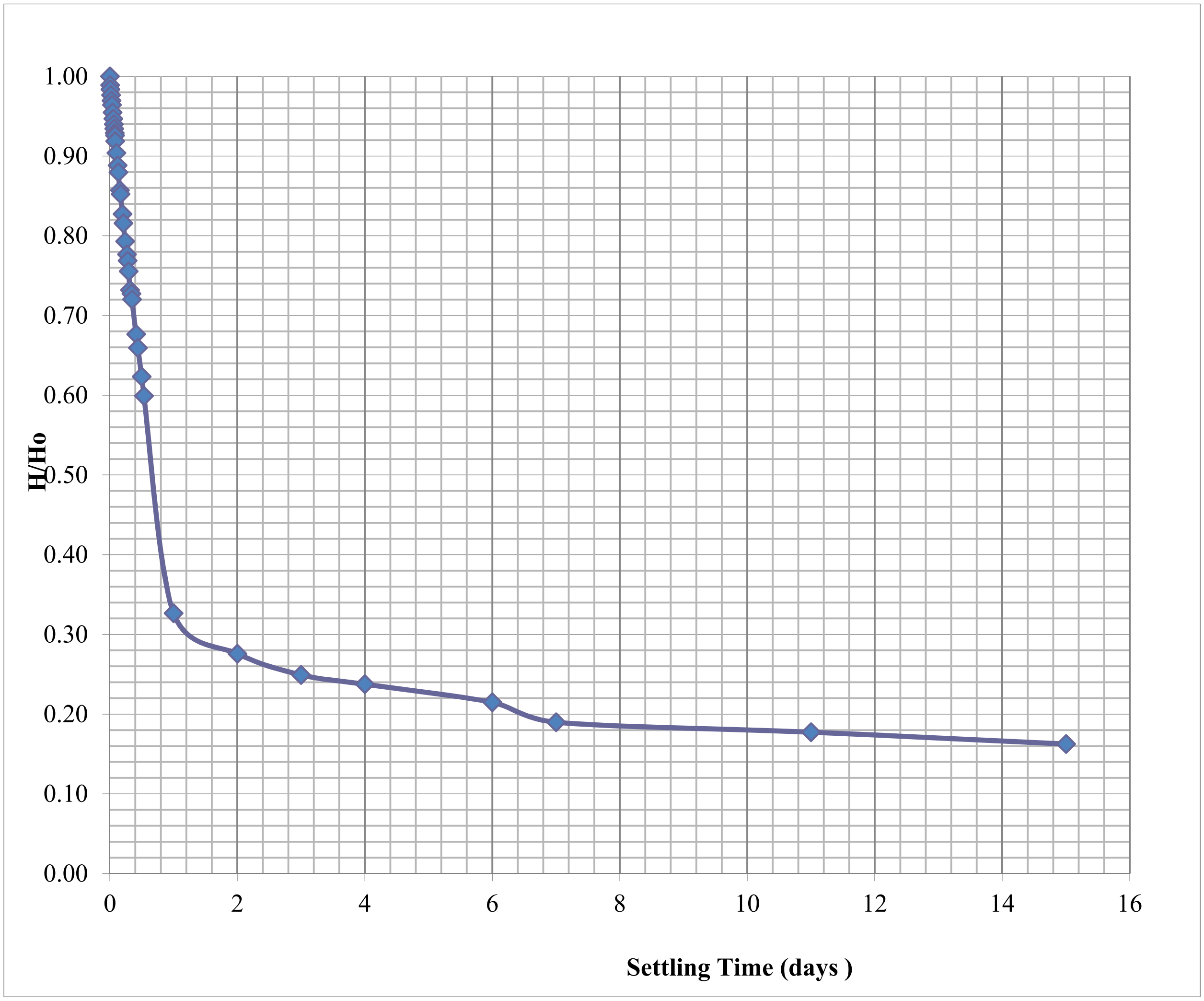
Dish Number	3
Weight of Dish with Cover (g)	340.82
Weight of Dish with Cover + Soil (g)	510.81
Weight of Dish with Cover + Ash (g)	505.52
Weight of Ash (g)	164.70
Weight of Soil (g)	169.99
Ash Content (%)	96.89
Organic Content (%)	3.1

2015-5 | Specific Gravity

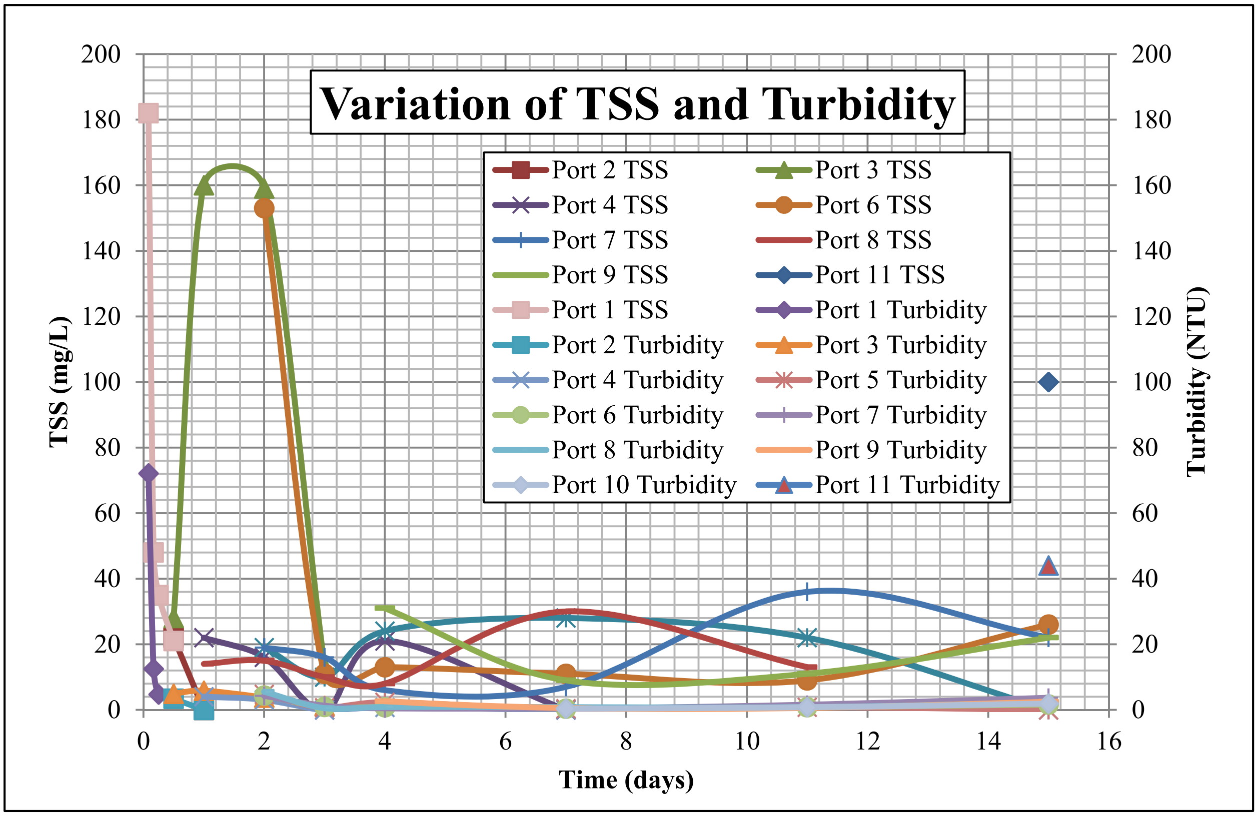
Flask Number	2
Temperature, T (˚C)	22.3
Weight of Flask, M_f (g)	203.89
Weight of Dry Soil, M_s (g)	59.49
Weight of Flask + Soil + Water, M_{fsw} (g)	738.40
Weight of Flask + Water, M_{fw} (g)	701.32
$M_{fw} – M_{fws} + M_s$ (g)	22.41
G_s (at T)	2.66
Correction Factor	0.9996
G_s (at 20˚C)	2.65

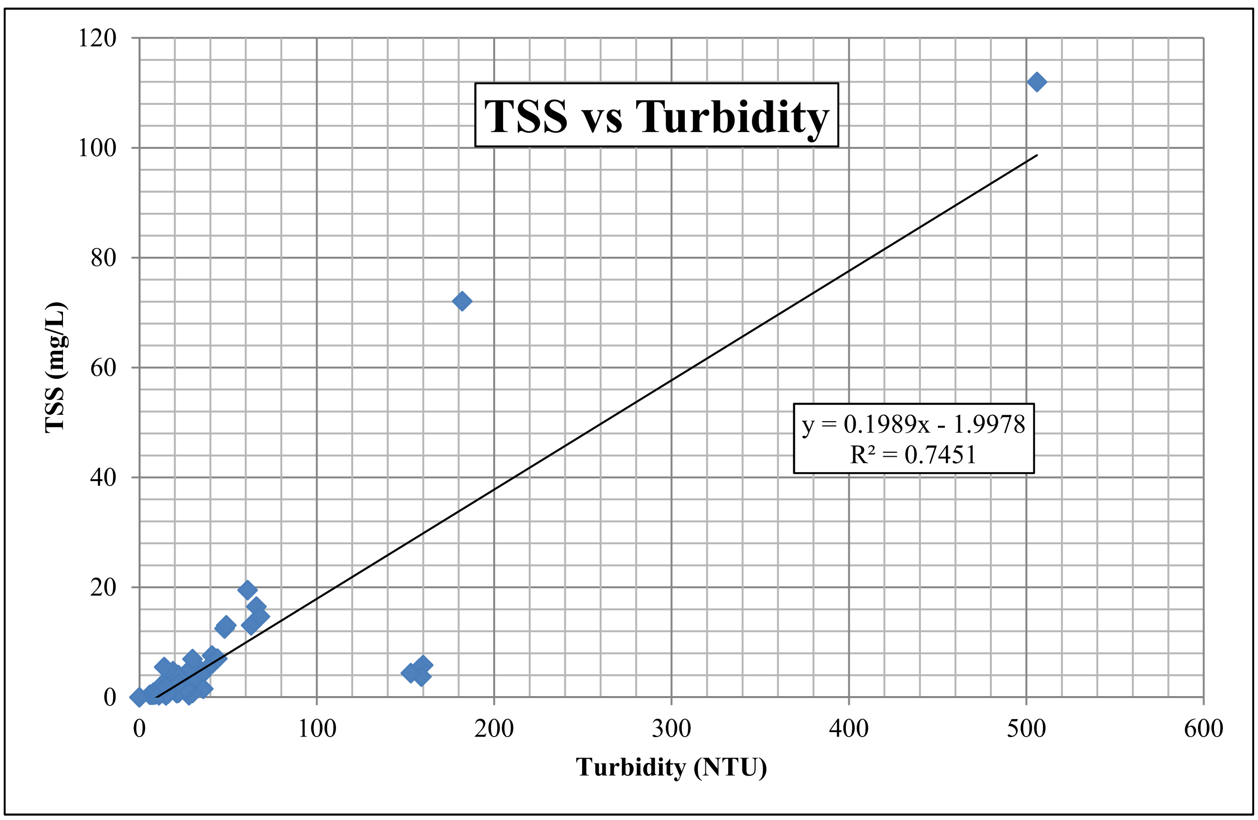
Temperature (˚C)	Correction Factor
17	1.0006
18	1.0004
19	1.0002
20	1
21	0.9998
22	0.9996
23	0.9993
24	0.9991
25	0.9988
26	0.9986
27	0.9983
28	0.998

2015-5 | Settling Curve



2015-5 | TSS and Turbidity





2015-4 | Bulk Density

Initial Concentration (g/L)=	99.4		Column Volume (in^3)=	15984.42		1 liter=	61.02 in^3
Specific Gravity=	2.65		Column Diameter (in)=	8		Column Height (in)=	79.5

Date	Test Time	C_s Avg (g/L)	Water Height (in)	Slurry Height (in)	V_t (in^3)	V_s (in^3)	V_t (L)	V_s (L)	Mass Settled (g)	Bulk Density (g/L)
3/6/2015	1h	0.51	79.375	76.375	15959	15356	973895	937086	96786535	103.28
	2h	0.18	79.125	73.5	15909	14778	970828	901811	96487701	106.99
	4h	0.06	78.875	68.1875	15859	13710	967760	836629	96187889	114.97
	6h	0.05	78.25	62.125	15733	12491	960092	762245	95422632	125.19
	12h	0.03	77.5625	49.875	15595	10028	951656	611943	94585816	154.57
3/7/2015	1d	0.07	76.5	26.125	15381	5253	938620	320542	93253446	290.92
3/8/2015	2d	0.06	75.25	22.0625	15130	4436	923283	270697	91734346	338.88
3/9/2015	3d	0.02	74.25	19.9375	14929	4009	911014	244624	90544466	370.14
3/10/2015	4d	0.02	73	19	14678	3820	895677	233121	89018165	381.85
3/13/2015	7d	0.01	71.4375	16.5625	14363	3330	876505	203214	87116733	428.69
3/17/2015	11d	0.02	70.6875	14.0625	14213	2827	867303	172540	86197563	499.58
3/21/2015	15d	0.02	69.5625	13	13986	2614	853500	159504	84821153	531.78

2015-5 | Testing Photos


START


1 HOUR


2 HOUR


4 HOUR


12 HOUR


1 DAY


2 DAY


3 DAY


4 DAY


7 DAY


11 DAY


15 DAY

APPENDIX C

GIS DATABASE

Available on flash drive

Vita

The author was born and raised in San Diego, California. Her preliminary education was completed at Coronado High School in Coronado, CA in 2008. She obtained her Bachelor's degree in civil and environmental engineering from Lafayette College in Easton, PA in 2012. She worked as a field engineer in New Jersey at Melick-Tully, and Associates from 2012 to 2013. She joined the University of New Orleans engineering graduate program to purse a Master's of Science in Civil Engineering and became a graduate research student for Dr. Malay Ghose-Hajra in 2014. Ms. Mebust has already published two papers at national conferences and has submitted another at another conference. Additionally, she has presented her research at three conferences. In addition to her graduate research assistant responsibilities, Ms. Mebust is a Graduate Engineer at Professional Service Industries, Inc. (PSI) in Jefferson, LA.