

Feasibility Study for the Landside Berth of the U.S.S. Clamagore

PATRIOTS POINT

Development Authority

Project # P36-T007-PG



Prepared by

DENNIS
CORPORATION

January 29, 2010

Mr. Bob Howard
Director of Operations
Patriots Point Naval & Maritime Museum
40 Patriots Point Road
Mt. Pleasant, South Carolina 29464

RE: Feasibility Report for the Landside Berth of the U.S.S. Clamagore

Dear Mr. Howard:

Dennis Corporation, along with Volkert, Inc., is pleased to submit the following report and recommendations to Patriots Point for the above referenced Project. As you will see from our research and findings we have developed two separate methods for the successful landside berth of the U.S.S. Clamagore. Both methods will safely distribute the weight equally around the sub allowing a safe relocation. This report will detail the process we plan to execute to ensure the USS Clamagore is not damaged during any phase of this project. Each method presents unique challenges with cost, time, and environmental impact. It will be important, to explain in detail which method may better suite the current needs of Patriots Point.

Our Project Team can provide all engineering services and construction management for both methods. In this report you will find each step of the project broken down into sub task and a purposed cost related to each task. It is important to know that many prices include in our construction estimates are actual purposed price from contractors who are capable to handle the work. This allows for very accurate construction cost estimates. It is also important to know that some of these prices are subject to change and decrease once advertised to the public on a basis of competitive bidding. From our report you will see that we estimate the trestle system and crane tower method to cost roughly \$5,765,499 and the cofferdam system to cost \$6.3 - \$6.6 million.

This project is very important to our firm and we have thoroughly enjoyed the opportunity to serve Patriots Point. Dennis Corporation is experienced with construction projects across the state of South Carolina, including the Charleston area specifically, and hopes we have the opportunity to make one of these envisioned methods reality.

Our team is committed to completing all project tasks on time and within budget. Your patience has been appreciated while we have been collecting data and completing research for this project. We have worked very hard to provide you with our best effort and hope you are pleased with our services. My project personnel have a long history of providing responsiveness to our clients and have always been successful in meeting proposed schedules and deadlines.

Thank you for the opportunity to submit this report and recommendation. We look forward to continuing a long term relationship with the Patriots Point Naval and Maritime Museum that will grow with your needs. We will become a seamless extension of your staff, delivering quality service, which fully exceeds your expectations.

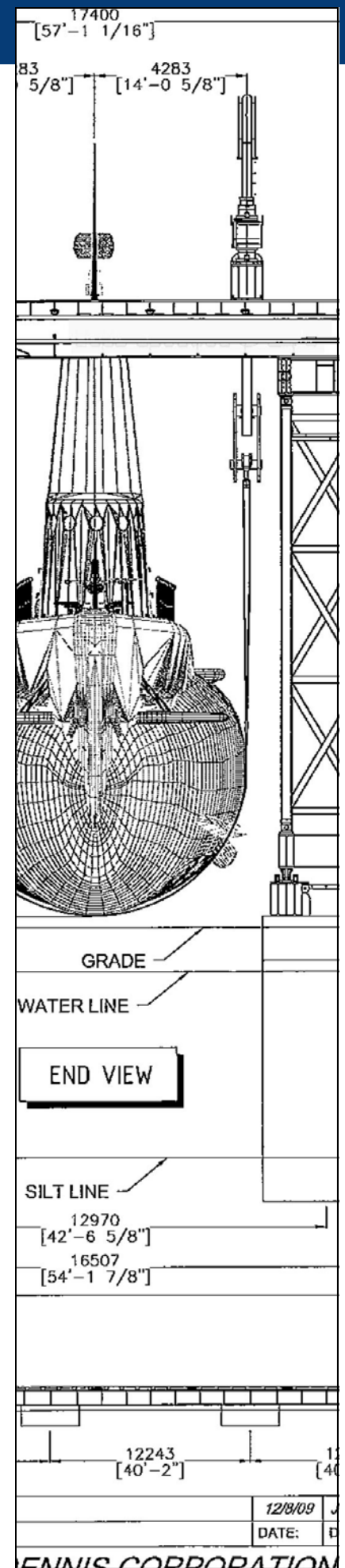
Sincerely,



Dwight Cathcart II
Special Projects Manager
Dennis Corporation

TABLE OF CONTENTS

SECTION 1 — SCOPE OF SERVICES.	PAGE 1
SECTION 2 — EXECUTIVE SUMMARY	PAGE 6
SECTION 3 — BACKGROUND & CHARACTERISTICS OF U.S.S. CLAMAGORE	PAGE 10
SECTION 4 — SITE PREPARATION	PAGE 11
SECTION 5 — CRANE LIFT OPERATION & METHOD ...	PAGE 14
A. 11x17 CRANE LIFT DRAWINGS	PAGE 24
SECTION 6 - RENDERINGS	PAGE 25
SECTION 7 - ALTERNATIVE COFFERDAM OPERATION & METHOD	PAGE 44
A. 11x17 COFFERDAM DRAWINGS	PAGE 51
SECTION 8 — COST/TIME EVALUATION	PAGE 52
SECTION 9 — ENVIRONMENTAL FEASIBILITY REPORT .	PAGE 58
SECTION 10 — CONCLUSION & RECOMMENDATION ...	PAGE 71
VOLKERT, INC. COMPLETE COFFERDAM EVALUATION REPOT	APPENDIX I
OCEAN TECHNICAL SERVICES MARINE SURVEY REPORT	APPENDIX II
GEOTECHNICAL REPORTS	APPENDIX III



SECTION 1 — Scope of Services

SCOPE OF SERVICES **Feasibility Study for U.S.S. Clamagore**

Introduction

The Landside Berth of the U.S.S. Clamagore (P36-T007-PG) will consist of five (5) project phases: Phase 1 will be an initial feasibility study to determine construction requirements and cost basis; Phase 2 will be to complete initial feasibility study; Phase 3 will be conceptual designs and permitting; Phase 4 will be final construction plans to include specifications, bidding documents and final permits; and Phase 5 will be advertising the project and construction management. To effectively move the U.S.S. Clamagore from her current waterborne berth in the Charleston Harbor to a dry berth on land, a thorough feasibility study (Phase 1 + Phase 2) must be completed to evaluate and analyze all areas that will be affected and involved in the project. Following the completion of a professional feasibility study the proper and most effective approach to the project will be identified and finalized. This will save time and money during the remainder of the project. The current marsh area and proposed resting place will be tested and evaluated to determine the best course of action. An internal and external marine survey must also be conducted to determine her structural strength.

Several methods have already been identified as possibilities to be used to move the submarine to a landside berth. One method is to construct a rail system to pull the submarine out of the water, similar to the process of how they are released into water. Another possible method is to construct a cofferdam around the submarine, which will then be used to flood the submarine to the desired elevation. In order to properly establish the best method, a proper feasibility study must be completed. An initial feasibility study can be conducted to determine estimated quantities and construction cost. This will include the following tasks:

- Task 1 – Project Management
- Task 2 – Study Prior Research and Designs
- Task 3 – Land and Hydrographic Survey
- Task 4 – Environmental Services
- Task 5 – Structural Alternative Evaluation
- Task 6 – Cost / Time Evaluation Study
- Task 7 – Submit Final Feasibility Study Report

SECTION 1 — Scope of Services

Task 1

Project Management

The CONSULTANT will be responsible for performing all project management tasks necessary to complete a limited engineering feasibility study for the U.S.S. Clamagore to determine if a method and proper landside berth operations are feasible.

The CONSULTANT will be responsible for all project coordination. This will include, but is not limited to, all coordination with internal and external members involved in the project. Coordination with all clients, members of Patriots Point, and sub-consultants.

The CONSULTANT will coordinate and direct all meetings to include all client meetings, internal meetings and conference calls, and provide an updated report as required or on a consistent, scheduled basis.

The CONSULTANT will provide project oversight during all tasks and sub-tasks to include managing all work teams and methods of payment during the life of the project. This will also involve supervising research and reviewing all documents prior to submittal.

Task 2

Study Prior Research and Designs

The CONSULTANT will review and study all prior research and designs of the U.S.S. Clamagore and the Patriots Point area. This will include, but is not limited to, all past inspections of the submarine, both internal and external, any previous survey data of the project area to include hydrographic surveys and land surveys, any dredging data that has been recorded, all designs and specification documents regarding the existing pedestrian pier and any growth or future development plans regarding the project area.

Task 3

Land and Hydrographic Survey

The CONSULTANT will perform traditional; GPS and hydrographic surveys to provide the design team with limited data which will spatially orient the current berth, retrieval route and final berth of the U.S.S. Clamagore. The survey will be tied to the South Carolina State Plane Coordinate System (NAD '83) and to published vertical datum (NAVD '88).

The upland survey will include record research to establish the property boundaries adjacent to the project area. The upland survey will also include limited topographic and planimetric features within the project area.

SECTION 1 — Scope of Services

The hydrographic survey will define the lowland, wetland and harbor areas of the project. Lines delineated by the environmental team, OCRM critical line and wetland areas, will be located and platted for permitting. The harbor floor around the berth and along the retrieval route will be surveyed and included along with the upland survey data in digital and hard copy format to the design team and owner.

Task 4

Environmental Services

The CONSULTANT will evaluate the anticipated environmental impacts of the project to assist with the determination of the most feasible alternative. The environmental evaluation will include a limited review of existing site conditions and existing information, along with State and Federal environmental regulations. The limited review of site conditions will involve the areas of wetland delineation, essential fish habitat (EFH) review, a protected species evaluation, and preliminary cultural resources. The limited review of existing information will include existing hydrographic surveys, sediment quality evaluations and other information provided by the Patriots Point Development Authority. Some of the activities that may be included in this study are listed below.

1. Conduct first phase of field reviews to examine water resources (including wetlands), essential fish habitat, protected species, and cultural resources that are present at the site. The future wetland delineation to be included in phase II will include submittal of a jurisdictional determination to the Charleston District United States Army Corps of Engineers for approval. The Consultant will also coordinate with State and Federal resource agencies for comments on essential fish habitat, protected species, and cultural resources in the project area.
2. Evaluate and discuss the proposed construction techniques for the project and determine the probable environmental impacts for the proposed techniques.
3. Develop list of required Federal and State permits required for the proposed project and probable durations of approvals.
4. Evaluate effect of environmental “windows” for the significant environmental issues on construction schedules.
5. Coordinate with State and Federal resource and regulatory agencies to present the proposed project and construction alternatives. Meetings with the agencies will be used to gain feedback that is specific to the project.
6. Recommend types of data gathering required to support design and permitting of the preferred alternative (e.g. sediment quality evaluations) and provide order of magnitude costs for the additional data gathering efforts.
7. Prepare an initial report that documents some of the alternatives that were evaluated, provides a limited environmental recommendation, and discusses estimated mitigation costs.

SECTION 1 — Scope of Services

Task 5

Construction Alternative Evaluation

The CONSULTANT will review all data and determine the most feasible and cost effective approach to move the U.S.S. Clamagore from her current water born location to a future landside berth. This will involve combining all past information with all the information gathered from the current phase I feasibility study, to include: recent submarine survey inspections, past dredging evaluation, past geotechnical investigations, land and hydrographic survey and initial environmental permitting requirements and determining which of the following methods is best achievable if any.

- 1. Cofferdam approach** – This approach will be similar to the method used on the USS Drum. The distance to raise the submarine is higher because of the final elevation above the waterline.
- 2. Rail System approach** – This approach involves the use of a steel frame mounted on a rail system that would carry the submarine to its berth. The sub would be blocked and secured to the frame and the frame would be hauled. Elevation and slope are critical.
- 3. Combination method** – This method would involve a combination of the two above methods.
- 4. Land Berth Foundation** – Regardless of the method to move the submarine to land, the final support foundation will need to be designed to spread the submarine loads to the frames of the outer hull. This foundation may need to be pile supported if the allowable bearing pressure is too low.
- 5. Quality Assurance** – The final approach technique will be reviewed for quality assurance with an eye toward protecting the vessel at all times, and providing a final berth that will support her adequately and safely.

Task 6

Cost / Time Evaluation Study

The CONSULTANT will evaluate the different scenarios of which the team has put together and evaluate the most cost efficient approach for the task at hand. Using the latest periodicals and Bid-Express services we will be able to compile an educated and “real” price to safely move the U.S.S. Clamagore to a landside berth. With time as major contributing factor, the Consultant will look at durations of the scenarios to identify the quickest method compared to cost.

Task 7

Final Report

The CONSULTANT will issue a final report with all the data and information collected during the phase I feasibility study. This report will include the determined best method to move the U.S.S. Clamagore from her current location to a landside berth, as well as the costs associated with the construction phase of the project.

SECTION 2 — Executive Summary

Executive Summary



Current Location of U.S.S. Clamagore

Dennis Corporation, along with Volkert, Inc., is pleased to submit our findings and recommendations for the Landside Berth Operation of the U.S.S. Clamagore. We have thoroughly enjoyed this project and hope that our research helps preserve the history of this great vessel. We feel honored that the Patriots Point Development Authority chose our team to complete this feasibility study and hope to continue our role in this project; as well as the purposed future construction projects involving this great submarine. We began working on this study in mid July but our research and work began long before. We originally began our research in early December 2008 when we approached Patriots Point to assist in developing a method that would securely relocate the U.S.S. Clamagore to land. We developed several ideas and scenarios for the submarine but it wasn't until

July 2009 that we began to take our visions and ideas and put them on paper to see how feasible they would be.

Several interesting scenarios were immediately discarded due to the change in grade elevation, environmental impacts, foundation dead loads, and the impacts to the Patriots Point Naval Museum. During our research, we met with a wide variety of engineers and consultants who have completed similar projects in the past. We met with companies at all levels of the project, to include dredging and crane tower operators, to discuss our scenarios. Throughout our study we turned over every rock and explored every type of situation. Companies such as BarnHart out of Memphis, Tennessee and Mammoet USA from Houston, Texas were kind enough to assist us in our research and provide some insight into our methods. Mammoet has hands down some of the most experience in moving and lifting heavy objects. Mammoet recently lifted and moved a 3,000 ton metal roof emplacing it over a full size soccer field in Germany using one of the exact same methods we have developed for the U.S.S. Clamagore. The interesting challenge during this project was not the weight but rather the fact that during the entire movement the 3,000 ton roof was hurricane proof.

Dennis Corporation has concluded that the only two feasible methods for Patriots Point to safely and securely move the U.S.S. Clamagore to a landside berth are the use of a marine trestle system with crane towers to lift the submarine onto land or the construction of a cofferdam system to move the submarine by floatation through channels to its final location.

Marine Trestle System with Crane Towers

In order to restore and preserve this landmark, a move to dry land has been determined to be the best course of action. In order to facilitate this, a Marine Trestle System will need to be constructed to support an eight tower crane system along with the submarine itself in order to facilitate the move. A marine trestle system is similar to a pedestrian pier and is used in almost every bridge construction project for barges to shuttle supplies across a waterway. Several local contractors currently own the required steel to complete this scope of project. In addition, they would be able to salvage the steel bringing a significant cost savings to Patriots Point. In a marine trestle system, the submarine will be dead lifted out above the water using stand jacks, as opposed to a canal inclined plane, where it is carried in a water-filled caisson. An inclined canal with rail system was originally studied, but the size of this project area did not allow enough space for the submarine to climb the embankment at the desired slope.



Rendering of Marine Trestle System

SECTION 2 — Executive Summary

The area selected for the submarine is located on the edge of the parking lot directly above the submarine's current location. The elevation of land is 21' higher than that of the Mean Low Water (MLW) level, so in order to effectively lift the submarine it will have to be lifted to an elevation of 25'. To install the trestle system, 90' steel pipe piles will be used to support the entire system. Several different size pipe piles can be used for this scenario; however, bearing calculations will have to be met to ensure load capacity. The use of different pipe piles will provide Patriots Point with a competitive bidding process, which can result in various scenarios for different contractors depending on what they have already on hand. As a result, one contractor may bid the construction of the trestle system significantly lower than another due to already owning the appropriate size pipe piles to meet the foundation dead loads required. This pipe pile will be removed once the project is complete; adding an additional salvaging cost savings to Patriots Point. The trestle system to be constructed will have two identical spans that will run roughly 625 LF each along the existing pedestrian pier of a total combined length of 1,250 LF. 325 LF will be constructed over water while the additional 300 LF will be constructed over land. We had originally purposed designing a special cradle that would be positioned underneath the submarine to displace the weight of the submarine; however, after further review this would be a large excessive expense to Patriots Point. The use of large metal support straps can be used to effectively lift the submarine without applying excess pressure to one area of the structural members of the submarine. Two miniature tug boats will be used to position the submarine between the two trestle systems. Additionally, air bags may be required to further stabilize the vessel as it makes the transition between the two trestle systems.



Selected area for final location

Support system

The U.S.S. Clamagore displaces 1,975 tons surfaced, according to general characteristics of the Guppy III conversion. Joseph Lombardi with Ocean Technical Services reported in a recent marine survey the surfaced weight to be 1,731. Therefore, the system will need to be able to support approximately 2,000 tons. The marine trestle system will be supported by steel pipe piles that are driven into the ground roughly 70' to reach the Cooper Marl, which in a recent Geotechnical Exploration Report, performed by S&ME in late October, was recorded at a depth of 40' – 83' below the mudline. These steel pipe piles will remain in the marsh for the duration of the operation. These pipe piles will be bolted to cross beams that will connect the two rows of supports, then each set of supports will be connected by parallel cross beams that will be bolted to the support system. The rails will be steel I-beams, all of which will be removed after the U.S.S. Clamagore has reached its final destination to minimize an environmental impact. The pilings will be driven using a crane supported leader and diesel pound drop hammer. The rig will first be positioned in the parking area of Patriots Point. The pile



Steel I-Beam Rail Pads

driving equipment will work out from the parking lot into the marsh area toward the U.S.S. Yorktown utilizing; the same trestle system it is constructing for a bridge as it works its way out 325' into the harbor. This entire operation can be done without the use of any barge or any equipment in the water allowing no impact to the daily operations of the museum. The excavator will drive the pilings on the land portion of the operation. Depending on the soil type found, a water jet method may be used on the land driven piles to help drive the pilings successfully. A water jet method is simply a stream of high pressure water that precedes driven pile to break up the surrounding soil and make the driving process easier. The pilings will then be connected through a system of parallel steel rails.

SECTION 2 — Executive Summary

Crane Towers and Skidding System



Example Tower System

Once the trestle system has been completed all wooden crane mats utilized by the pile driving equipment will be lifted, removed, and replaced with the skidding track system ready for the eight crane towers to be erected. Each crane tower will be constructed in the parking lot and will be connected making four identical systems. Strand jacks on top of the crane towers, each with a lifting capacity of 450 tons, will be used to lift the submarine directly out of the water in between the two trestle systems. The four systems will work in unison under an electrical remote control. The crane towers will then move hydraulically along a skidding track moving the submarine over existing concrete pedestal supports.

Alternative Cofferdam System

The other proposed method is to build a cofferdam into the already existing parking lot and float the U.S.S. Clamagore to the desired vertical height of approximately 28'. A trench, involving excavating

roughly 51,000 CY of existing material, would be dug in the current parking lot large enough to enclose the entire submarine and deep enough to sustain the 15'-17' draft of the submarine. Steel sheet piles will be used to support the walls of the excavated area and the submarine would be aligned in the cofferdam. The sheet piling wall would then be sealed to act as a lock. It will then be filled with water and sand by the use of pumps, which will raise the submarine to the desired elevation. Once all the water has been displaced with sand and the submarine is at the desired elevation; the steel sheet piles can be cut and the concrete pedestals can be constructed underneath the submarine.

Concrete Pedestal Supports

Upon reaching its final destination, the U.S.S. Clamagore will rest upon several large reinforced concrete supports. These cradles will both support and stabilize the ship for the restoration and visitation that will ensue following the move. The two methods researched in this report change the construction of the concrete pedestals dramatically. If the crane tower and strand jack method is used, additional steel pipe piles will be driven into the ground between the skidding systems at the same time the trestle system is being constructed. These pipe piles will be used to support the weight of the submarine at its final destination. Concrete supports will then be emplaced with the steel pipe piles making up the concrete pedestals that will support the submarine. If the cofferdam method is used, all material that would have originally been used to support the weight of the submarine located in the parking lot, will have been excavated for the trench and cofferdam and replaced with water and sand. Therefore, a larger amount of reinforced concrete will be required to construct a supporting bed for the submarine and the concrete pedestals to sit on. A one inch neoprene pad will be placed between the top of the concrete supports and the submarine to protect the hull of the U.S.S. Clamagore.

Restoration

The U.S.S. Clamagore will undergo a detailed structural hull survey to determine the existing conditions. The hull and superstructure were restored in 2001, as they had deteriorated over the years from saltwater corrosion, marine growth, and weather. If further repairs are necessary prior to the move, they will be performed in the water before the moving commences. Following the move, final repairs and restoration will need to be completed immediately as oxygen will enhance and speed up the corroding process. The task of the repair plan is to restore the structural and historical integrity of the U.S.S. Clamagore. In areas where it is sufficient, the hull will be sandblasted and painted. In areas where more extreme corrosion is present, panels will be cut away and new panels will be welded in their place. A lead-based paint survey and assessment will need to be

SECTION 2 — Executive Summary

conducted before any work can commence on the U.S.S. Clamagore. Proper precautions will be taken to protect the surrounding area from contamination for the paint removal. A geo-fabric material to catch all lead paint particles will be installed to protect the surrounding environment. The U.S.S. Clamagore will then be primed and painted to restore her beauty and ensure her long term existence.

Environmental Impact

To construct a work trestle or cofferdam within the Charleston harbor and the adjacent salt marsh wetlands, temporary impacts to “critical areas” will occur but minimized to the best of our ability. Critical areas are defined by the South Carolina Department of Health and Environmental Control – Ocean and Coastal Resource Management (SCDHEC-OCRM) as tidelands and coastal waters. Permits would be obtained from the U.S. Army Corps of Engineers (USACE) and SCDHEC-OCRM. The installation of temporary piles and a work trestle would constitute minor impacts and mitigation would likely not be required. This would streamline and expedite the permitting process. Our project team has conducted preliminary reviews of the environmental impacts and have conducted an initial coordination with the appropriate governmental agencies. Their report is enclosed in our feasibility study. Follow up meetings would need to occur to meet with representatives from the Charleston offices of these agencies to present the project and obtain final feedback on permitting. In general, the agencies will ask that minimization measures be put in place to preserve the existing habitat to the greatest extent possible. Environmental representatives would coordinate with the National Ocean and Atmospheric Administration (NOAA) to avoid any delays to the project that could be caused by impacting Essential Fish Habitat, such as the estuarine waters of the Charleston Harbor. The Crane Lift Operation provides less impacts to “critical areas” and will involve less mitigation and environmental protection measures due to minimum excavation. Due to the large excavated area required to construct a cofferdam many protective measures will have to be put into place to prevent impacts to the already identified “critical areas”.

As you will see in this report, we have narrowed our research into these two final methods; a trestle system with crane towers to lift the submarine and a cofferdam system. Both of these methods have been tested and proven and are feasible for the landside berth operation of the U.S.S. Clamagore. Each presents separate challenges, such as environmental impact, costs, and scheduling constraints. We have done our best to take into consideration the daily operations of Patriots Point and both methods have been developed to not hinder or affect the museum during any operational hours. We are fully aware of the unique nature of this project and the projects surrounding the many other naval ships located at Patriots Point, but may not be privy to all that is involved. Therefore, one method may suit your needs over the other taking into consideration something we were not aware of at the time of our research. We have enclosed all of our research and findings along with construction cost estimates, schedules, and our recommendation in this report.

SECTION 3 — Background & Characteristics of U.S.S. Clamagore

Background

The U.S.S. Clamagore (SS-343) was decommissioned on 12 June 1975 after 30 years of service, which included exercises and operations in the Florida Keys, Panama, Cuba, The Virgin Islands, Mediterranean Sea, North Atlantic, Portsmouth England, NS Argentina, Newfoundland, Charleston Harbor, New London Connecticut, and Puerto Rico. Though she did not see action during World War II, she did participate in offensive operations during the Cold War. She was donated as a museum ship on 6 August 1979. She was then added to the Patriots Point fleet in April 1981. She was built as a Balao-class submarine in 1945 by Electric Boat Co. in Groton, Connecticut. In 1948, the U.S.S. Clamagore underwent a GUPPY II conversion to improve performance under water. The Greater Underwater Propulsion Power Program (Guppy) was initiated by the United States Navy after World War II. This was an extensive conversion that gave the submarines a snorkel, a more streamlined hull, and a much greater battery capacity. The GUPPY II conversion included the addition of three new masts. The U.S.S. Clamagore was once again converted in 1962 and became one of only nine boats to be converted to GUPPY III. The GUPPY III Program included an addition of 15 feet to the hull increasing the total length from 307 feet to 322 feet. The boat was cut in half and lengthened on the forward end of the control room to create new space for sonar. She is now the only Guppy III submarine preserved in the United States and the only US submarine museum boat to have undergone GUPPY II and GUPPY III conversions. According to the South Carolina Department of Archives and History, Clamagore "is now the only surviving GUPPY type III submarine in the United States". She represents the continued adaptation and use of war-built diesel submarines by the Navy for the first two decades after war". The U.S.S. Clamagore was designated a National Historic Landmark on 29 June 1989.

Characteristics of the U.S.S. Clamagore

Displacement -	1,975 tons (2,007 t) surfaced 2,450 tons (2,489 t) submerged
Length -	322 feet (98 m)
Draft -	15" 11 ½" and the trim is 5 ¾" by the stern
Breadth or Beam -	27" 4 1/8"
Highest Point of fixed portion of vessel above Normal waterline -	36" 6 ½"



Existing Corrosion to U.S.S. Clamagore

SECTION 4 — Site Preparation

Site Preparation

A land and hydrographic survey was completed for this feasibility study to determine the dredging area for the U.S.S. Clamagore. This survey was used to determine calculations of the project area. In past discussions with Patriots Point officials, it was determined that the submarine still had several batteries. These batteries could weigh as much as 500 pounds each. It was additionally discussed that several of the ballast tanks are filled with water or an oil like mixture. As a result, the current estimated weight of 1,975 tons could be decreased if these remaining batteries were removed and the ballast tanks were cleaned or drained. This would in turn decrease the draft and weight of the submarine. The draft of the U.S.S. Clamagore is reported to be roughly 16 feet. In order to float the U.S.S. Clamagore and reach a minimum depth required to safely navigate the vessel, dredging below the water surface must occur. However, existing conditions and nearby pedestrian piers presented certain challenges to this step of the project. It was concluded that the required dredging had to be minimized and stay far enough away from existing piers to not disturb their foundations. Two existing piers are within the project area, both constructed with 14" concrete piles, which include batter piles driven below the surface of the water at roughly a 45 degree angle. Therefore, it was determined by members of Volkert, Inc. that the dredge centerline must be at least 75 feet away from existing pier foundations.



Project Area

SECTION 4 — Site Preparation

Hydraulic dredging is the preferred method to reach the desired depth to float the submarine. This method of dredging and the dredging area will be almost identical for both the Crane Lift Method and the alternative Cofferdam Method. This form of dredging is done by mixing the water with the material to be removed, and pumping it away as sludge. Hydraulic dredging is more versatile, more efficient, and more economical to operate our mechanical dredges, because both the digging and disposing functions are performed by one self-contained unit in the majority of instances. Suction dredging of this type resembles a giant vacuum during its operation. A mixture of water and material is drawn through a suction pipe lowered to ground surface under water. The sludge mixture will then be discharged through a pipeline to a disposal area or onto a barge. Dredges of this type

can dig deeper than others, but are limited to soft, free flowing alluvial type material, such as the material around the U.S.S. Clamagore. For this operation we plan to use smaller portable suction dredging vessels, which will be able to fit under the existing pedestrian pier at low tide gaining access directly to the dredging area without removing any existing pier sections. A 10" swinging ladder dredge and related submerged pipeline are used in our cost estimate and have been used on previous dredging operations at Patriots Point. This will not affect museum operations. The small dredge will then pump the sludge material to a nearby vessel, which will then take the material across the Cooper River to Drum Island or 10,500' of submerged pipeline will be used to pump the material directly to the North Side of Drum Island. It is our understanding that Patriots Point currently maintains a permit to dispose of dredged material on this island, as long as the required capacity or quantities are maintained and do not exceed what is authorized.



Dredging Area

A geotechnical exploration report was completed for this feasibility study. The purpose of this exploration was to evaluate the subsurface conditions at the site pertinent to the temporary support system. It was important to locate the depth of the Cooper Marl, which will be required to achieve bearing capacity for steel pipe piles used to construct the trestle system to support the crane towers. The subsurface conditions in the Cooper River were explored by taking two soil test borings. The borings were performed from a barge to depths of about 83.5 to 87 feet below the barge deck. Test locations were established in the field by estimating distances from existing site features. Coordinates for test locations were obtained with handheld GPS units with submeter accuracy. Boring elevations were estimated from published tide data. The over water exploration initially encountered 20 to 30 feet of very soft clay like silt. Beneath the silty clay layer, the subsurface conditions generally consisted of very loose to loose sand to the top of Cooper Marl. The marl was encountered at a depth of about 40 feet below the mudline, which corresponds to an elevation of about -48 ft-NAVD88. The marl continued to the deepest explored depth of about 83 feet below the mudline. The water depth at boring locations ranged from a low 0 feet at SPT-1 to over 9 feet at SPT-2 during our investigation.

Should they be required timber dolphins could be included in both cost estimates as an additional cost. It was identified early in our study that there may be a need to move the submarine prior to it making its move to land. An estimate is included, which covers all labor, materials, equipment, and supervision to construct (1) 13-foot pile timber dolphin and one (1) 7-foot pile timber dolphin. These dolphins would be located offset from, but parallel to, the existing main concrete access pier connecting to the landside facility. The purpose of the timber dolphins would be to provide limited temporary berthing supports to the U.S.S. Clamagore should they be required. In the event the submarine cannot make one single movement to the cofferdam or the crane lifting trestle system a planned temporary berthing position alongside the main concrete access pier could accommodate the submarine for several weeks. These timber dolphins can be installed utilizing a floating crane barge and material barge located on the far side of the pedestrian pier; as shown in the drawings for the Crane

SECTION 4 — Site Preparation

Lift Method. Subject barges will be positioned for up to ten (10) days in the access channel currently used by Fort Sumter Tours, but will be able to be repositioned each morning so as to not interfere with the tour boats. This installation, process would be conducted at night with the use of heavy lighting equipment again; not affecting the museums operations or causing any safety concerns to visitors of the facility.

<u>Dolphin Support Emplacement</u>	
Mobilization / Demobilization	\$16,500
Materials	\$30,000
Labor	\$31,500
Lighting Equipment	\$2,000
Total	\$80,000

Moving of the vessel

Our construction cost estimate includes the furnishing of up to three (3) small tug boats and a minimum eight-man crew to relocate the U.S.S. Clamagore from its current berthing position between the two trestle systems ready for the execution of the Crane Lift Operation. This work will need to be accomplished during slack high water or slack low water, after completion of planned dredging on a near windless day. Our construction cost does not include any repairs to the U.S.S. Clamagore that may be required to float her between the two trestle support systems or into the purposed cofferdam. For the Cofferdam Method a similar movement process will be used, but more precautions will need to be taken.

Adding buoyancy

Although we understand that the testing of the ballast tanks will be carried out by a different party, adding buoyancy may be required. The testing of the tanks will be done by pressurizing them one by one with air. The data gathered from this survey plus the submarine's general data, can be put in a GHS Software; where a Naval Architect will be able to calculate if she will float and, if not, what additional buoyancy is required. In addition, the stability will be checked as well.

The additional buoyancy required will dictate what the best solution is for a floating body. If it is just a matter of trimming the stern or the bow it could be accomplished using a lift bag, but when it becomes more serious flexifloats or a super size lift bag could be the solution. The floating bodies will be connected to the submarine with steel wire, shackles, and pad eyes. With the inner hull still intact it would be surprising if enormous amounts of buoyancy was needed.

Buoyancy of 2,000 tons will never be required to refloat the submarine, it will always be less. It will be a balance between draught, stability, buoyancy, and water level. You can think of a scenario where the submarine does float, but there is not enough water, dredging would be part of the solution in this case, however adding floatation devices may be required for additional buoyancy. A Naval Architect should calculate and double check all of this to avoid any unforeseen additional cost. This will more than likely take place during the final marine survey. After the survey and inspection have been completed, the buoyancy of the submarine will be determined and additional needs will be reviewed. In the best case where only pressurization of the ballast tanks of the submarine are required and limited floatation devices are required for stability, estimated fees for these services and materials have been proposed to range from **\$80,000 to \$180,000**. These fees have not been included in our cost estimate because the need for them has not yet been determined.



Example Buoyancy Tanks



SECTION 5 — Crane Lift Operation & Method

Our Project team has investigated a number of potential solutions for the relocation of the U.S.S. Clamagore. This effort has presented some very interesting technical challenges; however, the design and construction team has developed a strategy to meet these challenges and do so in a safe and cost effective manner. Of critical importance to this effort is to ensure that the Clamagore is properly handled to protect the historic nature of the vessel. These activities must be thoroughly planned, documented, and a systematic process implemented. The Department of the Interior's Standard for Historic Vessel Preservation Projects sets the benchmark for the goals of this project that include:

- Protection: Safeguarding the physical condition of the vessel from further deterioration or damage.
- Stabilization: Reestablishing the structural integrity of the vessel through the reinforcement of structural members or by arresting material deterioration that could lead to structural failure.
- Preservation: Maintaining the existing form, integrity, and materials of the vessel.
- Rehabilitation: Alterations or additions only when such alterations or additions will not have a serious impact on the historic fabric of the vessel.
- Restoration: Work shall be based upon verifiable historical, pictorial, or physical evidence to protect vessel's historic fabric.

The sheer size of the vessel in the tight quarters and shallow waters at Patriots Point complicates maneuvering the vessel adjacent to U.S.S. Yorktown pedestrian access facilities. At approximately three hundred and twenty-two (322) feet in length and nearly twenty-eight (28) feet wide, the location of extraction of the Clamagore will be limited by the available plan area, physical obstructions, location and boundary of salt marshes, and ultimate location for display area. Furthermore, the Clamagore will need to be lifted nearly twenty-five (25) feet above the water surface elevation due to the grade difference in the parking area adjacent to the welcome center.

Field reviews were conducted with design and construction staff and heavy lift contractors. It was determined that the most feasible staging location for the Clamagore is parallel to the existing pedestrian facility extending from the welcome center. This position minimizes environmental impacts; takes advantage of existing channel features; moves the vessel as close to its final location as possible; and orients the vessel along its future alignment. This location will allow for little to no impact to the daily operations of the museum.

The positioning of the vessel is an important factor for the type and placement of lifting equipment. Since the vertical grade difference between the waterline and the parking lot is roughly 21 feet, the team concluded that the lifting feat would best be accomplished with a temporary work trestle foundation system and a crane tower system with a strand jack assembly that has the ability to straddle the Clamagore. Two independent work trestles will be constructed along each side of the vessel. The trestles will be sized such that a conventional crane can work from the finished grade elevation of the parking lot and work outward toward the direction of the Yorktown while constructing new sections of the trestle. Trestles on both sides can be installed simultaneously or one side constructed first, followed by the second as determined by the contractor's means and methods.

Each trestle will consist of structural steel bents spaced approximately fifteen (15) to thirty (30) feet on center longitudinally along the trestle. Each bent will be supported on two (2) or three(3) steel pipe piles driven down to the Cooper Marl formation to achieve appropriate supporting capacity. Since the elevation of the trestle will be approximately twenty-one (21) feet above the waterline, batter steel bracing piles will be installed in the waterway sections to provide lateral support of the systems.



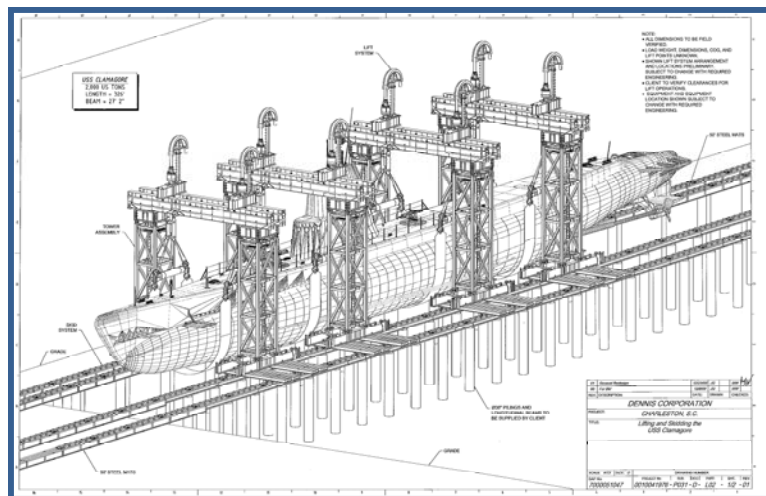
Similar Crane Tower System

SECTION 5 — Crane Lift Operation & Method

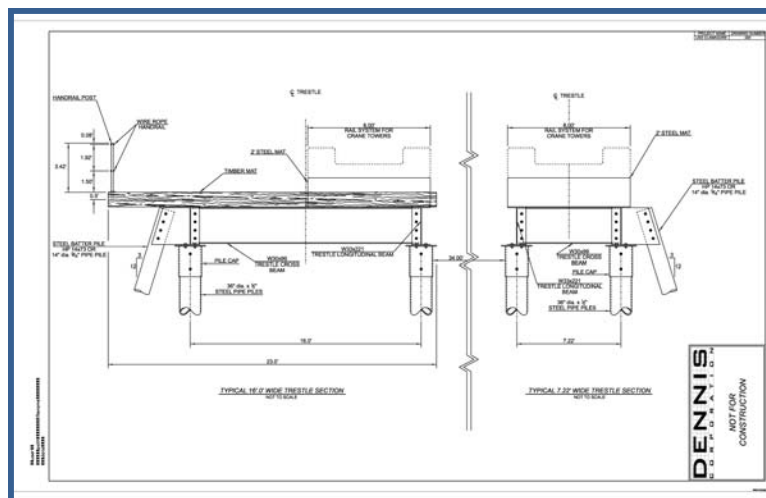
The bent caps will be constructed with structural steel tubes with an inside diameter greater than the outside diameter of the pipe piles to permit ease of placement over pipe piles at the conclusion of pile installation. The cap tubes are topped with a solid steel plate welded along the perimeter with a full penetration weld. The cap plates support a structural steel gusset plate to which a steel cap beam will be used to provide connection between the pile supports. The caps will be inter-connected with structural steel beams that will provide longitudinal support of the skidding system for the gantry crane. The trestle will be equipped with a timber platform system and safety railing to provide safe access of workers to the equipment during hauling operations. As described previously in this report, the soil material above the Cooper Marl is generally very loose material. Therefore, support in the parking lot area for the gantry system would be limited. It is intended that the foundation system installed in the waterway would be utilized on the landside, as well. This would ensure that appropriate support of the system is provided.

Steel pipe piles are the preferred pile type for this project for many reasons. They are very durable and resistant to corrosion. They are ideal for marine conditions and they can be driven in loose material to high depths. The use of steel pipe piles gives you inside and outside friction resistance, which will make them stronger to support the load weights and less likely to move while driving nearby pipe piles. One of the greatest advantages to the use of steel pipe piles is that they can be removed by vibrating them loose from the bottom layer of Cooper Marl and reused by the contractor. This provides a salvaging price for Patriots Point. Ultimately Patriots Point will not be responsible for purchasing any of the steel for this method because the majority of local marine contractors already have the same materials in their yards to construct such a trestle. This type of trestle is used on almost every bridge construction job to transport materials by crane around the job site.

The pipe piles will be driven using a crane supported leader and diesel powered drop hammer or a hydraulically operated hammer depending on the contractor's preference. The pile driving equipment will work from the parking lot out over the marsh and water area toward the U.S.S. Yorktown. The equipment will actually utilize the newly constructed trestle system as it works out over the water. As a result, no barges will be required and no heavy equipment will be in the water. More importantly, no sections of the nearby pedestrian pier will need to be



Temporary Work Trestle Foundation System



Breakdown of Trestle System



Steel Pipe Piles to be Used

SECTION 5 — Crane Lift Operation & Method

removed. Test loads will be conducted on the piles to make sure load bearing capacity is met. Two types of test loads can be performed on piles. These are the constant rate of penetration (CRP) test and the maintained load (ML) test. In the latter type, the loads are applied in increments. In the CRP test the pile is jacked into the soil; the load being adjusted to give a constant rate of downward movement to the pile, which is maintained until failure point is reached. Failure is defined either as the load at which the pile continues to move downward without further increase in load, or the load at which the penetration reaches a value equal to one-tenth of the diameter of the pile at the base.

The crane lift system is designed for strength and mobility. The crane tower units are designed to support the heavy loads of the system using a structural steel x-frame design for the vertical towers. The towers are supported on a hydraulic chassis containing independently controlled tandem wheel groups that provide a large footprint for load spreading and control over the tower base during movement. These towers are connected to each other through structural steel beam units to enable the tower groups to operate as a single unit. The tandem chasses are computer controlled to ensure that the strand jack units work together seamlessly thus providing consistent support and protection of the Clamagore. The units are equipped with cable lift systems, that will be attached to steel saddle supports which will be maneuvered under the Clamagore prior to the lift.



Hydraulic Gantry Studied For This Project

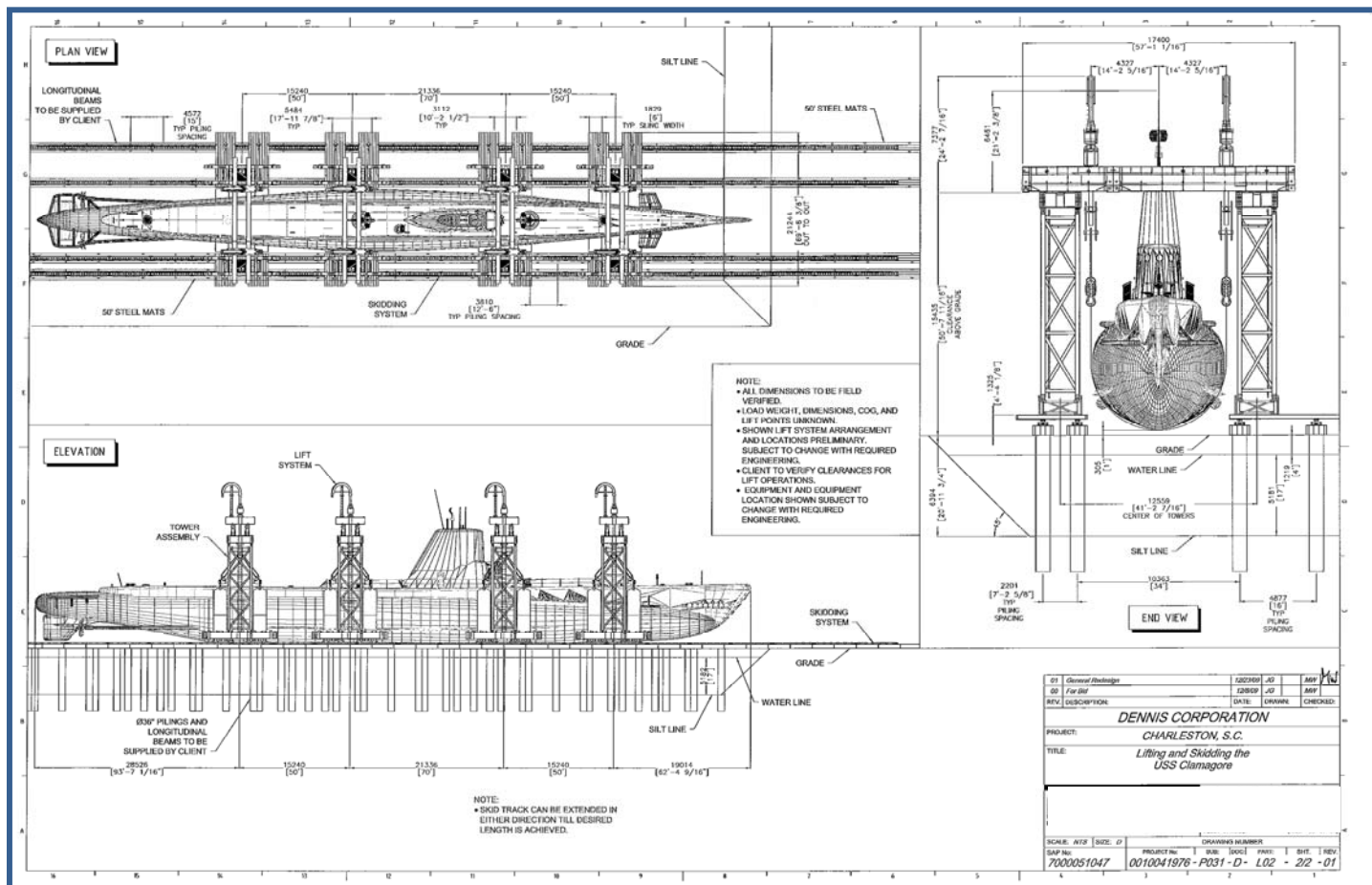
Appropriate support for the vessel is required for distribution of loading evenly throughout the structure. The concrete pedestals will be fabricated using reinforced concrete along with structural steel members. Steel pipe piles can be driven in the ground at the same time the trestle system is being constructed at a minimum cost adding structural support to the already loose existing foundation material. The concrete system would consist of cast-in-place concrete footings that support concrete stem walls cast with the transverse curvature of the vessel. The number and location of the concrete wall systems would be such to ensure long-term stability of the Clamagore. A structural steel frame was researched to go underneath the submarine for support during lifting. Longitudinally the saddle would have consisted of wide flange beams, and the beams would be connected transversely to form the frame. Cross-bracing would have been provided to prevent racking of the frame and ensure frame stability. The support beams would have consisted of a curved web with both top and bottom flanges. All connections would have been welded. Upon researching this, we realized the cost to design and construct such a device was much higher than any anticipated. We also realized that steel support belts had already been used with this type of crane tower system to lift similar marine vessels and are sufficient for this method.



Example Concrete Support Pedestals

SECTION 5 — Crane Lift Operation & Method

As seen in the End View in the graphic shown below, multiple strand jack units will be required to fully distribute the weight of the vessel. The system has the advantage, due to its geometry, of lifting the Clamagore above finished grade to facilitate the movement of the vessel to its intended final location. As noted above, the units are computer controlled and crane tower systems will operate simultaneously as a continuous operation.



The advantages to this system are summarized as follows:

- The trestle system is installed using "top-down" construction methods that eliminates the need for equipment to enter the waterway and significantly minimizes marsh impacts;
- The entire trestle can be installed prior to re-positioning of the Clamagore without impacting access to the Yorktown;
- The trestle is a temporary system that can be removed after relocation of the vessel. This important feature is critical to permitting and will result in reduced costs due to salvage value of materials;
- The innate geometry of crane towers permits the Clamagore to be efficiently lifted from the waterline up and above the elevation of the adjacent parking lot;
- Strand Jacks are available with very high lifting capacities and they can be used in tandem to distribute loading for trestle foundation and vessel support; and,
- The strand jack system utilizes high strength cabling that can be connected to steel saddle support belts under the vessel to enact the lifting operation. These saddle supports are a critical component to **protecting** the physical condition of the Clamagore, **stabilizing** the hull to preserve its integrity, and **preserving** the existing shape and form of the vessel.

SECTION 5 — Crane Lift Operation & Method

Component		Estimated Loads (lbs)
Tower System		2,200,000
Contingency	25%	550,000
Submarine		4,000,000
Contingency	15%	600,000
Railing System		200,000
Contingency	10%	20,000
Total		7,570,000

Load per Gantry Tower Support	473	tons
2 Pile Bent: Per Pile Load	237	tons
3 Pile Bent: Per Pile Load	158	tons

To develop an estimate of cost for the relocation of the Clamagore, including the installation of the proposed crane tower and strand jack system, a determination of system loads and structure capacity are required. The development of loads was based on historical data for the Clamagore; available data on similar crane tower systems; and typical temporary trestle type construction. The table here summarizes the total estimated loading for the systems with appropriate contingency factors. The haul scenario presented in the preceding graphics results in the 7.57 million pound loading being distributed equally to the eight vertical supports of the tower system resulting in approximately 480 ton per support. These loads are then transmitted through the skidding system and temporary trestle superstructure into the trestle beams and caps. The cap loads in turn transmit loading into the foundation material either by a two or three pile support. As shown in the table here, a two-pile bent will have approximately a 240 ton load and a three-pile bent will have a 160 ton loading.

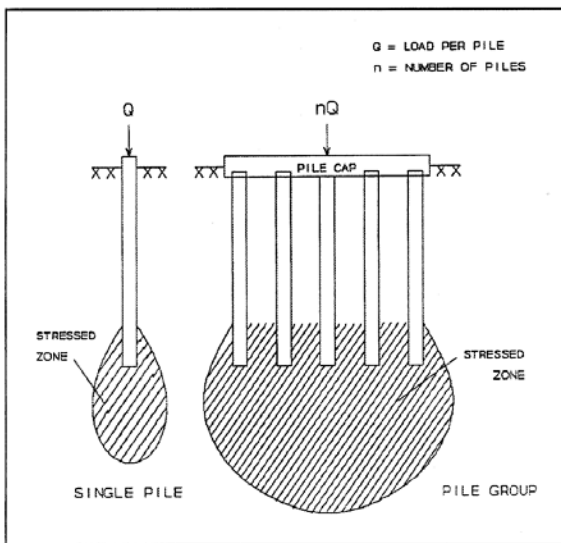
To assist in this effort, S&ME performed field exploration to evaluate the subsurface conditions at the site pertinent to the temporary support of the vessel as it is moved to its proposed final location on land. For this work, S&ME performed two soil test borings in the

project area from a barge to depths of approximately 83.5 feet to 87 feet below the approximate water surface elevation. Test locations were horizontally located in the field by estimating distances from existing site features. Data for the test locations published in the summary report were obtained with handheld GPS units with submarine-meter accuracy. Elevations reported for the borings were estimated from published tidal data.

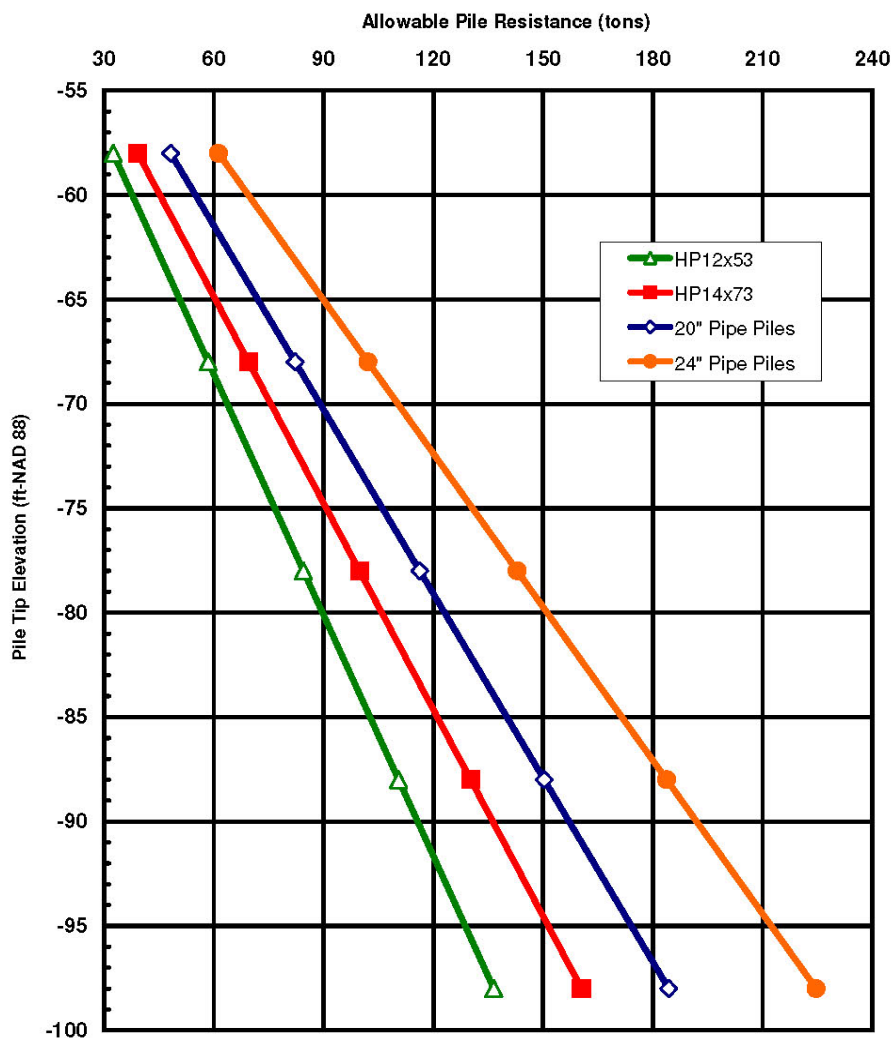
Laboratory testing was performed on five soil samples obtained from the exploration generally in accordance with appropriate ASTM standards. The borings provided feedback that soft clay like silts and loose sands overlay the Cooper Marl which was encountered at an approximate elevation of about -48 feet.

Based on their review of the laboratory work and field work, S&ME recommended the use of driven H-pile and open-ended pipe piles. Pile driving is accomplished using a mechanical device that physically hammers piles into soil to depths such that support capacity for the applied loading is achieved. Diesel pile hammers are typically used for the installation of these types of steel pile supports. The system consists of a large two-stroke diesel engine attached to a piston providing the driving weight of the hammer. The pile driving operation begins when the crane operator raises the piston using cabling supporting the pile driver which draws air into the engine cylinder. The weight is dropped using a quick-release device and the piston's weight compresses air in the hammer cylinder instantaneously, producing tremendous heating that provides ignition of the diesel fuel. Diesel fuel is continually injected into the cylinder. Each time the falling weight strikes the pile head, engine ignition drives the weight back up, again drawing in more fuel-air mixture, and the cycle starts over until the fuel runs out or is stopped by the pile crew.

SECTION 5 — Crane Lift Operation & Method



The exploration data was utilized to develop recommendations related to center-to-center pile spacings and the capacity of the soil material to support loadings from the proposed trestle system and vessel. It was recommended that the piles be spaced approximately three pile diameters apart in order to prevent capacity reduction due to "group effects". Group effects are generally realized when piles are closely spaced. The capacity of piles and pile groups are achieved by the piles ability to develop stresses and stress zones within the supporting soil mass. Because the stressed zone of the individual piles overlap one another in closely spaced pile groups, the total stressed zone area is actually less than the sum of the stress zones for each pile in the group if it was standing-alone. By spacing out the piles, each pile acts independent of the adjacent piles and thus the full capacity of the each pile is realized.



S&ME developed a capacity versus depth chart as shown here assuming adequate pile spacing for several pile types. This chart provides the flexibility to assess pile configurations, types, and loading conditions and help quickly determine the most economical foundation type for design. Using the component loading for the two and three-pile bent scenarios, pile types were investigated. Since the pile load range for the two bent types is between 160 and 240 tons at unfactored, service load conditions, it is determined from the chart that the HP 12, HP 14, and 20-inch pipe piles would not be appropriate pile sections due to the extensive length required to achieve axial capacity. The 24-inch and 36-inch piles can be installed at these load capacities at a more reasonable depth. A two-pile bent would require approximately 105 feet of 36-inch pipe pile to achieve the 240 ton capacity, assuming the top elevation of the pile to be approximately elevation 25 feet. For a three-pile arrangement using 24-inch diameter pipe piles at 160 tons, each pile would need to be approximately 105 feet as well. The final tip elevation of the installed piles will be approximately at elevation -80 feet.

SECTION 5 — Crane Lift Operation & Method

To develop the structural capacity for this loading condition and provide for a pipe section that can be reasonably transported, a minimum half-inch thick walled pipe section was determined to be required. Computing the weight of steel for both the arrangements, it is determined that both foundation systems would have approximately the same amount of material. Based on this, it would be expected that economy would be achieved by installing the 36-inch pipe piles since fewer would be required for installation, thus reducing construction time frame.

Prior to the start of construction, the capacity of the piles will be assessed using the common procedure of Dynamic Pile Testing. The Pile Driving Analyzer™ (PDA) as described in ASTM D4945. It will be used for this work, which provides an economical and rapid method of installing a limited number of production piles while obtaining installation information for the remaining piles. This procedure provides for more accurate determining of pile lengths in the field based on actual installation behavior. S&ME has recommended that at least three piles be installed and PDA tested at equal spacing along the length of the structure. The PDA testing will generally occur by restrike driving 5 days after installation to determine their capacity. An Engineering Technician working under the direction of the Geotechnical Engineer should monitor all pile driving to verify that the piles are encountering expected driving resistances and note any damage or other problems during installation.

One critical component to the pile installation effort will be the mitigation, monitoring, assessment and controlling of noise, and vibrations caused by the pile installation equipment that may be harmful to adjacent structures, vessels, and humans. Therefore, an assessment of the source, potential noise, and vibration receivers must be established. We will also establish a criteria for noise levels and ground velocity, acceleration and the displacement. A plan will be developed that will incorporate the most practical and effective measures to mitigate noise and vibration from the pile driving activities at the Site. This plan includes the following elements:

- Continually provide noise and vibration monitoring;
- Develop effective reporting procedures and storing of monitoring data;
- Use action levels to evaluate noise and vibration from operations and take action as prescribed;
- Utilize acoustical insulation around the perimeter of the site, if required by the analysis;
- Evaluate movable acoustic curtain to shield the pile driving hammer and pile from residences and hotel (requires access agreements for these properties);
- Provide schedule of pile driving with restricted times.



Pile Installation

Criteria for noise and vibration will be developed specifically for the project. However, general threshold levels and appropriate action items for exceedance have been reviewed and deemed appropriate base levels for the project. These threshold levels will be reviewed with the contractor, and he will be responsible for developing a noise and vibration monitoring plan for the project. General requirements for this work may be as follows:

SECTION 5 — Crane Lift Operation & Method

Noise

Action levels have been established and are based upon the implementation of the noise abatement measures described in this plan including granting of access to the adjacent properties. The following three “action” noise threshold values will be used to assess the effectiveness of mitigation during pile driving at the site:

- “warning” noise threshold value of 75 dBA;
- “temporary halt” noise threshold value of 80 dBA;
- “stop work” noise threshold value of 85 dBA;
- If the “warning” noise action level is exceeded during active pile driving, then the cause will be investigated. Work itself would not necessarily be stopped. On-site engineers will verify the placement and integrity of the ‘moveable sound curtain’ and that it is optimized for noise mitigation. The placement would immediately be corrected;
- If the “temporary halt” noise threshold value action level is exceeded then work will be temporarily halted, if necessary, while the apparent cause is investigated and corrections made. If the cause is related to placement of the curtain then this would be corrected and work would resume. If the cause is due to other reasons, such as equipment or operation factors, then these would be corrected, and work resumed. If this level is exceeded due to obstructions in the ground which cause refusal, the drive will continue until the pile reaches capacity.

If the “stop work” noise action level is exceeded, then a review into the cause will immediately be investigated. Work would stop and the effectiveness of the implemented mitigation measures would be reviewed and additional mitigation measures implemented. If this level is exceeded because of obstructions in the ground which cause refusal, the drive will be stopped and the remaining installation scheduled as necessary with adjacent effected properties.

Vibration

The following two vibration “action level” threshold values will be used to assess the effectiveness of mitigation during pile driving at the site:

- “warning” vibration threshold value of 0.2 inches per second peak particle velocity;
- “stop work” vibration threshold value of 0.5 inches per second peak particle velocity;
- If the vibration “warning” threshold level is exceeded, then the situation will be reviewed to identify the potential cause;
- If the vibration “stop work” threshold is exceeded, damage to structures is possible and work will be stopped until the potential causes of such vibration have been reviewed and possible mitigation methods investigated.

As previously noted, one significant advantage of this proposed temporary trestle system is that the installation and removal can be performed with minimal impact to the environment. Furthermore, the use of pipe piles provides the contractor the ability to extract and recover the pile material, thus reducing cost to the project. Vibratory pile hammers often provide contractors the ability to perform this work. These hammers contain a system of rotating weights powered by hydraulic motors to develop vertical harmonic vibrations transmitted into the pile. The pile driving equipment is lifted and positioned over the pile by means of a crane, and are physically fastened to the pile by clamping or bolting depending on the contractors equipment and procedures. Typical equipment uses hydraulic fluid that is supplied to the driver by a pump powered by a diesel engine. The connection of the pump and the vibratory hammer is generally through long hoses that enable the existing trestle platform to be used for the crane support and power to the equipment for the extraction process. Therefore, no work equipment will need to be in the waterway for this effort. Vibratory hammers offer other benefits including: 1) lower noise output thus mitigating noise pollution to the adjacent businesses, condominiums, and hotels; 2) higher frequency vibrations that will minimize potential impact to adjacent structures and facilities; and 3) the equipment is readily available to contractors.

SECTION 5 — Crane Lift Operation & Method

Based on the proposed system presented and the associated work required to re-position the Clamagore for the hauling operation, total cost for this project is estimated to be **\$5,765,499**. The trestle system is estimated to be approximately 1,250 feet in total length at an installation cost of about \$877 per linear foot. The crane tower system cost includes delivery of the system to the site, assembly, fifty (50) days of operational support, disassembly, and de-mobilization of the equipment. The vessel support cost includes minimal aesthetic treatments. No costs have been included for rehabilitation and restoration of the vessel after it has been set in its land berth.



Trestle System with Crane Matting

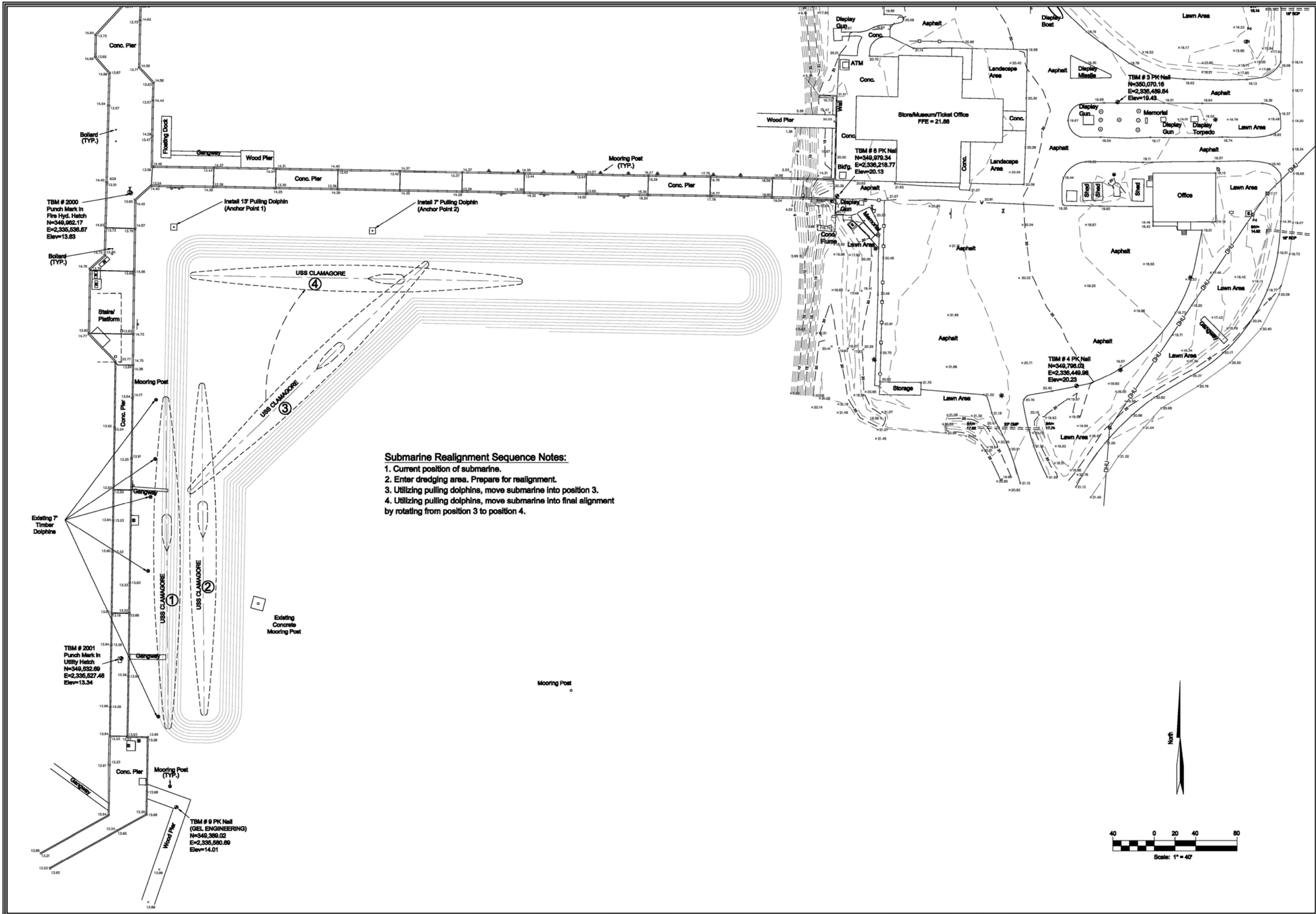
SECTION 5 — Crane Lift Operation & Method



Project USS Clamagore
Subject Preliminary Foundation Dead Loads

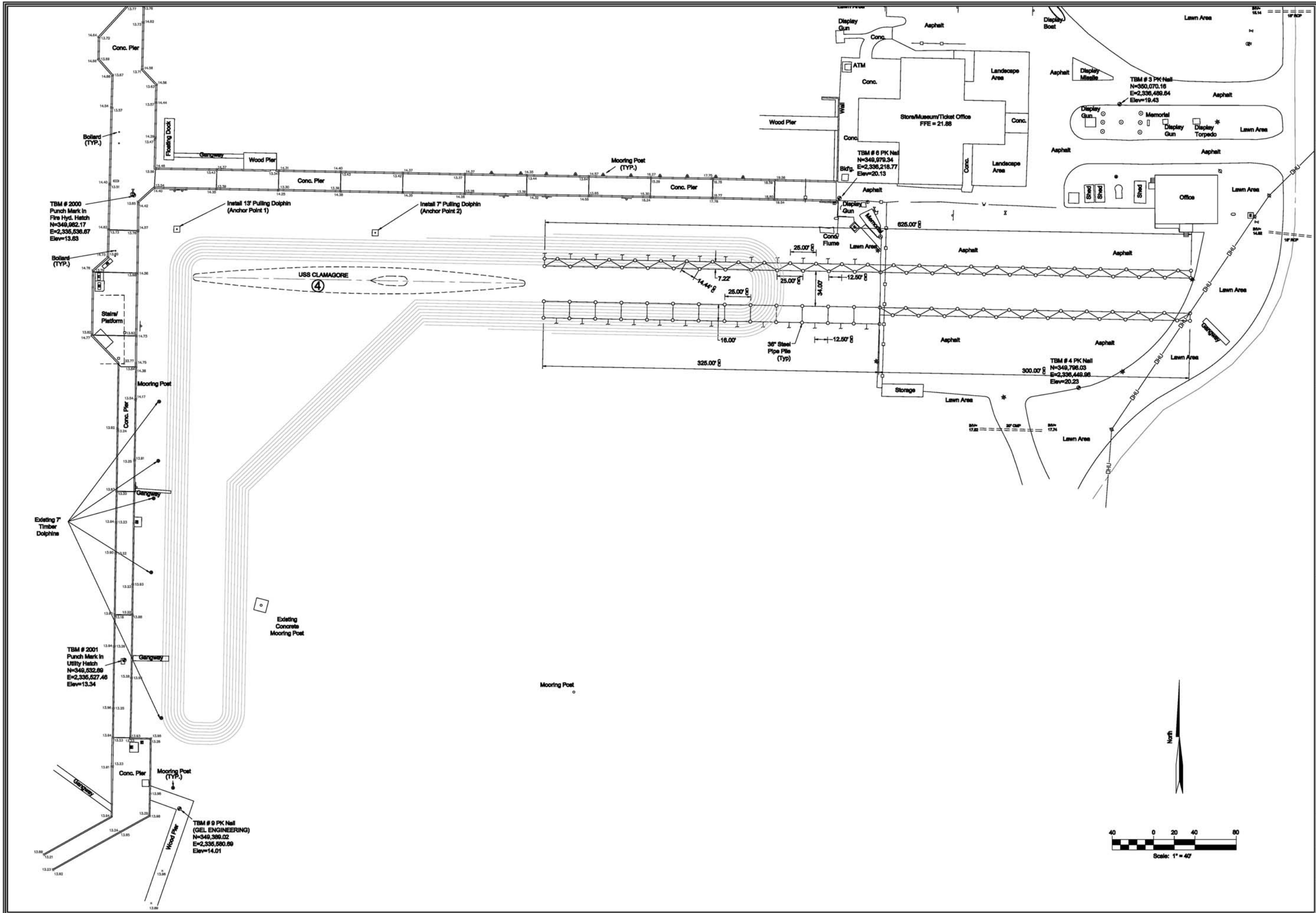
Date 12/4/2009

Tower System Self Weight				
	Weight	Qty	Total	
50ft Bases	42,000	4	168,000	Lbs
Towertops	17,686	8	141,488	Lbs
40ft Tower Sections	27,378	12	328,536	Lbs
20ft Tower Sections	14,608	4	58,432	Lbs
KBR Beam Assembly	197,300	4	789,200	Lbs
Clamp Beams	570	32	18,240	Lbs
Heavy Skidtrack	2,683	40	107,320	Lbs
Skid Beam	1,787	16	28,592	Lbs
11.6m Beam	24,119	8	192,952	Lbs
5.8m Beam	13,834	8	110,672	Lbs
Jack Support	9,899	4	39,596	Lbs
900t Strandjack	8,500	4	34,000	Lbs
Umbrella	2,667	4	10,668	Lbs
Lifting Block	4,960	4	19,840	Lbs
Spreader	4,000	4	16,000	Lbs
Rigging	12,000	4	48,000	Lbs
Wire	2,000	4	8,000	Lbs
Subtotal			2,119,536	Lbs
Contingency 25%			529,884	Lbs
Tower System Self Weight			2,649,420	Lbs
Calculated Weight of Tower System			2,700,000	Lbs
Submarine Lift Weight			4,000,000	Lbs
Lift Factor 15%			600,000	Lbs
Lift Weight			4,600,000	Lbs
Lift Weight + Tower System Weight			7,300,00	Lbs
Assumptions:				
Submarine COG assumed to be centered between towers.				
Tower System Weight Distributions assumed to be even across towers.				
Each foundation carries 1/4 of Towersystem weight.				
No dynamic loads considered (wind, skidding etc...).				
Dynamic loads will put a Moment on tower system, which can transfer to foundations.				
Tower Load Distribution at initial Lift				
Land Side Foundation Dead Loads		1,287,000 Lbs per Foundation (Dead Load)		
Water Side Foundation Dead Loads		2,363,000 Lbs per Foundation (Dead Load)		
Tower Load Distribution at center				
Land Side Foundation Dead Loads		1,825,000 Lbs per Foundation (Dead Load)		
Water Side Foundation Dead Loads		1,825,000 Lbs per Foundation (Dead Load)		
Tower Load Distribution over Land				
Land Side Foundation Dead Loads		2,363,000 Lbs per Foundation (Dead Load)		
Water Side Foundation Dead Loads		1,287,000 Lbs per Foundation (Dead Load)		

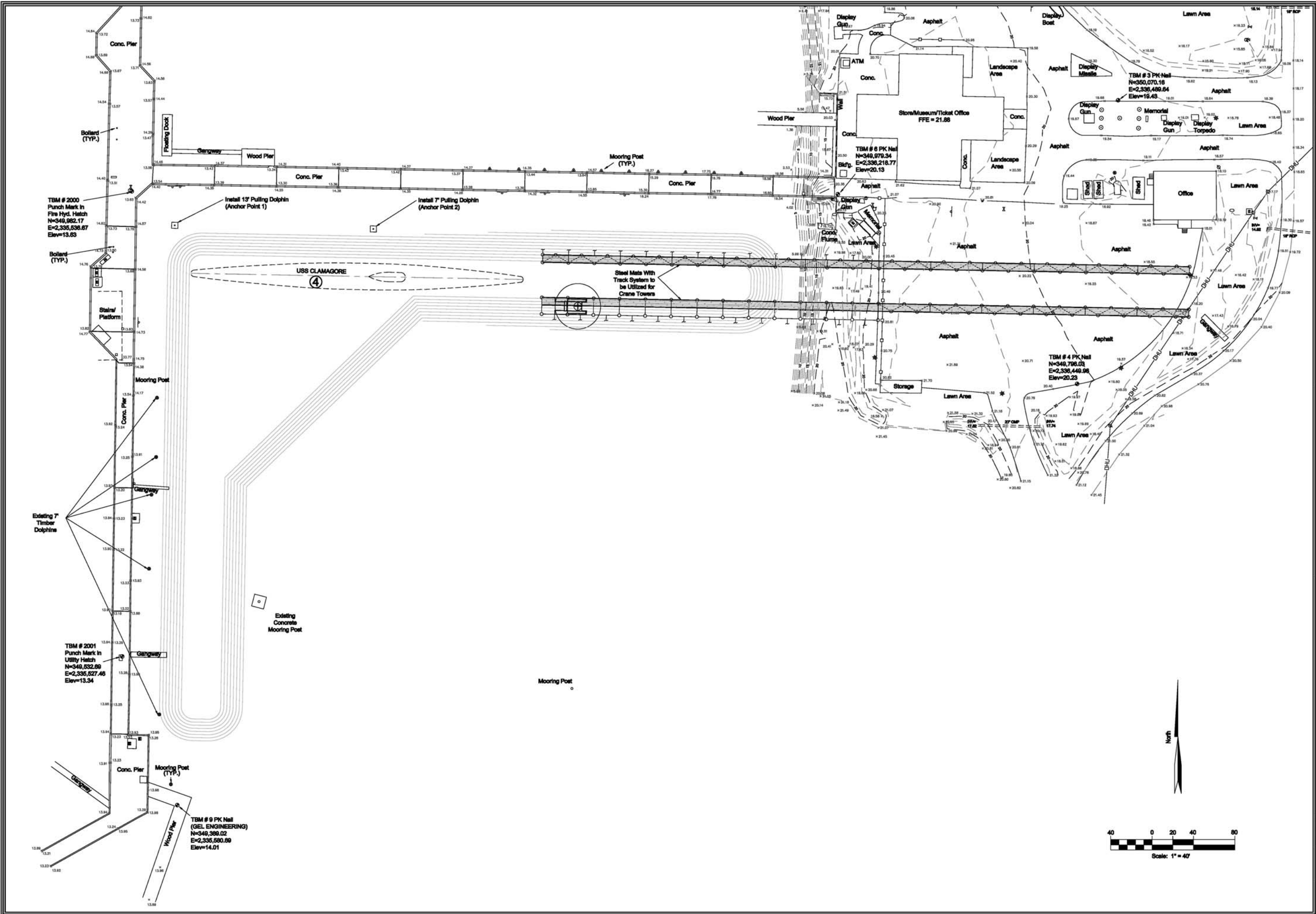


Submarine Realignment Sequence Notes:
1. Current position of submarine.
2. Enter dredging area. Prepare for realignment.
3. Utilizing pulling dolphins, move submarine into position 3.
4. Utilizing pulling dolphins, move submarine into final alignment by rotating from position 3 to position 4.

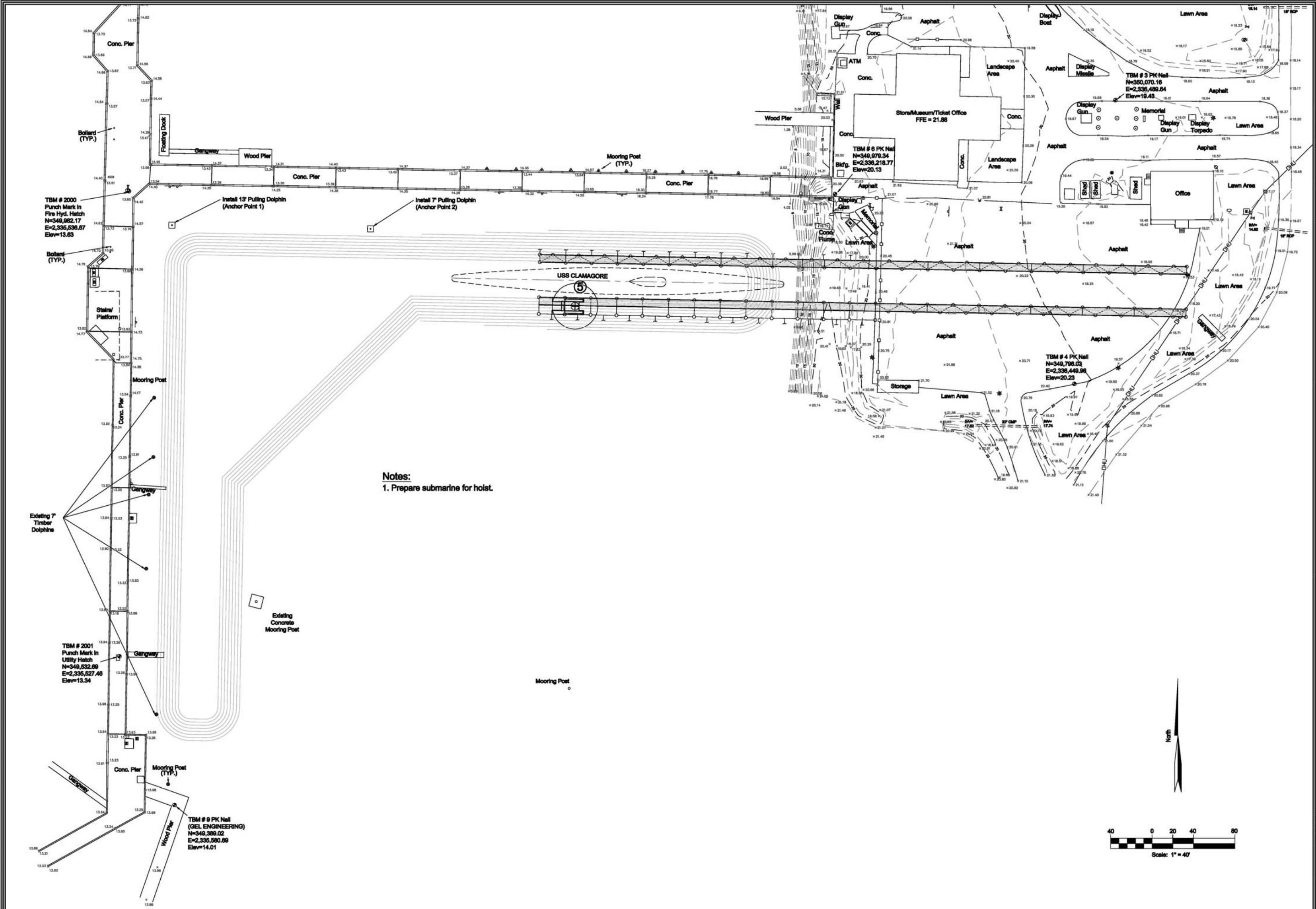
Description	
Date	Revision
Drawn By	Checked By
Landside Berth Crane Lift Operation	
DENNIS CORPORATION	
PATRIOTS POINT USS CLAMAGORE Not For Construction	
January 2009	Charleston County
South Carolina	
Project B0014.03	
Scale As Shown	
Sheet C3	



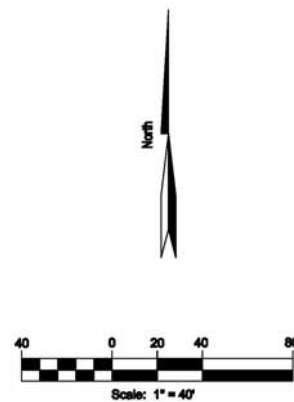
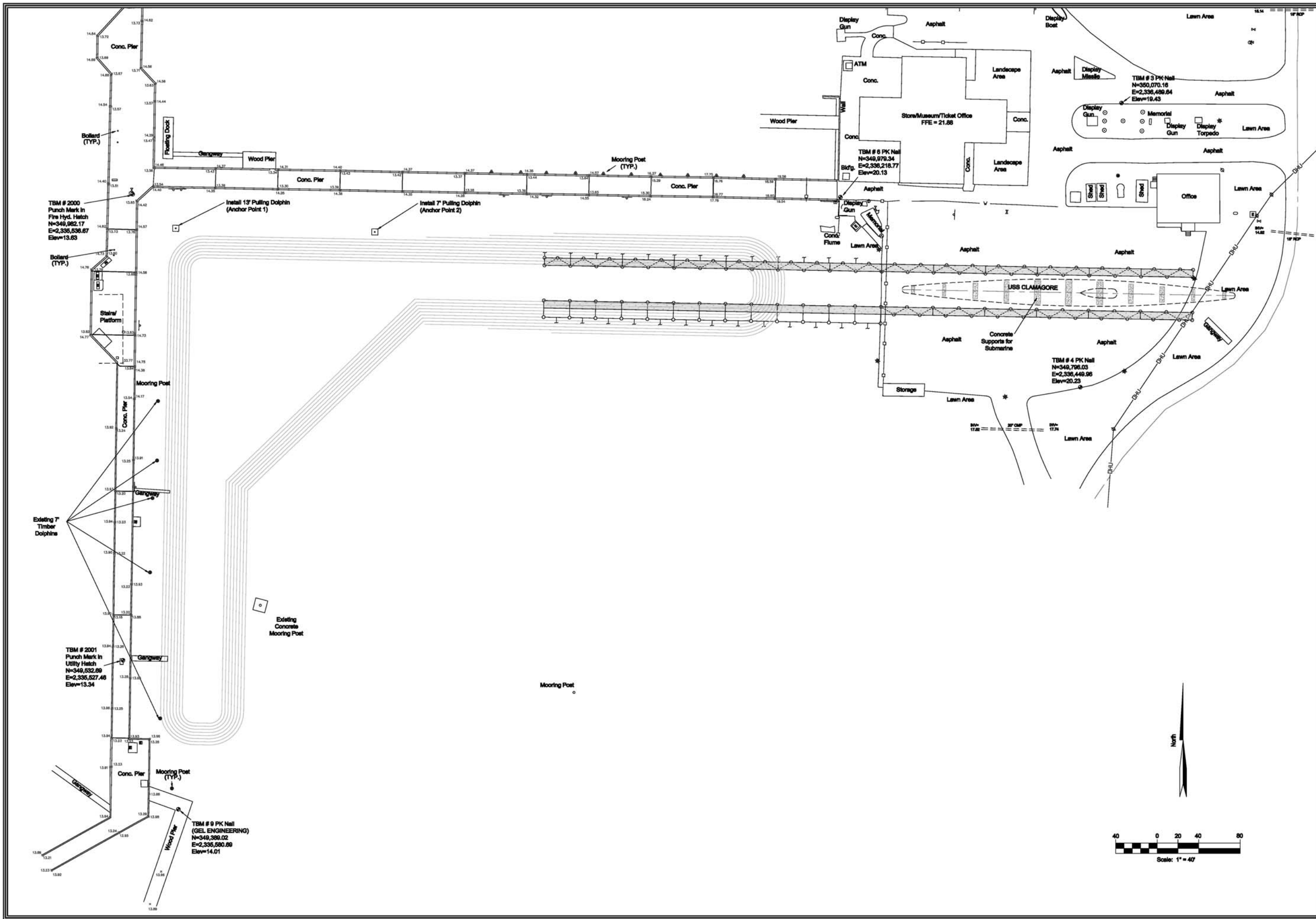
Description		Date	Revision	Drawn By	Checked By
Landside Berth Crane Lift Operation					
DENNIS CORPORATION					
PATRIOTS POINT USS CLAMAGORE Not For Construction			January 2009		
Project			Charleston County		
B0014.03			South Carolina		
Scale					
As Shown					
Sheet					
C4					



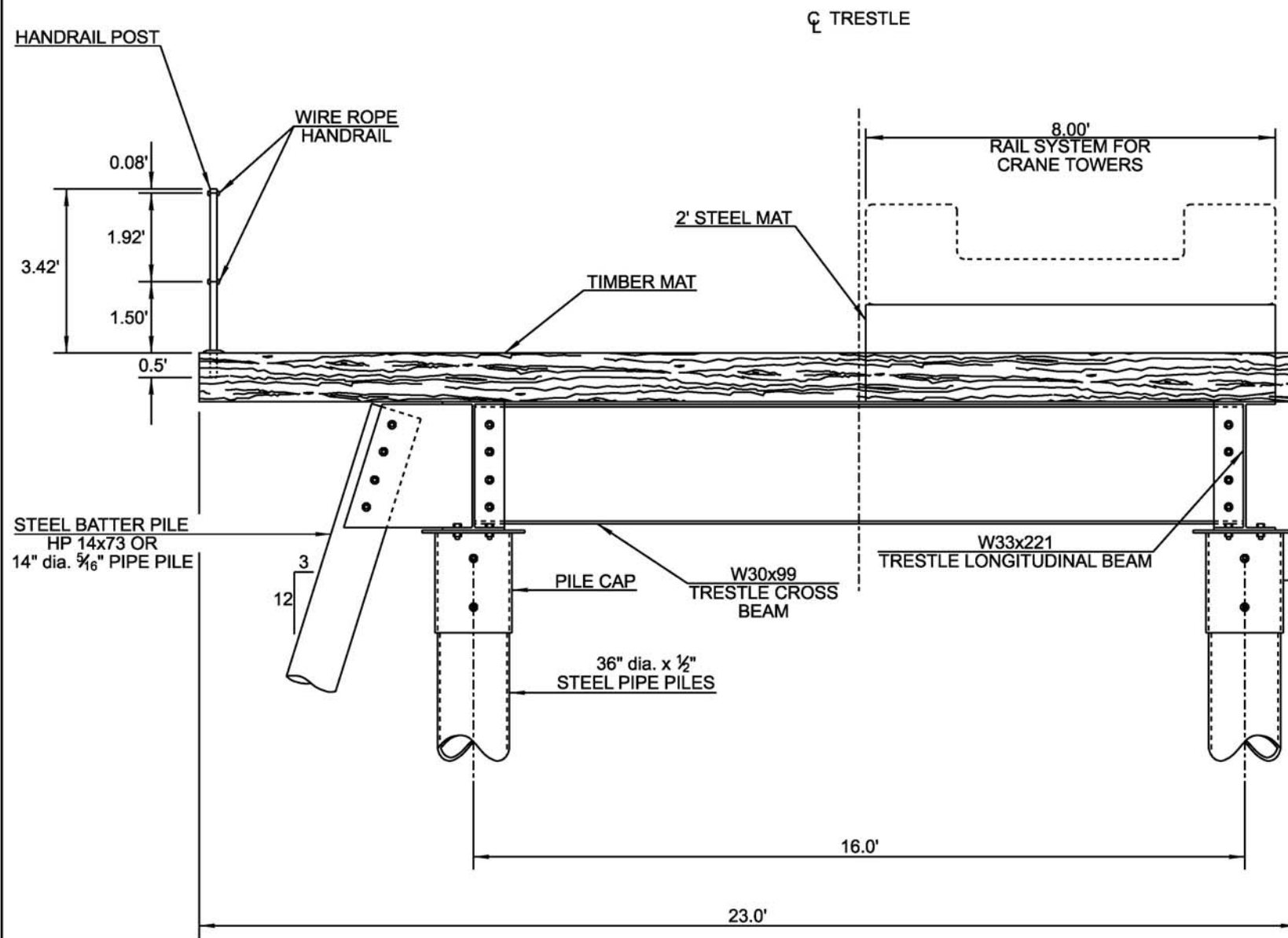
PATRIOTS POINT USS CLAMAGORE <i>Not For Construction</i>			January 2009		Charleston County	South Carolina
Project B0014.03						
Scale As Shown						
Sheet C5						
DENNIS CORPORATION						
Landside Berth Crane Lift Operation						
Drawn By		Revision		Date		Description
Checked By						



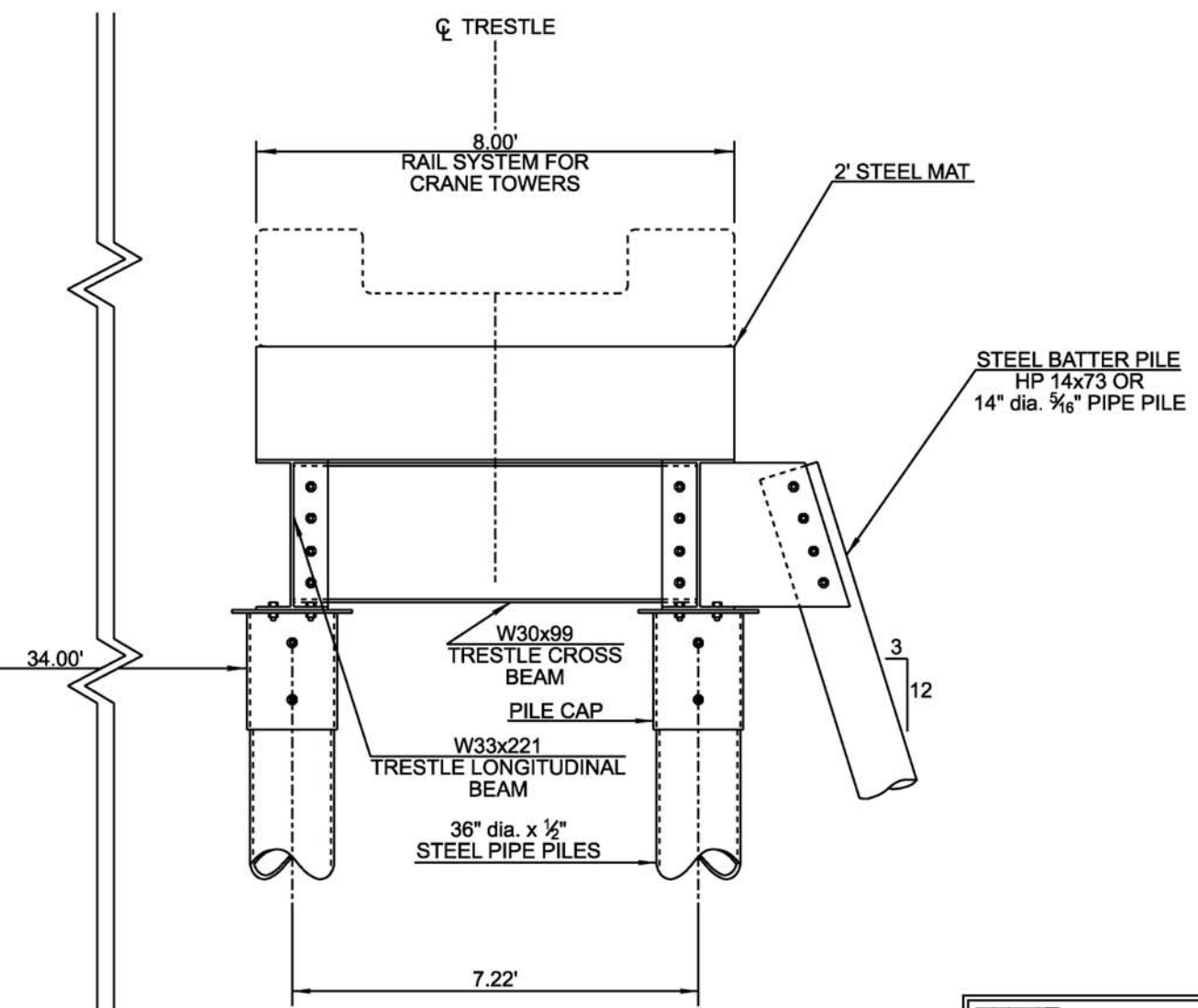
Description		Date	Revision	Drawn By	Checked By
Landside Berth Crane Lift Operation					
DENNIS CORPORATION					
PATRIOTS POINT USS CLAMAGORE Not For Construction					
Project		January 2009			
B0014.03		Charleston County			
Scale		South Carolina			
As Shown					
Sheet					
C6					



Description	
Date	Revision
Drawn By	Checked By
Landside Berth Crane Lift Operation	
DENNIS CORPORATION	
PATRIOTS POINT USS CLAMAGORE Not For Construction	
Project	B0014.03
Scale	As Shown
Sheet	C7
January 2009	Charleston County South Carolina



TYPICAL 16.0' WIDE TRESTLE SECTION
NOT TO SCALE

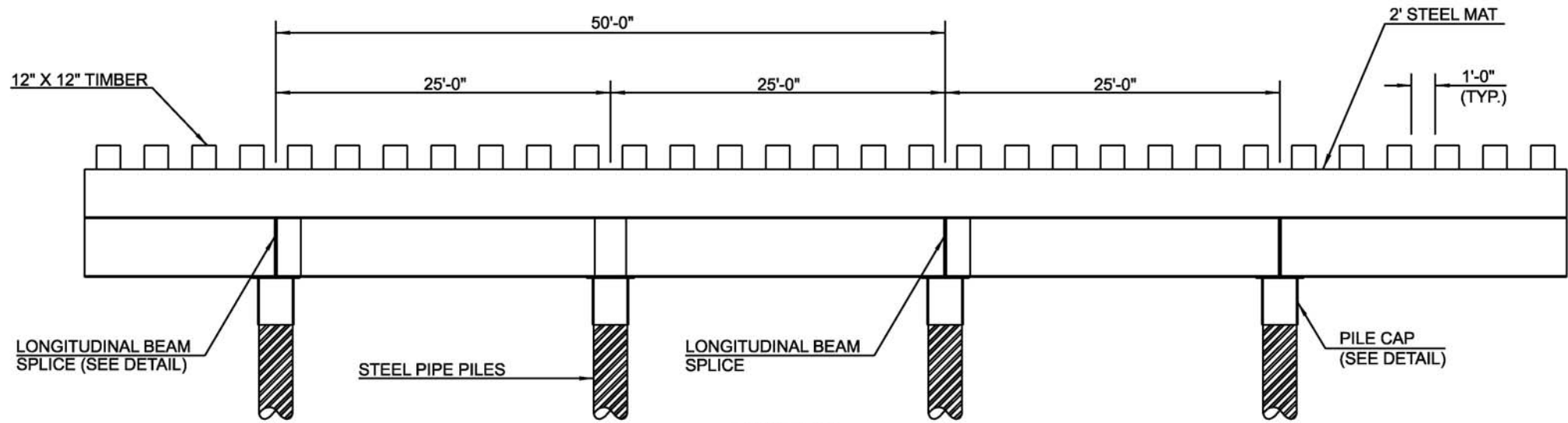


TYPICAL 7.22' WIDE TRESTLE SECTION
NOT TO SCALE

DENNIS
CORPORATION

NOT FOR
CONSTRUCTION

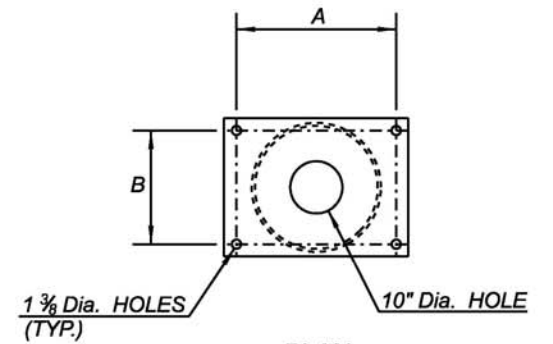
user's
path's
date's



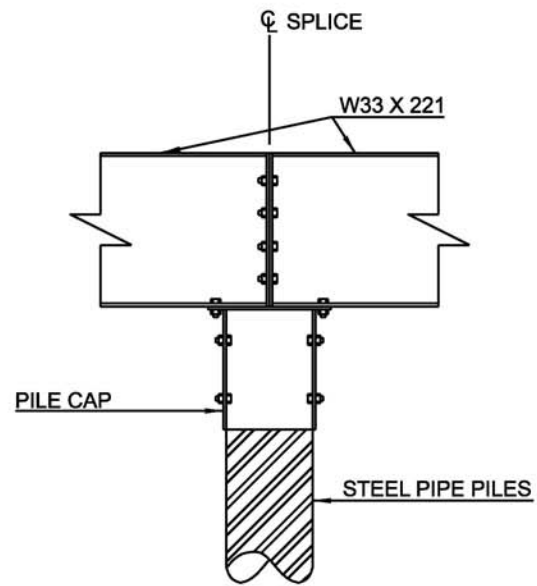
ELEVATION
NOT TO SCALE

- NOTES:
1. MAIN MEMBERS ARE TO MEET THE MINIMUM REQUIREMENTS OF ASTM A992 OR ASTM A572 GRADE 50. STEEL PLATE AND SECONDARY MEMBERS MAY BE ASTM A36 $F_y=36,000$ psi.
 2. STEEL PIPE PILES WILL MEET THE MINIMUM REQUIREMENTS OF ASTM A572 Gr. 50.
 3. WELDING MAY BE PERFORMED WITH E6010 OR E7018 ELECTRODES PER AWS D-1.1, "STRUCTURAL WELDING CODE". LOW HYDROGEN ELECTRODES ARE TO BE PROTECTED AGAINST MOISTURE CONTAMINATION.
 4. BOLTS ARE TO BE $1\frac{1}{4}"$ dia. ASTM 325 HIGH STRENGTH BOLTS UNLESS OTHERWISE SHOWN ON THESE STANDARDS. $1\frac{1}{4}"$ dia PINS MAY BE A36 MATERIAL OR EQUIVALENT.

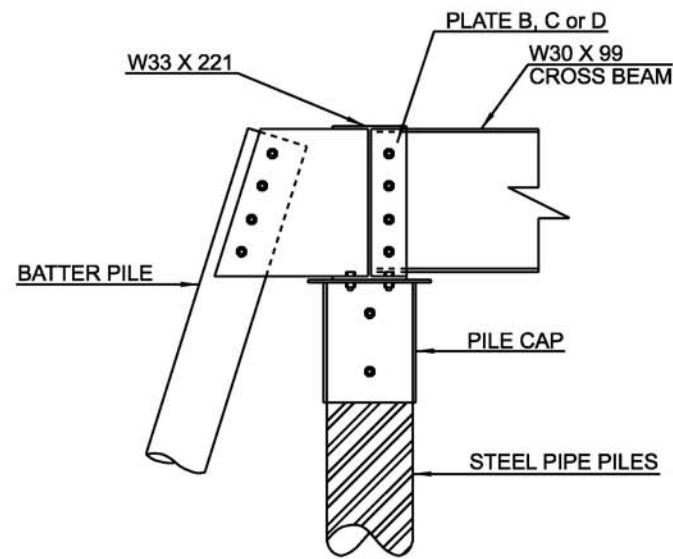
- DESIGN:
1. AISC STEEL CONSTRUCTION MANUAL THIRTEENTH EDITION. STRESS ANALYSIS BY LRFD; PILE BEARING BASED ON ASCE LOAD FACTOR DESIGN.



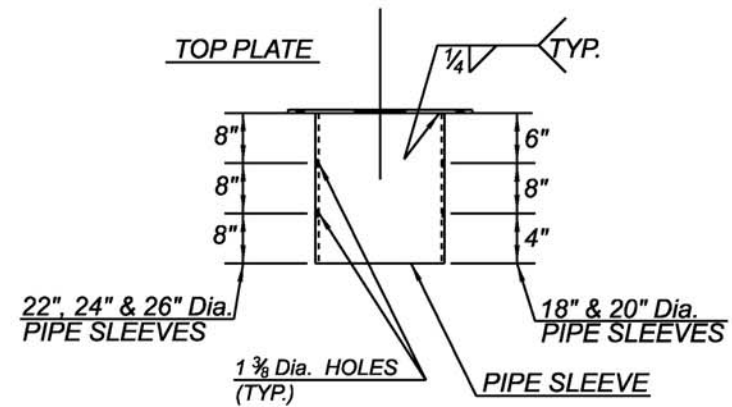
PLAN



LONGITUDINAL BEAM SPLICE
NOT TO SCALE

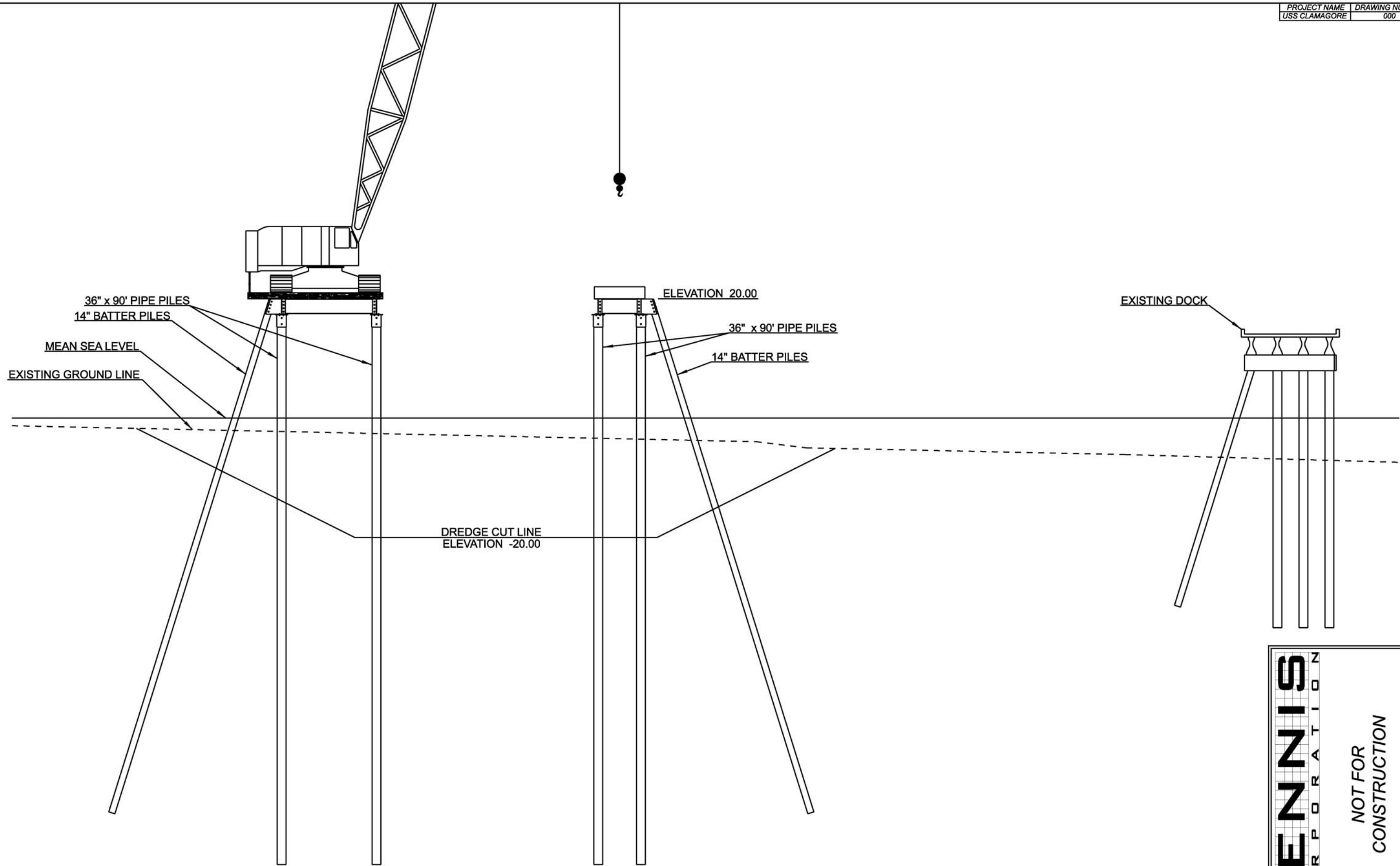


BATTER PILE &
CROSS BEAM CONNECTION
NOT TO SCALE



ELEVATION
STANDARD PILE CAPS
NOT TO SCALE

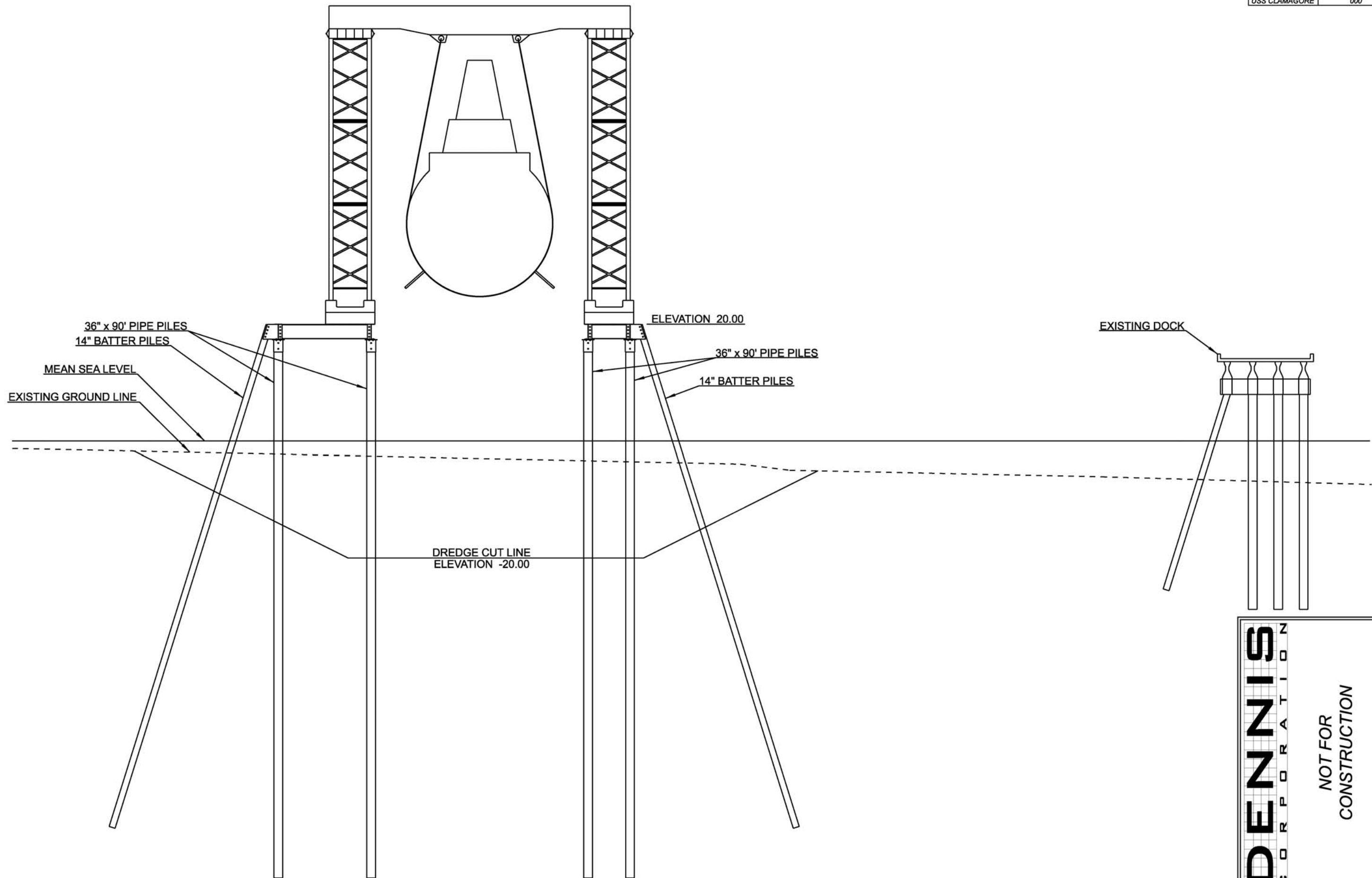
NOT FOR
CONSTRUCTION



\$\$\$user\$\$\$
\$\$\$path\$\$\$filename\$\$\$
\$\$\$date\$\$\$

DENNIS
CORPORATION

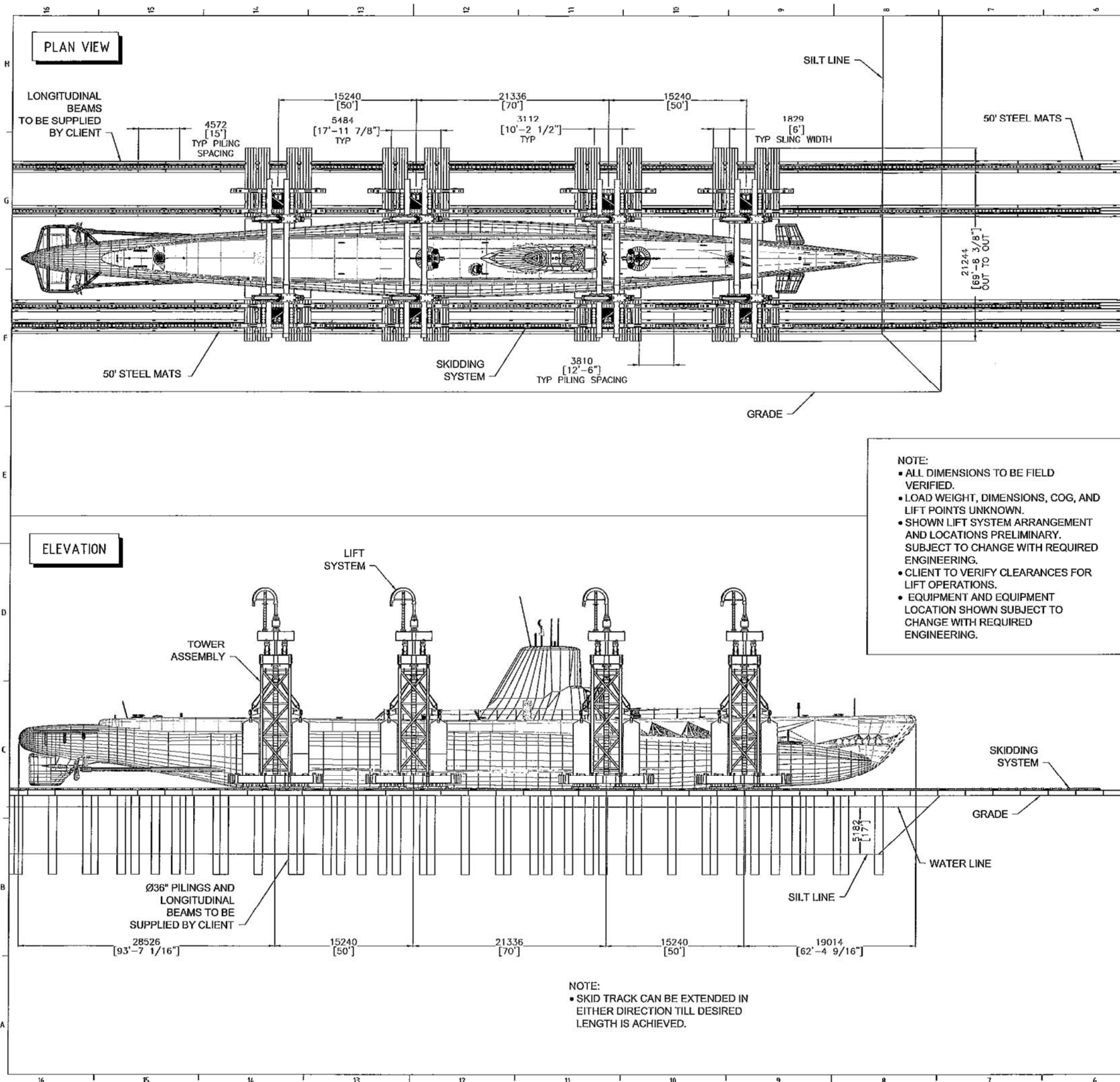
NOT FOR
CONSTRUCTION



\$\$\$user\$\$\$
\$\$\$path\$\$\$filename\$\$\$
\$\$\$date\$\$\$

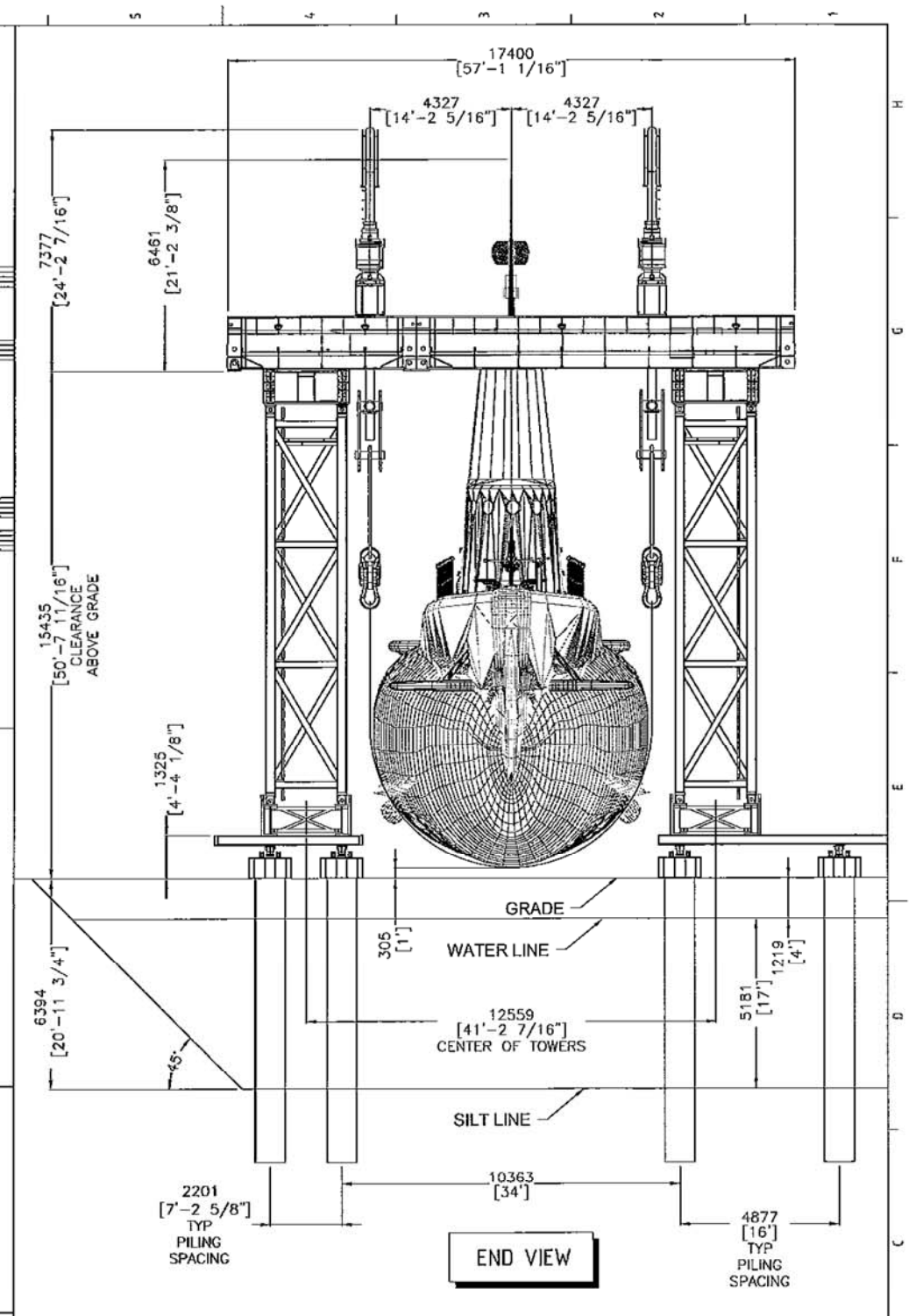
DENNIS
CORPORATION

NOT FOR
CONSTRUCTION



NOTE:

- ALL DIMENSIONS TO BE FIELD VERIFIED.
- LOAD WEIGHT, DIMENSIONS, COG, AND LIFT POINTS UNKNOWN.
- SHOWN LIFT SYSTEM ARRANGEMENT AND LOCATIONS PRELIMINARY. SUBJECT TO CHANGE WITH REQUIRED ENGINEERING.
- CLIENT TO VERIFY CLEARANCES FOR LIFT OPERATIONS.
- EQUIPMENT AND EQUIPMENT LOCATION SHOWN SUBJECT TO CHANGE WITH REQUIRED ENGINEERING.



01	General Redesign	12/23/09	JG	MW	MW
00	For Bid	12/8/09	JG	MW	MW
REV.	DESCRIPTION:	DATE:	DRAWN:	CHECKED:	
PROJECT: DENNIS CORPORATION					
TITLE: CHARLESTON, S.C.					
Lifting and Skidding the USS Clamagore					
SCALE: NTS	SIZE: D	DRAWING NUMBER			
SAP No:	PROJECT No:	SUB:	DOC:	PART:	SHT. REV.
7000051047	0010041976-P031-D-	L02	-	2/2	-01

USS CLAMAGORE
2,000 US TONS
LENGTH = 326'
BEAM = 27' 2"

- NOTE:
- ALL DIMENSIONS TO BE FIELD VERIFIED.
 - LOAD WEIGHT, DIMENSIONS, COG, AND LIFT POINTS UNKNOWN.
 - SHOWN LIFT SYSTEM ARRANGEMENT AND LOCATIONS PRELIMINARY. SUBJECT TO CHANGE WITH REQUIRED ENGINEERING.
 - CLIENT TO VERIFY CLEARANCES FOR LIFT OPERATIONS.
 - EQUIPMENT AND EQUIPMENT LOCATION SHOWN SUBJECT TO CHANGE WITH REQUIRED ENGINEERING.

LIFT
SYSTEM

TOWER
ASSEMBLY

SKID
SYSTEM

GRADE

50' STEEL MATS

Ø36" PILINGS AND
LONGITUDINAL BEAMS TO
BE SUPPLIED BY CLIENT

GRADE

50' STEEL MATS

01	General Redesign	12/23/09	JG	MW	MW
00	For Bid	12/8/09	JG	MW	MW
REV.	DESCRIPTION:	DATE:	DRAWN:	CHECKED:	

DENNIS CORPORATION

PROJECT: CHARLESTON, S.C.

TITLE: Lifting and Skidding the
USS Clamagore

SCALE: NTS	SIZE: D	DRAWING NUMBER				
SAP No:	PROJECT No:	SUB:	DOC:	PART:	SHT:	REV:
7000051047	0010041976-P031-D-	L02	-	1/2	-	01

SECTION 6 — Renderings

Rendering Index

Slide 1 – Existing Conditions of Project Area

Slide 2 – Dredging Area

Slide 3 – Existing Condition with Dredging area

Slide 4 – U.S.S. Clamagore entering dredged channel

Slide 5 - U.S.S. Clamagore turning in channel

Slide 6 - U.S.S. Clamagore completing turn

Slide 7 – Trestle Construction

Slide 8 – Close Up of Trestle System

Slide 9 – Trestle System with crane mating

Slide 10 – Crane matting being removed and replaced with skidding track and crane towers being constructed in distant parking area along with concrete pedestals

Slide 11 - Crane towers with strand jacks moving down trestle system ready for lifting

Slide 12 - U.S.S. Clamagore entering trestle system channel ready for lifting

Slide 13 - U.S.S. Clamagore being lifted by strand jacks

Slide 14 - U.S.S. Clamagore moving along skidding system to concrete pedestals

Slide 15 - U.S.S. Clamagore being lowered to concrete pedestals

Slide 16 – Opposite angle of U.S.S. Clamagore being lowered to concrete pedestals

Slide 17 – Faraway view of entire system

Slide 18 – Final resting position of U.S.S Clamagore

SECTION 6 — Renderings

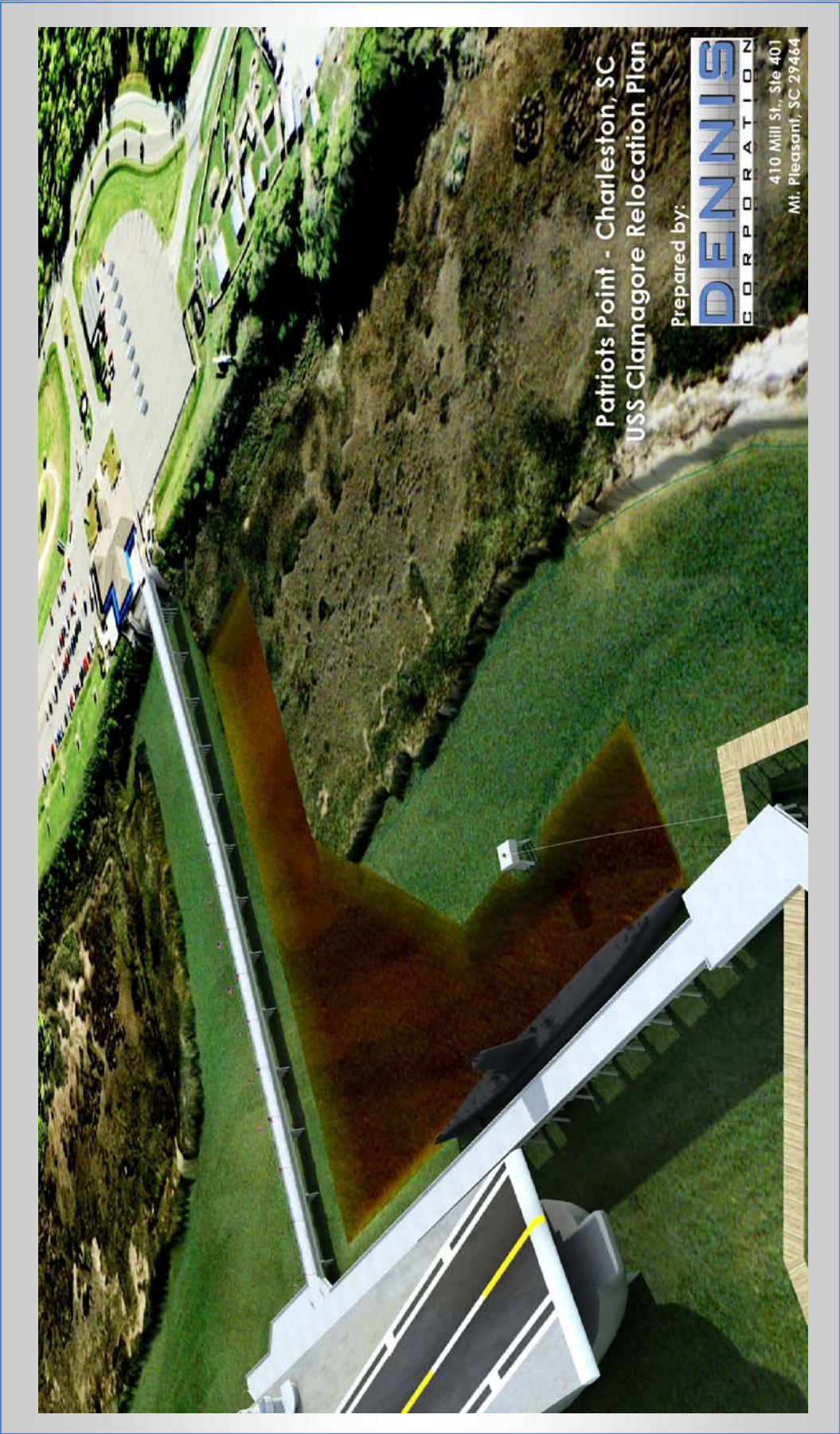


Patriots Point - Charleston, SC
USS Clamagore Relocation Plan

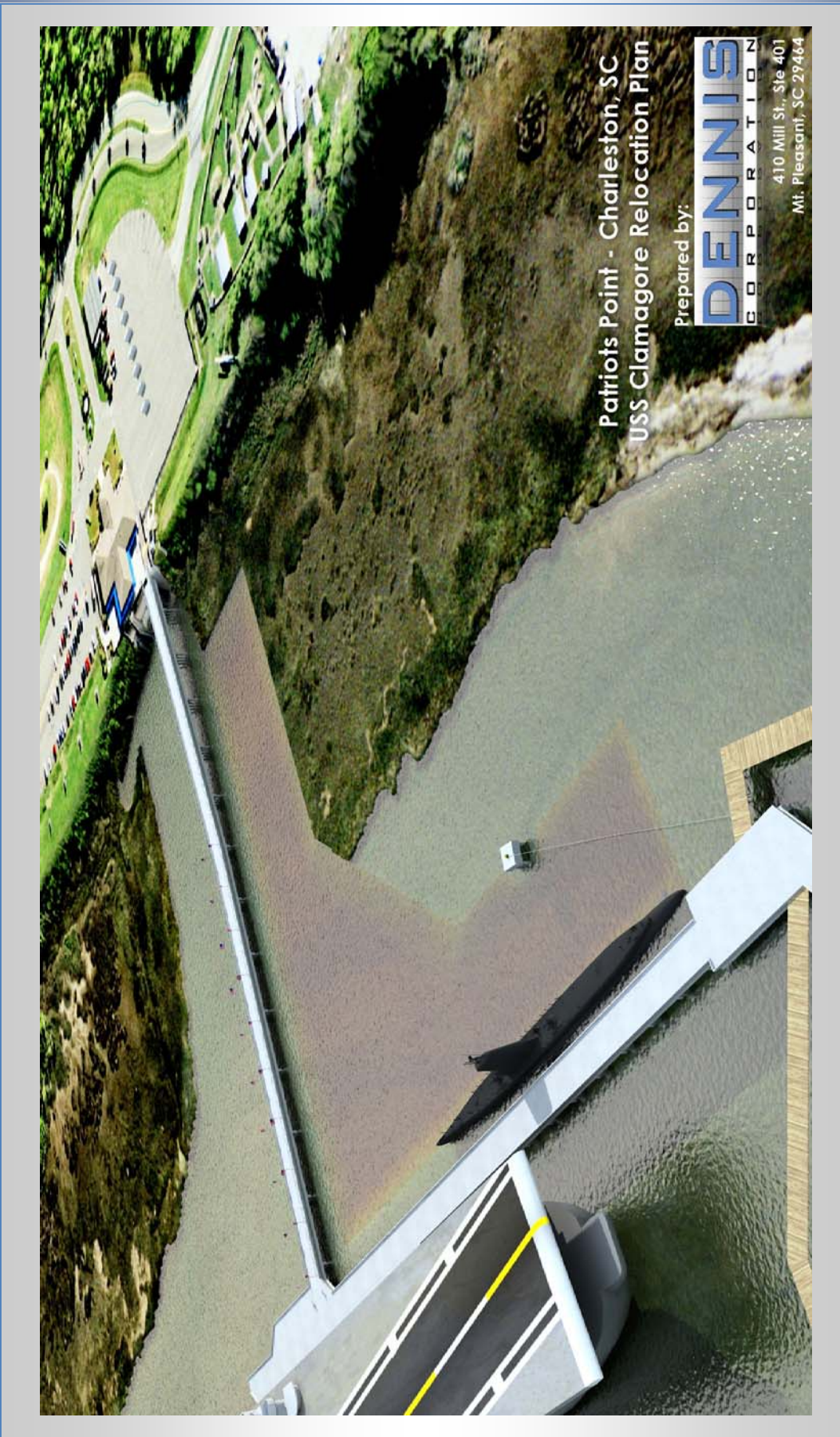
Prepared by:

DENNIS
CORPORATION

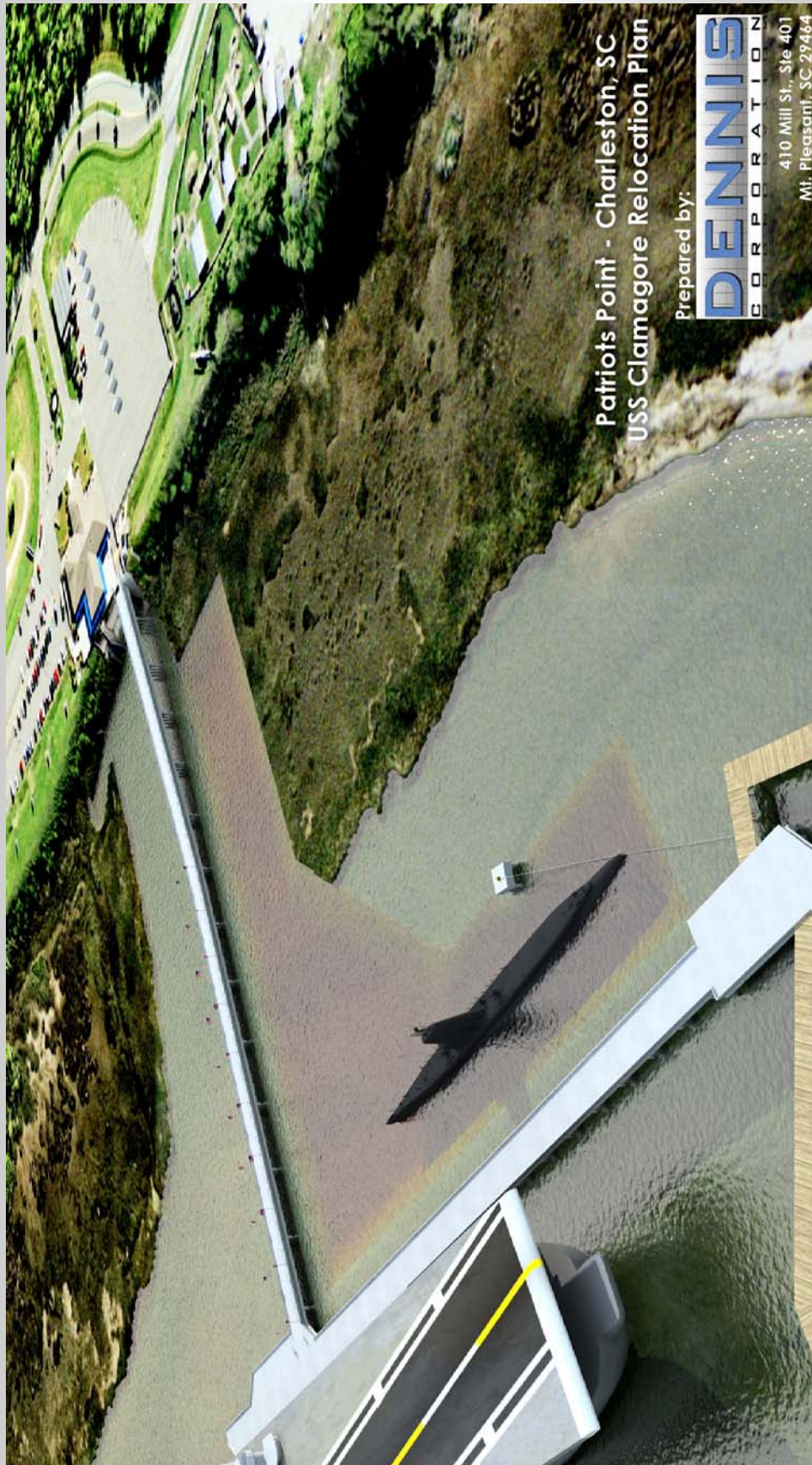
410 Mill St., Ste 401
Mt. Pleasant, SC 29464

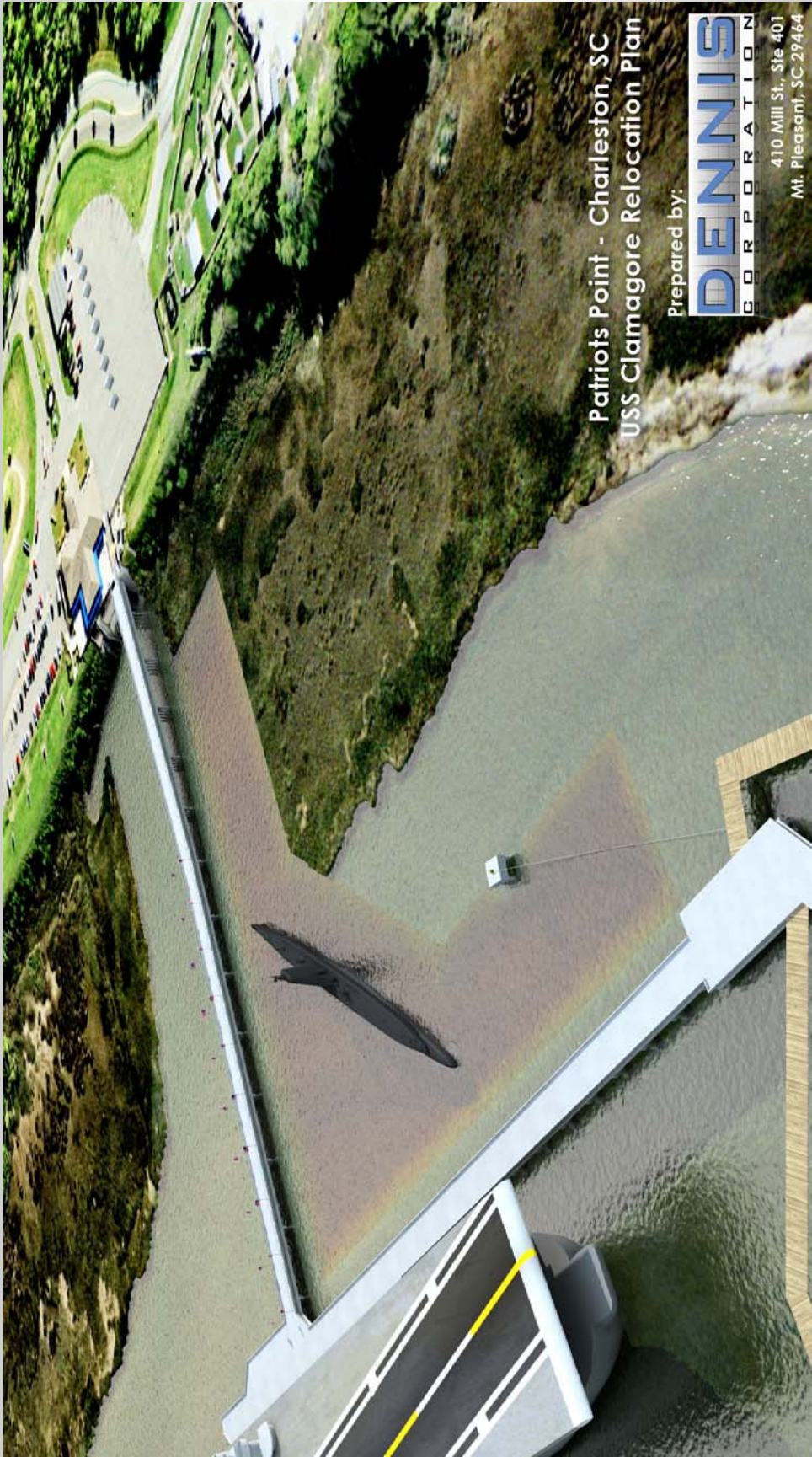


SECTION 6 — Renderings



SECTION 6 — Renderings





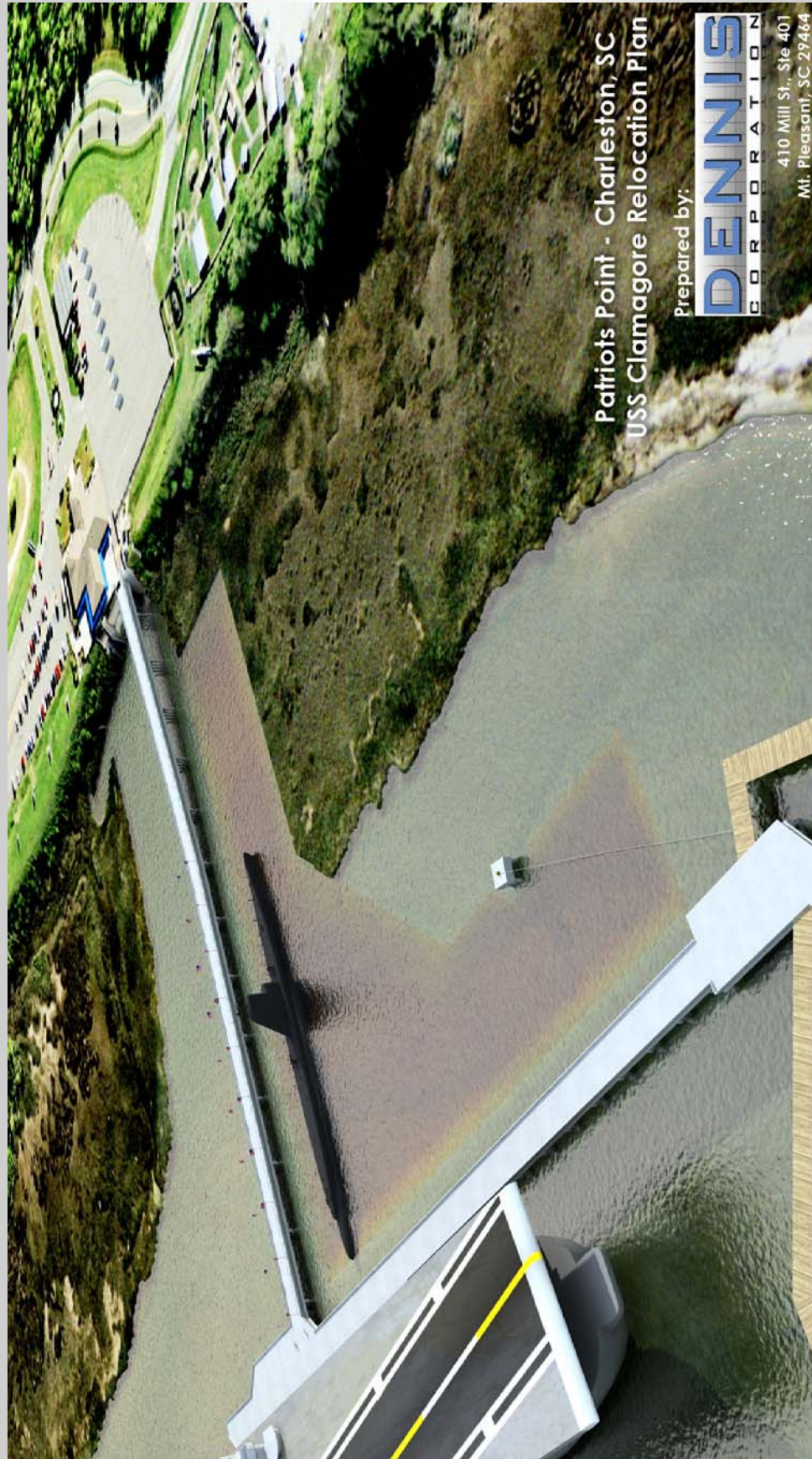
Patriots Point - Charleston, SC
USS Clamagore Relocation Plan

Prepared by:

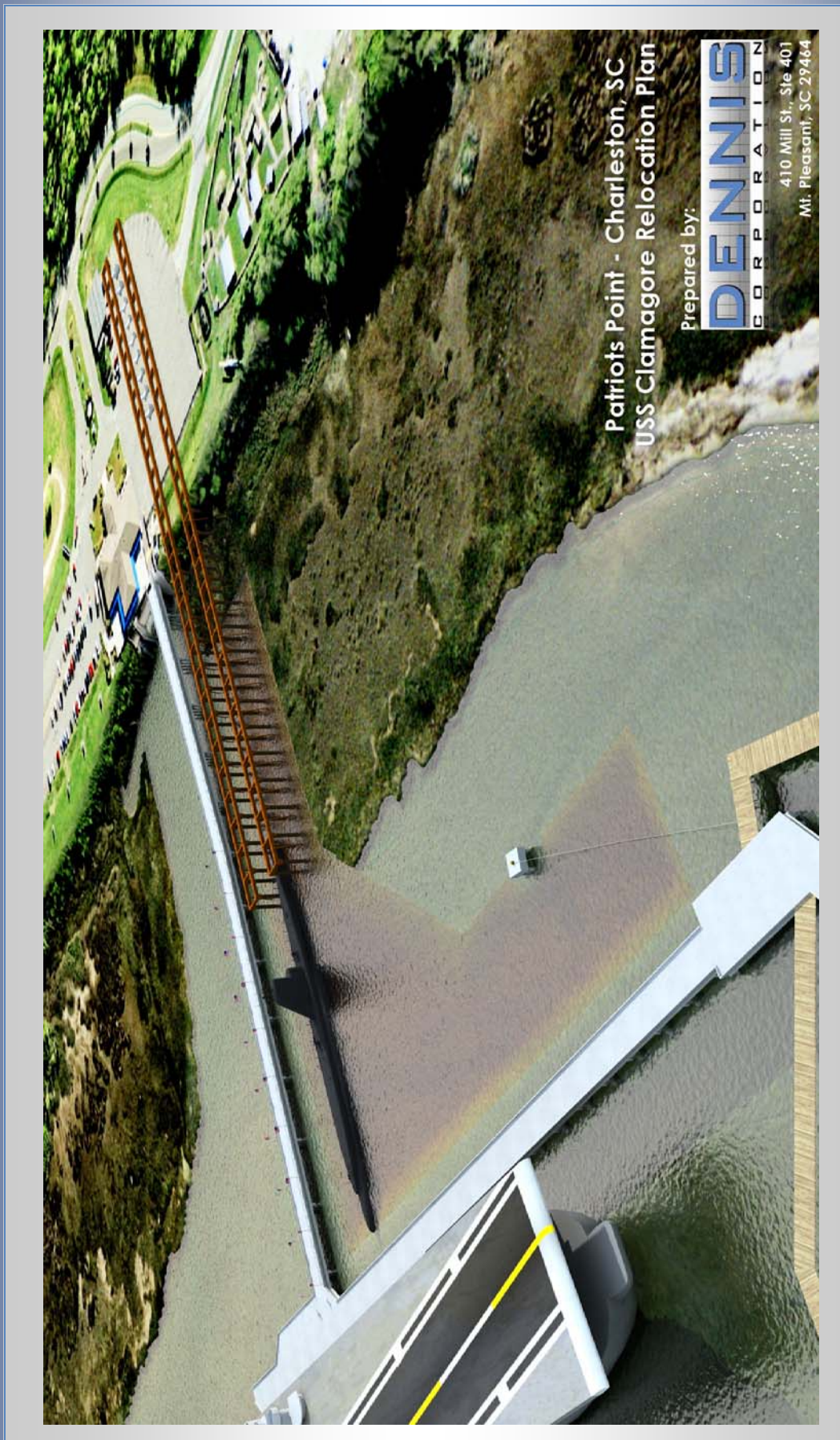
DENNIS
CORPORATION

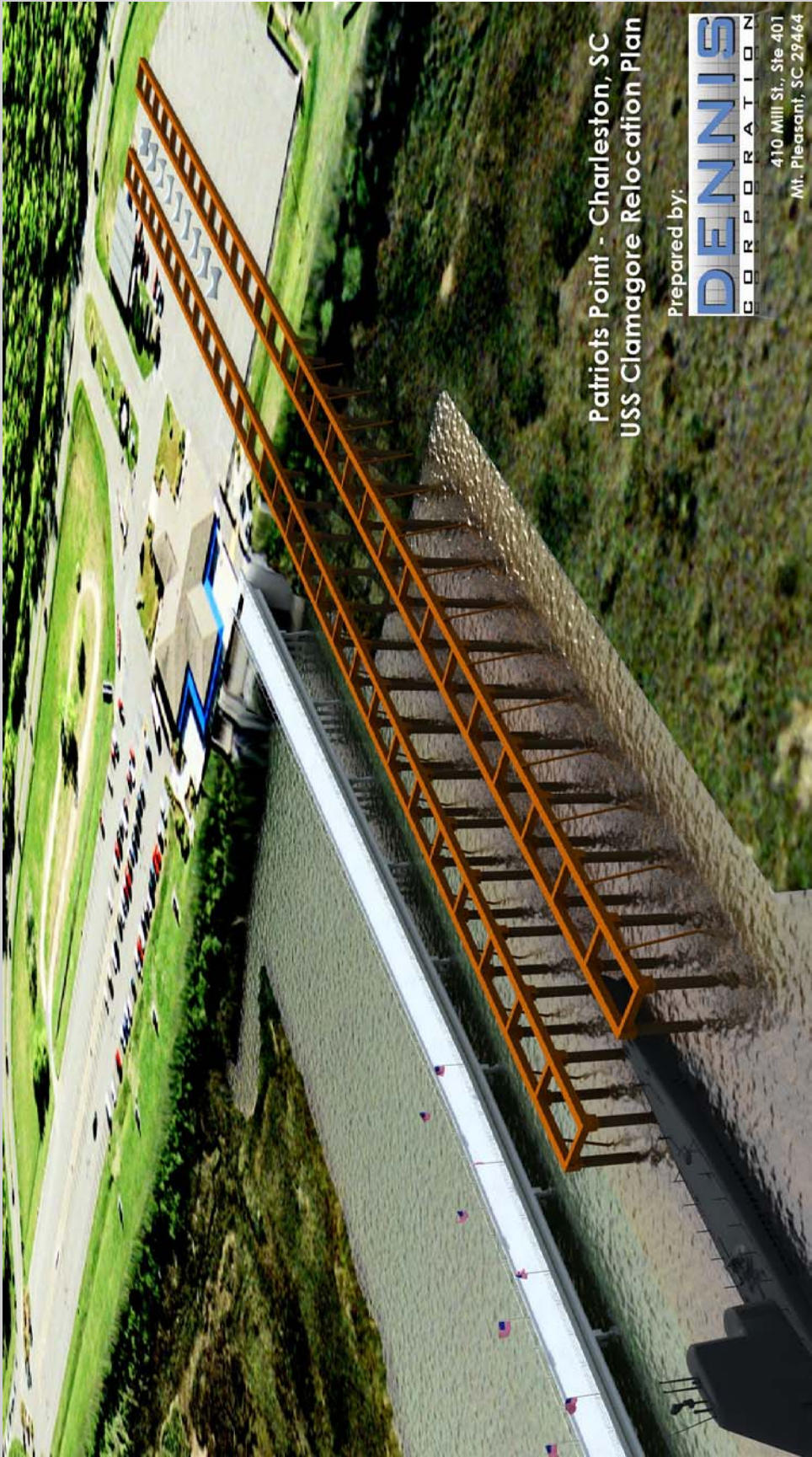
4110 Mill St., Ste 401
Mt. Pleasant, SC 29464

SECTION 6 — Renderings



SECTION 6 — Renderings





Patriots Point - Charleston, SC
USS Clamagore Relocation Plan

Prepared by:



410 Mill St., Ste 401
Mt. Pleasant, SC 29464

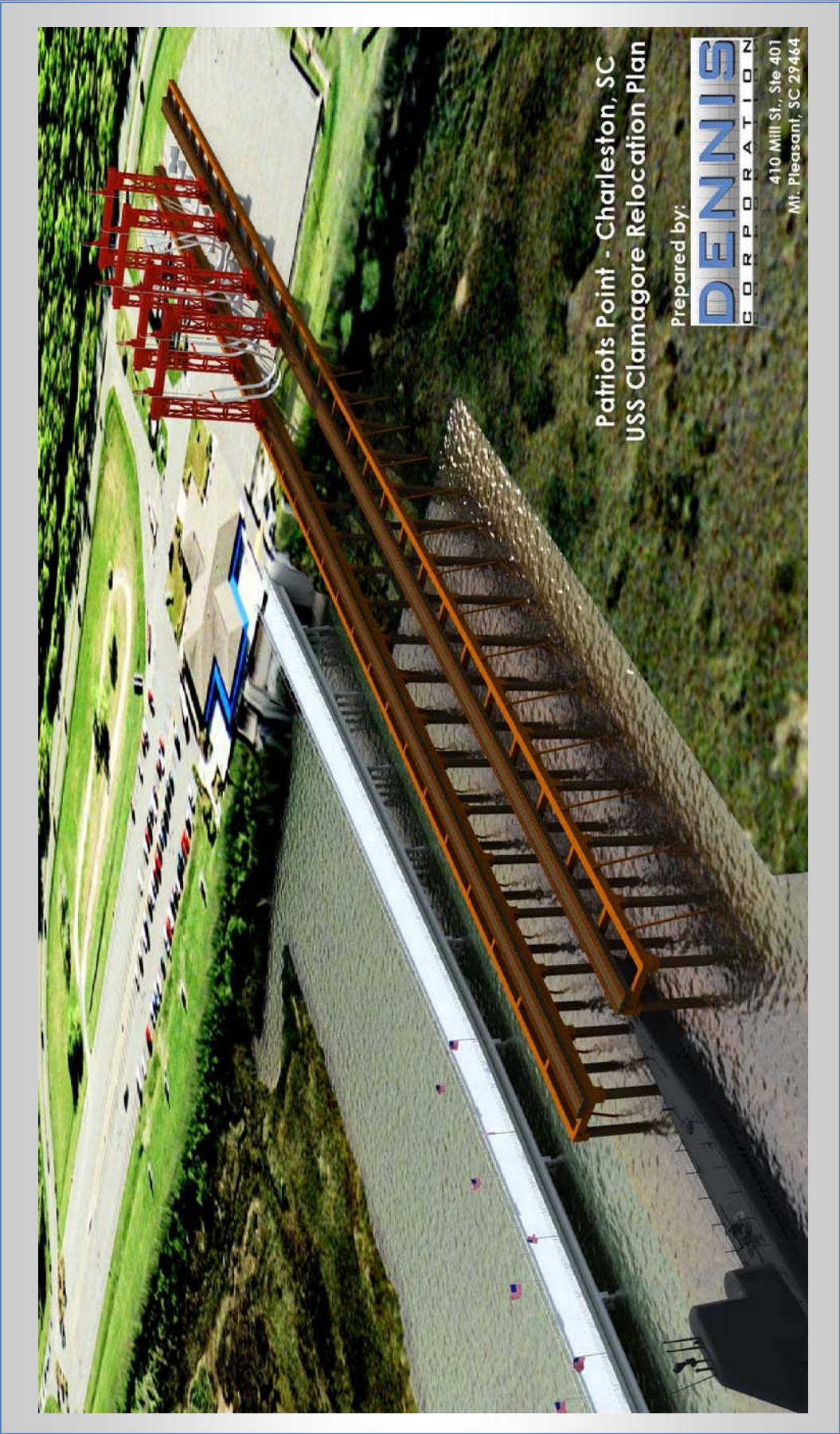


Patriots Point - Charleston, SC
USS Clamagore Relocation Plan

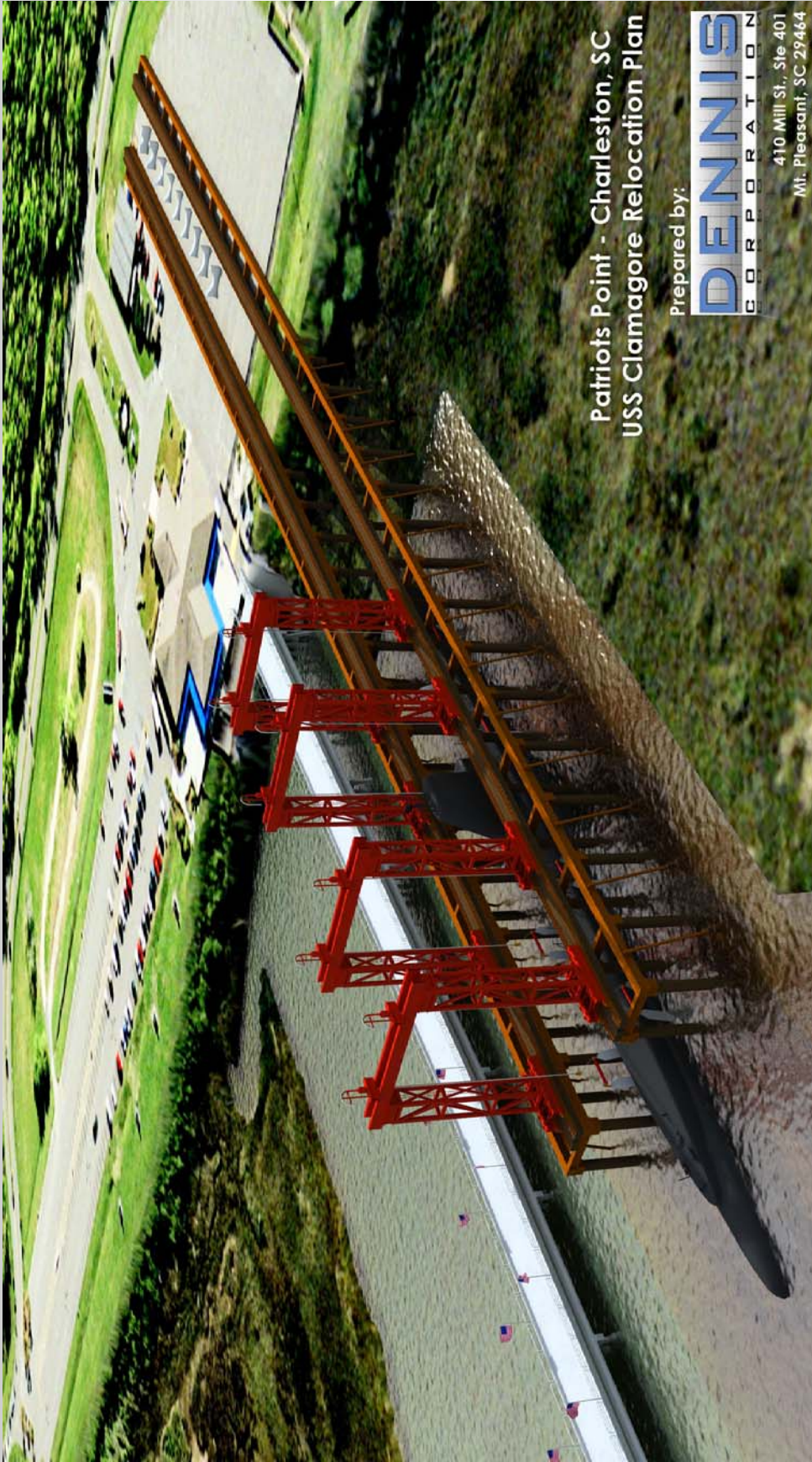
Prepared by:



410 Mill St., Ste 401
Mt. Pleasant, SC 29464







Patriots Point - Charleston, SC
USS Clamagore Relocation Plan

Prepared by:



410 Mill St., Ste 401
Mt. Pleasant, SC 29464



Patriots Point - Charleston, SC
USS Clamagore Relocation Plan

Prepared by:

DENNIS
CORPORATION

410 Mill St., Ste 401
Mt. Pleasant, SC 29464

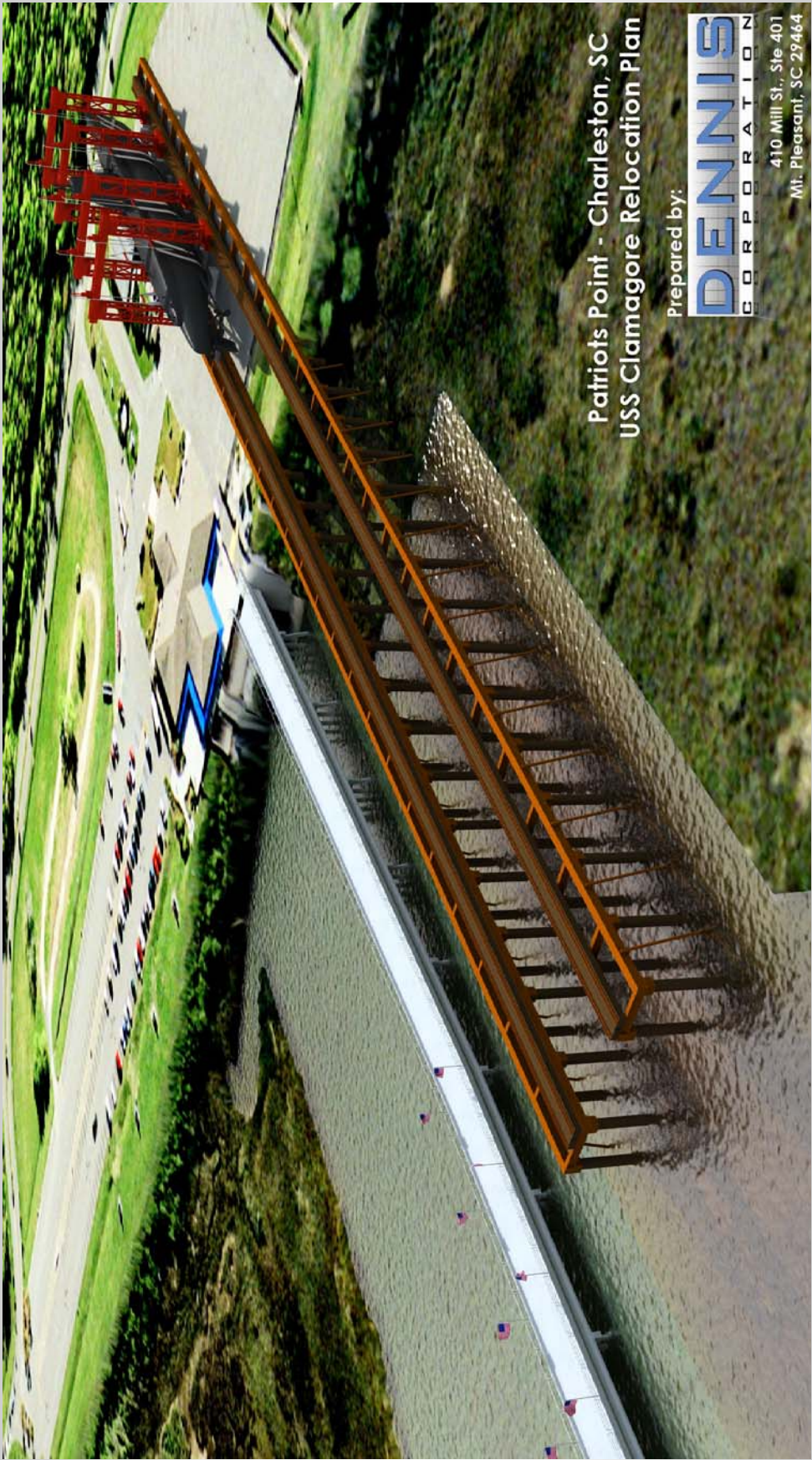


Patriots Point - Charleston, SC
USS Clamagore Relocation Plan

Prepared by:



410 Mill St., Ste 401
Mt. Pleasant, SC 29464

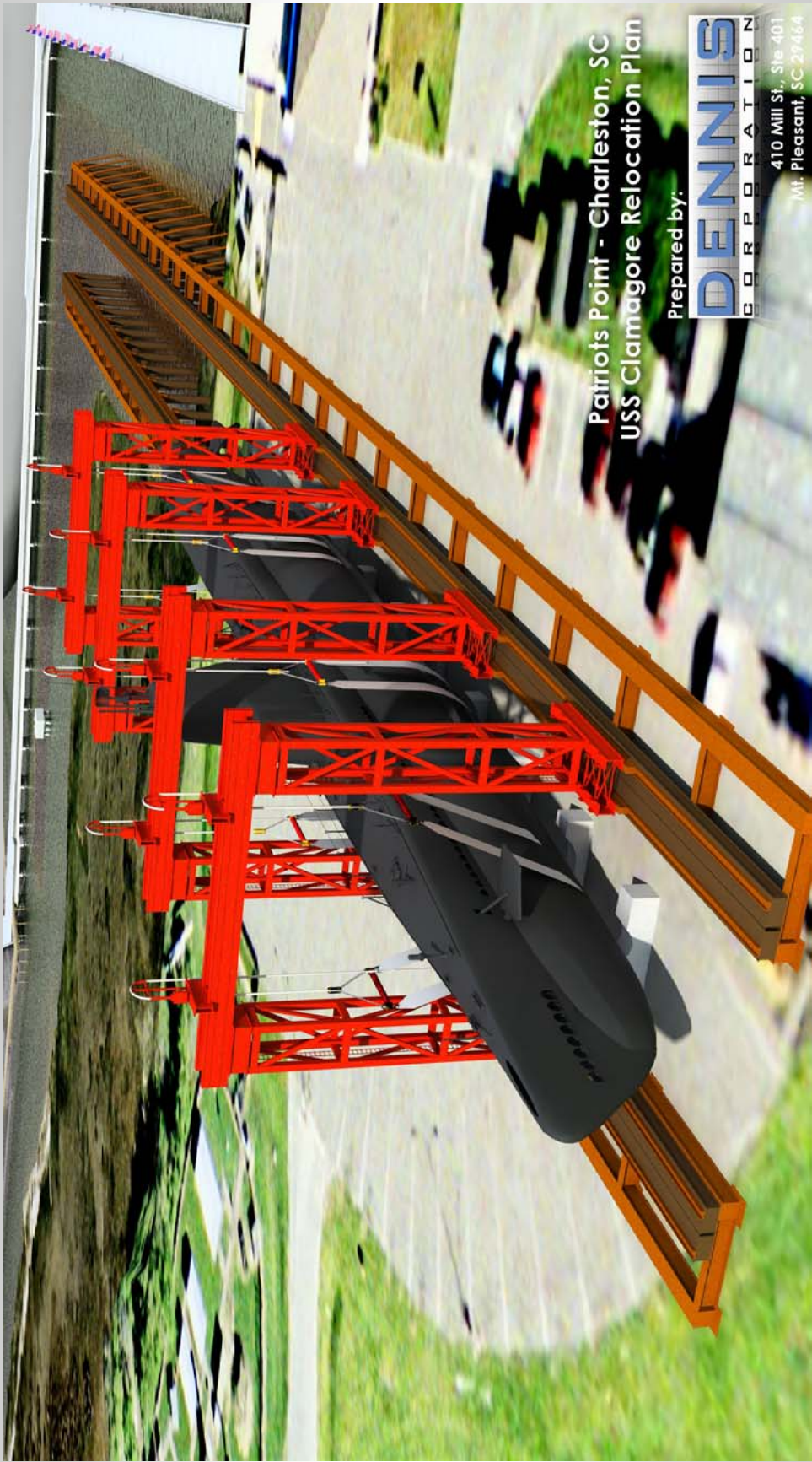


Patriots Point - Charleston, SC
USS Clamagore Relocation Plan

Prepared by:

DENNIS
CORPORATION

410 Mill St., Ste 401
Mt. Pleasant, SC 29464



Patriots Point - Charleston, SC
USS Clamagore Relocation Plan

Prepared by:

DENNIS
CORPORATION

410 Mill St., Ste 401
Mt. Pleasant, SC 29464



Patriots Point - Charleston, SC
USS Clamagore Relocation Plan

Prepared by:



410 Mill St., Ste. 401
Mt. Pleasant, SC 29464



Patriots Point - Charleston, SC
USS Clamagore Relocation Plan

Prepared by:
DENNIS
CORPORATION
410 Mill St., Ste 401
Mt. Pleasant, SC 29464

SECTION 7 — Alternative Cofferdam Operation & Method

Executive Summary

Patriots Point Development Authority commissioned the team of Dennis Corporation and Volkert, Inc. to perform a feasibility study to move the U.S.S. Clamagore to a landside berth. The team was to evaluate two alternatives of moving the submarine to a landside berth. The rail alternative would be performed by Dennis Corporation and the cofferdam alternative would be performed by Volkert, Inc. This report only addresses the cofferdam alternative.

Scope of Work

The cofferdam alternative was to include the following items of work:

1. Review geotechnical report for soil stability to utilize cofferdam alternative.
2. Determine submarine support surcharge loads.
3. Preliminary design of support pedestal.
4. Determine excavation depth for sheet pile.
5. Run sheet pile analysis.
6. Determine construction cost of sheet piles.
7. Determine construction cost of landside excavation.
8. Compile final report with construction cost estimate.

The cofferdam alternative would be accomplished by:

- dredging a channel to the uplands;
- driving a sheet pile cofferdam in the existing parking lot south of the museum and ticket office;
- excavating the soil within the cofferdam;
- floating the submarine into the cofferdam;
- sealing off the end of the cofferdam;
- raise the submarine by using water and underwater backfill;
- construct concrete pedestals and foundation underneath the submarine;
- cutoff sheet pile cofferdam below ground level;
- reconstruct parking lot around submarine;
- provide stair access and utilities to submarine.



Cofferdam Location

SECTION 7 — Alternative Cofferdam Operation & Method

COFFERDAM ALTERNATIVE

Feasibility Process and Assumptions

The first assumption was the width and centerline of the dredging and how close to get to the existing U.S.S. Yorktown concrete access bridge. Not knowing the pile tips, we decided to maintain the dredge centerline at 75 feet away from the nearest edge of the bridge concrete pile cap. Final design would require close scrutiny of existing bridge record drawings and geotechnical report to determine possible interference or potential bridge stability issues.

The second design consideration was determining the dredge depth required to float the U.S.S. Clamagore into the cofferdam. Minimizing the draft of the submarine is critical to the success of the project. Removing the existing batteries could change the draft substantially. In one of the discussions with Patriots Point personnel, we were told that the submarine floated at high tide. This would place the minimum dredge depth at elevation -8 feet NAVD 88 at high tide, or a total draft of 13 feet. With the tides being semidiurnal this would give the moving process approximately 2 to 3 hours to move the submarine into the cofferdam. This should be enough time with an organized process sequence.

Once the submarine is in the cofferdam, the tide would recede and the submarine would sit on the bottom until the next high tide. The soil at the bottom of the cofferdam would have to be shaped to mimic the bottom of the submarine for stability. The open end of the cofferdam would then take several days to be closed by installing sheet pile, waterproofing, and adding structural reinforcement.

The raising of the submarine to its final location may require as many as 30 to 40 steps. The submarine will have to be raised a vertical height of approximately 28 feet. Each step would require water and sand to be pumped into the cofferdam to raise the submarine. To keep the sheet pile wall stabilized, temporary structural bracing frames would have to be installed and adjusted above and below the submarine during the course of raising the submarine. There would be continuous monitoring of the sheet pile wall for movement and stability.

During the course of moving the submarine to its final location, insurance may be considered for submarine damage caused by a construction incident.

It is important to remember that after the submarine rests above ground, the task of sandblasting, repairing holes, and painting will need to begin. The cost of these repairs is not included in this estimate.



Filling Cofferdam



Final Location

Cofferdam Method Used for U.S.S. Drum



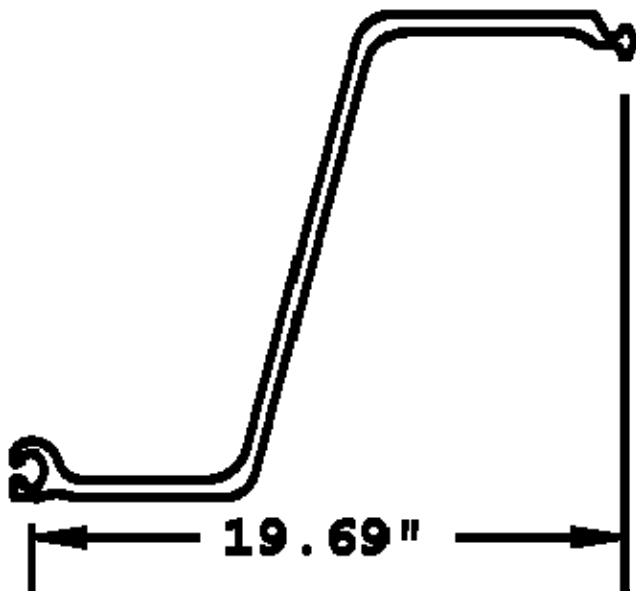
Construction of Concrete Pedestals

SECTION 7 — Alternative Cofferdam Operation & Method

The other method to successfully move the U.S.S. Clamagore to a landside berth is the construction of a Cofferdam System. This has been determined feasible by members of the project team. This method would involve dredging roughly the same area as the Crane Lift Method; however the dredging area for this method would require material to be removed all the way up to the bank of the parking lot. This method would then require excavating over 40,000 CY of material from the wetland embankment and existing parking lot. Excavating would have to reach the desired depth of over 25 feet in order to achieve the desired draft to float the submarine into the cofferdam. A three sheet steel pile system will be driven into the sides of the excavated area. These steel sheet piles will then be water sealed and braced with structural steel frames. The submarine will be floated into the cofferdam and the cofferdam will be sealed with a closure sheet pile wall. Temporary bracing will be required during the many steps in the construction, and careful monitoring of the wall deflections will be needed. Water will be pumped into the cofferdam and then replaced with sand, raising the submarine. This sequence will be repeated until the submarine reaches the desired height of roughly 28'. Once it has reached the required elevation the steel sheet piles will be cut and removed so the concrete pedestals can be constructed under the submarine. The design of this method will involve a 40 step construction sequence.



"AZ" Sheet Piling- Notice the joint is shaped like an "A"



"PZ" Sheet Piling

Sheet pile walls are commonly used for numerous types of retaining walls on both large and small waterfront structures. Applications can range from retention of soil on a small scale to large dock structures for ocean going ships. Steel is the most commonly used construction material for sheet piling for numerous reasons. Steel is resistant to stresses developed from driving and is relatively lightweight given the small cross-sectional area of the application. If installed and extracted properly, the sheet piles can be reused numerous times. Steel has a long service life above and below water with minimal protection and lengths of individual sheets can be increased by bolting or welding. Steel sheet piling is available in numerous shapes and sizes.

For this method application, "AZ" pile would be preferable. "Z" shaped piles are considered one of the most efficient piles available. "Z" piles have their interlocks located at the outer fibers of the wall, assuring the designer of their published section modulus. Available styles of "Z" piles are "AZ" and "PZ". The "PZ" piling is produced with a ball and socket interlock system. The ball and socket is flexible upon setting, yet is extremely durable under driving conditions. For this application, we feel that a rigid application is warranted and therefore recommend the "AZ" pile. The "AZ" pile joint has flat a-shaped connections that do not allow flexibility in the joint thereby further securing the joint. The piles would be hot rolled into shape at a mill and shipped to the site for installation by an excavator mounted vibratory hammer. This method is nearly twice as efficient as the conventional driving method. Steel I-beams will be driven first to guide the driving of the walls and further support the sheet piling. Cross bracing of the I-beams in several locations with horizontal beams will be used as a driving template. The sheet piling would need to

SECTION 7 — Alternative Cofferdam Operation & Method

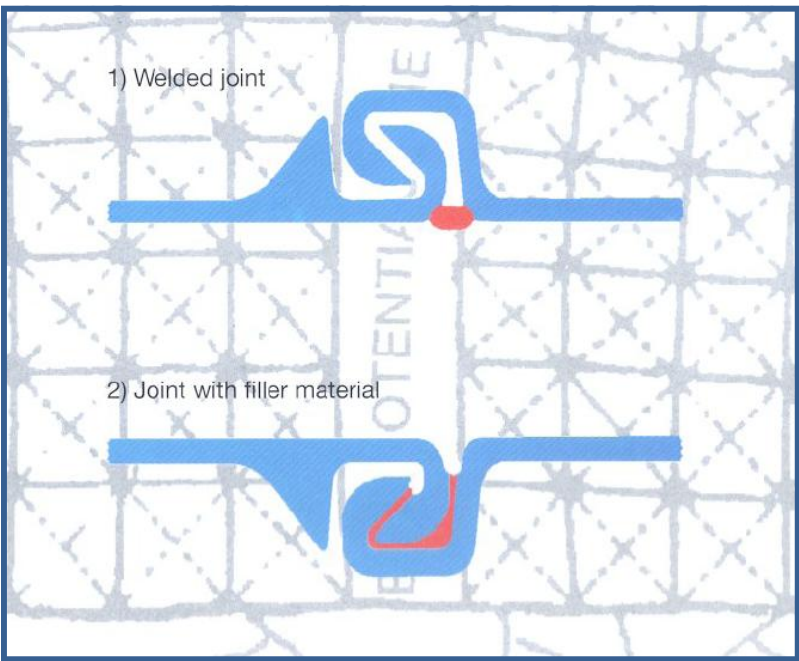
be anchored as this wall would be considerably high. Support braces will be welded to the walls to connect the tie rods. The upper tie rod and brace may be welded by conventional welding methods and the lower tie rod will be welded by divers once the sheet piles are driven.

Proper driving is essential to impervious walls. There are several drive methods that are used today. The pitch and drive method is commonly used in northern Europe and consists of driving each pile to the full depth before pitching the next sheet. This can be damaging to the wall but can be successful provided the piles are well guided. This is slightly faster than other methods. Another method for successful pile driving is panel driving. In panel driving, the first pair of sheets are pitched, aligned, and plumbed before they are driven. The first pair is driven to an intermediate depth and then the remainder of the panel is pitched. The last pair are aligned, plumbed, and then driven. The remainder of the panel is driven working backwards toward the first pair. When the second panel is pitched, the last pair of the first panel becomes the first pair of the second panel and the first panel is then driven to final depth. This process continues until all panels are driven to final depth. The method for driving the steel sheet piles will be determined by the selected contractor.

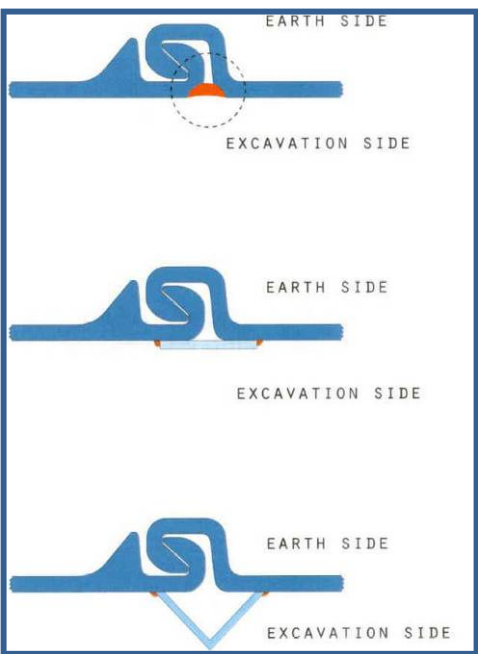


The crane is used to install the supporting I-beams.

This structure will need to be impervious to water so an interlock sealing system will be used to keep water out. The steel sheets are completely impervious and the only possible route for breach is through the joints. A bituminous filler material is the simplest and most cost effective method for sealing the joints. Bituminous filler is composed of a tar compound, asphalt, or a mixture of the two. This filler is hot fed into the sheet pile interlocks either at the factory or on site. Petrochemicals may have a negative impact on the durability of the bituminous filling system. In application of the bituminous filler, care must be taken to make sure the joints are dry before the filler is installed. For this particular application, this method will be rejected for that reason. A water-swelling filler system may be used in lieu of the bituminous filler. The water-swelling product expands in water and seals the joints between the sheet piles thereby creating an impervious structure. This system is effective up to twenty five meters of water pressure and possesses excellent durability for fresh and sea water environments as



“AZ” Pilings Welding v/s Filler.



Welding options.

SECTION 7 — Alternative Cofferdam Operation & Method



A crane is used to direct long pilings.



Excavator Mounted Vibratory Hammer (EMVH) emplacing support rods.



Another example of an EMVH emplacing support rods.

well as environments where mineral oils and fuels may be present. The installation of a water-swelling system would be preferably in a workshop with a clean, dry environment. Yet another alternative to these systems is welding of the panels after installation of the piles. The weld provides a barrier that is as impervious as the steel itself; however, this system is more expensive than either of the aforementioned methods. Double or triple sets of piles can be welded at a workshop for cost savings and ease of construction of the wall. The interlock that is threaded on the job, is welded on site after installation. This joint can be filled with bituminous product prior to being installed to ensure proper welding of the joint and to prevent any contamination of the joint prior to the weld. In this case the positioning of the bituminous sealer must be installed in a way as not to make contact with the weld.

Upon completion of the installation of the sheet pile walls; the water will be removed, fill will be dumped and compacted for added support of the system. Options for fill include but are not limited to sand, gravel, rip rap, and coquina. Concrete supports may be emplaced at the bottom level to help support the submarine during the lifting and pumping sequence.

With this method comes some unique challenges. The environmental impacts will be greater making the permitting process more difficult. A larger environmental mitigation site will be required for this method. The existing storm drain line located on the outside perimeter of the parking lot will have to be moved increasing the cost. Due to having to excavate all the existing material underneath the submarine, material will have to be brought in to be used as fill to establish a strong enough foundation to handle the weight of the resting submarine. A concrete slab will then have to be poured underneath the entire submarine to be used as a suitable foundation for the concrete pedestals. Unlike the crane-lift method where the concrete pedestals are going to be constructed using pipe piles driven into the existing material at the same time as the trestle system is constructed; this method will require a large quantity of reinforced concrete to be used for constructing the supporting pedestals. This method will also require a spoil site to be located on-site to collect all excavated material.

SECTION 7 — Alternative Cofferdam Operation & Method



“PZ” Sheet Piling Retaining Wall

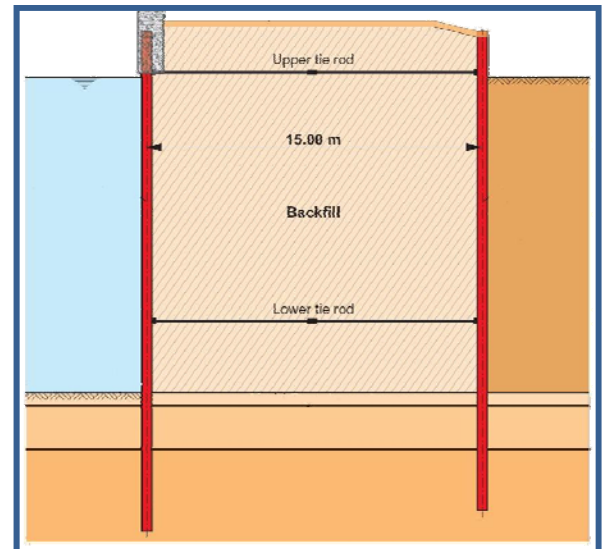


Close up of “PZ” Joint Shape

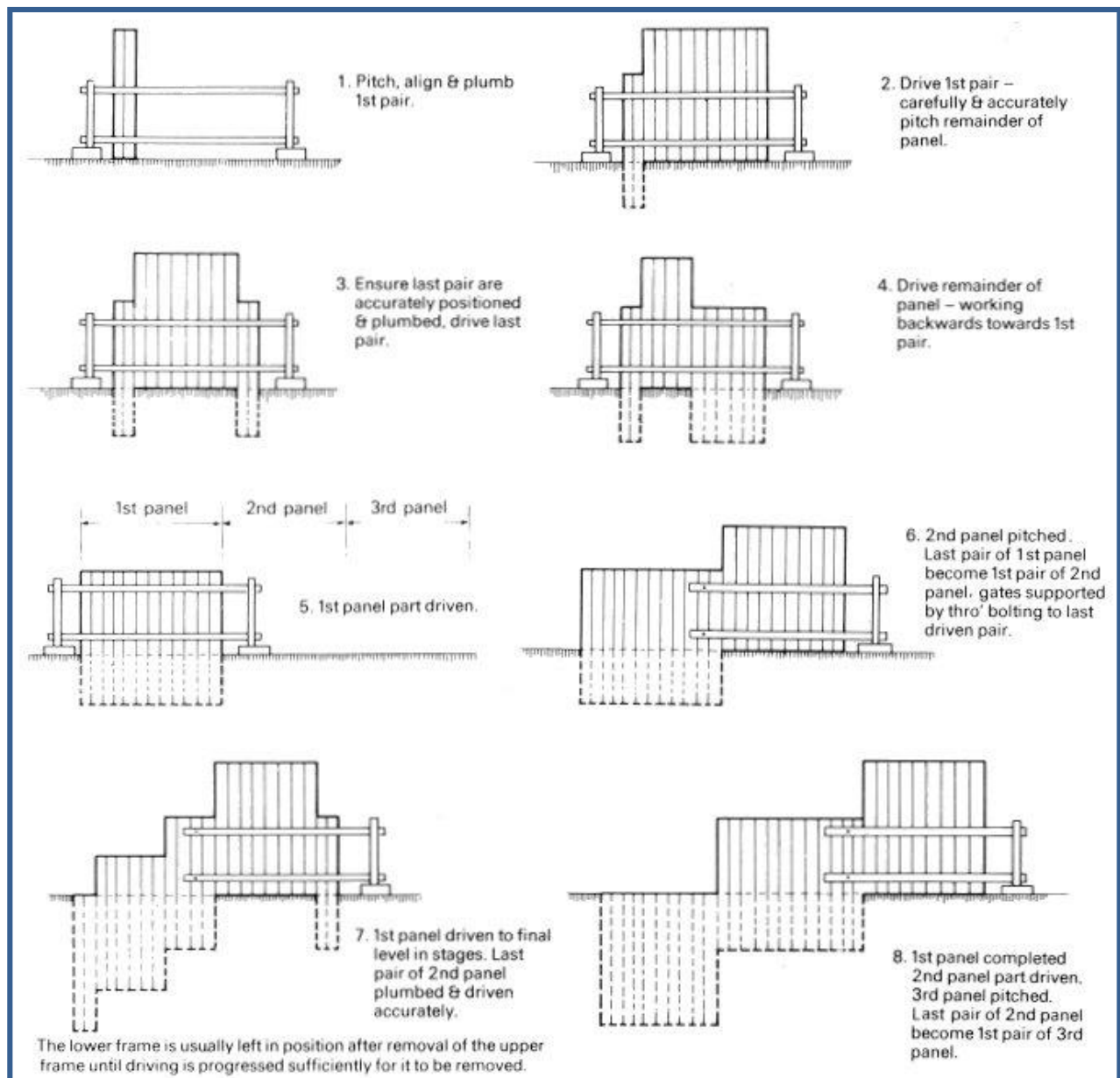
SECTION 7 — Alternative Cofferdam Operation & Method



Tie Rods between the sheet piling walls

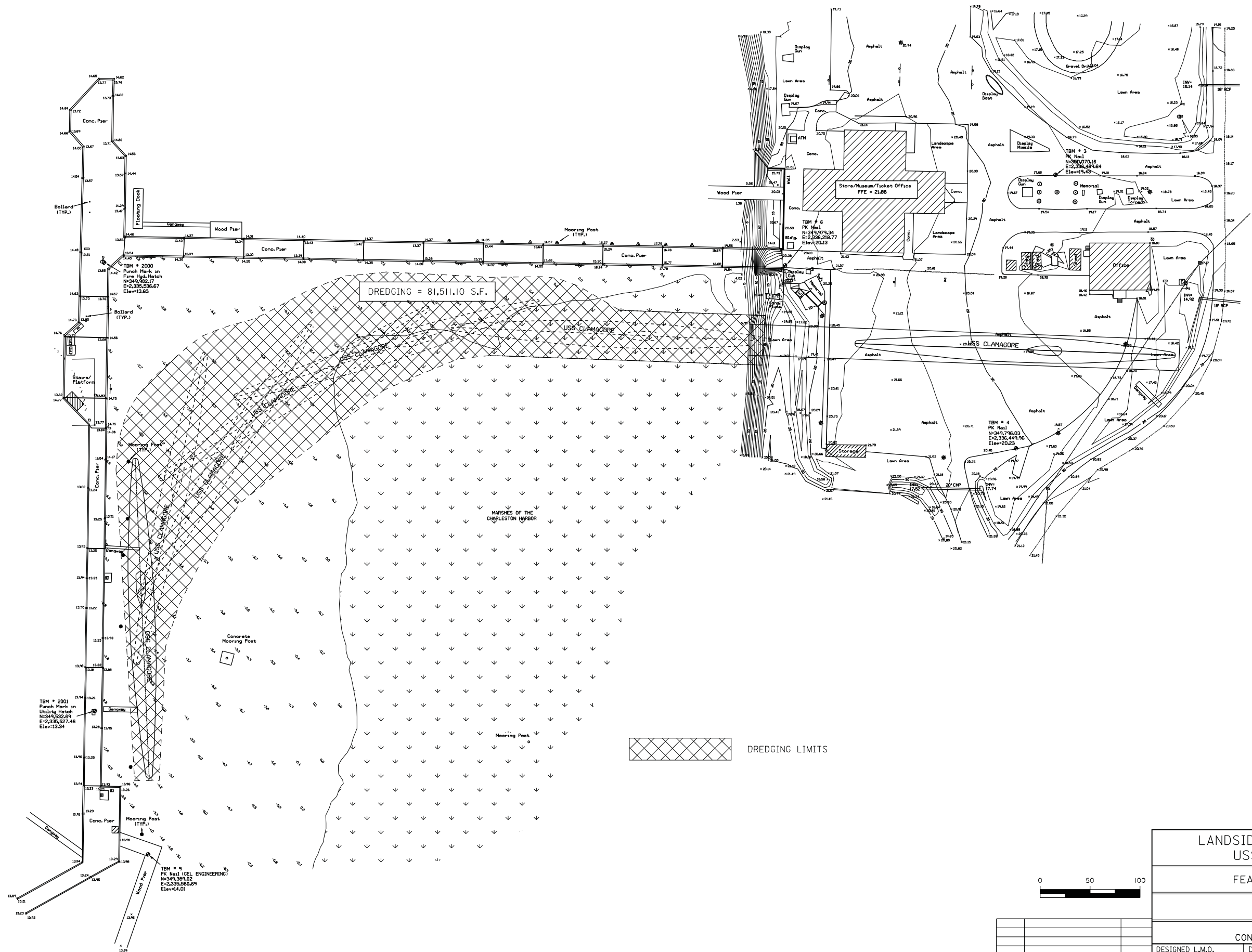


A schematic example of a sheet pile wall



Description of panel driving

PROJECT NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
978301.10	2010		

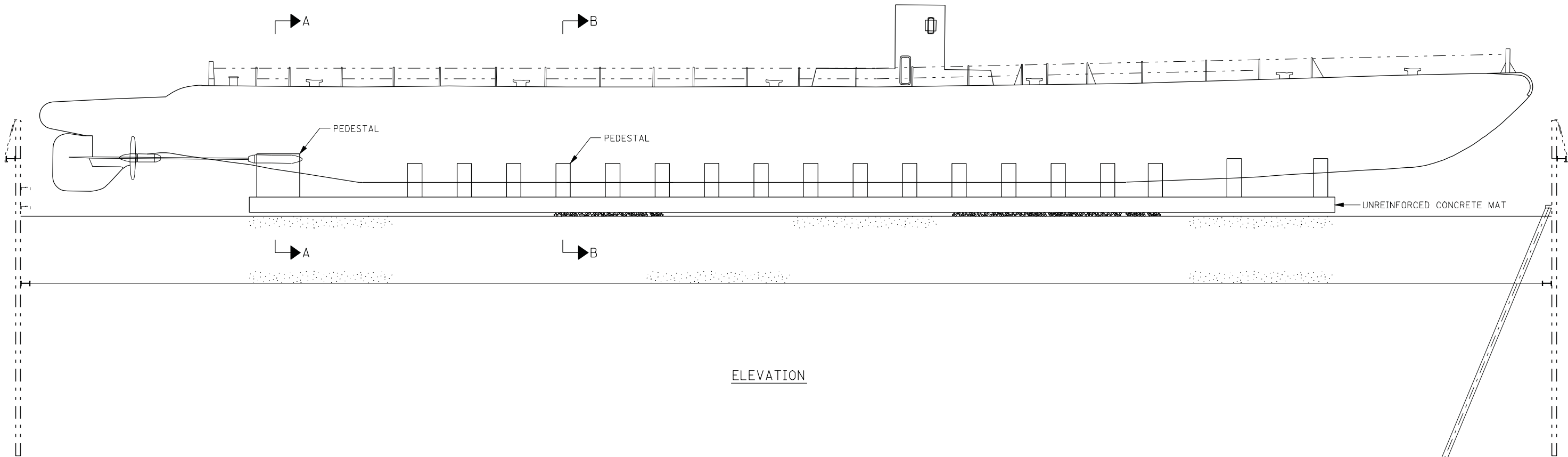


LANDSIDE BERTH FOR THE USS CLAMAGORE		
FEASIBILITY STUDY		
SITE PLAN		
VOLKERT INC. CONSULTING ENGINEERS		
DESIGNED L.M.O.	DETAILED P.W.S.	QUANTITIES L.M.O.
CHECKED	CHECKED	CHECKED
DATE		DWG.NO.

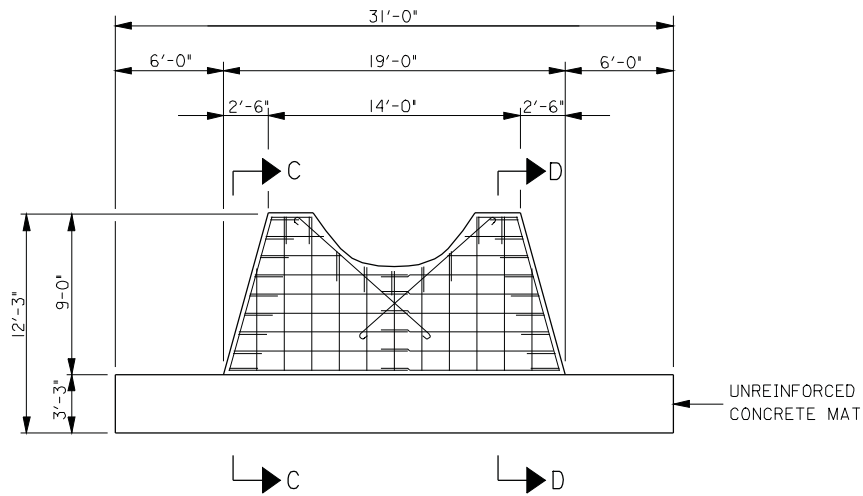
REVISIONS

PS 00001A
978301.10
2010
21-JAN-2010 09:35

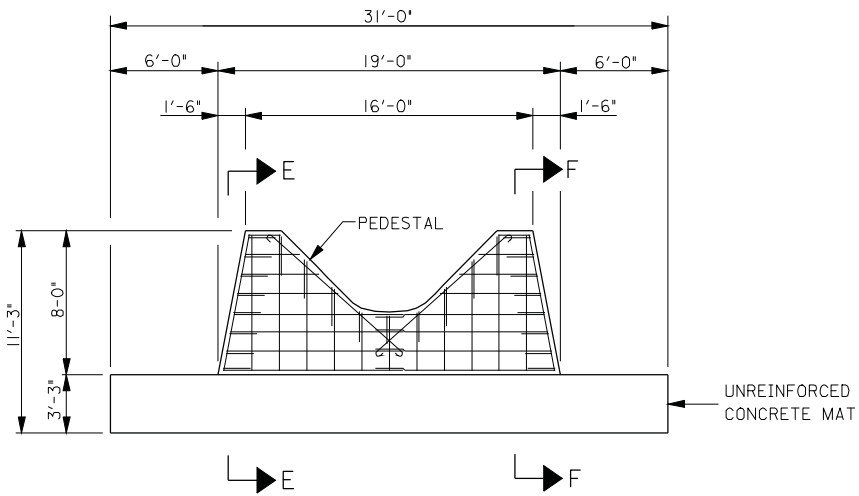
PROJECT NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
978301.10	2010		



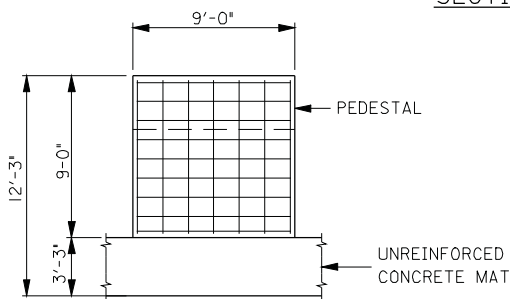
ELEVATION



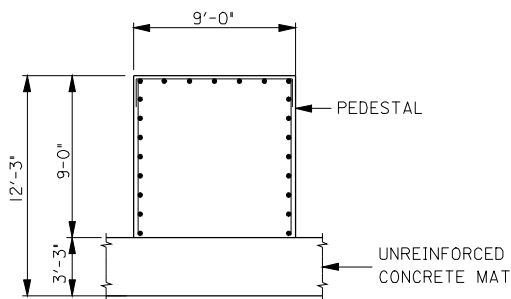
SECTION A-A



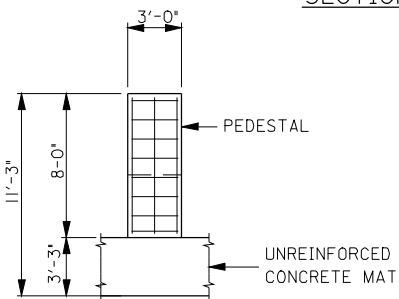
SECTION B-B



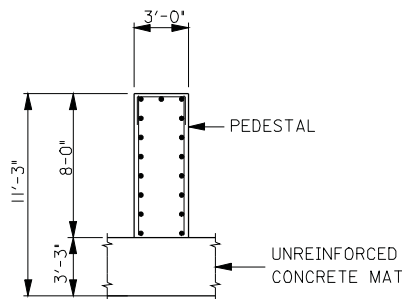
SECTION C-C



SECTION D-D



SECTION E-E



SECTION F-F

LANDSIDE BERTH FOR THE USS CLAMAGORE		
FEASIBILITY STUDY		
FOUNDATION DETAILS		
VOLKERT INC. CONSULTING ENGINEERS		
DESIGNED L.M.O.	DETAILED P.W.S.	QUANTITIES L.M.O.
CHECKED	CHECKED	CHECKED
DATE		DWG.NO.

REVISIONS		

31'-0" LOCK

T.O.W. EL. +35.00

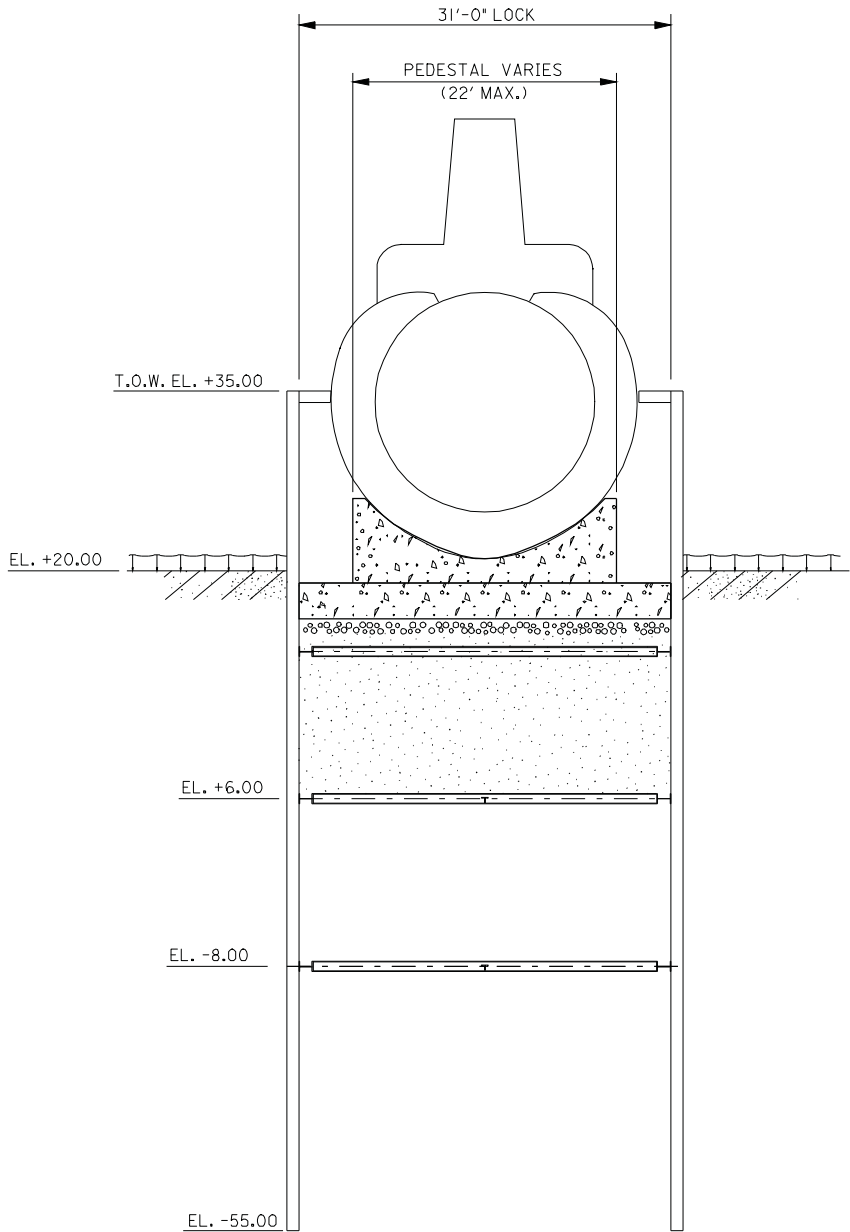
EL. +20.00

EL. -8.00

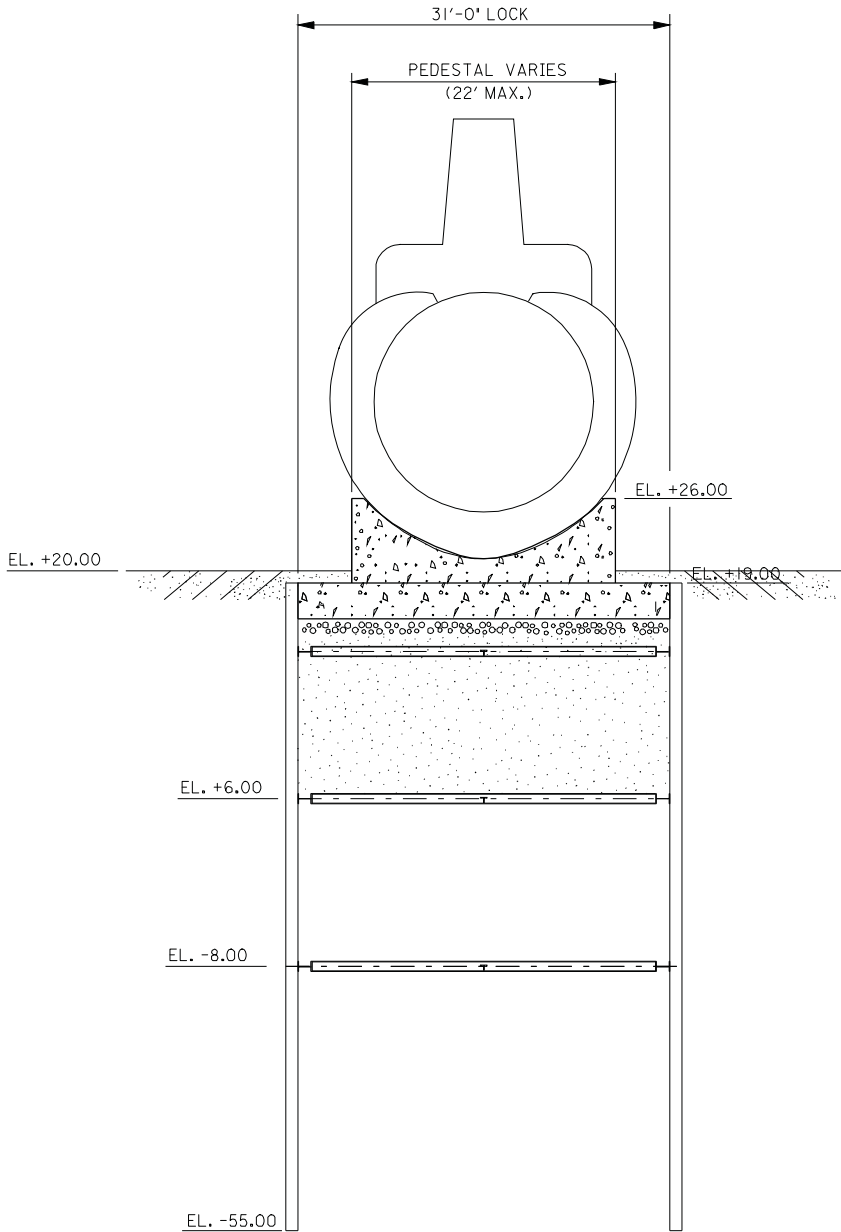
EL. -55.00

The diagram shows a cross-section of a lock chamber. At the bottom, there is a gate structure. Above the gate, a large circular structure is visible, likely a lock gate or a large pipe. The water level is indicated by a horizontal line with a downward-pointing triangle. The diagram includes elevation markers on the left side: T.O.W. EL. +35.00, EL. +20.00, EL. -8.00, and EL. -55.00. The width of the lock chamber is labeled as 31'-0" LOCK.

PROJECT NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
978301.10	2010		



PEDESTAL CONSTRUCTION



SHEETPILE REMOVAL

NOTE:

SCHEMATIC DRAWINGS SHOWING PARTIAL SEQUENCE OF RAISING SUBMARINE TO FINAL LOCATION.

LANDSIDE BERTH FOR THE USS CLAMAGORE		
FEASIBILITY STUDY		
LOCK SHEET WALL AND BRACING (SHEET 2 OF 2)		
VOLKERT INC. CONSULTING ENGINEERS		
DESIGNED L.M.O.	DETAILED P.W.S.	QUANTITIES L.M.O.
CHECKED	CHECKED	CHECKED
DATE		DWG.NO.

REVISIONS		

SECTION 8 — Cost/ Time Evaluation Study

Crane Lift Operation Project Cost

It is important to know that every price included in the construction cost estimate for the Crane Tower Lift Method are actual proposed costs from contractors that are local or close to the project site. As a result our cost estimate is very accurate. The Following Cost estimate includes:

- Engineering Fees;
- Mobilization Fees;
- 10% contingency added to crane tower operation and skidding system;
- Marine Survey Work;
- 5% Contingency added to entire Project Cost.

This estimate does not include environmental mitigation cost that may be required by governmental agencies. It does not include immediate repairs to the submarine that may be required prior to movement. It also does not include any restoration cost that will be required following her landside berth. We did not include the cost for any temporary dolphins or floatation devices because the need for such devices has not yet been determined.

Engineering / Development of Plans and Specifications	\$175,000
Permitting	\$42,000
Construction Management	\$200,000
Project Management	\$75,000
Dredging	
Mobilization	\$210,400
Dredging 22,500 Cubic Yards X \$10.90 CY	\$245,250
Total	\$455,650
Movement of Submarine	
3 boat operation / 8 man crew	\$7,500
Trestle System Construction	
Mobilization	\$170,700
625 LF of trestle X 2 sides at \$877 per LF	\$1,096,250
Total	\$1,266,950
Crane Tower Construction and Skidding System	
<i>Insurance and Bonds Included</i>	
<i>10% Contingency Already Included in each Line Item</i>	
Mobilization (78 heavy transport trucks)	\$550,000
Project Management	\$150,000
Skidding system emplacement	\$80,000
Grading and System Calculation	\$135,000
Foundation Checks	\$60,000
On-Site Engineering	\$75,000
Materials	\$360,000
Labor for assembly of crane system	\$450,000
Labor for disassembly of crane system	\$350,000
Directs	\$300,000
QC Management	\$50,000
Skidding system disassembly	\$60,000
De-mobilization	\$300,000
Total	\$2,290,000

SECTION 8 — Cost/ Time Evaluation Study

Construction of Concrete Supports			
	(2) 36" Pipe Supports driven 70' for each pedestal to include reinforced concrete		\$190,000
Access Platform and Railing			
	Stairs and Platform	LS	\$22,400
	Handrails on Submarine	275 LF X \$40.00	\$11,000
	Total		\$33,400
Erosion Control			
	Floating Turbidity Barrier	480 SY X \$31.00	\$14,880
	Hay Bales	200 ea X \$10.00	\$2,000
	Silt Fence Type "A"	200 LF X \$25.00	\$5,000
	6' Security Fence	400 LF X \$40.00	\$16,000
	Total		\$37,880
TOTAL COST for ENGINEERING + CONSTRUCTION			\$5,403,380
Marine Surveyor			
	To Float submarine on her designed light displacement waterline for the future move of vessel into cofferdam		\$35,000
	Determine extent of degradation of submarine underwater		\$19,000
	Prepare Planning for and supervision of move of submarine into cofferdam		\$35,000
	Total Marine Survey Work		\$89,000
Total Cost for Engineering + Construction + Marine Survey			\$5,492,380
	5% Contingency added to entire overall project cost		\$273,119
<u>TOTAL PROJECT COST</u>			\$5,765,499

SECTION 8 — Cost/ Time Evaluation Study

Alternative Cofferdam Method Project Cost

Project Management		
	LS	Total
Project Start Up		\$100,000
Insurance & Bonds		
	% Construction Cost	Total
Insurance & Bonds	4.00%	\$180,000
General Conditions		
	LS	Total
Supervision, temporary utilities, consumables, etc.		\$100,000
Excavation & Backfill		
	CY	Total
Wetland Excavation	10,000 CY X \$7.50 CY	\$75,000
Dredge Excavation	20,000 CY X \$11.00 CY	\$220,000
Excavation Within Lock	10,000 CY X \$10.00 CY	\$100,000
Channel Backfill	10,000 CY X \$10.00 CY	\$100,000
Underwater Backfill in Lock	10,000 CY X \$10.00 CY	\$100,000
Haul & Place On-Site Material	10,000 CY X \$5.00 CY	\$50,000
Excavation for Pedestals	1,100 CY X \$8.50 CY	\$9,350
Foundation Bedding Material	300 CY X \$45.00 CY	\$13,500
Removal		
	SY	Total
Removal of Asphalt Parking Lot	6,700 SY X \$4.00 SY	\$26,800
Storm Drain System		
	LS	Total
Inlets and Piping		\$36,000
Concrete		
	CY	Total
Unreinforced Concrete Mat	1137 CY X \$150.00 CY	\$170,500
Concrete Pedestals	1000 CY X \$450.00 CY	\$450,000

SECTION 8 — Cost/ Time Evaluation Study

Structural Steel		
		Total
Steel Sheet Piling	63540 sf X \$15.50 sf	\$984,870
Drive & Cut-Off Sheet Piling	63540 sf X \$17.50 sf	\$1,111,950
Structural Steel for Temporary Upper Strut Bracing	61500 lb X \$2.00 lb	\$123,000
Structural Steel for Lower Strut Bracing	125,000 lb X \$2.00 lb	\$250,000
14" Steel Pipe Piles	312 LF X \$60.00 LF	\$18,720
Waterproof Sheet Pile Interlocks	20,600 LF X \$10.00 LF	\$216,000
Spoil Site		
	LS	Total
Discharge Control and Maintenance		\$40,000
Moving U.S.S. Clamagore		
	LS	Total
Float Move and Rest U.S.S. Clamagore in Lock		\$164,000
Access Stairs and Platform		
	LS	Total
Stairs & Platform	LS	\$22,400
Handrails	60 LF X \$40.00 LF	\$11,000
Utility Construction		
	LS	Total
Supplying Water & Electricity		\$35,000
Floating Turbidity Barrier		
	SY	Total
Floating Turbidity Barrier	2500 SY X \$31.00 SY	\$77,500
Erosion Control		
		Total
Hay Bales	200 ea X \$10.00 ea	\$2,000
Silt Fence, Type "A"	200 LF X \$25.00 LF	\$5,000
6' Security Chain Link Fence	400 LF X \$40.00 LF	\$16,000
Total Estimated Construction Cost		
Rough Magnitude of Construction Cost		\$4.7 - 5.0M *

* Above estimate does not include Engineering

SECTION 8 — Cost/ Time Evaluation Study

COFFERDAM ALTERNATIVE

ADDITIONAL COST

Marine Surveyor

To float the submarine on her designed light displacement waterline for the future move of vessel into cofferdam.

\$ 35,000

Determine extent of degradation of submarine underwater

\$ 19,000

Prepare planning for and supervision of move of submarine into cofferdam

\$ 35,000

Permitting

\$ 50,000

Development of Plans and Specifications

\$ 252,000

Construction Management

\$ 208,000

15% Contingency

\$ 800,000

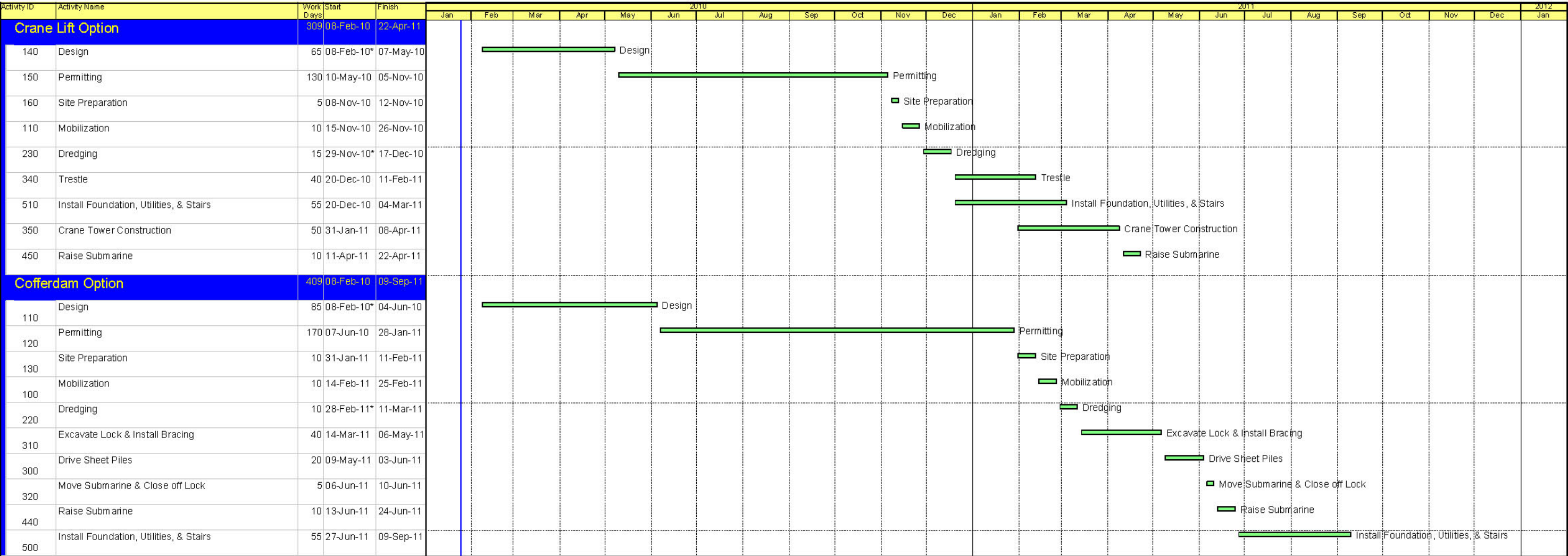
ROUGH MAGNITUDE OF COMPLETE PROJECT COST

\$6.3 – 6.6M *

* Does not include cost to prepare submarine for floatation and movement

* Does not include cost to prepare submarine hull for display

This estimate does not include environmental mitigation cost that may be required by governmental agencies. It does not include immediate repairs to the submarine that may be required prior to movement. It also does not include any restoration cost that will be required following her landside berth. We did not include the cost for any temporary dolphins or floatation devices because the need for such devices has not yet been determined.



U.S.S. Clamagore Relocation and Restoration Environmental Feasibility Study



Prepared by:

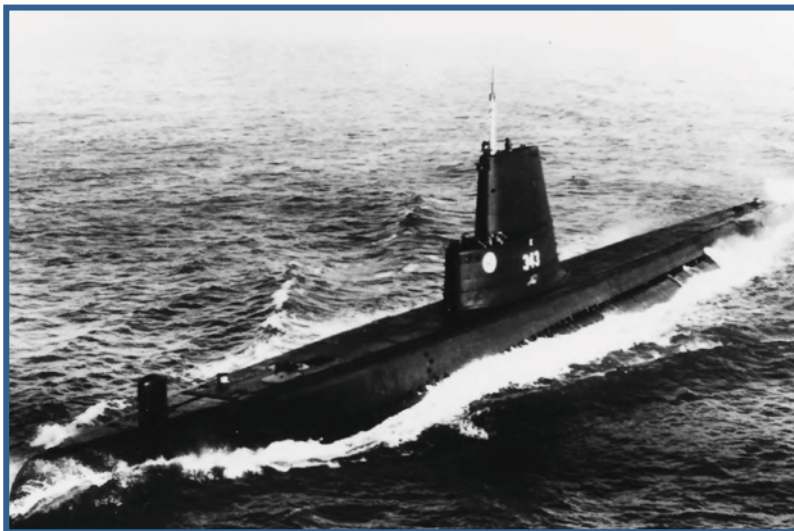
DENNIS
CORPORATION

SECTION 9 — Environmental Feasibility Report

Introduction

The Patriots Point Naval and Maritime Facility is located at the mouth of the Cooper River in Mount Pleasant, SC. It contains the U.S.S. Yorktown (CV-10) aircraft carrier, the U.S.S. Laffey (DD-724) destroyer and the U.S.S. Clamagore (SS-343) submarine as well as the Medal of Honor Museum and Cold War Submarine Memorial.

The U.S.S. Clamagore was built as a Balao-class submarine in 1945 by Electric Boat Co. in Groton, Connecticut and was added to the Patriots Point fleet in 1981. The U.S.S. Clamagore is currently docked in the Cooper River end of Charleston Harbor in shallow open brackish water and rests on the mud river bottom during low tide. The submarine was designated a National Historic Landmark in 1989 by the National Park Service. Currently, the U.S.S. Clamagore is open to the public for self-guided tours but is in need of repair to prevent further damage to the vessel or create potential environmental hazards to its surrounding habitat in the Charleston Harbor. Severe rusting is breaking down the hull of the submarine and without necessary maintenance, the submarine would not be preserved and kept structurally safe for future generations of the public to visit.



**U.S.S. Clamagore (SS-343) in her GUPPY II Configuration,
Circa 1960**

Courtesy of: Patriots Point

The primary purpose of this document is to provide a preliminary assessment of proposed alternatives, to determine the potential environmental impacts, and to analyze the feasibility of restoring the submarine with respect to environmental concerns.

Alternatives

To restore and preserve this national landmark, a move to dry land has been determined to be the best course of action. Once ashore, the submarine would undergo a thorough evaluation and repairs would be made to preserve this historic landmark for future generations. Several alternatives have been evaluated to move the submarine as safely and efficiently as possible with the minimization of impacts to the environment.

Crane Tower and Trestle System

A crane tower and trestle system is one way that the U.S.S. Clamagore could be moved to dry land. To move the approximately 2,000 ton vessel, dredging would need to take place to move the submarine to a marine trestle system parallel to the existing pedestrian bridge. It is estimated that approximately 10,500 feet of pipeline would be used to pump approximately 22,500 cubic yards of dredged material across Charleston Harbor to Drum Island, a confined disposal facility. The marine trestle system would be built over both tidal marsh and open water. The marine trestle system would be supported by steel pipe piles that are driven into the ground and would remain for the duration of the operation. The pipe piles would be bolted to cross beams that would connect the two rows of supports and then each set of supports would be connected by parallel rails that would also be bolted to the support system. The rails would also be steel I-beams all of which would be removed after the U.S.S. Clamagore has reached its final destination to create as little environmental impact as possible. The pilings would be driven with an excavator mounted vibratory hammer that would be positioned on a barge or temporary trestle to drive the pilings in the water. The excavator would also drive the pilings on the land portion of the operation to transition the submarine from the rail system to the upland area.

SECTION 9 — Environmental Feasibility Report

Depending on the soil type found, a water jet method could also be used on the land driven piles to help drive the pilings successfully. The pilings would then be connected through a system of parallel steel rails that would support the submarine for the duration of the move.

Cofferdam System

A possible construction alternative is to build a cofferdam system and float the U.S.S. Clamagore to the designed height. A trench would be dug in the place of the proposed track system and the submarine would be aligned in the trench. A sheet piling wall would then be installed to encapsulate the submarine to act as a lock. The lock would be filled with water to raise the submarine to the elevation necessary to bring it to land. Water would then be drained, thereby lowering the U.S.S. Clamagore into position. The environmental impact of this system would directly impact a larger area of marsh habitat and open estuarine waters. The lock system would require dredging a larger area than the marine trestle system and would also require clearing additional salt marsh habitat near the shore bank. To obtain a permit for this project, it must be demonstrated to the USACE that the "least environmentally damaging practicable alternative" has been selected.

No-Build Alternative

Leaving the submarine in place is not a viable alternative. With the U.S.S. Clamagore being a National Historic Landmark, the vessel would eventually rust in-place beyond repair. This alternative would not coincide with the goal of Patriots Point which is to preserve vessels for the foreseeable future as a maritime museum.

Restoration

The area that has been proposed as the location for the submarine is within the parking lot directly east of the submarine's current location. Upon reaching its destination, the U.S.S. Clamagore would rest upon several large reinforced concrete cradles. These cradles would both support and stabilize the ship for the restoration and visitation that would ensue following the move. The reinforced concrete cradles used to support the boat would range from approximately four feet by fifteen feet to five feet by thirty feet, varying for the width of the submarine. There would also be a one inch neoprene pad in between the top of the concrete supports and the submarine to protect the hull of the U.S.S. Clamagore.

The U.S.S. Clamagore would undergo a detailed structural hull survey to determine the extent of the damage. The hull and superstructure were restored in 2001, as they had deteriorated over the years from saltwater corrosion, marine growth and weather. If further repairs are necessary prior to the move, they would be performed in the water before moving commences. Following the move, repairs and restoration would continue. The task of the repair plan would be to restore the structural and historical integrity of the U.S.S. Clamagore. In areas where it is sufficient, the hull would be sandblasted and painted. In areas where more extreme corrosion is present, panels would be cut away and new panels welded in their place. A lead-based paint survey and assessment would need to be conducted before any work can commence on the U.S.S. Clamagore. Proper precautions would be taken to protect the surrounding area from contamination for the paint removal. A geo-fabric material to catch any potential lead paint particles would be installed to protect the surrounding environment. The U.S.S. Clamagore would then be primed and painted to restore her beauty and ensure her long term health.

SECTION 9 — Environmental Feasibility Report

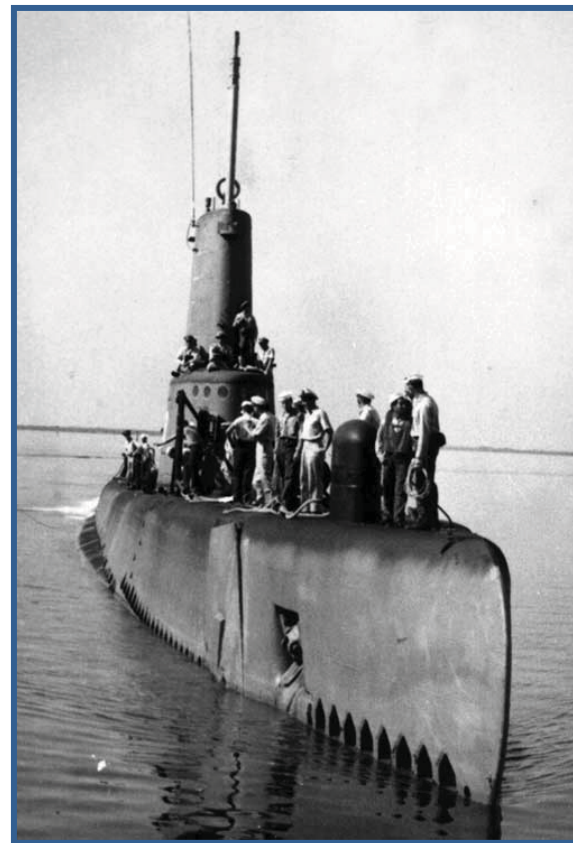
Cultural Resources

The U.S.S. Clamagore is a treasured piece of US naval history and it is the objective of the Patriots Point Naval and Maritime Museum to preserve her for future generations. The vessel represents the only surviving GUPPY type III submarine in the United States. She characterizes the continued adaptation and use of war-built diesel submarine by the Navy for the first two decades after World War II.

The submarine is a unique component of the Patriots Point Naval and Maritime Museum which also has two other ships on the National Register of Historic Places, the U.S.S. Yorktown (CV-10) and the U.S.S. Laffey (DD-724). The U.S.S. Laffey was dry docked in fall 2009 for an estimated \$9 million in repairs which were completed in December 2009.

Potential Cultural Impacts

A review of the South Carolina Institute of Archaeology and Anthropology's Arch Site did not yield any additional archaeological sites of significance within the vicinity of the project. There may be historically significant properties in the project area that have not been surveyed. To fully determine the status of cultural resources in the project area, a cultural resources study addressing both aboveground and archaeological resources will need to be undertaken which will be subject to the National Historic Preservation Act (NHPA) Section 106 review by the State Historic Preservation Officer (SHPO). Concurrence would need to be obtained from SHPO to move the submarine and restore it.



U.S.S. Clamagore underway (Date Unknown)
Courtesy of: Historical Naval Ships Association
(www.hnsa.org)

Natural Resources

The U.S.S. Clamagore is currently docked in the Cooper River end of Charleston Harbor in shallow brackish water and rests on the mud river bottom. To move the vessel, dredging must take place to move the approximately 322-foot submarine to a marine trestle system or cofferdam. There is an approximate elevation difference of 21 feet between the surface of the water and the location of the current parking area to where the vessel will be moved.

Essential Fish Habitat (EFH)

The South Atlantic Fishery Management Council (SAFMC) is tasked with conserving and managing fish stocks for a portion of the Atlantic coast. Four habitat types that are designated as EFH by the SAFMC are present within the project study area: estuarine waters, intertidal flats, oyster reef, and estuarine emergent wetlands.

Estuarine water column

An estuary is a semi-enclosed coastal body of water which has at least an intermittent connection with the open sea and within which sea water mixes with fresh water that has been derived from land drainage. Estuaries are constantly changing systems with respect to tidal action, fresh water flow, and temperature variations. The water column is a key area for phytoplankton, which are important primary producers in the aquatic food web. Many species utilize the water column for support and migration, taking advantage of nutrients moving through the column from the entire estuarine system.

SECTION 9 — Environmental Feasibility Report

Intertidal flat

An intertidal area is subsystem of an estuarine system (Cowardin et al., 1979) where sediments from the estuarine and freshwater environment are deposited. The flats are subject to the tides, remaining covered and uncovered on a daily basis. These areas are important in coastal systems such as nursery, foraging, and refuge areas for a variety of species, their predators, and their prey (Peterson and Peterson, 1979). The flats also contribute greatly to overall primary productivity (SAFMC, 1998). Permanent dwellers filter out phytoplankton and detritus in these areas. Unvegetated intertidal flats are present within the limits of the project.

Estuarine Emergent Wetlands

Within the project study area estuarine emergent wetlands, or salt marshes, are present between the intertidal flats and upland areas. Estuarine marshes are important areas for many invertebrates as well as nursery grounds for other species. The marshes within the project site are an exposed area, flooded by tides and dominated with emergent *Spartina alterniflora* vegetation in the lower reaches.

Oyster Reefs

Once valued primarily as a harvestable resource, oysters are now recognized as key elements of many estuarine ecosystems. The eastern oyster, *Crassostrea virginica*, creates complex habitats utilized by fish, crustaceans, bivalves, and numerous other invertebrates and vertebrates. During feeding, oysters can filter large quantities of water, improving water clarity and quality while transferring nutrients from the water column to the benthos.

A South Carolina Department of Natural Resources (SCDNR) oyster reef is found just east of the existing submarine's location and is a concern within the limits of the project. The South Carolina Oyster Restoration and Enhancement (SCORE) Program is a community-based habitat restoration and monitoring program allowing community volunteers to work with SCDNR scientists to restore and monitor oyster habitat along the SC coast.

Managed Fishery Species

Red drum (*Sciaenops ocellatus*)

Red drum larvae are generally carried into estuaries on tides and currents (SAFMC, 1998). Larvae and post larvae are found in tidal flats, shallow waters, and within emergent vegetation beds. Young juveniles can be found in backwaters, tidal flats, bays, shallow waters, and other tidally influenced systems. As temperatures drop in tidal creeks, these young fish may move to the edges of deeper channels and deep holes in the estuary. Warmer water temperatures in the spring permit juveniles to feed in the tidal areas, continuing with maturation to the submarine adult stage. Submarine adults can overwinter in the estuary (Wenner, C., 2004) and move to near shore or offshore areas after reaching the adult phase (SAFMC, 1998).

White shrimp (*Litopenaeus setiferus*)

Recruitment of white shrimp into estuarine waters generally begins in April and May (SAFMC 1998). The mud-silt substratum and salinity distribution of the estuary provide a suitable feeding environment for juvenile shrimp, providing benthic worms, plant matter, and decaying animals (Wenner, E., 2004). Juveniles forage and mature in tidally influenced nursery areas. Beginning in August and running through December, white shrimp egress to more saline waters. Some smaller adult individuals may remain in the estuary over the winter (SAFMC 1998).

Brown shrimp (*Farfantepenaeus aztecus*)

Year-round spawning of brown shrimp occurs offshore in deeper water habitat with the eggs hatching soon after release (Lassuy, 1983). Postlarvae begin moving into estuarine areas around February, with the peak movement periods occurring through March and April (Wenner, E., 2004). Postlarvae remain in the estuary, foraging and developing into juveniles. Juveniles feed on detritus, algae, polychaetes, amphipods, nematodes, ostracods, chironomid larvae, and mysids (Lassuy, 1983). The shelter of the vegetated salt marsh provides an optimal area for shrimp to safely forage (SAFMC, 1998). Egress of adult brown shrimp to offshore areas generally takes place during May through August (Lassuy, 1983).

SECTION 9 — Environmental Feasibility Report

Other Fishes

The waters and associated marshes of the Cooper River also serve as nursery and forage habitat for other species including black drum (*Pogonia cromis*), striped bass (*Morone saxatilis*), Atlantic menhaden (*Brevoortia tyrannus*), and blue crab (*Callinectes sapidus*) that serve as prey for other species (e.g., mackerels, snappers, and groupers) that are managed by the SAFMC, and for highly migratory species (e.g., billfishes and sharks) that are managed by the National Marine Fisheries Service. Blue crab and many finfish prey upon penaeid shrimp. Commercially important larval fishes move through the estuarine waters in mid-winter to feed on plankton (SAFMC, 1998).

Threatened and Endangered Species

Table 1 - Endangered Species listed for Charleston County

Common Name	Scientific Name	Federal Status	State Status
Manatee	<i>Trichechus manatus</i>	Endangered	Endangered
Bald Eagle	<i>Haliaeetus leucocephalus</i>	Bald & Golden Eagle Protection Act (BGEPA)	BGEPA
Wood Stork	<i>Mycteria Americana</i>	Endangered	Endangered
Red-cockaded woodpecker	<i>Picoides borealis</i>	Endangered	Endangered
Piping Plover	<i>Charadrius melodus</i>	Threatened	Threatened
Kemp's Ridley Sea Turtle	<i>Lepidochelys kempii</i>	Endangered	Endangered
Leatherback Sea Turtle	<i>Dermochelys coriacea</i>	Endangered	Endangered
Loggerhead Sea Turtle	<i>Caretta caretta</i>	Threatened	Threatened
Green Sea Turtle	<i>Chelonia mydas</i>	Threatened	Threatened
Flatwoods Salamander	<i>Ambystoma cingulatum</i>	Threatened	Endangered
Shortnose Sturgeon	<i>Acipenser brevirostrum</i>	Endangered	Endangered
Sea-beach Amaranth	<i>Amaranthus pumilus</i>	Threatened	Threatened
Canby's Dropwort	<i>Oxypolis canbyi</i>	Endangered	Endangered
Pondberry	<i>Lindera melissifolia</i>	Endangered	Endangered
American Chaffseed	<i>Schwalbea Americana</i>	Endangered	Endangered

Source: US Fish & Wildlife Service: Ecological Services Division

A review of the SC Heritage Trust Program's Rare, Threatened and Endangered Species Inventory revealed no federally listed species to be historically found within 1 mile of the project area. However, potential suitable habitat exists within the project review area for the following species:

West Indian Manatee (*Trichechus manatus*)

This large marine mammal lives in South Carolina estuaries, shallow open water or near warm water outfalls. It is an herbivore feeding upon aquatic plants including water hyacinth and hydrilla. Manatees tend to migrate to warmer waters during the winter and cannot survive in water colder than 46 degrees.

Threats: Overharvesting for meat, oil and leather; mortality due to collisions with boats and barges. Decline is also related to coastal development and loss of suitable habitat, particularly destruction of seagrass beds.

Bald Eagle (*Haliaeetus leucocephalus*)

This bird of prey is protected by the Bald and Golden Eagle Protection Act of 1940. This act prohibits any form of possession or taking of both bald and golden eagles while also protecting them from disturbances that may agitate or bother an eagle to a degree that causes or is likely to cause injury, decrease in its productivity or

SECTION 9 — Environmental Feasibility Report

substantially interfere with normal breeding, feeding or sheltering behavior. Bald Eagles tend to live along coastlines, rivers, large lakes or streams which provide adequate feeding grounds. This bird typically nests in SC between October and late May and returns year after year to the same nesting site once they have successfully established a nest.

Threats: Human activities that can cause eagles to abandon their nest or to not properly incubate eggs or care for young.

Wood Stork (*Mycteria Americana*)

These large, long-legged wading birds primarily feed on small fish in fresh and brackish wetlands and nest in cypress or other wooded swamps. Suitable feeding habitat is present for this species within the project area however there is no suitable nesting habitat near Patriots Point.

Threats: Decline mostly due to loss of suitable feeding habitat; other factors include loss of nesting habitat, prolonged drought/flooding, raccoon predation of nests and human disturbance of rookeries.

Kemp's Ridley Sea Turtle (*Lepidochelys kempii*)

This sea turtle spends the majority of its time in the near shore and inshore waters of the Gulf of Mexico but may be found in bays along the Atlantic as far north as Massachusetts. The Kemp's Ridley sea turtle's diet consists of mostly crabs but also shrimp, snails, clams, jellyfish, sea stars and fish.

Threats: Overharvesting of eggs and adults for food and skins, often drown when caught in commercial shrimp nets. Also mortality due to boat propellers and refuse.

Leatherback Sea Turtle (*Dermochelys coriacea*)

The largest of all sea turtles, the Leatherback rarely nests in SC and is found worldwide in tropical and temperate waters of the Atlantic Ocean. Its visits often coincide with an abundance of cannonball jellyfish. It is the most pelagic of the sea turtles found in SC.

Threats: Loss or degradation of nesting habitat due to coastal development and beach armoring; incidental take from channel dredging and commercial trawling.

Loggerhead Sea Turtle (*Caretta caretta*)

The Loggerhead may be found hundreds of miles from shore as well as inshore areas such as bays, lagoons, salt marshes, creeks, ship channels and the mouths of large rivers. Coral reefs, rocky places and ship wrecks are often used as feeding areas. Loggerheads tend to nest on ocean beaches and occasionally on estuarine shorelines with suitable sand.

Threats: Natural predation; loss or degradation of nesting habitat due to coastal development and beach armoring; disorientation of hatchlings by beachfront lighting; and incidental take from channel dredging and commercial trawling.

Green Sea Turtle (*Chelonia mydas*)

Green sea turtles are usually found in fairly shallow waters (except when migrating) inside reefs, bays, and inlets. They are attracted to lagoons and shoals with an abundance of marine grass and algae. This species rarely nests in SC.

Threats: Exploitation for food, high predation, drowning when trapped in fishing and shrimping nets. Degradation of foraging habitat; marine pollution and debris; watercraft strikes; and incidental take from channel dredging and commercial fishing operations.

SECTION 9 — Environmental Feasibility Report

Shortnose Sturgeon (*Acipenser brevirostrum*)

This anadromous fish occurs along most of the eastern seaboard and is found in most major rivers and estuaries. They tend to stay relatively close to shore and feed on mollusks and large crustaceans. Juveniles are believed to feed on benthic insects and crustaceans.

Threats: Construction of dams and pollution of many large river systems during the period of industrial growth in the late 1800s and early 1900s may have resulted in substantial loss of suitable habitat. Habitat alterations from discharges, dredging or disposal of material into rivers or related development activities involving estuarine/riverine mudflats and marshes remain as constant threats to the shortnose sturgeon population.

Potential Natural Resources Impacts

The proposed work requires the installation of temporary structures in the estuarine water column, intertidal flats, oyster reef, and salt marshes. This may cause temporary direct impacts during construction and temporary indirect impacts such as turbidity increases, shading, and increased noise.

Proposed dredging will cause a temporary increase in turbidity levels of the adjacent water column, but ambient conditions should resume once the work is completed. This temporary increase in turbidity will not contravene water quality standards nor change designated uses of this section of the Cooper River since tidally influenced water bodies, such as this, exhibit naturally high turbidity levels. Mobile brown and white shrimp and red drum should be able to avoid injury from the placement of these structures by temporarily relocating to another area. Incidental takes may occur, especially for eggs and early larval stages, but these instances should be few and would not contribute to a substantial reduction in any species populations. Mortality to these and other prey items of the managed fishes may occur, but should be minor.

Open Water

To move the U.S.S. Clamagore safely into position onto the Marine Trestle System or Cofferdam System, dredging of the river bottom will be required to create a path for the submarine. Dredging may be required for the areas of river bottom where tugboats will be used to move the vessel into place. It is estimated that approximately 22,500 cubic yards of river bottom will be excavated. The dredge spoils will be pumped under the Charleston Harbor to the confined disposal facility on Drum Island. South Carolina Department of Health and Environmental Control (SCDHEC) Erosion Control measures will be implemented and utilized at the spoils off-load site, as well as the around the spoils site. Following removal of sediments, the submarine would be removed from the water. In-water, structures can provide a suitable submarinestrate for invertebrate communities and provide viable forage sites for aquatic species. The removal of the submarine should not cause a significant loss of in-water habitat.

Estuarine Emergent Wetlands

A proposed Marine Trestle System or Cofferdam System will be situated from the open water of the Cooper River, across a tidal marsh where the submarine will be placed. The area currently serves as part of the parking area for the Patriots Point Maritime Museum. To construct the Marine Trestle System or Cofferdam System, temporary impacts to critical areas will occur. The installation of temporary piles and a work trestle along with the use of steel sheet piles will constitute minor impacts and mitigation would likely not be required for this action. Once the U.S.S. Clamagore has been relocated, the marine trestle system and associated piles would be removed. The steel sheet piles included with the Cofferdam Method will more than likely be cut and remain in place. Benthic recolonization and salt marsh revegetation should occur upon project completion.



View of the potential open water and tidal marsh impact site from aboard the U.S.S. Yorktown.

SECTION 9 — Environmental Feasibility Report

Oyster Reefs



**A section of the oyster reef at Patriots Point.
(Photo Taken December 2009)**

Dredging areas around the submarine could have an impact on the oyster beds nearby managed by the SCDNR. The agency's SCORE program built an oyster reef in June 2004 which was later expanded in 2005 and 2006. The oyster reef is situated between the marsh and east of the U.S.S. Clamagore. It is likely that parts of the oyster reef will be impacted by the proposed dredging and may need to be relocated. Temporary siltation will occur and could likely have a short-term effect on recruitment of new larvae to the remaining reef.

Environmental Permits and Agency Coordination

SCDHEC-OCRM Critical Area Permit

The Federal Coastal Zone Management Act of 1972 requires that activities in the coastal zone comply with approved state coastal management guidelines. The South Carolina Coastal Zone Management Act (1977, as amended 1993 by Act 181) gives authority to SCDHEC- Ocean and Coastal Resource Management (OCRM) to promote the economic and social welfare of the citizens of this South Carolina while protecting the sensitive and fragile areas in the coastal counties and promoting sound development of coastal resources. A permit would be required from SCDHEC-OCRM for activities within the critical area and the coastal zone. SCDHEC-OCRM classifies commercial dredging as a major activity. Permitted projects within critical areas usually require mitigation to offset impacts to tidal lands. The SCDHEC-OCRM office reviews all critical area permits to ensure that avoidance and minimization requirements are met. Project staff will work with the OCRM office to ensure that impacts to these critical areas are kept to a minimum.

SCDHEC – Bureau of Water - Section 401 Water Quality Certification

SCDHEC administers the Water Quality Certification program pursuant to Section 401 of the Clean Water Act (CWA). Section 401 requires that the State issue certification for any activity, which requires a Federal Section 404 permit and may result in a discharge to State waters. This certification must state that applicable effluent limits and water quality standards will not be violated. Regulation 61-101 Water Quality Certification (WQC) outlines the procedures and policies for implementing the State water quality certifications. During review of applications for WQC, the SCDHEC looks at whether or not there are feasible alternatives to the activity, if the activity will adversely affect existing or designated uses. The Federal Section 404 permit cannot be issued if certification is denied. Project staff will work with SCDHEC 401 Water Quality certification staff to ensure that standards are not violated during construction of the project and a 401 permit has been obtained prior to the commencement of any work.

SCDHEC National Pollutant Discharge Elimination System (NPDES) Permit

Construction activities should not permanently remove or impair any existing uses of the Charleston Harbor. During construction activities, there is the potential for erosion on exposed areas and temporary siltation occurring in the harbor unless adequately addressed. The contractor will be required to minimize this potential impact through implementation of construction best BMPs in compliance with the NPDES Construction General Permit (SCR100000) and reflecting policies contained in 23 CFR 650 B. Specifications would be incorporated that would address seeding and erosion control measures. The potential erosion and sediment impacts would be limited in scope and duration and would be mitigated with the implementation and maintenance of the referenced BMPs.

SECTION 9 — Environmental Feasibility Report

USACE Section 404 Permit

Coordination with the USACE will ensure that all necessary permits are approved prior to any construction activities in the waters of the US. A pre-construction meeting should be held between project staff and the district engineer to ensure that avoidance and minimization measures will be followed to reduce environmental impacts to tidal marsh and open water.

The Federal Clean Water Act (CWA) is the basis of law regulating wetlands and other waters, known as "waters of the United States". Section 404 of the CWA regulates the discharge of dredge or fill material into waters of the US. The USACE holds the primary federal authority for regulation of discharges into waters and wetlands. A Nationwide Permit is required when the proposed action would have only minimal individual and cumulative environmental impacts. Effective March 19, 2007 there are 49 active Nationwide Permits. Nationwide Permit 22 is proposed for this project because it pertains to the removal of vessels. Mitigation requirements will be coordinated with the USACE and SCDHEC.

Section 404 of the CWA of 1972, administered and enforced by the USACE, requires individuals and organizations to obtain a permit from the USACE for projects that would result in the discharge of temporary or permanent fill into jurisdictional waters of the US. The permit process requires the analysis of alternatives that avoid and minimize stream and wetland encroachments. Through this analysis, it must be demonstrated that there are no practicable alternatives to the proposed action that would result in fewer adverse impacts on the aquatic ecosystem. In addition, the CWA states that no discharge shall be permitted unless measures have been taken to minimize potential adverse impacts. The appropriate permit will depend on final impact quantities and coordination with the USACE. These activities could be covered under Nationwide Permit (NWP) 22 which is required when temporary structures or minor discharges of dredged or fill material are required for the removal of wrecked, abandoned, or disabled vessels, or the removal of man-made obstructions to navigation. While NWP 22 does not have any set limits on dredge material, fill or tidal impacts, the district engineer may authorize activities under this NWP only after it is determined that the impacts to the critical resource waters will be no more than minimal.

A pre-construction notification must be submitted to the district engineer prior to the activity if: (1) The vessel is listed or eligible for listing on the National Register of Historic Places; or (2) the activity is conducted on a special aquatic site, including coral reefs and wetlands. If condition 1 is triggered, the permittee cannot commence the activity until informed by the district engineer that compliance with Section 106 of the NHPA has been satisfied.

USACE Section 10 Construction in Federal Navigable Waters Permit

Section 10 of the Rivers and Harbors Act of 1899 (33 U.S.C. 401 et seq) requires approval of the USACE prior to the accomplishment of any work in or over navigable waters of the U.S., or which affects the course, location, condition, or capacity of such waters. The waters of the Cooper River are considered Section 10 waters, and therefore a Construction in Federal Navigable Waters permit will be required. Coordination with the USACE by project staff will ensure the issuance of a Section 10 permit prior to project commencement.

State Historic Preservation Office (SHPO)

Section 106 of the National Historic Preservation Act (NHPA) of 1966 (as amended) requires federal agencies to consider the effects of their actions on historic properties such as buildings, structures, districts, and objects. In accordance with 36 CFR 800.4, archival research and coordination with SHPO will be performed to identify and help predict the locations of significant cultural resources in the vicinity of the proposed action. The U.S.S. Clamagore itself is a significant part of US Naval history and all actions to restore her to her original state will require the approval of the SHPO.

SECTION 9 — Environmental Feasibility Report

SCDNR

The South Carolina Nongame and Endangered Species Conservation Act (NESCA) under South Carolina Code Title 50, Chapter 15 provides state protection of species whose prospect of survival or recruitment within the state are in jeopardy. The Wildlife and Marine Resources Divisions within the South Carolina Department of Natural Resources (SCDNR) administers provisions of the NESCA. Under the NESCA, the taking, possessing, transporting, exporting, processing, selling, offering for sale, or shipping of nongame wildlife deemed to be in need of management is prohibited.

Coordination with SCDNR SCORE staff will take place to ensure that oyster bed impacts are kept to a minimum. It is possible that some oyster beds would need to be relocated because they are in the area that dredging must be done to move the submarine into position before its travel up the proposed marine trestle system and into its final position.



SCORE volunteers take measurements along the reefs at Patriots Point during the summer of 2004.

Courtesy of: SCDNR

US Fish and Wildlife Service (USFWS)

Pursuant to Section 7 of the federal Endangered Species Act (ESA) of 1973 (16 USC, Section 1531, et seq., see also 50 CFR part 402), a field survey of the project study area will be conducted. The USFWS and the National Oceanic and Atmospheric Administration (NOAA) share responsibility for administration of the Endangered Species Act. The amended Act provides for the conservation of threatened and endangered species and the habitat upon which they depend. Section 7 of the Act requires federal agencies to consult with the USFWS and NOAA to ensure that activities are not likely to jeopardize the continued existence of listed species or adversely impact their critical habitat. Project staff would coordinate with USFWS and NOAA staff once field surveys are complete.

National Oceanic and Atmospheric Administration (NOAA)

In conformance with the Magnuson-Stevens Fishery Conservation and Management Act of 1976 (as amended 1996) NOAA-NMFS manages fisheries and EFH. Within the project study area, EFH is present in estuarine emergent salt marsh, intertidal, oyster reef, and open water estuarine areas. Managed species include red drum (*Sciaenops ocellatus*), white shrimp (*Litopenaeus setiferus*), and brown shrimp (*Farfantepenaeus aztecus*). During review of impacts, NOAA-NMFS may issue conservation recommendations for fish protection. Conditions may include implementation of BMPs to minimize impacts or seasonal restrictions, such as working during the winter months to avoid the spawning season for managed species.

Several threatened and endangered marine species are covered by the ESA but are under the purview of the NOAA. Coordination and communication with the NOAA will be performed by project staff to maintain compliance with Section 7 of the ESA as well as the Magnuson-Stevens Fishery Conservation and Management Act.

SECTION 9 — Environmental Feasibility Report

Mitigation

In order to move the U.S.S. Clamagore, dredging of the riverbed around the vessel will be necessary to move the submarine into position to be moved ashore using the Marine Trestle System or Cofferdam System. It is estimated that approximately 1.87 acres of open water will be dredged removing approximately 22,500 cubic yards of mud bottom from the Cooper River/Charleston Harbor.

It is estimated that approximately 7.8 credits would be needed for an estimated .71 acres of tidal marsh that would be dredged in addition to open water around the submarine. Currently, there are no public tidal mitigation banks in SC available for the purchase of credits to offset impacts resulting from this action. It is estimated that tidal marsh credits would cost approximately \$30,000 per credit which would make the cost of mitigation approximately \$234,000. With no banks available, mitigation would be provided on-site and in-kind where possible. Costs may vary significantly and can be much less than \$234,000. Project staff will work with the USACE and SCDHEC – OCRM to determine an appropriate mitigation site to offset impacts to the tidal marsh.

Future Data Collection

Threatened/Endangered Species and EFH Surveys

Pursuant to Section 7 of the ESA, environmental staff will conduct a field survey to identify and/or determine the likely existence of protected species or suitable habitat for protected species within the project area. Refer to Table 1 for a current list of threatened and endangered species found in Charleston County obtained from the USFWS. All findings will be reported to the USFWS and NOAA for concurrence.

Additionally, surveys of EFH would also be conducted pursuant to the Magnuson-Stevens Fishery Conservation and Management Act of 1976 (as amended 1996). Findings would be reported to NOAA for concurrence.

Wetlands Delineation

A delineation of all critical area and wetlands will be performed according to the methodology outlined in the *1987 Corps of Engineers Wetland Delineation Manual*. National wetland inventory maps, soil maps, and aerial photography will be reviewed in conjunction with field work. Once all field work is complete, a wetland delineation and jurisdictional determination will be submitted to the USACE for approval. This delineation is required before the issuance of any USACE permits.

Sediment Analysis

A sediment analysis of the area to be dredged will be required before any dredging can take place. This analysis includes:

- Field activities associated with collection of soil data including borings and sampling;
- Laboratory analysis of sediment samples;
- Grain Size Sieve Analysis;
- Summary of analytical data.

Once complete, a report will be given to the USACE project manager for review.

Cultural Resources Survey

An underwater and terrestrial archaeological survey will be conducted as required for compliance with Section 106 of the NHPA of 1966. Archival research and coordination with the SHPO will be performed to identify and help predict the locations of significant cultural resources in the vicinity of the proposed action. Archaeological and architectural surveys to be performed will provide the necessary management data to allow for the sites and properties to be evaluated for recommendations of eligibility to the NRHP.

SECTION 9 — Environmental Feasibility Report

The SHPO will enlist the review of all plans by the Maritime Research Division (MRD) of the South Carolina Institute of Archaeology and Anthropology (SCIAA). The MRD reviews all major projects that have the potential to impact intertidal and submerged cultural resources along and in state waters. Projects that are likely to disturb both known and unknown archaeological underwater sites may require a cultural resource survey prior to construction. The majority of projects, however, require that a statement be attached to the permit requiring the applicant to contact the MRD and the SHPO if archeological materials are encountered during construction or disturbance.

Conclusion and Cost Summary

The relocation and restoration of the U.S.S. Clamagore is a top priority for the Patriots Point Naval and Maritime Museum in Mount Pleasant, SC. It is in the best interest of the museum that the submarine be moved to dry land so that the public can continue to enjoy the beauty and historical significance of this unique World War II era submarine while witnessing her hull restoration. Environmental impacts will be a major concern of all parties involved and all measures will be taken to avoid and minimize the effects of this project on the surrounding environment. The issuance of environmental permits requires that the Least Environmentally Damaging Practicable Alternative is selected. Based on the summary of preliminary impacts, both the Marine Trestle System and the Cofferdam Lock System would require dredging. The Marine Trestle System would further create temporary indirect impacts, such as shading, with the installation of the work trestle and rail. The Cofferdam Lock System alternative would require the removal and excavation of additional salt marsh habitat, or critical areas. Therefore, the marine trestle system would be the environmentally preferred alternative based on the feasibility analysis. Impacting wetlands and waters of the US requires mitigation through approved banks or other feasible methods. With no approved banks available in South Carolina for salt marsh impacts, alternative mitigation would need to be agreed upon with the permitting agencies. These costs would likely range from \$70,000 to \$200,000. The following is a summary of environmental permitting costs expected for future development of the project:

- Preparation and submittal of Environmental Permit Applications;
- Agency Coordination;
- Mitigation Identification of Onsite or Offsite Locations;
- Threatened and Endangered Species Survey;
- Cultural Resource Study;
- Sediment Analysis.

Total Additional Environmental Permitting Services: \$42,000

SECTION 10 — Conclusion and Recommendation

Findings and recommendation

The relocation and restoration of the U.S.S. Clamagore is very important to the Patriots Point Naval and Maritime Museum and Dennis Corporation. In order to secure her future and allow the public to continue enjoying her history, a move to dry land should be completed in the near future.

From our report, it is clear that these two methods are feasible to relocate the submarine; however, Dennis Corporation recommends the Crane Lift Method as the preferred method. The Crane Lift Method provides the best opportunity for Patriots Point should a landside berth operation ever be executed. From all information herein, it is clear this method is the best course of action based on feasibility, liability, cost, construction schedule, environmental impacts, permitting, and impacts to Patriots Point.

In addition to being the preferred method in all the categories stated above, we feel the over-all method stands to be a high profile attraction for visitors to Patriots Point. During construction and specifically during the moving process local residents of Charleston, as well as tourists, will have an opportunity to see first hand possibly the largest lifted object in the State of South Carolina. Patriots Points will stand to have a spike in revenue generation during this period to assist in financing the project. It is very important to consider that once this marine vessel is relocated to land, restoration of her hull would need to commence immediately. Restoring this vessel would be extremely cost effective if completed on the grounds and time schedule of Patriots Point. Having to dry-dock this vessel for repairs could be roughly four-times the cost than repairing her in the proposed future location. If included into operations involving the U.S.S. Laffey some of the construction cost could be reduced such as dredging. Additionally permitting would be easier and cost effective, if completed in conjunction with permits required for the U.S.S. Laffey. Once fully restored this vessel would compete with the U.S.S. Yorktown as the show casing piece of the Patriots Point Naval and Maritime Museum. As a result, visitors would have easier access to this historic vessel increasing revenues for Patriots Point through ticket sales. Another unique opportunity this method could provide is to advertise it as a Design-Build project with the cofferdam method being a possible alternative bidding item.

Design – Build is a contractor procurement and project delivery method that combines both the design and construction phase into one contract, thus allowing these phases to proceed concurrently, while saving both time and resources. Design – Build is a particularly effective tool for typically complex projects that call for innovation and speed of completion. It has been used in building construction for a number of years; however, it is a relatively new approach being used more and more in South Carolina. Design - Build contracts typically are for larger amounts of money and companies must have the ability to bond that amount. Selection is done by evaluating the contractor's proposals and determining which gives the best value. Cost is a factor in the selection. Cost and the technical merits of their proposal are weighed together to make the best value selection. Details are provided to the contractor teams up front on how the areas of their proposal will be weighed in the selection process. The prime contractor will hire many subcontractors and will have established DBE goals to achieve. We anticipate the subcontractors will be predominantly local companies allowing bids to come in potentially lower than our own developed construction cost estimate based on the availability of materials and equipment. Due to the current economic climate Design-Build bids have been coming in much lower for SCDOT contracts. The Design - Build contractor will have to follow all AASHTO specifications and approved State specifications in accordance with the law. Design - Build projects have a set budget and the contractor's proposal can't go over that amount. Design - Build is a lump sum contract. If the contractor is able to build the project for less than their bid, the contractor keeps the savings. More than 10 states are using Design - Build as a delivery method for highway construction projects. The highest profile projects have been in Utah, Colorado and South Carolina.

We hope you find this report beneficial to your planning process and that our findings will be included and incorporated into the future master plan for Patriots Point. Do not hesitate to contact us if you require additional information. Our project team is readily available to give an oral presentation to the Patriots Point Development Authority (PPDA). It has been a honor to be part of this project and we hope to continue to serve Patriots Point in future developments.

APPENDIX I — **Volkert, Inc. Cofferdam Evaluation Report**

COFFERDAM EVALUATION REPORT

MOVING USS CLAMAGORE TO LAND BERTH

**FOR
DENNIS CORPORATION, INC.**

EXECUTIVE SUMMARY

January 18, 2010

VOLKERT



Clayton L. Hare, Jr.
01/18/10

COFFERDAM EVALUATION REPORT

MOVING USS CLAMAGORE TO LAND BERTH

**FOR
DENNIS CORPORATION, INC.**

EXECUTIVE SUMMARY

January 18, 2010

VOLKERT



Volkert, Inc.

3809 Moffett Road (36618)
P.O. Box 7434
Mobile, AL 36670-0434

Office 251.342.1070
Fax 251.342.7962
volkert@volkert.com

www.volkert.com

January 18, 2010

Contract No. 978301.10

USS Clamagore Feasibility Study
Task No. 1 – Cofferdam Evaluation
Study and Report for Dennis Corp.

Dwight Cathcart II
Dennis Corporation
5000 Thurmond Mall, Suite 114
Columbia, SC 29201

**SUBJECT: Cofferdam Evaluation for Moving
USS Clamagore to Land Berth**

Dear Mr. Cathcart:

We are pleased to submit, for your review, the cofferdam evaluation for moving the USS Clamagore to a land berth.

The total cost estimate to construct the project is estimated between \$6.3 million to \$6.6 million. A pay item breakdown is presented in the report.

We have attached schematic drawings showing the sheet pile wall and bracing sequence to raise the submarine to its final location. Also attached are tentative foundation and pedestal design drawings.

If any questions arise during your review, please give us a call.

Sincerely,

Clay L. Hare, P.E.
Senior Vice President

Office Locations:

Birmingham, Foley, Huntsville, Mobile, Alabama • Gainesville, Orlando, Pensacola, Tampa, Florida • Atlanta, Georgia
Collinsville, Illinois • Baton Rouge, Slidell, Louisiana • Biloxi, Mississippi • Jefferson City, Missouri • Raleigh, North Carolina
Chattanooga, Tennessee • Alexandria, Virginia • Washington, D.C.



COFFERDAM EVALUATION REPORT

MOVING USS CLAMAGORE TO LAND BERTH

**FOR
DENNIS CORPORATION, INC.**

EXECUTIVE SUMMARY

January 18, 2010

VOLKERT

COFFERDAM ALTERNATIVE

Executive Summary

Patriots Point Development Authority commissioned the team of Dennis Corporation and Volkert, Inc. to perform a feasibility study to move the USS Clamagore to a landside berth. The team was to evaluate two alternatives of moving the submarine to a landside berth. The rail alternative would be performed by Dennis Corporation and the cofferdam alternative would be performed by Volkert, Inc. This report only addresses the cofferdam alternative.

Scope of Work

The cofferdam alternative was to include the following items of work:

1. Review geotechnical report for soil stability to utilize cofferdam alternative
2. Determine submarine support surcharge loads
3. Preliminary design of support pedestal
4. Determine excavation depth for sheet pile
5. Run sheet pile analysis
6. Determine construction cost of sheet piles
7. Determine construction cost of landside excavation
8. Compile final report with construction cost estimate

The cofferdam alternative would be accomplished by:

- dredging a channel to the uplands
- driving a sheet pile cofferdam in the existing parking lot south of the museum and ticket office
- excavating the soil within the cofferdam
- floating the submarine into the cofferdam
- sealing off the end of the cofferdam
- raise the submarine by using water and underwater backfill
- construct concrete pedestals and foundation underneath the submarine
- cutoff sheet pile cofferdam below ground level
- reconstruct parking lot around submarine
- provide stair access and utilities to submarine

COFFERDAM ALTERNATIVE

Feasibility Process and Assumptions

The first assumption was the width and centerline of the dredging and how close to get to the existing USS Yorktown concrete access bridge. Not knowing the pile tips, we decided to maintain the dredge centerline at 75 feet away from the nearest edge of the bridge concrete pile cap. Final design would require close scrutiny of existing bridge record drawings and geotechnical report to determine possible interference or potential bridge stability issues.

The second assumption was determining the dredge depth required to float the USS Clamagore into the cofferdam. Minimizing the draft of the submarine is critical to the success of the project. Removing the existing batteries could change the draft substantially. In one of the discussions with Patriot Point personnel, we were told that the submarine floated at high tide. This would place the minimum dredge depth at elevation -8 feet NAVD 88 at high tide, or a total draft of 13 feet. With the tides being semidiurnal this would give the moving process approximately 2 to 3 hours to move the submarine into the cofferdam. This should be enough time with an organized process sequence.

Once the submarine is in the cofferdam, the tide would recede and the submarine would sit on the bottom until the next high tide. The soil at the bottom of the cofferdam would have to be shaped to mimic the bottom of the submarine for stability. The open end of the cofferdam would then take several days to be closed by installing sheet pile, waterproofing, and adding structural reinforcement.

The raising of the submarine to its final location may require as many as 30 to 40 steps. The submarine will have to be raised a vertical height of approximately 28 feet. Each step would require water and sand to be pumped into the cofferdam to raise the submarine. To keep the sheet pile wall stabilized, temporary structural bracing frames would have to be installed and adjusted above and below the submarine during the course of raising the submarine. There would be continuous monitoring of the sheet pile wall for movement and stability.

During the course of moving the submarine to its final location insurance may be considered for submarine damage caused by a construction incident.

It is important to remember that after the submarine rests above ground, the task of sandblasting, repairing holes, and painting will need to begin. The cost of these repairs is not included in this estimate.

CONSTRUCTION COST ESTIMATE

MOBILIZATION/DEMOBILIZATION		
	LS	Total
Project Start up		\$ 100,000
INSURANCE & BONDS		
	% Construction Cost	Total
Insurance & Bonds	4.0%	\$ 180,000
GENERAL CONDITIONS		
	LS	Total
Supervision, temporary utilities, consumables, etc.		\$ 100,000
EXCAVATION & BACKFILL		
	CY	Total
Wetland Excavation	10,000 cy X \$7.50 cy	\$ 75,000
Dredge Excavation	20,000 cy X \$11.00 cy	\$ 220,000
Excavation Within Lock	10,000 cy X \$10.00 cy	\$ 100,000
Channel Backfill	10,000 cy X \$10.00 cy	\$ 100,000
Underwater Backfill in Lock	10,000 cy X \$10.00 cy	\$ 100,000
Haul & Place On-Site Material	10,000 cy X \$5.00 cy	\$ 50,000
Excavation for Pedestals	1,100 cy X \$8.50 cy	\$ 9,350
Foundation Bedding Material	300 cy X \$45.0 cy	\$ 13,500
REMOVAL		
	SY	Total
Removal of Asphalt Parking Lot	6,700 sy X \$4.00 sy	\$ 26,800
STORM DRAIN SYSTEM		
	LS	Total
Inlets and Piping		\$ 36,000
CONCRETE		
	CY	Total
Unreinforced Concrete Mat	1137 cy X \$150.00 cy	\$ 170,500
Concrete Pedestals	1000 cy X \$450.00 cy	\$ 450,000
STRUCTURAL STEEL		
		Total
Steel Sheet Piling	63540 sf X \$15.50 sf	\$ 984,870
Drive & Cut-Off Sheet Piling	63540 sf X \$17.50 sf	\$ 1,111,950
Structural Steel for Temporary Upper Strut Bracing	61500 lb X \$2.00 lb	\$ 123,000
Structural Steel for Lower Strut Bracing	125,000 lb X \$2.00 lb	\$ 250,000

14" Steel Pipe Piles	312 lf X \$60.00 lf	\$ 18,720
Waterproof Sheet Pile Interlocks	20,600 lf X \$10.00 lf	\$ 216,000
<u>SPOIL SITE</u>		
	LS	Total
Discharge Control and Maintenance		\$ 40,000
<u>MOVING USS CLAMAGORE</u>		
	LS	Total
Float, Move and Rest USS Clamagore in Lock		\$ 164,000
<u>ACCESS STAIRS AND PLATFORM</u>		
		Total
Stairs & Platforms	LS	\$ 22,400
Handrails	60 lf X \$40.00 lf	\$ 11,000
<u>UTILITY CONSTRUCTION</u>		
	LS	Total
Supplying Water & Electricity		\$ 35,000
<u>FLOATING TURBIDITY BARRIER</u>		
	SY	Total
Floating Turbidity Barrier	2500 sy X \$31.00 sy	\$ 77,500
<u>EROSION CONTROL</u>		
		Total
Hay Bales	200 ea X \$10.00 ea	\$ 2,000
Silt Fence, Type "A"	200 lf X \$25.00 lf	\$ 5,000
6' Security Chain Link Fence	400 lf X \$40.00 lf	\$ 16,000

<u>TOTAL ESTIMATED CONSTRUCTION COST</u>		
		Total
ROUGH MAGNITUDE OF CONSTRUCTION COST		\$4.7 - 5.0M *

*Above estimate does not include Engineering

COFFERDAM ALTERNATIVE

ADDITIONAL COST

Marine Surveyor

To float the submarine on her designed
light displacement waterline for the future
move of vessel into cofferdam. \$ 35,000

Determine extent of degradation of
submarine underwater \$ 19,000

Prepare planning for and supervision
of move of submarine into cofferdam \$ 35,000

Permitting \$ 50,000

Development of Plans and Specifications \$ 252,000

Construction Management \$ 208,000

15% Contingency \$ 800,000

ROUGH MAGNITUDE OF COMPLETE PROJECT COST \$6.3 – 6.6M *

* Does not include cost to prepare submarine for floatation and movement

* Does not include cost to prepare submarine hull for display

CONCEPTIONAL DESIGN PLANS

The conceptional design plans include the following drawings:

Site Plan

Lock Sheet wall and bracing (2 sheets)

USS Clamagore Foundation Detail and Surface Profile

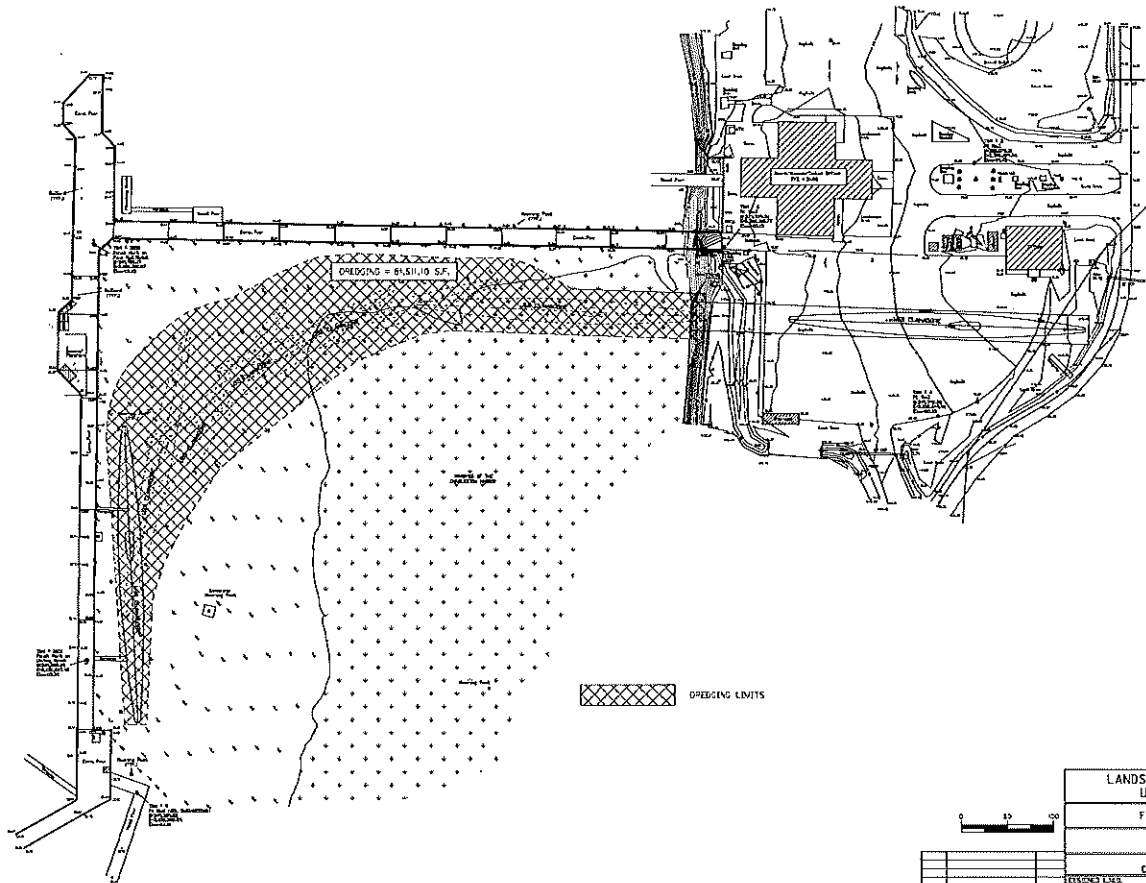
APPENDIX

Three sheet pile computer analysis

Geotechnical Report

1. THESE PLANS WERE PREPARED BY THE U.S. NAVY ARCHITECTURAL DIVISION, WASHINGTON, D.C. IN 1962.
 2. THESE PLANS WERE PREPARED FOR THE U.S. NAVY ARCHITECTURAL DIVISION, WASHINGTON, D.C. IN 1962.
 3. THESE PLANS WERE PREPARED FOR THE U.S. NAVY ARCHITECTURAL DIVISION, WASHINGTON, D.C. IN 1962.
 4. THESE PLANS WERE PREPARED FOR THE U.S. NAVY ARCHITECTURAL DIVISION, WASHINGTON, D.C. IN 1962.
 5. THESE PLANS WERE PREPARED FOR THE U.S. NAVY ARCHITECTURAL DIVISION, WASHINGTON, D.C. IN 1962.
 6. THESE PLANS WERE PREPARED FOR THE U.S. NAVY ARCHITECTURAL DIVISION, WASHINGTON, D.C. IN 1962.
 7. THESE PLANS WERE PREPARED FOR THE U.S. NAVY ARCHITECTURAL DIVISION, WASHINGTON, D.C. IN 1962.
 8. THESE PLANS WERE PREPARED FOR THE U.S. NAVY ARCHITECTURAL DIVISION, WASHINGTON, D.C. IN 1962.
 9. THESE PLANS WERE PREPARED FOR THE U.S. NAVY ARCHITECTURAL DIVISION, WASHINGTON, D.C. IN 1962.
 10. THESE PLANS WERE PREPARED FOR THE U.S. NAVY ARCHITECTURAL DIVISION, WASHINGTON, D.C. IN 1962.

PROJECT NO.	DATE	BY	CHKD.
19327-0	21-5		

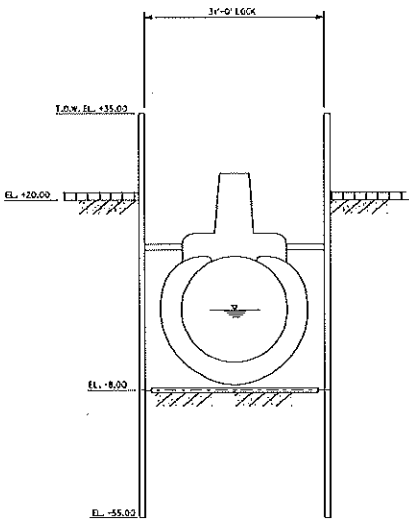


LANDSIDE BERTH FOR THE USS CLAMAGORE			
FEASIBILITY STUDY			
SITE PLAN			
VOLPERT INC. CONSULTING ENGINEERS			
DESIGNED BY	SKETCHED BY	ENGINEER'S NAME	DATE
SKETCHED	LOCKED	LOCKED	1962-05
REVISIONS			
DATE			

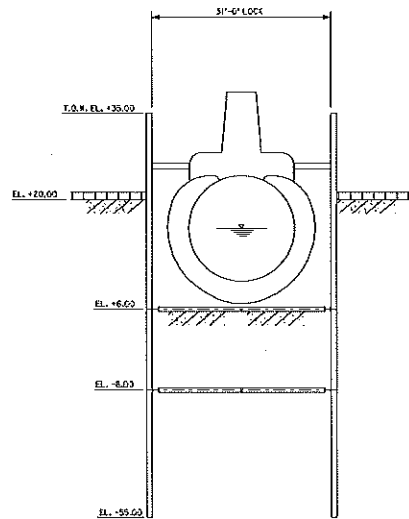


LANDSIDE BERTH FOR THE USS CLAMAGORE		
FEASIBILITY STUDY		
FOUNDATION DETAILS		
VOLKERT INC. CONSULTING ENGINEERS		
DESIGNED LMB QTY=12	BUILT IN PLACE QTY=12	QUANTITIES LMB QTY=12
DATE		DESK

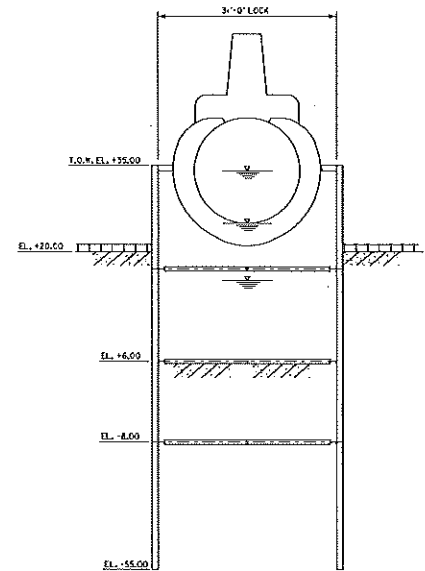
REVISION	DATE	BY	CHKD
1	10/10/00	W	W



FLOAT SUBMARINE INTO LOCK



RAISE SUBMARINE TO INTERMEDIATE ELEVATION



RAISE SUBMARINE TO FINAL ELEVATION

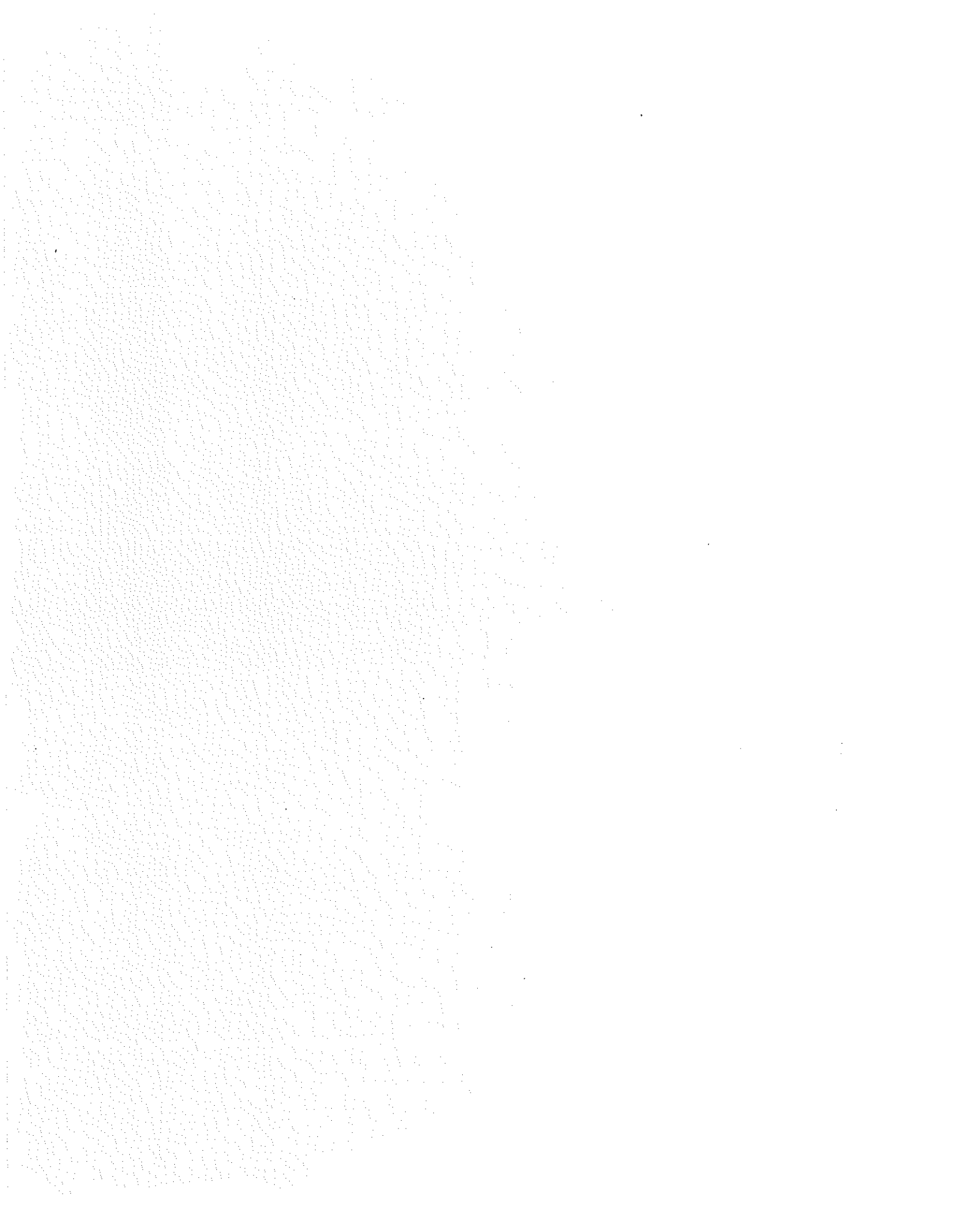
NOTE:
SCHEMATIC DRAWINGS SHOWING PARTIAL SEQUENCE
OF RAISING SUBMARINE TO FINAL LOCATION.

LANDSIDE BERTH FOR THE USS CLAMAGORE			
FEASIBILITY STUDY			
LOCK SHEET WALL AND BRACING (SHEET 1 OF 2)			
VOLBERT INC. CONSULTING ENGINEERS			
DESIGNED LMS	DRAWN PAA	CHECKED LMS	DATE
REVISIONS	1	2	3

NOT TO SCALE
FOR INFORMATION ONLY
DO NOT CONSTRUCT
27 JANUARY 2000

REVISIONS

APPENDIX



Sheet Pile Design According to Blum-Method

Project Name:

Date: 1/15/2010

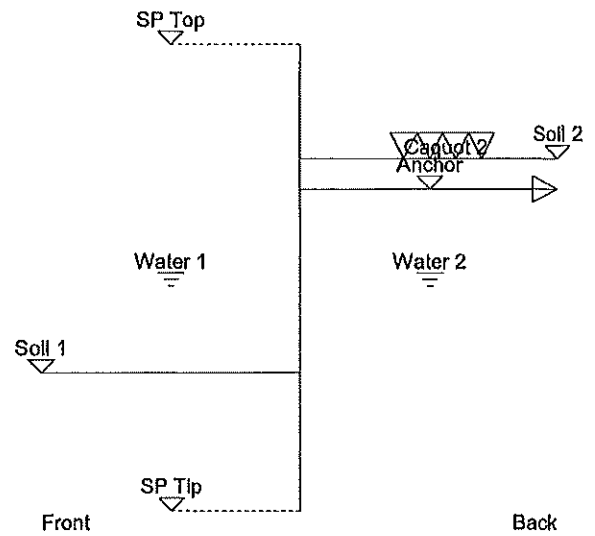
Author:

Company:

Comment:

Geodata

	Unit
Sheet Pile Top Level [ft]	-27.000
Sheet Pile Tip Level [ft]	34.088
Soil Level in Front [ft]	16.000
Soil Level behind [ft]	-12.000
Anchor level [ft]	-8.000
Water Level in Front [ft]	3.000
Water Level behind [ft]	3.000
Soil Surface Inclination in Front [Deg]	0.000
Soil Surface Inclination behind [Deg]	0.000
Caquot Surcharge in Front [kip/ft ²]	0.000
Caquot Surcharge behind [kip/ft ²]	0.200
Anchor Inclination [Deg]	0.000
Earth Support	Free



Soil Layers

Layers in Front

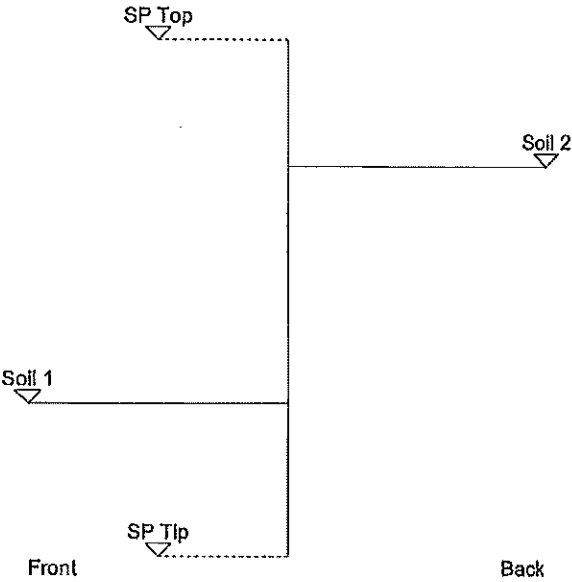
	Layer Tip [ft]	Density Moist [kip/ft ³]	Density Submerged [kip/ft ³]	Kph	Phi [Deg]	Delta [Deg]	Cohesion [kip/ft ²]
Layer 1	25.000	0.100	0.040	1.000	20.000	14.000	0.360
Layer 2	56.000	0.110	0.085	3.250	32.000	14.000	0.000
Layer 3	125.000	0.110	0.075	1.000	44.000	14.000	3.000

Layers behind

	Layer Tip [ft]	Density Moist [kip/ft ³]	Density Submerged [kip/ft ³]	Kph	Phi [Deg]	Delta [Deg]	Cohesion [kip/ft ²]
Layer 1	25.000	0.100	0.040	1.000	20.000	14.000	0.360
Layer 2	56.000	0.110	0.085	0.310	32.000	14.000	0.000
Layer 3	125.000	0.110	0.075	1.000	44.000	14.000	3.000

Boussinesq

	Distance Wall [ft]	Width Surcharge [ft]	Depth Surcharge [ft]	Surcharge [klp/ft2]
--	-----------------------	----------------------------	----------------------------	------------------------

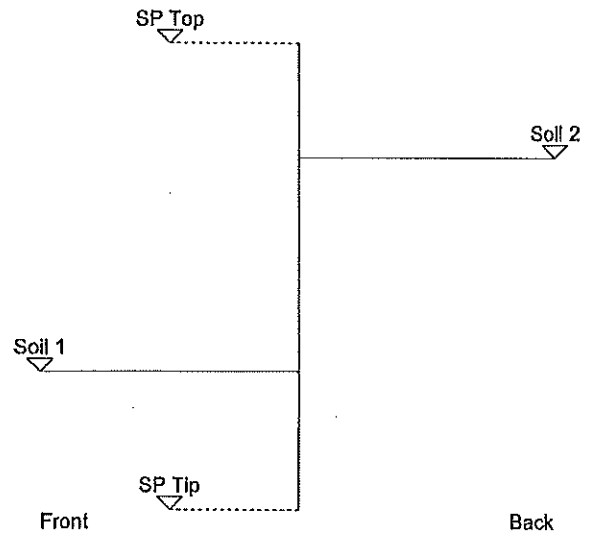


Userdefined Pressures

	Pressure Top [kip/ft2]	Pressure Tip [kip/ft2]	Depth Top [ft]	Depth Tip [ft]
--	------------------------	------------------------	----------------	----------------

Concentrated Forces

	Horiz. Component [klp/ft]	Vert. Component [klp/ft]	Depth Horiz. Comp. [ft]
--	---------------------------------	--------------------------------	----------------------------



Pile Section

Name	AZ13
Inertia [in4/ft]	144.258
Modulus [in3/ft]	24.180
Area [in2/ft]	6.468
Mass [lbs/ft2]	22.018
Steel Grade [lb/in2]	50000.000
Requested Safety	1.000

All Values

Depth [ft]	Deflection [ft]	Rotation [Rad]	Gross Force [kip/ft]	Moment [kip/ft]	Total Pressure [kip/ft2]	Earth Pressure in Front [kip/ft2]	behind [kip/ft2]	Water Pressure [kip/ft2]	Userdefined Pressure [kip/ft2]
-27.000	1.503	-0.079	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-26.180	1.438	-0.079	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-26.180	1.438	-0.079	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-25.360	1.373	-0.079	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-25.360	1.373	-0.079	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-24.539	1.308	-0.079	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-24.539	1.308	-0.079	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-23.719	1.243	-0.079	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-23.719	1.243	-0.079	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-22.899	1.178	-0.079	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-22.899	1.178	-0.079	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-22.079	1.114	-0.079	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-22.079	1.114	-0.079	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-21.258	1.049	-0.079	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-21.258	1.049	-0.079	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-20.438	0.984	-0.079	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-20.438	0.984	-0.079	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-19.618	0.919	-0.079	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-19.618	0.919	-0.079	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-18.798	0.854	-0.079	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-18.798	0.854	-0.079	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-17.978	0.789	-0.079	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-17.978	0.789	-0.079	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-17.157	0.724	-0.079	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-17.157	0.724	-0.079	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-16.337	0.659	-0.079	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-16.337	0.659	-0.079	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-15.517	0.595	-0.079	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-15.517	0.595	-0.079	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-14.697	0.530	-0.079	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-14.697	0.530	-0.079	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-13.877	0.465	-0.079	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-13.877	0.465	-0.079	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-13.056	0.400	-0.079	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-13.056	0.400	-0.079	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-12.236	0.335	-0.079	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-12.236	0.335	-0.079	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-12.000	0.316	-0.079	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-12.000	0.316	-0.079	0.000	0.000	0.000	0.000	-0.520	0.000	0.000
-11.180	0.252	-0.079	0.000	0.000	0.000	0.000	-0.438	0.000	0.000
-11.180	0.252	-0.079	0.000	0.000	0.000	0.000	-0.438	0.000	0.000
-10.360	0.187	-0.079	0.000	0.000	0.000	0.000	-0.356	0.000	0.000
-10.360	0.187	-0.079	0.000	0.000	0.000	0.000	-0.356	0.000	0.000
-9.539	0.122	-0.079	0.000	0.000	0.000	0.000	-0.274	0.000	0.000
-9.539	0.122	-0.079	0.000	0.000	0.000	0.000	-0.274	0.000	0.000
-8.719	0.057	-0.079	0.000	0.000	0.000	0.000	-0.192	0.000	0.000
-8.719	0.057	-0.079	0.000	0.000	0.000	0.000	-0.192	0.000	0.000
-8.000	0.000	-0.079	0.000	0.000	0.000	0.000	-0.120	0.000	0.000
-8.000	0.000	-0.079	-14.331	0.000	0.000	0.000	-0.120	0.000	0.000
-7.180	-0.065	-0.079	-14.331	-11.755	0.000	0.000	-0.038	0.000	0.000
-7.180	-0.065	-0.079	-14.331	-11.755	0.000	0.000	-0.038	0.000	0.000
-6.360	-0.129	-0.078	-14.313	-23.504	0.044	0.000	0.044	0.000	0.000
-6.360	-0.129	-0.078	-14.313	-23.504	0.044	0.000	0.044	0.000	0.000
-5.539	-0.193	-0.078	-14.243	-35.220	0.126	0.000	0.126	0.000	0.000
-5.539	-0.193	-0.078	-14.243	-35.220	0.126	0.000	0.126	0.000	0.000
-4.719	-0.257	-0.077	-14.106	-46.851	0.208	0.000	0.208	0.000	0.000
-4.719	-0.257	-0.077	-14.106	-46.851	0.208	0.000	0.208	0.000	0.000
-3.899	-0.319	-0.076	-13.902	-58.342	0.290	0.000	0.290	0.000	0.000
-3.899	-0.319	-0.076	-13.902	-58.342	0.290	0.000	0.290	0.000	0.000
-3.079	-0.380	-0.073	-13.630	-69.638	0.372	0.000	0.372	0.000	0.000
-3.079	-0.380	-0.073	-13.630	-69.638	0.372	0.000	0.372	0.000	0.000
-2.258	-0.439	-0.071	-13.292	-80.684	0.454	0.000	0.454	0.000	0.000
-2.258	-0.439	-0.071	-13.292	-80.684	0.454	0.000	0.454	0.000	0.000
-1.438	-0.497	-0.069	-12.885	-91.424	0.536	0.000	0.536	0.000	0.000

Depth [ft]	Deflection [ft]	Rotation [Rad]	Cross Force [kip/ft]	Moment [kip-ft/ft]	Total Pressure [kip/ft ²]	Earth Pressure in Front [kip/ft ²]	behind [kip/ft ²]	Water Pressure [kip/ft ²]	Userdefined Pressure [kip/ft ²]
-1.438	-0.497	-0.069	-12.885	-91.424	0.536	0.000	0.536	0.000	0.000
-0.618	-0.553	-0.067	-12.412	-101.803	0.618	0.000	0.618	0.000	0.000
-0.618	-0.553	-0.067	-12.412	-101.803	0.618	0.000	0.618	0.000	0.000
0.202	-0.608	-0.064	-11.871	-111.767	0.700	0.000	0.700	0.000	0.000
0.202	-0.608	-0.064	-11.871	-111.767	0.700	0.000	0.700	0.000	0.000
1.022	-0.657	-0.061	-11.263	-121.259	0.782	0.000	0.782	0.000	0.000
1.022	-0.657	-0.061	-11.263	-121.259	0.782	0.000	0.782	0.000	0.000
1.843	-0.705	-0.057	-10.588	-130.225	0.864	0.000	0.864	0.000	0.000
1.843	-0.705	-0.057	-10.588	-130.225	0.864	0.000	0.864	0.000	0.000
2.663	-0.751	-0.054	-9.846	-138.610	0.946	0.000	0.946	0.000	0.000
2.663	-0.751	-0.054	-9.846	-138.610	0.946	0.000	0.946	0.000	0.000
3.000	-0.768	-0.052	-9.521	-141.876	0.980	0.000	0.980	0.000	0.000
3.000	-0.768	-0.052	-9.521	-141.876	0.980	0.000	0.980	0.000	0.000
3.820	-0.809	-0.048	-8.704	-149.351	1.013	0.000	1.013	0.000	0.000
3.820	-0.809	-0.048	-8.704	-149.351	1.013	0.000	1.013	0.000	0.000
4.640	-0.847	-0.044	-7.860	-156.146	1.046	0.000	1.046	0.000	0.000
4.640	-0.847	-0.044	-7.860	-156.146	1.046	0.000	1.046	0.000	0.000
5.461	-0.881	-0.040	-6.988	-162.237	1.078	0.000	1.078	0.000	0.000
5.461	-0.881	-0.040	-6.988	-162.237	1.078	0.000	1.078	0.000	0.000
6.281	-0.912	-0.035	-6.091	-167.603	1.111	0.000	1.111	0.000	0.000
6.281	-0.912	-0.035	-6.091	-167.603	1.111	0.000	1.111	0.000	0.000
7.101	-0.939	-0.031	-5.166	-172.221	1.144	0.000	1.144	0.000	0.000
7.101	-0.939	-0.031	-5.166	-172.221	1.144	0.000	1.144	0.000	0.000
7.921	-0.962	-0.026	-4.214	-176.069	1.177	0.000	1.177	0.000	0.000
7.921	-0.962	-0.026	-4.214	-176.069	1.177	0.000	1.177	0.000	0.000
8.742	-0.982	-0.021	-3.235	-179.126	1.210	0.000	1.210	0.000	0.000
8.742	-0.982	-0.021	-3.235	-179.126	1.210	0.000	1.210	0.000	0.000
9.562	-0.997	-0.016	-2.229	-181.369	1.242	0.000	1.242	0.000	0.000
9.562	-0.997	-0.016	-2.229	-181.369	1.242	0.000	1.242	0.000	0.000
10.382	-1.009	-0.011	-1.197	-182.776	1.275	0.000	1.275	0.000	0.000
10.382	-1.009	-0.011	-1.197	-182.776	1.275	0.000	1.275	0.000	0.000
11.202	-1.016	-0.007	-0.138	-183.325	1.308	0.000	1.308	0.000	0.000
11.202	-1.016	-0.007	-0.138	-183.325	1.308	0.000	1.308	0.000	0.000
12.022	-1.019	-0.002	0.949	-182.994	1.341	0.000	1.341	0.000	0.000
12.022	-1.019	-0.002	0.949	-182.994	1.341	0.000	1.341	0.000	0.000
12.843	-1.019	0.003	2.062	-181.761	1.374	0.000	1.374	0.000	0.000
12.843	-1.019	0.003	2.062	-181.761	1.374	0.000	1.374	0.000	0.000
13.663	-1.014	0.008	3.202	-179.604	1.407	0.000	1.407	0.000	0.000
13.663	-1.014	0.008	3.202	-179.604	1.407	0.000	1.407	0.000	0.000
14.483	-1.005	0.013	4.369	-176.501	1.439	0.000	1.439	0.000	0.000
14.483	-1.005	0.013	4.369	-176.501	1.439	0.000	1.439	0.000	0.000
15.303	-0.993	0.018	5.563	-172.429	1.472	0.000	1.472	0.000	0.000
15.303	-0.993	0.018	5.563	-172.429	1.472	0.000	1.472	0.000	0.000
16.000	-0.979	0.022	6.599	-168.193	1.500	0.000	1.500	0.000	0.000
16.000	-0.979	0.022	6.599	-168.193	0.780	-0.720	1.500	0.000	0.000
16.820	-0.959	0.026	7.238	-162.519	0.780	-0.753	1.533	0.000	0.000
16.820	-0.959	0.026	7.238	-162.519	0.780	-0.753	1.533	0.000	0.000
17.640	-0.936	0.030	7.878	-156.319	0.780	-0.786	1.566	0.000	0.000
17.640	-0.936	0.030	7.878	-156.319	0.780	-0.786	1.566	0.000	0.000
18.461	-0.910	0.034	8.518	-149.595	0.780	-0.818	1.598	0.000	0.000
18.461	-0.910	0.034	8.518	-149.595	0.780	-0.818	1.598	0.000	0.000
19.281	-0.880	0.038	9.158	-142.346	0.780	-0.851	1.631	0.000	0.000
19.281	-0.880	0.038	9.158	-142.346	0.780	-0.851	1.631	0.000	0.000
20.101	-0.847	0.042	9.797	-134.572	0.780	-0.884	1.664	0.000	0.000
20.101	-0.847	0.042	9.797	-134.572	0.780	-0.884	1.664	0.000	0.000
20.921	-0.811	0.046	10.437	-126.274	0.780	-0.917	1.697	0.000	0.000
20.921	-0.811	0.046	10.437	-126.274	0.780	-0.917	1.697	0.000	0.000
21.742	-0.772	0.049	11.077	-117.451	0.780	-0.950	1.730	0.000	0.000
21.742	-0.772	0.049	11.077	-117.451	0.780	-0.950	1.730	0.000	0.000
22.562	-0.731	0.052	11.717	-108.103	0.780	-0.982	1.762	0.000	0.000
22.562	-0.731	0.052	11.717	-108.103	0.780	-0.982	1.762	0.000	0.000
23.382	-0.687	0.055	12.356	-98.230	0.780	-1.015	1.795	0.000	0.000
23.382	-0.687	0.055	12.356	-98.230	0.780	-1.015	1.795	0.000	0.000
24.202	-0.642	0.057	12.996	-87.833	0.780	-1.048	1.828	0.000	0.000
24.202	-0.642	0.057	12.996	-87.833	0.780	-1.048	1.828	0.000	0.000
25.000	-0.595	0.059	13.619	-77.216	0.780	-1.080	1.860	0.000	0.000

Depth [ft]	Deflection [ft]	Rotation [Rad]	Cross Force [kip/ft]	Moment [kip-ft/ft]	Total Pressure [kip/ft ²]	Earth Pressure In Front [kip/ft ²]	behind [kip/ft ²]	Water Pressure [kip/ft ²]	Userdefined Pressure [kip/ft ²]
25.000	-0.595	0.059	13.619	-77.216	-0.370	-1.170	0.800	0.000	0.000
25.820	-0.546	0.061	13.231	-66.193	-0.575	-1.397	0.821	0.000	0.000
25.820	-0.546	0.061	13.231	-66.193	-0.575	-1.397	0.821	0.000	0.000
26.640	-0.495	0.063	12.675	-55.558	-0.780	-1.623	0.843	0.000	0.000
26.640	-0.495	0.063	12.675	-55.558	-0.780	-1.623	0.843	0.000	0.000
27.461	-0.443	0.064	11.951	-45.447	-0.985	-1.850	0.865	0.000	0.000
27.461	-0.443	0.064	11.951	-45.447	-0.985	-1.850	0.865	0.000	0.000
28.281	-0.390	0.065	11.059	-35.999	-1.190	-2.076	0.886	0.000	0.000
28.281	-0.390	0.065	11.059	-35.999	-1.190	-2.076	0.886	0.000	0.000
29.101	-0.336	0.066	9.999	-27.351	-1.395	-2.303	0.908	0.000	0.000
29.101	-0.336	0.066	9.999	-27.351	-1.395	-2.303	0.908	0.000	0.000
29.921	-0.281	0.067	8.771	-19.642	-1.600	-2.529	0.929	0.000	0.000
29.921	-0.281	0.067	8.771	-19.642	-1.600	-2.529	0.929	0.000	0.000
30.742	-0.226	0.067	7.374	-13.010	-1.805	-2.756	0.951	0.000	0.000
30.742	-0.226	0.067	7.374	-13.010	-1.805	-2.756	0.951	0.000	0.000
31.562	-0.171	0.067	5.810	-7.591	-2.010	-2.983	0.973	0.000	0.000
31.562	-0.171	0.067	5.810	-7.591	-2.010	-2.983	0.973	0.000	0.000
32.382	-0.115	0.068	4.077	-3.525	-2.215	-3.209	0.994	0.000	0.000
32.382	-0.115	0.068	4.077	-3.525	-2.215	-3.209	0.994	0.000	0.000
33.202	-0.060	0.068	2.176	-0.949	-2.420	-3.436	1.016	0.000	0.000
33.202	-0.060	0.068	2.176	-0.949	-2.420	-3.436	1.016	0.000	0.000
34.022	-0.004	0.068	0.107	-0.001	-2.625	-3.662	1.038	0.000	0.000
34.022	-0.004	0.068	0.107	-0.001	-2.625	-3.662	1.038	0.000	0.000
34.088	0.000	0.068	-0.065	0.000	-2.641	-3.681	1.039	0.000	0.000

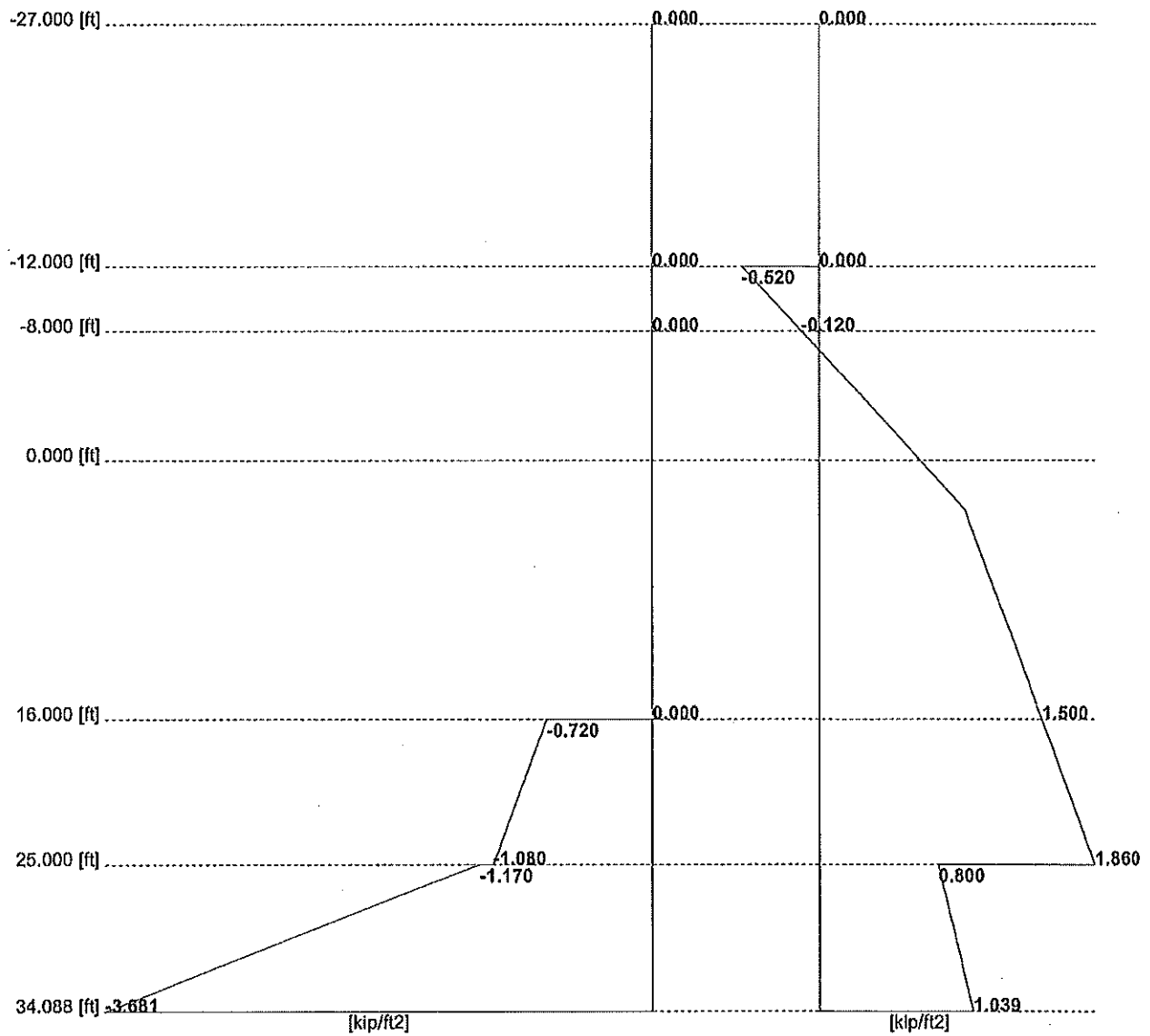
Extremal Values

	z Min [ft]	Min	z Max [ft]	Max
Deflection [ft]	12.022	-1.019	-27.000	1.503
Cross Force [kip/ft]	-7.180	-14.331	25.000	13.619
Moment [kipft/ft]	11.202	-183.325	-8.000	0.000

Pile Check

		Depth [ft]
Name	AZ13	
Inertia [in4/ft]	144.258	
Modulus [in3/ft]	24.180	
Area [in2/ft]	6.468	
Mass [lbs/ft2]	22.018	
Steel Grade [lb/in2]	50000.000	
Minimal Moment [kip/ft]	-183.325	11.202
Maximal Moment [kip/ft]	0.000	-8.000
Normal Forces at Max. Moment [kip/ft]	3.200	11.202
Normal Forces at Min. Moment [kip/ft]	-0.319	-8.000
Deflection at Min. Moment [ft]	-1.016	11.202
Deflection at Max. Moment [ft]	0.000	-8.000
Min. Stress at Min. Moment [lb/in2]	-92095.148	11.202
Max. Stress at Min. Moment [lb/in2]	93084.563	11.202
Min. Stress at Max. Moment [lb/in2]	-49.342	-8.000
Max. Stress at Max. Moment [lb/in2]	-49.342	-8.000
Safety < Req. Safety = 1.000	0.537	
Sheet Pile Top Level [ft]	-27.000	
Sheet Pile Tip Level [ft]	34.088	
Sheet Pile Length [ft]	61.088	
Included OverLength [ft]	0.000	
Vertical Equilibrium [kip/ft]	18.246	
Anchor Force (horiz.) [kip/ft]	-14.331	

Earth Pressure Diagram



Water Pressure Diagram

-27.000 [ft] 0.000

-12.000 [ft] 0.000

-8.000 [ft] 0.000

0.000 [ft]

16.000 [ft] 0.000

25.000 [ft] 0.000

34.088 [ft] 0.000
[kip/ft2]

Userdefined Pressure Diagram

-27.000 [ft] 0.000

-12.000 [ft] 0.000

-8.000 [ft] 0.000

0.000 [ft]

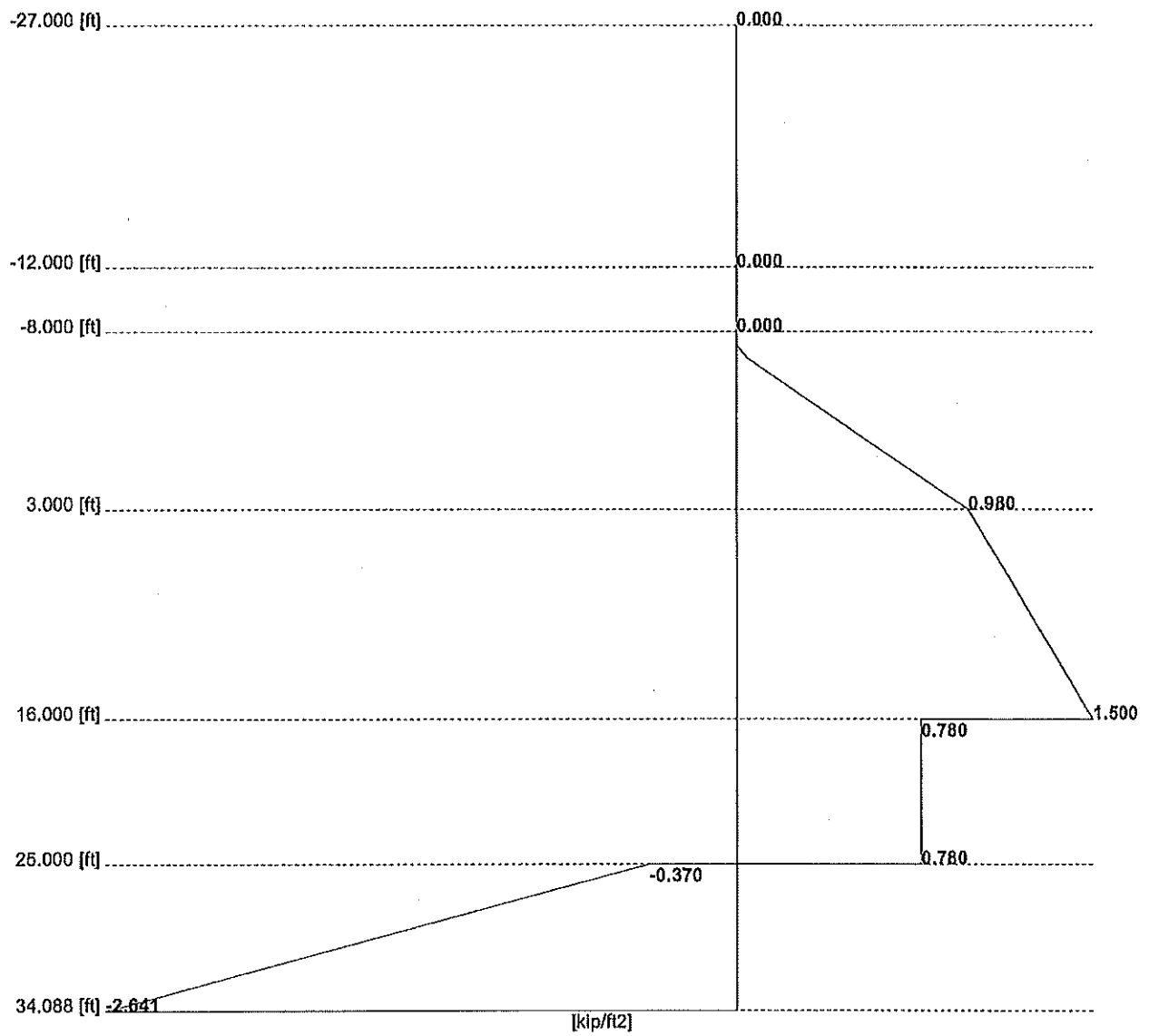
16.000 [ft] 0.000

25.000 [ft] 0.000

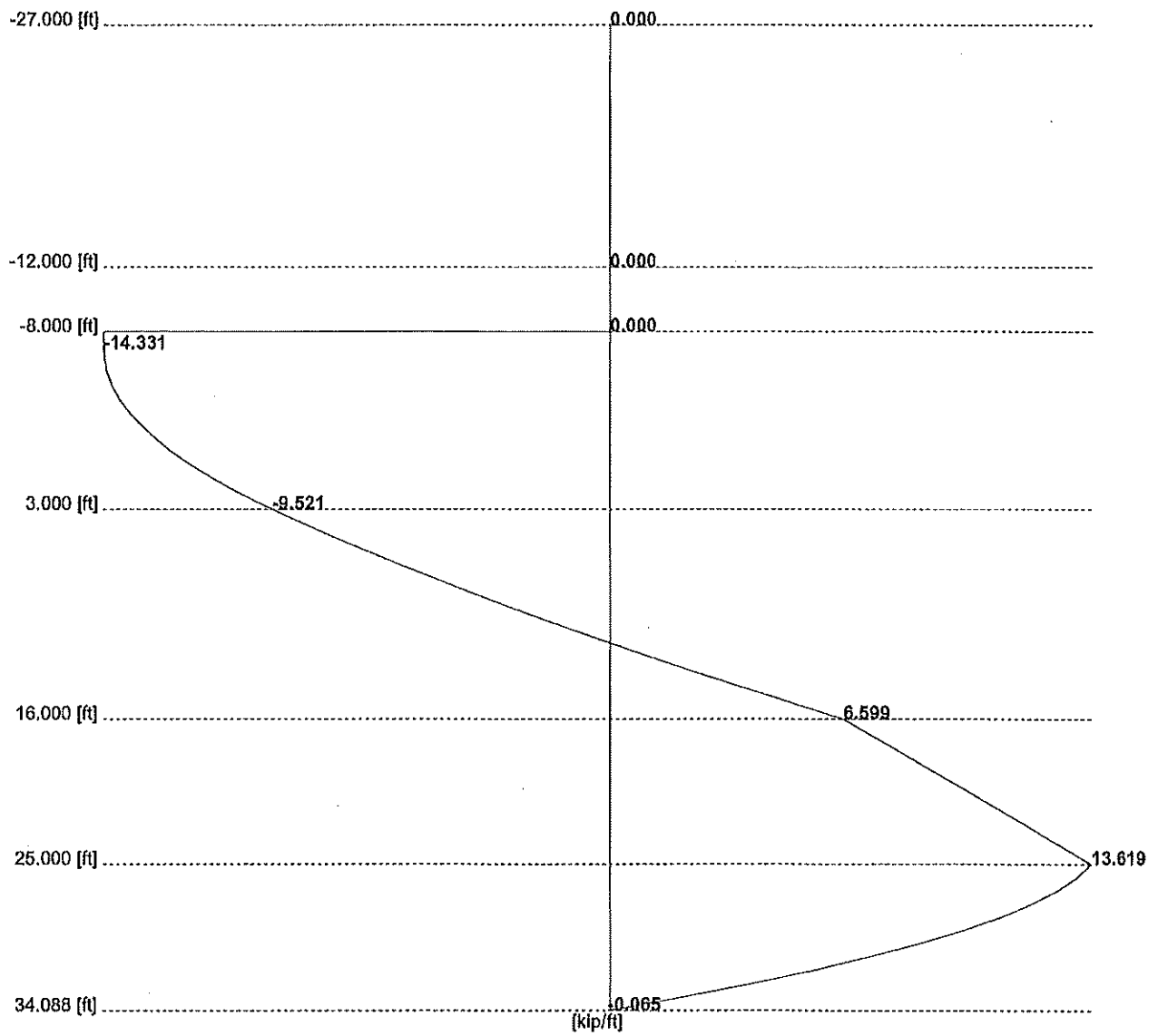
34.088 [ft] 0.000
[kip/ft2]

Boussinesq Diagram

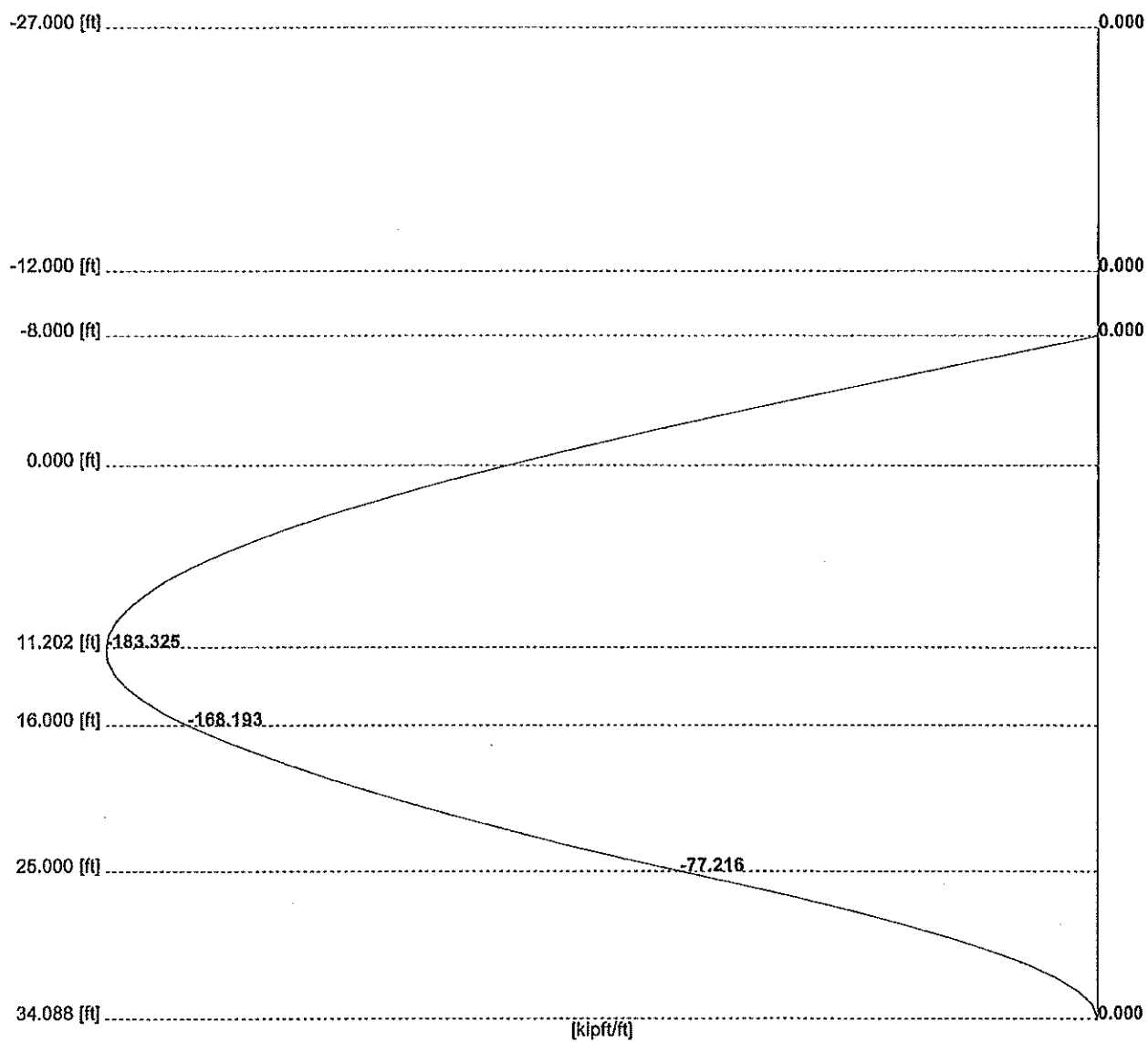
Total Pressure Diagram



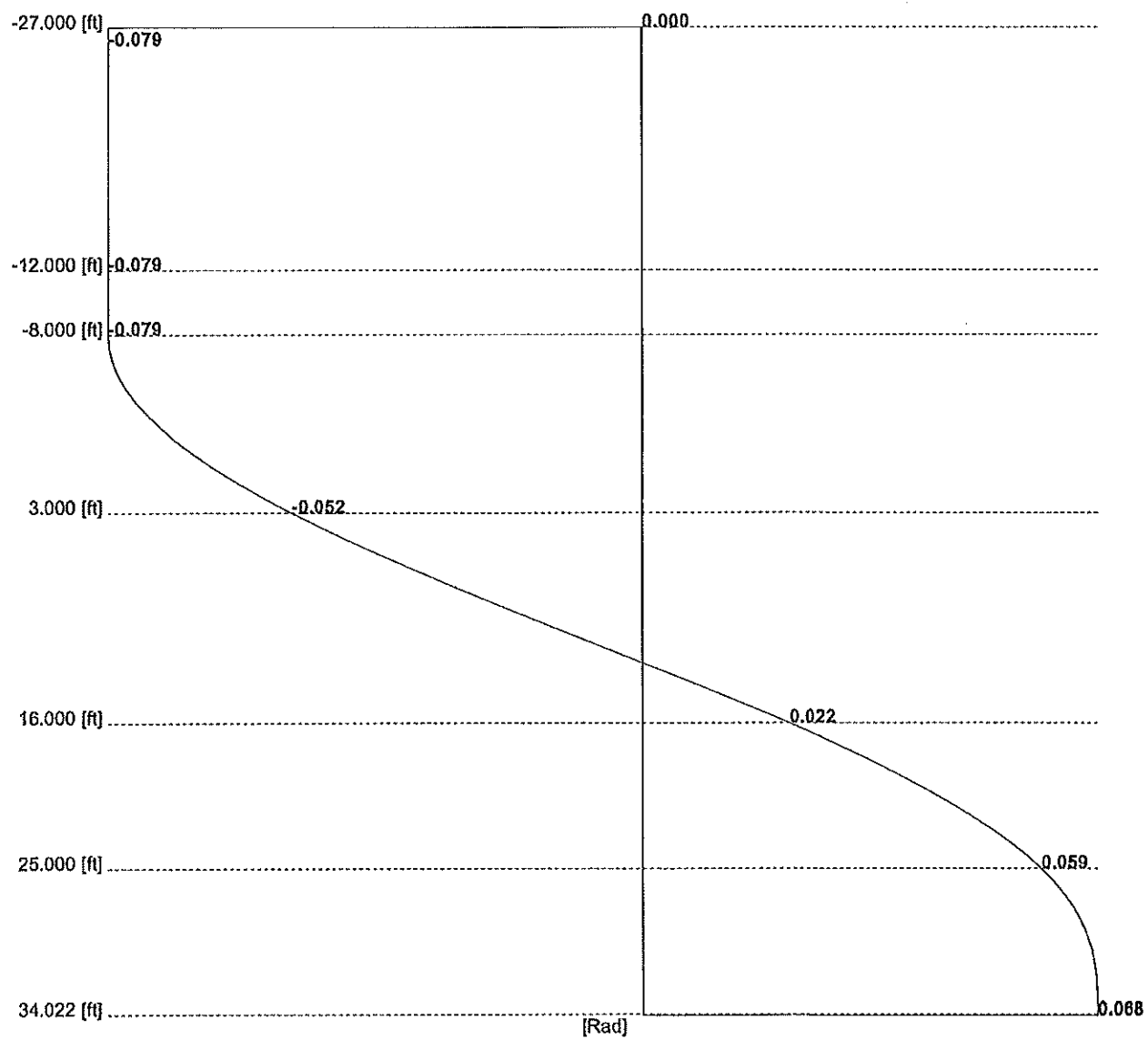
Cross Force Diagram



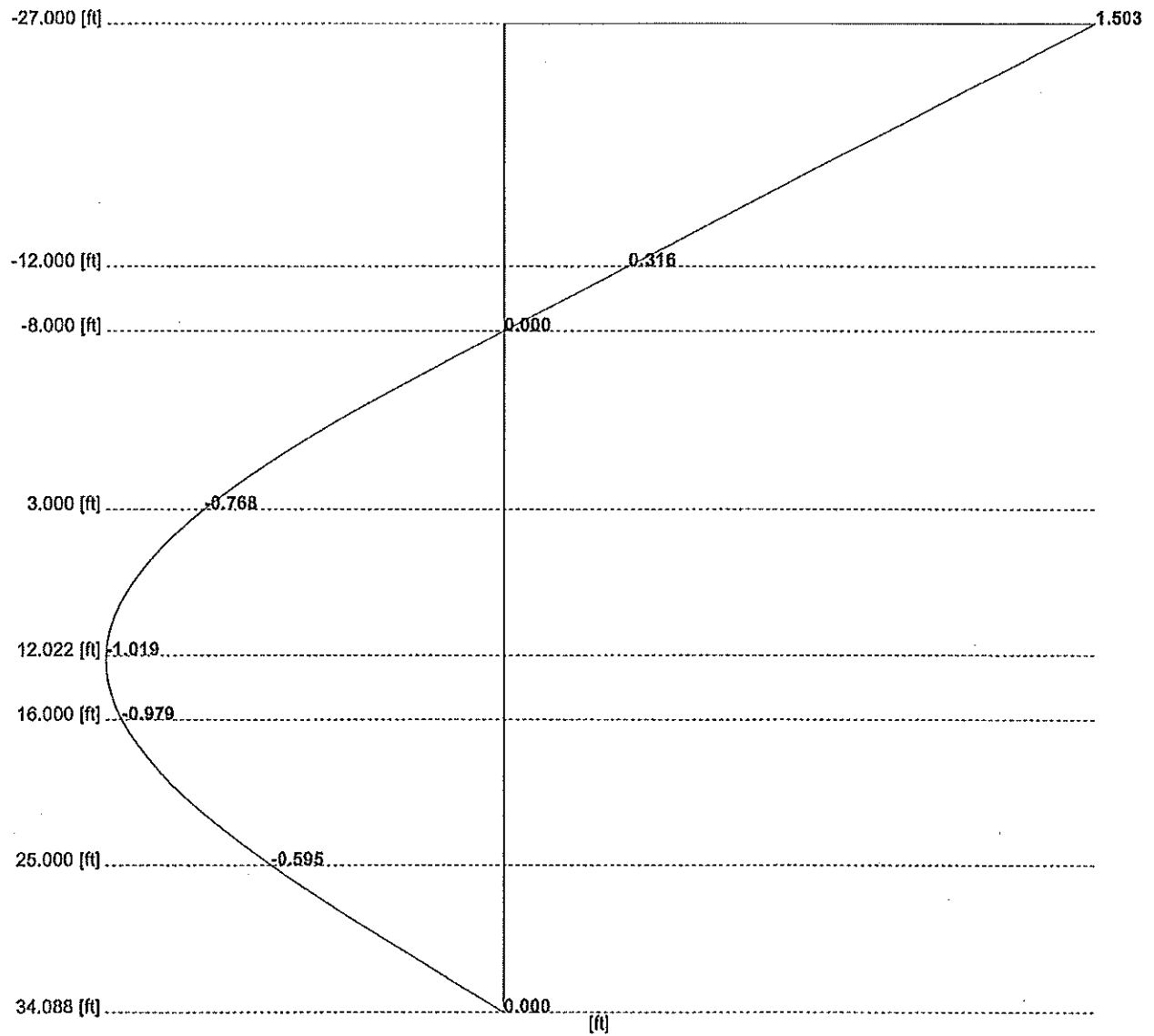
Moment Diagram

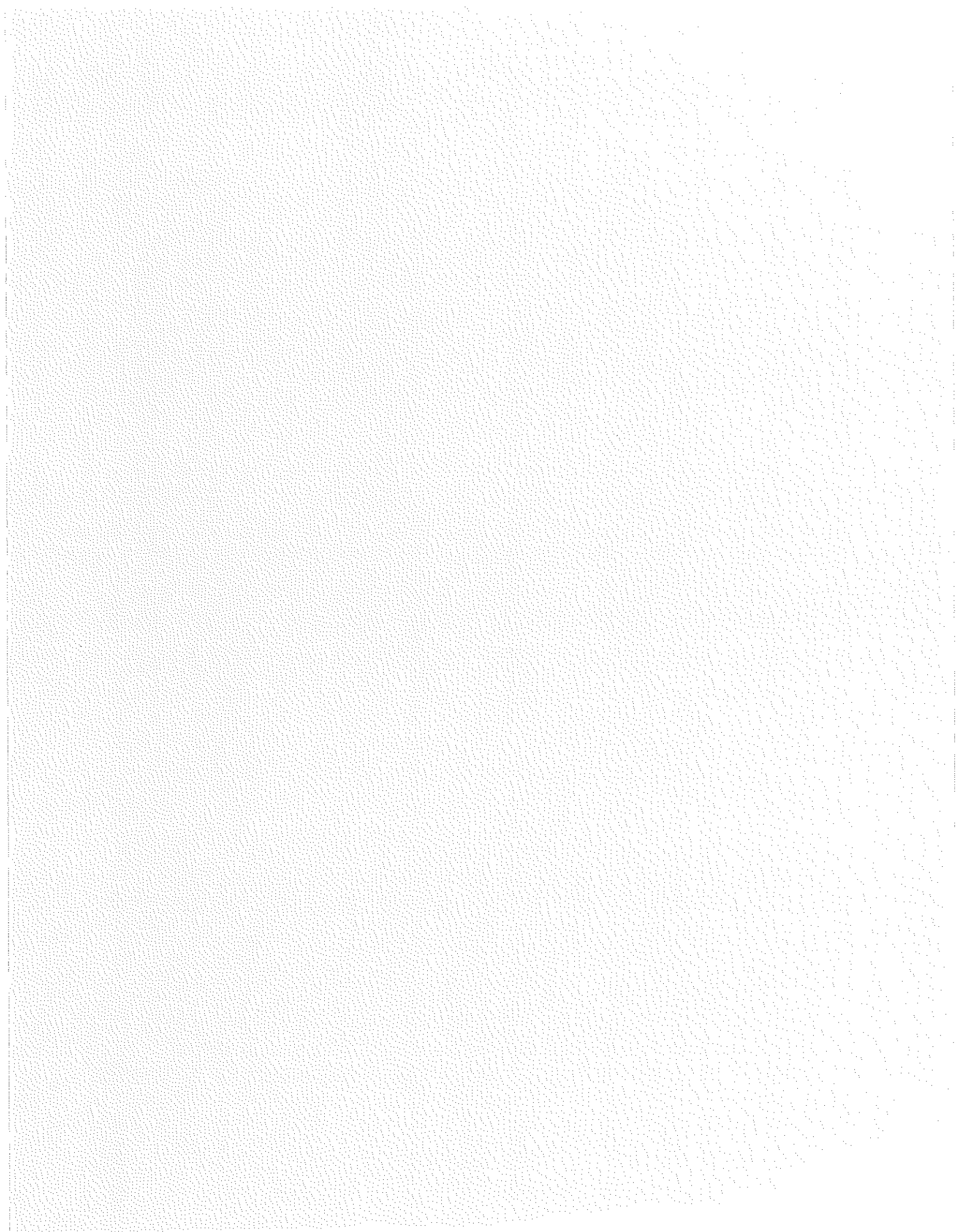


Rotation Diagram



Deflection Diagram





Sheet Pile Design According to Blum-Method

Project Name:

Date: 1/15/2010

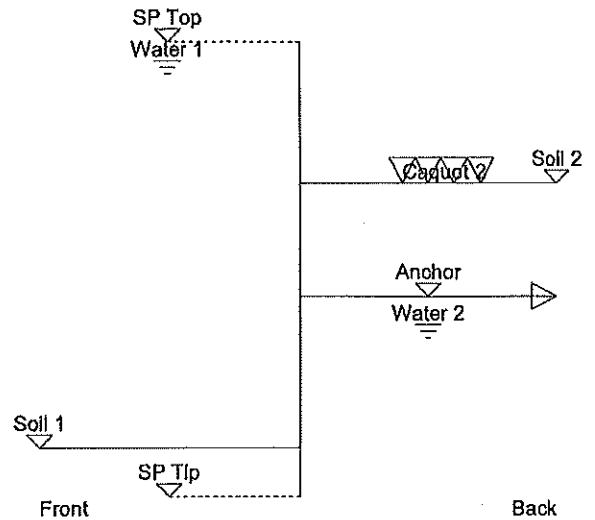
Author:

Company:

Comment:

Geodata

	Unit
Sheet Pile Top Level [ft]	-27.000
Sheet Pile Tip Level [ft]	21.217
Soil Level in Front [ft]	16.000
Soil Level behind [ft]	-12.000
Anchor level [ft]	0.000
Water Level in Front [ft]	-25.000
Water Level behind [ft]	3.000
Soil Surface Inclination in Front [Deg]	0.000
Soil Surface Inclination behind [Deg]	0.000
Caquot Surcharge in Front [kip/ft ²]	0.000
Caquot Surcharge behind [kip/ft ²]	0.200
Anchor Inclination [Deg]	0.000
Earth Support	Free



Soil Layers

Layers in Front

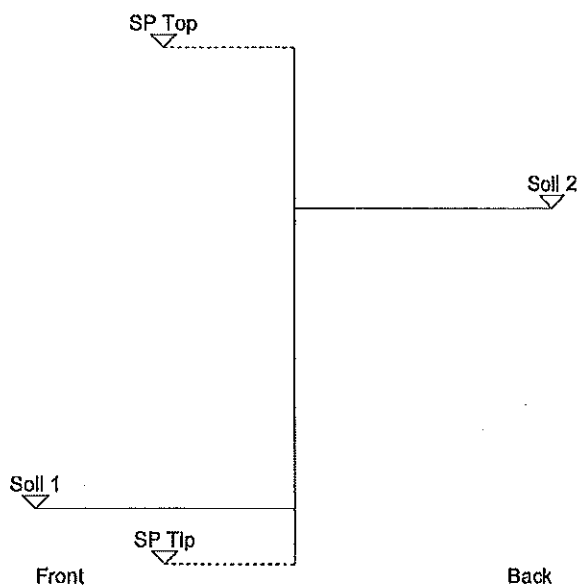
	Layer Tip [ft]	Density Moist [kip/ft3]	Density Submerged [kip/ft3]	Kph	Phi [Deg]	Delta [Deg]	Cohesion [kip/ft2]
Layer 1	25.000	0.100	0.040	1.000	20.000	14.000	0.360
Layer 2	56.000	0.110	0.085	3.250	32.000	14.000	0.000
Layer 3	125.000	0.110	0.075	1.000	44.000	14.000	3.000

Layers behind

	Layer Tip [ft]	Density Moist [kip/ft3]	Density Submerged [kip/ft3]	Kph	Phi [Deg]	Delta [Deg]	Cohesion [kip/ft2]
Layer 1	25.000	0.100	0.040	1.000	20.000	14.000	0.360
Layer 2	56.000	0.110	0.085	0.310	32.000	14.000	0.000
Layer 3	125.000	0.110	0.075	1.000	44.000	14.000	3.000

Boussinesq

	Distance Wall (ft)	Width Surcharge (ft)	Depth Surcharge (ft)	Surcharge (kip/ft2)
--	-----------------------	----------------------------	----------------------------	------------------------

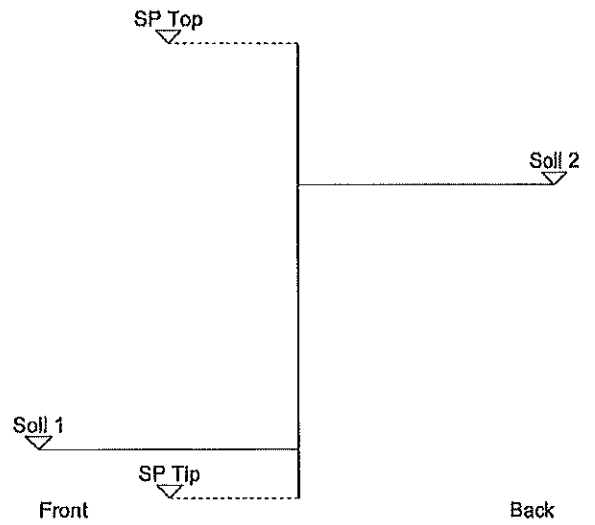


Userdefined Pressures

	Pressure Top [kip/ft ²]	Pressure Tip [kip/ft ²]	Depth Top [ft]	Depth Tip [ft]
--	-------------------------------------	-------------------------------------	----------------	----------------

Concentrated Forces

	Horiz. Component [kip/ft]	Vert. Component [kip/ft]	Depth Horiz. Comp. [ft]
--	---------------------------------	--------------------------------	----------------------------



Pile Section

Name	AZ13
Inertia [in4/ft]	144.258
Modulus [in3/ft]	24.180
Area [in2/ft]	6.468
Mass [lbs/ft2]	22.018
Steel Grade [lb/in2]	50000.000
Requested Safety	1.000

All Values

Depth [ft]	Deflection [ft]	Rotation [Rad]	Cross Force [kip/ft]	Moment [kip/ft]	Total Pressure [kip/ft]	Earth Pressure in Front [kip/ft]	behind [kip/ft]	Water Pressure [kip/ft]	Userdefined Pressure [kip/ft]
-27.000	-0.755	0.035	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-26.180	-0.728	0.035	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-26.180	-0.728	0.035	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-25.360	-0.697	0.035	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-25.360	-0.697	0.035	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-25.000	-0.684	0.035	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-25.000	-0.684	0.035	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-24.180	-0.655	0.035	-0.021	-0.006	-0.052	0.000	0.000	-0.052	0.000
-24.180	-0.655	0.035	-0.021	-0.006	-0.052	0.000	0.000	-0.052	0.000
-23.360	-0.626	0.035	-0.086	-0.047	-0.104	0.000	0.000	-0.104	0.000
-23.360	-0.626	0.035	-0.086	-0.047	-0.104	0.000	0.000	-0.104	0.000
-22.539	-0.597	0.035	-0.193	-0.158	-0.157	0.000	0.000	-0.157	0.000
-22.539	-0.597	0.035	-0.193	-0.158	-0.157	0.000	0.000	-0.157	0.000
-21.719	-0.568	0.035	-0.342	-0.375	-0.209	0.000	0.000	-0.209	0.000
-21.719	-0.568	0.035	-0.342	-0.375	-0.209	0.000	0.000	-0.209	0.000
-20.899	-0.539	0.035	-0.535	-0.732	-0.261	0.000	0.000	-0.261	0.000
-20.899	-0.539	0.035	-0.535	-0.732	-0.261	0.000	0.000	-0.261	0.000
-20.079	-0.510	0.035	-0.771	-1.264	-0.313	0.000	0.000	-0.313	0.000
-20.079	-0.510	0.035	-0.771	-1.264	-0.313	0.000	0.000	-0.313	0.000
-19.258	-0.481	0.035	-1.049	-2.007	-0.365	0.000	0.000	-0.365	0.000
-19.258	-0.481	0.035	-1.049	-2.007	-0.365	0.000	0.000	-0.365	0.000
-18.438	-0.453	0.035	-1.370	-2.996	-0.418	0.000	0.000	-0.418	0.000
-18.438	-0.453	0.035	-1.370	-2.996	-0.418	0.000	0.000	-0.418	0.000
-17.618	-0.424	0.035	-1.734	-4.266	-0.470	0.000	0.000	-0.470	0.000
-17.618	-0.424	0.035	-1.734	-4.266	-0.470	0.000	0.000	-0.470	0.000
-16.798	-0.395	0.035	-2.141	-5.852	-0.522	0.000	0.000	-0.522	0.000
-16.798	-0.395	0.035	-2.141	-5.852	-0.522	0.000	0.000	-0.522	0.000
-15.978	-0.367	0.035	-2.590	-7.790	-0.574	0.000	0.000	-0.574	0.000
-15.978	-0.367	0.035	-2.590	-7.790	-0.574	0.000	0.000	-0.574	0.000
-15.157	-0.339	0.034	-3.082	-10.113	-0.626	0.000	0.000	-0.626	0.000
-15.157	-0.339	0.034	-3.082	-10.113	-0.626	0.000	0.000	-0.626	0.000
-14.337	-0.311	0.034	-3.618	-12.858	-0.679	0.000	0.000	-0.679	0.000
-14.337	-0.311	0.034	-3.618	-12.858	-0.679	0.000	0.000	-0.679	0.000
-13.517	-0.283	0.034	-4.195	-16.059	-0.731	0.000	0.000	-0.731	0.000
-13.517	-0.283	0.034	-4.195	-16.059	-0.731	0.000	0.000	-0.731	0.000
-12.697	-0.256	0.033	-4.816	-19.752	-0.783	0.000	0.000	-0.783	0.000
-12.697	-0.256	0.033	-4.816	-19.752	-0.783	0.000	0.000	-0.783	0.000
-12.000	-0.233	0.033	-5.377	-23.301	-0.827	0.000	0.000	-0.827	0.000
-12.000	-0.233	0.033	-5.377	-23.301	-0.827	0.000	-0.520	-0.827	0.000
-11.180	-0.207	0.032	-6.077	-27.996	-0.879	0.000	-0.438	-0.879	0.000
-11.180	-0.207	0.032	-6.077	-27.996	-0.879	0.000	-0.438	-0.879	0.000
-10.360	-0.182	0.031	-6.820	-33.282	-0.932	0.000	-0.358	-0.932	0.000
-10.360	-0.182	0.031	-6.820	-33.282	-0.932	0.000	-0.358	-0.932	0.000
-9.539	-0.158	0.030	-7.605	-39.195	-0.984	0.000	-0.274	-0.984	0.000
-9.539	-0.158	0.030	-7.605	-39.195	-0.984	0.000	-0.274	-0.984	0.000
-8.719	-0.134	0.029	-8.434	-45.770	-1.036	0.000	-0.192	-1.036	0.000
-8.719	-0.134	0.029	-8.434	-45.770	-1.036	0.000	-0.192	-1.036	0.000
-7.899	-0.112	0.028	-9.305	-53.042	-1.088	0.000	-0.110	-1.088	0.000
-7.899	-0.112	0.028	-9.305	-53.042	-1.088	0.000	-0.110	-1.088	0.000
-7.079	-0.091	0.026	-10.219	-61.046	-1.140	0.000	-0.028	-1.140	0.000
-7.079	-0.091	0.026	-10.219	-61.046	-1.140	0.000	-0.028	-1.140	0.000
-6.258	-0.071	0.025	-11.154	-69.811	-1.138	0.000	0.054	-1.193	0.000
-6.258	-0.071	0.025	-11.154	-69.811	-1.138	0.000	0.054	-1.193	0.000
-5.438	-0.054	0.023	-12.075	-79.339	-1.109	0.000	0.136	-1.245	0.000
-5.438	-0.054	0.023	-12.075	-79.339	-1.109	0.000	0.136	-1.245	0.000
-4.618	-0.038	0.020	-12.972	-89.613	-1.079	0.000	0.218	-1.297	0.000
-4.618	-0.038	0.020	-12.972	-89.613	-1.079	0.000	0.218	-1.297	0.000
-3.798	-0.026	0.018	-13.845	-100.613	-1.049	0.000	0.300	-1.349	0.000
-3.798	-0.026	0.018	-13.845	-100.613	-1.049	0.000	0.300	-1.349	0.000
-2.978	-0.014	0.015	-14.693	-112.318	-1.019	0.000	0.382	-1.401	0.000
-2.978	-0.014	0.015	-14.693	-112.318	-1.019	0.000	0.382	-1.401	0.000
-2.157	-0.005	0.012	-15.517	-124.709	-0.989	0.000	0.464	-1.454	0.000
-2.157	-0.005	0.012	-15.517	-124.709	-0.989	0.000	0.464	-1.454	0.000
-1.337	0.000	0.008	-16.316	-137.766	-0.960	0.000	0.546	-1.506	0.000

Depth [ft]	Deflection [ft]	Rotation [Rad]	Cross Force [kip/ft]	Moment [kip/ft]	Total Pressure [kip/ft2]	Earth Pressure In Front [kip/ft2]	behind [kip/ft2]	Water Pressure [kip/ft2]	Userdefined Pressure [kip/ft2]
-1.337	0.000	0.008	-16.316	-137.766	-0.960	0.000	0.546	-1.506	0.000
-0.517	0.002	0.004	-17.091	-151.468	-0.930	0.000	0.628	-1.558	0.000
-0.517	0.002	0.004	-17.091	-151.468	-0.930	0.000	0.628	-1.558	0.000
0.303	0.000	0.000	-17.841	-165.795	-0.900	0.000	0.710	-1.610	0.000
0.303	0.000	0.000	-17.841	-165.795	-0.900	0.000	0.710	-1.610	0.000
1.123	0.002	0.005	-18.567	-180.728	-0.870	0.000	0.792	-1.662	0.000
1.123	0.002	0.005	-18.567	-180.728	-0.870	0.000	0.792	-1.662	0.000
1.944	0.008	0.010	-19.268	-196.247	-0.840	0.000	0.874	-1.716	0.000
1.944	0.008	0.010	-19.268	-196.247	-0.840	0.000	0.874	-1.716	0.000
2.764	0.018	0.015	-19.945	-212.330	-0.810	0.000	0.956	-1.767	0.000
2.764	0.018	0.015	-19.945	-212.330	-0.810	0.000	0.956	-1.767	0.000
3.000	0.022	0.017	-20.136	-217.062	-0.802	0.000	0.980	-1.782	0.000
3.000	0.022	0.017	-20.136	-217.062	-0.802	0.000	0.980	-1.782	0.000
3.820	0.038	0.023	-20.780	-233.844	-0.769	0.000	1.013	-1.782	0.000
3.820	0.038	0.023	-20.780	-233.844	-0.769	0.000	1.013	-1.782	0.000
4.640	0.060	0.029	-21.397	-251.143	-0.736	0.000	1.046	-1.782	0.000
4.640	0.060	0.029	-21.397	-251.143	-0.736	0.000	1.046	-1.782	0.000
5.461	0.087	0.036	-21.988	-268.937	-0.703	0.000	1.078	-1.782	0.000
5.461	0.087	0.036	-21.988	-268.937	-0.703	0.000	1.078	-1.782	0.000
6.281	0.119	0.044	-22.551	-287.205	-0.671	0.000	1.111	-1.782	0.000
6.281	0.119	0.044	-22.551	-287.205	-0.671	0.000	1.111	-1.782	0.000
7.101	0.159	0.052	-23.088	-305.923	-0.638	0.000	1.144	-1.782	0.000
7.101	0.159	0.052	-23.088	-305.923	-0.638	0.000	1.144	-1.782	0.000
7.921	0.205	0.060	-23.697	-325.071	-0.605	0.000	1.177	-1.782	0.000
7.921	0.205	0.060	-23.697	-325.071	-0.605	0.000	1.177	-1.782	0.000
8.742	0.258	0.069	-24.080	-344.626	-0.572	0.000	1.210	-1.782	0.000
8.742	0.258	0.069	-24.080	-344.626	-0.572	0.000	1.210	-1.782	0.000
9.562	0.319	0.079	-24.636	-364.565	-0.539	0.000	1.242	-1.782	0.000
9.562	0.319	0.079	-24.636	-364.565	-0.539	0.000	1.242	-1.782	0.000
10.382	0.388	0.089	-24.965	-384.868	-0.507	0.000	1.275	-1.782	0.000
10.382	0.388	0.089	-24.965	-384.868	-0.507	0.000	1.275	-1.782	0.000
11.202	0.465	0.100	-25.367	-405.511	-0.474	0.000	1.308	-1.782	0.000
11.202	0.465	0.100	-25.367	-405.511	-0.474	0.000	1.308	-1.782	0.000
12.022	0.551	0.111	-25.742	-426.473	-0.441	0.000	1.341	-1.782	0.000
12.022	0.551	0.111	-25.742	-426.473	-0.441	0.000	1.341	-1.782	0.000
12.843	0.647	0.123	-26.090	-447.732	-0.408	0.000	1.374	-1.782	0.000
12.843	0.647	0.123	-26.090	-447.732	-0.408	0.000	1.374	-1.782	0.000
13.663	0.752	0.135	-26.411	-469.265	-0.375	0.000	1.407	-1.782	0.000
13.663	0.752	0.135	-26.411	-469.265	-0.375	0.000	1.407	-1.782	0.000
14.483	0.868	0.148	-26.706	-491.051	-0.343	0.000	1.439	-1.782	0.000
14.483	0.868	0.148	-26.706	-491.051	-0.343	0.000	1.439	-1.782	0.000
15.303	0.995	0.161	-26.973	-513.067	-0.310	0.000	1.472	-1.782	0.000
15.303	0.995	0.161	-26.973	-513.067	-0.310	0.000	1.472	-1.782	0.000
16.000	1.112	0.173	-27.179	-531.934	-0.282	0.000	1.500	-1.782	0.000
16.000	1.112	0.173	-27.179	-531.934	-1.002	-0.720	1.500	-1.782	0.000
16.820	1.260	0.188	-28.001	-554.564	-1.002	-0.753	1.533	-1.782	0.000
16.820	1.260	0.188	-28.001	-554.564	-1.002	-0.753	1.533	-1.782	0.000
17.640	1.420	0.203	-28.823	-577.868	-1.002	-0.786	1.566	-1.782	0.000
17.640	1.420	0.203	-28.823	-577.868	-1.002	-0.786	1.566	-1.782	0.000
18.461	1.593	0.219	-29.645	-601.845	-1.002	-0.818	1.598	-1.782	0.000
18.461	1.593	0.219	-29.645	-601.845	-1.002	-0.818	1.598	-1.782	0.000
19.281	1.779	0.235	-30.466	-626.497	-1.002	-0.851	1.631	-1.782	0.000
19.281	1.779	0.235	-30.466	-626.497	-1.002	-0.851	1.631	-1.782	0.000
20.101	1.979	0.253	-31.288	-651.823	-1.002	-0.884	1.664	-1.782	0.000
20.101	1.979	0.253	-31.288	-651.823	-1.002	-0.884	1.664	-1.782	0.000
20.921	2.194	0.271	-32.110	-677.823	-1.002	-0.917	1.697	-1.782	0.000
20.921	2.194	0.271	-32.110	-677.823	-1.002	-0.917	1.697	-1.782	0.000
21.217	2.275	0.277	-32.405	-687.340	-1.002	-0.929	1.709	-1.782	0.000

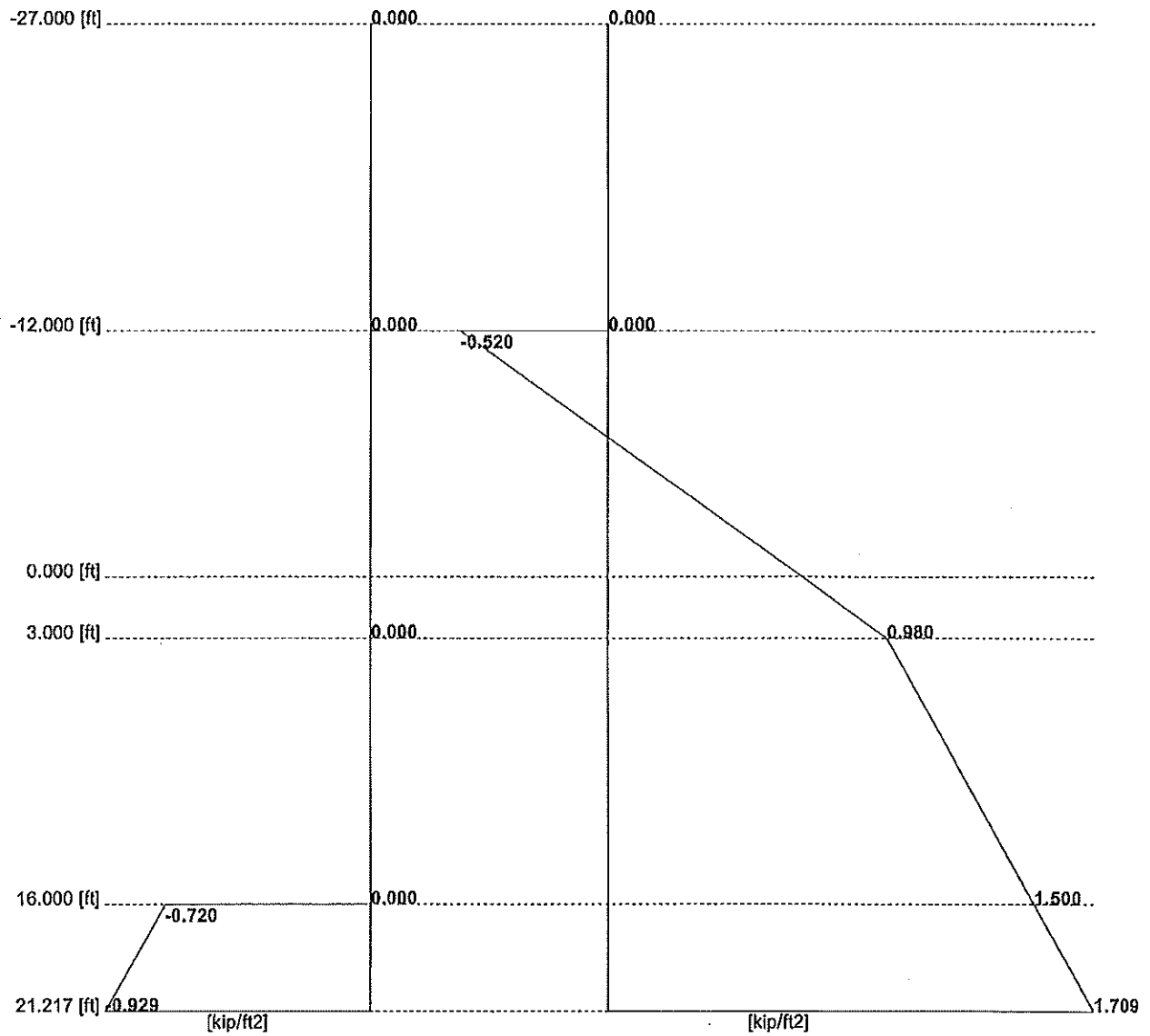
Extremal Values

	z Min [ft]	Min	z Max [ft]	Max
Deflection [ft]	-27.000	-0.755	21.217	2.275
Gross Force [kip/ft]	21.217	-32.405	-27.000	0.000
Moment [kipft/ft]	21.249	-688.412	-24.998	0.000

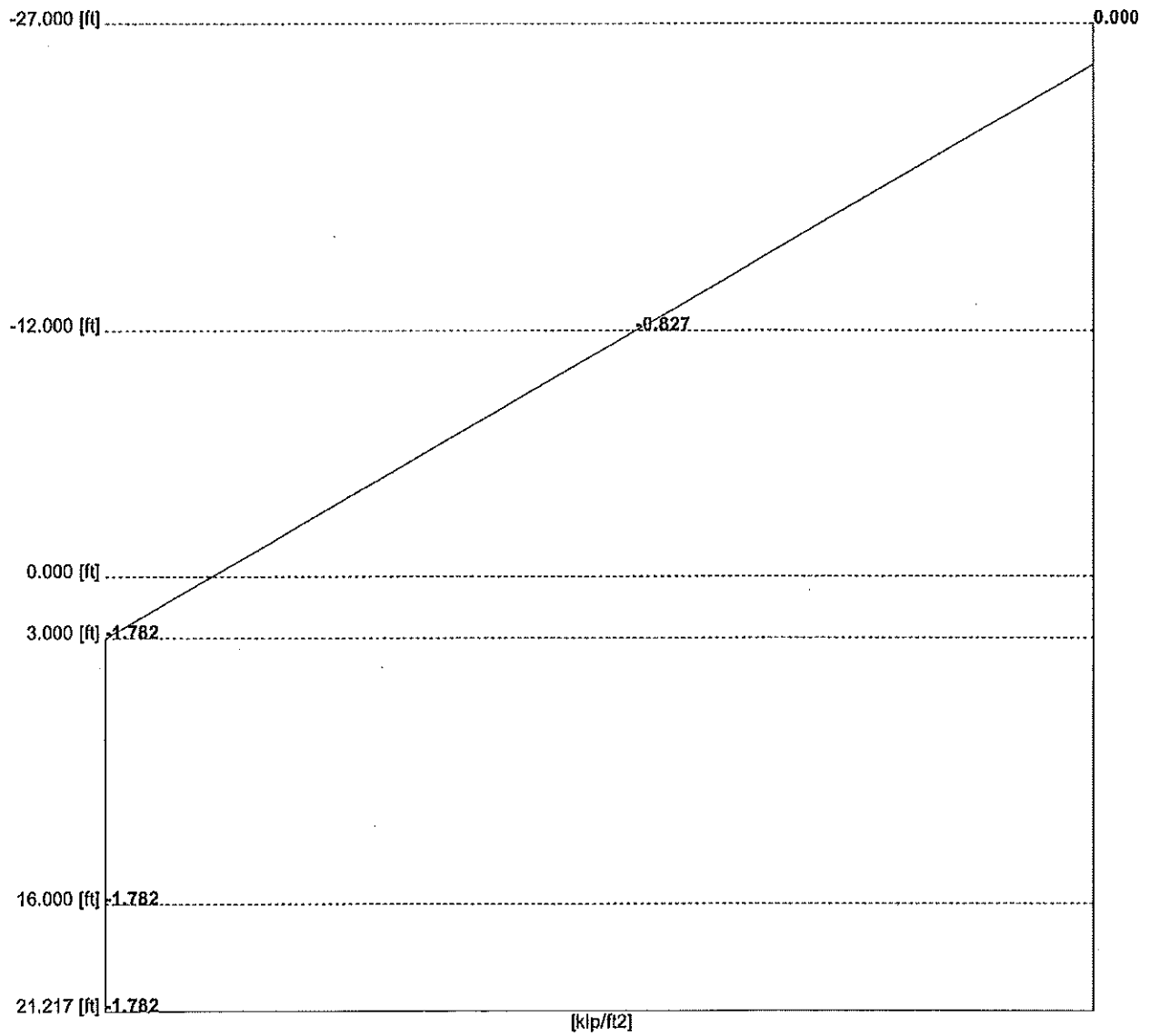
Pile Check

		Depth [ft]
Name	AZ13	
Inertia [in4/ft]	144.258	
Modulus [in3/ft]	24.180	
Area [in2/ft]	6.468	
Mass [lbs/ft2]	22.018	
Steel Grade [lb/in2]	50000.000	
Minimal Moment [kip/ft]	-688.412	21.249
Maximal Moment [kip/ft]	0.000	-24.999
Normal Forces at Max. Moment [kip/ft]	8.034	21.249
Normal Forces at Min. Moment [kip/ft]	0.000	-24.999
Deflection at Min. Moment [ft]	0.000	21.249
Deflection at Max. Moment [ft]	-0.655	-24.999
Min. Stress at Min. Moment [lb/in2]	-340388.188	21.249
Max. Stress at Min. Moment [lb/in2]	342872.469	21.249
Min. Stress at Max. Moment [lb/in2]	0.000	-24.999
Max. Stress at Max. Moment [lb/in2]	0.000	-24.999
Safety < Req. Safety = 1.000	0.146	
Sheet Pile Top Level [ft]	-27.000	
Sheet Pile Tip Level [ft]	21.217	
Sheet Pile Length [ft]	48.217	
Included OverLength [ft]	0.000	
Vertical Equilibrium [kip/ft]	8.034	
Anchor Force (horiz.) [kip/ft]	32.397	

Earth Pressure Diagram



Water Pressure Diagram



Userdefined Pressure Diagram

-27.000 [ft] 0.000

-12.000 [ft] 0.000

0.000 [ft]

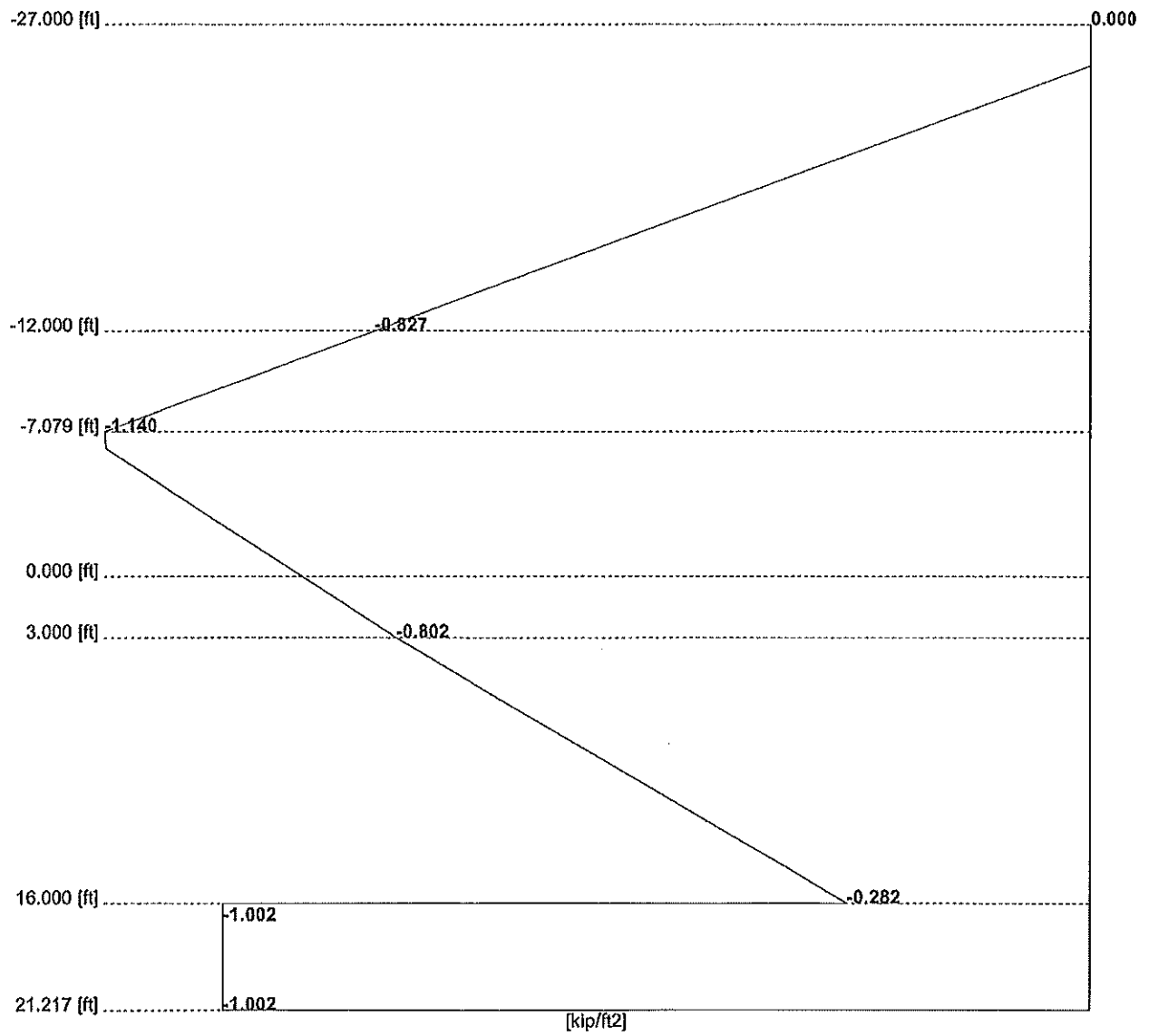
3.000 [ft] 0.000

16.000 [ft] 0.000

21.217 [ft] 0.000
[kip/ft2]

Boussinesq Diagram

Total Pressure Diagram



APPENDIX II — **Information from Joe Lombardi**

TABLE OF CONTENTS

	Page
I. Vessel History	5
II. The Basic Structure of Naval Submarines	10
III. Preamble	17
IV. Vessel Data	18
V. Hull – Exterior	26
VI. Hull – Interior	41
VII. Electronics, Ventilation, Firefighting, Maintenance Plan	63
VIII. Supplemental Recommendations	64
IX. Summary	67

JOSEPH W. LOMBARDI

Marine Surveyor & Consultant

OCEAN TECHNICAL SERVICES, LLC.

P.O. Box 1576, Manchester, Massachusetts 01944 Office (978)-526-1894 Fax (978)-526-8390

Vessel Survey Report No. 2344

Vessel surveyed at: Berth Site, Patriot's Point Museum, Mt. Pleasant, SC
Dates of survey: 19 - 28 April 2008

Vessel surveyed: U.S.S. CLAMAGORE (SS - 343)

Survey commissioned by: Mr. Bob Howard
Patriots Point Naval & Maritime Museum
40 Patriots Point Road
Mount Pleasant, SC 29464

Office 843-881-5978
Fax 843-881-5979

Purpose of survey: Structural Survey

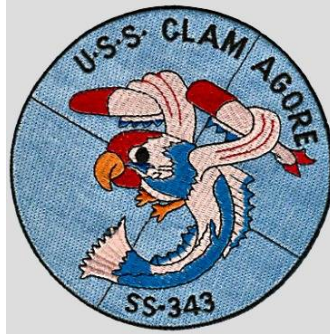
DISCUSSION

The Code of Federal Regulations (CFR), American Boat & Yacht Council (ABYC), International Marine Organization (IMO), National Fire Protection Association (NFPA), and the Society of Naval Architects and Marine Engineers (SNAME) are utilized in compiling this report; individual reference to subchapters of the above is not made within the body of this report. Other sources include the 'U.S. Navy Towing Manual', Naval Sea Systems Command, 'Manual on Ship Construction', George C. Manning: Van Nostrand Co., and 'Standards For Steel Hulled Vessels', American Bureau of Shipping, 'Stability and Trim for the Ship's Officer' by William E. George, Cornell Maritime Press and 'Ship Design and Construction' by the Society of Naval Architects and Marine Engineers.



VESSEL HISTORY

Keel Laid down by Electric Boat Division of General Dynamics Corp., Groton, CT 16MAR44;
Launched: 25FEB45 with Miss Mary Jane Jacobs sponsoring;
Commissioned: 28JUN45 with Cdr Sam Colby Loomis, Jr., in command;
Decommissioned: 12JUN75 and struck from the Navy List 27JUN75;
Serving as Museum Ship at Patriot's Point, Charleston, South Carolina.



World War II came to end while USS CLAMAGORE (SS-343) was on a training cruise off Panama. In January, 1946, CLAMAGORE became Flagship of Submarine Squadron FOUR based in Key West, Florida. CLAMAGORE carried the Squadron Flag until 1 August 1959.



U.S.S. CLAMAGORE at Key West, 1946, before conversions.

The U.S. Naval Shipyard, Philadelphia, Pennsylvania, was the site of CLAMAGORE's conversion to high speed GUPPY II (Greater Underwater Propulsion Power) submarine in the spring and summer of 1948. During this conversion, she received the snorkel installation.

During 1949 Fleet Tactical Exercise, CLAMAGORE was accorded the honor of being selected Flagship for Vice Admiral Duncan, USN, Commander Task Fleet, and Rear Admiral Fife, USN, Commander Submarine Force, U.S. Atlantic Fleet.

During 1955 CLAMAGORE made two trips to Guantanamo Bay, Cuba, rendering services to the Fleet Training Group for the periods 25 March to 25 April and 22 August to 16 September. Other ports visited

VESSEL HISTORY (cont.)

during 1955 were Havana, Fort Lauderdale, and Pensacola, Florida. In November CLAMAGORE entered Charleston Naval Shipyard for installation of a new battery.



U.S.S. CLAMAGORE, post 1948 conversion to snorkel boat.

Upon leaving the shipyard in February, 1956, CLAMAGORE returned to Key West for operations. She visited Tampa, Mayport, and Miami, and Havana and Guantanamo Bay, Cuba; prior to entering the Charleston Naval Shipyard in September, 1956, for a regular scheduled overhaul.

The overhaul was completed in February, 1957, and CLAMAGORE went to New London Connecticut and Newport, Rhode Island prior to returning to Key West. A trip to Guantanamo Bay, Cuba preceded an extended cruise to Portsmouth, England, which was followed by liberty in Argentina, Newfoundland, on the return to Key West in December.

In February, 1958, CLAMAGORE participated in ASWEX 1-58. From June to August, CLAMAGORE was in Charleston Naval Shipyard for a battery renewal. During the local operations from Key West, V visited Savannah, Mobile, Alabama; and Tampa and Fort Lauderdale, Florida.

Local operations from Key West and a trip to Guantanamo Bay, Cuba were made from January to April, 1959. In April, CLAMAGORE participated in Exercise LANTBEX 1-59 and returned to Key West in June. The arrival of CLAMAGORE at Charleston Naval Shipyard for an overhaul on 29 June coincided with the change in home port of Submarine Squadron FOUR to Charleston. Overhaul was completed in December. From April to July, 1960 CLAMAGORE served with the U.S. Sixth Fleet in the Mediterranean.

During January and February, 1961, CLAMAGORE participated in operation Springboard in the Caribbean. From August to December, 1961, CLAMAGORE participated in Operation UNITAS II which was a joint antisubmarine warfare training exercise with eight South American countries: Argentina, Brazil, Chile, Colombia, Ecuador, Peru, Venezuela and Uruguay. During this cruise CLAMAGORE steamed around the southern tip of the South American Continent.

CLAMAGORE entered Charleston Naval Shipyard in May, 1962, for conversion to a GUPPY III type submarine. During this conversion, the ship was cut in half and a 15 foot, 55 ton section was added. The latest and most sophisticated electronics and fire control system were also installed.

VESSEL HISTORY (cont.)

On 2 July 1962 the new hull section was christened by Miss Ann Beshany, 16-year-old daughter of Captain P.A. Beshany, then Commander Submarine Squadron FOUR.

The conversion to a GUPPY III was completed in February, 1963. On 1 June 1963 CLAMAGORE changed homeports to New London, Connecticut at which time she was transferred from Submarine Squadron FOUR to Submarine Squadron TWO. During January and February of the following year, CLAMAGORE participated in Springboard, 1964, visiting San Juan in Puerto Rico and Saint Croix in the Virgin Islands. In late May she entered Portsmouth Naval Shipyard for battery renewal. Leaving the shipyard in July, CLAMAGORE visited Portsmouth, England in September, 1964. After an extended cruise, CLAMAGORE returned to New London in November, 1964.



U.S.S. CLAMAGORE departing New London, post GUPPY III conversion.

In early April, 1965, CLAMAGORE departed New London for a joint NATO operation south of Iceland with British, Dutch, American, and French submarines and aircraft. Upon completion of the very successful exercise, CLAMAGORE visited Londonderry in Northern Ireland in late May, 1965, for a wash-up conference. Following her return to New London in June; CLAMAGORE entered the Philadelphia Naval Shipyard on 23 July 1965. During this overhaul, CLAMAGORE received an extensive repair of its hydraulic system, the installation of the STEINKE Escape System, the modernization of its fire control system, and the overhaul of its main propulsion motors and generators. These and other repairs cost approximately \$1,650,000. This shipyard overhaul was completed on 19 January 1966.

In early 1966 the CLAMAGORE was devoted to Springboard deployments and various other operational tasks. In March of 1967 CLAMAGORE entered Portsmouth Naval Shipyard for main battery renewal. Upon leaving the shipyard she rejoined the fleet for a Mediterranean deployment. She returned to New London in late 1967 and in March 1968 left for extensive operations in the North Atlantic. Her efforts resulted in her eight Battle "E".

After the 1968 overhaul in Philadelphia CLAMAGORE was engaged in type training, SSBN training cruises and local operations. In August, she headed south toward Bermuda where she participated in SUBASWEX 4-69. After more local operations out of New London, she returned to the Virgin Islands for a Weapons System Acceptance Trial.

VESSEL HISTORY (cont.)

1970 began with another Springboard deployment followed by a battery renewal. Another Mediterranean deployment followed the shipyard period where she operated extensively with aircraft, surface craft, and submarines from various allied navies. CLAMAGORE then operated up and down the coast from Halifax, Nova Scotia to the Virgin Islands during much of 1971. September of 1971 found her engaged in operations in the Norwegian Sea. She spent the remainder of the 1971 in New London in upkeep and preparation for her scheduled overhaul. The 1972 overhaul was accomplished in Philadelphia. This major effort was completed in June, one month short of schedule.

The remainder of 1972 was devoted to a two-month deployment to the Caribbean encompassing refresher training, type training and a highly successful Weapons System Acceptance Trial. November 1972 saw the satisfactory completion of Successful Nuclear Weapons Acceptance Inspection.

In 1973, a month of local operations preceded a restricted availability at Portsmouth for main battery renewal and a main engine replacement. During the availability, preparations were begun for the upcoming UNITAS XIV deployment.



Clamagore (SS-343) against pier, Tiru (SS-416), Blenny (SS-324) & Albacore (AGSS-569), circa early 80's at the Philadelphia Navy Yard.

CLAMAGORE decommissioned 12 June 1975 and was struck from the Navy List on 27 June 1975 and now serves as a Museum Ship at Patriot's Point, Charleston, South Carolina.

THE BASIC STRUCTURE OF NAVAL SUBMARINES

The structure of a modern submarine consists of a watertight envelope, which is designed to resist the pre-determined operational hydrostatic pressure. The principal elements are stiffened cylindrical sections, stiffened conical sections and the noncircular sections of the stiffened pressure hull, and closed end sections. Additionally, there is a secondary structure, which does not withstand the submerged sea pressure, called the non-pressure hull or outer hull.

The primary structural components, as in any ship, are the hull plating, hull stiffeners, and bulkheads. In the case of submarines, however, the thickness of the pressure hull plating is considerably greater than the hull plating for a surface ship since it is designed to resist the hydrostatic loads of depths above 400 feet. This heavy steel shell, approaching 7/8 inch thick, is further strengthened by circular ring frames positioned externally and/or internally depending on location. These hull frames are of either T or H cross section and are either rolled or welded-up shapes. They are generally spaced at 0.1 to 0.2 diameters apart.

Further wing bulkheads are placed to form tank boundaries, and additional stiffening with the shaped-end closure bulkheads complete the watertight hull.

To further delineate the study of submarine structure, we must first consider the structure in several main categories.

PRESSURE HULL

The pressure (strength) hull or the inner hull, as it is commonly referred to, must be comparatively strong and heavy to withstand hydrostatic pressures of deep submergence (test depth pressure). The principal structure associated with the pressure hull include the transverse bulkheads, which subdivide the submarine's length into watertight compartments, and circular transverse frames, both inside and out, which strengthen the hull and prevent collapsing when subject to test depth pressures. The pressure hull must form a watertight shell completely enclosing the operating spaces of the ship.

OUTER HULL

The outer hull forms the external boundary of the submarine except for appendages such as the superstructure, conning tower, and fairwater (sail). The principal outer hull structure includes a system of frames and bulkheads to subdivide the enclosed volume into tankage compartments. Certain portions of the outer hull, however, are subject to test depth pressures. These tanks (hard tanks) have heavily constructed frames and bulkheads which are almost a continuation of pressure hull framing rather than the lighter structure always found in the portion of the outer hull forming external boundaries for tanks not subject to sea pressure. The outer hull structure also includes the vertical and flat plate keels.

APPENDAGES

Appendages are structural items, control surfaces, piping, and other gear external to the outer hull. It should be noted that the total volume displaced by a submerged ship equals the volume displaced by the outer hull plus the volume of the appendages.

Member SAMS, ABYC, HNSA & SNAME



THE BASIC STRUCTURE OF NAVAL SUBMARINES (cont.)

SUPERSTRUCTURE AND FAIRWATER

The superstructure and fairwater are constructed of lightweight plating and fiberglass panels bolted to the steel frames, as they are not subjected to any severe stresses and are not an integral part of the vessel's strength members. The form of the superstructure and fairwater provides an easy flow of water around blunt projections, thereby de-creasing submerged resistance to forward motion. It is important to note that the void space en-closed by the superstructure and fairwater has nothing to do with the ship's submersible properties as it is completely vented and free flooding.

TANKAGE

Generally, submarine tankage can be separated into two main classes: high-pressure tanks and non-pressure tanks. High pressure tanks are heavily constructed tanks built to withstand test depth pressures. During normal submerged operations, these tanks are completely full either with seawater, fuel oil, or a combination of both. Non-pressure tanks are of light construction and, though exposed to the sea, are not subject to hydrostatic pressures. During normal submerged operations, these tanks are always completely full either with seawater, fuel oil, or a combination of both. Non-pressure tanks not directly connected to the sea, such as normal fuel oil tanks, are equipped to admit seawater and maintain pressure equilibrium.

Another division of the principal tankage is by groups according to their function. The abbreviations HP and NP in the following list refer to the high pressure and non-pressure classification:

1. Diving ballast, NP, (soft)
 - a. Main ballast tanks
 - b. Fuel ballast tanks - used as such when converted to be a part of the main ballast system
2. Variable ballast, HP, (hard)
 - a. Forward trim tank
 - b. Auxiliary tanks
 - c. After trim tank
 - d. Variable fuel oil tanks

Safety and negative tanks can also be used in the variable ballast system.

3. Fuel tanks
 - a. Normal fuel tanks, NP
 - b. Fuel ballast tank, NP - used as such when not part of the main ballast system
 - c. Variable fuel oil tanks, HP
 - d. Fuel oil collecting and expansion tanks, NP
- 4.) Special purpose tanks
 - a. Bow buoyancy tanks, NP
 - b. Safety tank, HP
 - c. Negative tank, HP

THE BASIC STRUCTURE OF NAVAL SUBMARINES (cont.)

Test Depth and High Yield

A definition of HY steel, (high yield) as well as the relation between test depth and crush depth is in order. It is difficult to discuss these concepts without also discussing hull strength. These explanations are sandwiched between narratives of harrowing dives that took American submarines far below their test depths.

The following provides some basic information on submarine hull strength including the definition of test depth and high yield:

Test depth is a theoretical number corresponding to the amount of area pressure that can be applied to a hull before it is violated by either distortion, warping, buckling or cracking. The pressure hull acts to prevent an equalization of pressure on both sides of the hull surface. When pressure is equal on both sides of a hull, such as is the case in a submarine's external ballast tanks, there is no need to attend to the problem of potential collapse.

Test depth can be thought of as an engineering estimate of what pressure will be required on one side of a hull to breach the hull, taking into account such factors of hull strength as hull diameter, hull thickness, framing, and intrusions. Naval engineers tend to be conservative in their estimates and the varied factors tend to render an estimate as just that, an estimate. The engineers back into the problem by first estimating the crush depth of a hull, then creating the theoretical test depth by applying a decimal factor to the crush depth. Different national navies apply varying factors. The United States Navy has used a factor of 1.5, but this has changed many times. Of course, computers are able to make such estimates much more trustworthy, however, the accounts described "Steep Angles and Deep Dives" are, for the most part, in hulls designed before the advent of the computer.

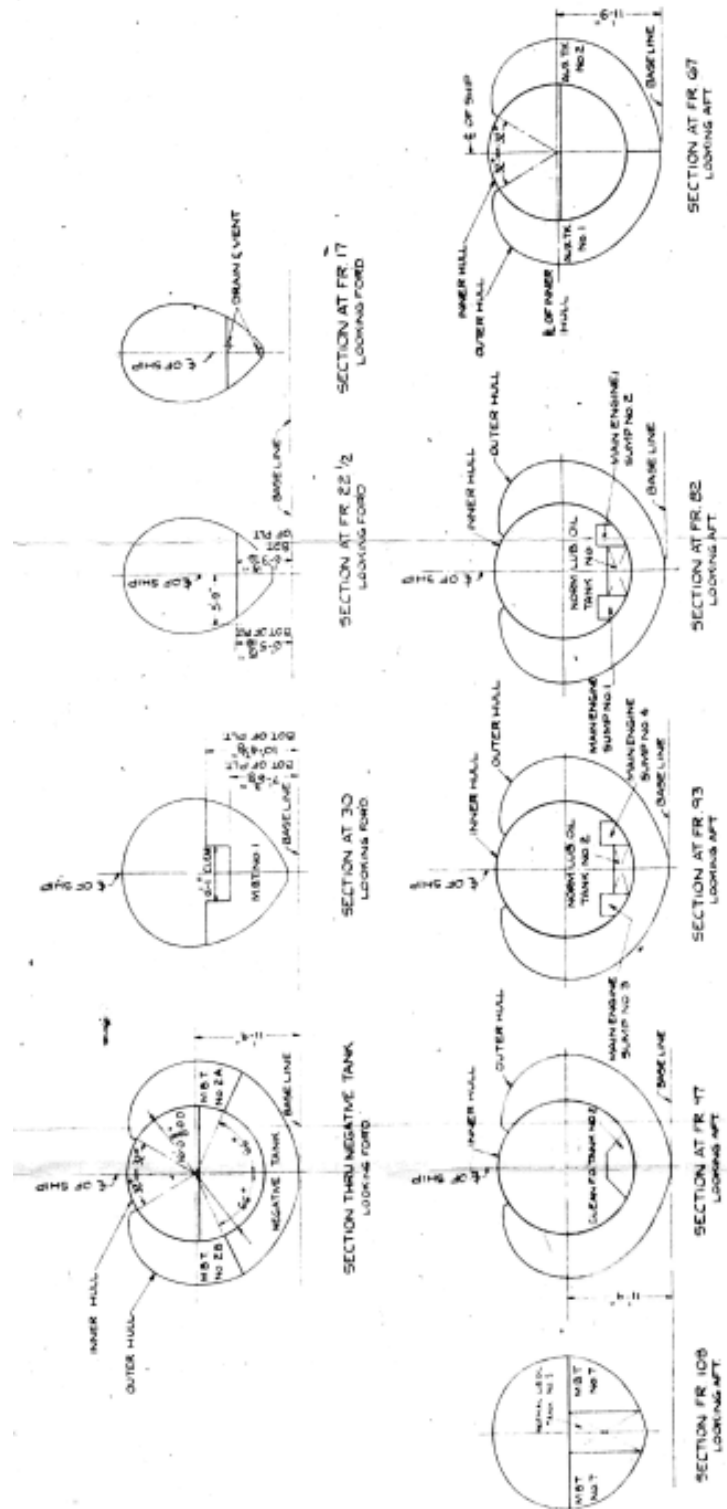
In the U.S. Navy, hull designers depend on the experience of submarines to verify their estimates. Buships requires a submarine captain to immediately notify both Buships and the Chief of Naval Operations in writing when a boat under his command exceeds test depth. The captain's professional career may be jeopardized by a zealous attention to recording a dive that went wrong. Only in wartime can a captain reasonably explain the need to exceed test depth. For this reason submarines exceeding test depth sometimes fail to make note of the dive in their deck logs.

The simplest application of determining hull strength is the hull thickness. The thicker the hull metal the stronger the hull and the deeper the test depth, assuming all other factors are constant. Prior to the Balao class U.S. submarine, hulls were built of mild steel (MS) which had a maximum tensile strength of 60,000 pounds per square inch and a yield strength of 45,000 psi with 23 percent elongation. The thickness of hull plating until about 1943 was specified in terms of the weight of a square foot of plate rather than the actual thickness, and this was gradually increased from 20 pound plate (approximately one half inch) to twenty seven and a half pounds per square inch in the Salmon (SS-182).

Another change in the Balao class was the change in material used for hulls. High tensile steel was a chromium-vanadium alloy with a maximum tensile strength of 50,000 psi with 20 percent elongation. When the composition was changed to titanium-manganese alloy, because of wartime shortages, the strength dropped to 45,000 psi. The Salmon's hull was about seven eighths of an inch thick giving her a test depth of 250 feet. Conning tower shells were thicker as protection against surface guns.

The thick-skinned boats came along in 1942 with a test depth of 412 feet. These boats had the same seven eighths inch thick hull as Salmon, but the quality of hull steel ie., high tensile strength steel had significantly improved. The crush depth of these boats was estimated to be around 450 feet. Fleet type submarines built during the Second World War were to last through much of the cold war. These boats have careers that have lasted over fifty years with several still being used by foreign navies.

THE BASIC STRUCTURE OF NAVAL SUBMARINES (cont.)



Hull sections for CLAMAGORE.

THE BASIC STRUCTURE OF NAVAL SUBMARINES (cont.)

After the war the Navy built several fast attack submarines. These had hulls about an inch and a half thick. They had a test depth of 700 feet. The same hull thickness and quality of steel was used on the early nuclear submarines.

A modern nuclear powered submarine normally has a test depth of over 2000 feet. This huge increase in operational depth came about from increasing the thickness of a hull, from strides in improving the quality of steel, from improvements in the manufacturing process and in hull framing.

Steel is an alloy made up of several metals other than iron. These may include chromium, nickel, manganese, titanium and a host of others. Metallurgy is the science of combining these elements to produce an iron metal that meets a specific need, in this case a hull which is resistant to sea pressure. During the Second World War Krupp of Germany and others used advanced techniques to produce hull plating of unusually high quality. America inherited some of the formulae and steel mills benefited by the German experience.

The key to producing metal hulls suitable to deep diving submarines is the quality of yield strength in combination with compression strength. Accurately controlled element content and relatively high percentages of alloy additives produces strength. The compression strength curve is relatively flat until it reaches a point where the molecules can no longer bind, then the metal fails by cracking and splitting. On the other hand it is possible to produce a metal hull that has the quality of bending rather than rupturing. It yields under pressure where its elasticity, (elongation) gradually succumbs to increasing pressure. The trick for the metallurgist is to strike a compromise and to use the correct ratio of alloy elements to gain a hull plate that resists pressure to the maximum through high compression strength, but yields enough to forestall the rupturing of the metal.

Steel strength is often measured by tensile strength. In this test the metal is pulled on both ends until it parts. Tensile strength is related to compression strength even though the tests are opposite, one pulling and the other pushing. For this reason submarine steel strength is often measured in tensile strength, not withstanding the nature of sea pressure as a compression force.

ALBACORE was constructed of HY-80 steel, the first of its kind to utilize this material.

Current American submarines such as the SEAWOLF and VIRGINIA use HY (high yield) 100 metals.

These designators attend to the elements used in the submarine hull's alloy where essentially the higher the number the more resilient and resistant the metal is to pressure.

The combination of elements to produce an alloy with great strength is only half the story of producing submarine hulls. The second factor in the manufacturing process is the tempering of the steel and shaping of the plates into a final form. Once again, the basic concept is that a slow-cooling steel tends to be resilient and a quick cooling steel tends to be brittle. Metallurgists in the middle ages learned this early on and after shaping a red hot sword on an anvil plunged it into water. This gave the sword a fine cutting edge resistant to chipping and dulling. The down side was that when struck by another sword it tended to shatter rather than yield. Thus, a submarine's hull plating is cooled at a specific rate designed to produce the best combination of stress and yield factors.

The shaping of the plate in the factory is accomplished with huge hydraulic rollers. The shaping process is also a compromise. Some alloys are cold rolled. This is the optimum in terms of preserving the alloy's strength in the shaping process, however, as the thickness of the plate increases the effect of the rolling becomes less and less. The modern mill now uses computers to cold roll submarine hull plates. Each pass through the rollers bends the steel a small amount until after many (in some cases hundreds) of such passes through the rollers the plate conforms to the correct hull curvature.

THE BASIC STRUCTURE OF NAVAL SUBMARINES (cont.)

In determining the diameter of the pressure hull the engineer takes into account the metal thickness that will be required to meet a given strength level. The less the diameter the thinner the metal can be. The size of machinery largely determines the diameters of submarines. As the design of the submarine progresses the diameter of the hull inevitably increases. (Modern Trident missile submarines have a forty three foot diameter pressure hull) This necessitates a thicker hull where the alloys used and the shaping process is constant. Once again, the hull design process is one of compromise where interplaying factors are balanced against one another until a final design with an estimate of test depth is reached.

The curved plates of metal to make up the submarine's hull are further strengthened by frames. Lateral framing was known to the Vikings, although they started with a hull shape and only after the strakes had been laid did they imbed the frames into the preformed hull. Submarine hull strength is in large part a function of frame strength and spacing. Cross sections of frames are normally "T" shaped and can be within the pressure hull, on the exterior of the pressure hull, or both. The externally braced hull was the standard in submarine design, because piping and conduit cannot penetrate frames without compromising strength. With modern welding techniques it has been possible to grip the hull plate to the frame with such force that external framing is successful.

The distance between frames is crucial to determining test depth since this distance is where a compressed hull will yield or fail. The distance is a design function taking into account the factors described in this section.

The cylinder is the optimal shape for a submarine hull. A sphere is better still, however, the shape of a sphere does not accommodate a moving vessel through water. Only in experimental and exploration vehicles is the spherical hull shape used. A submarine is in essence, a long cylinder, made up of many sections welded together.

The tapered ends of the fleet type submarine (forward torpedo room and after torpedo room) called for innovation since the cylindrical form had to be compromised. These compartments were flattened for hydrodynamic reasons. Fleet type boats had exterior framing, however, in these end compartments the frames were interior as well as exterior. The deviation from circularity although small, produced a bending moment putting the shell plating under compression and the face plate of the frame under tension. Thus, the mass-produced fleet type boats had framing partly on the inside and partly on the outside of the pressure hull.

Three dimensional curvature for modern hemispherical bows require conical shaping, and tapered hull plating that in turn requires extensive welding.

The welding of the many plates and commensurate framing necessitates the greatest care. The weld seam must have the same strength as the abutting hull plates. This means that if welding is accomplished by hand the welder must be of the highest technical competence. Although a submarine may be similar to others in its class each is essentially hand built. Automation is limited, but computerization is extensive.

Hull butting is exact. Each cylindrical hull section must precisely match the adjoining section. Each cylindrical section has its edges ground to an approximate forty five degree knife edge. When two sections are mated the two edges form a trough. Actually, there are two troughs, one on the inside of the cylinder and the other on the outside. The welder (or machine) places the first bead at the deepest point of the trough. The next weld layer is placed on top of the deeper layer. As the process continues and the wedge shaped trough widens, more and more beads are placed side by side to fill the trough. Many hundreds of beads are required to bring the level of beading to the surface of the abutting hull sections. It is a long and tedious job and quality inspections are constant. Unfortunately, a perfect cylindrical hull with precise welding and engineered frame spacing must be punctured to allow various pipes, coaxial cables and rotating shafts access to the exterior of the hull.

THE BASIC STRUCTURE OF NAVAL SUBMARINES (cont.)

Wherever such a hull opening occurs the hull must be reinforced by building up the thickness of the surrounding area. The larger the opening (such as for hatches) the stronger must be the build-up. Even when every effort is made to compensate for the loss of strength from a hull opening the point of violation will be the point of failure when the hull exceeds test depth.

Time destroys the hull from several directions. The metal itself fatigues over time. Additionally, the sea takes its toll with corrosion eating at the metal. Hull modifications requiring welding, heat the hull and thereby reduce the effectiveness of the initial tempering. Nicks, gouges and scrapes collectively take their toll.

GUPPY III CONFIGURATION

A problem that became evident in the mid-1950 operations was the increasing amount of electronic equipment that was required on a submarine. The ESM equipment, the sonar equipment and the new fire control computer took up a lot of space. Certain boats, which already had the majority of the Guppy conversion work done (already Guppy II) and were in decent condition, were taken into the shipyard, cut in half and lengthened with a new 15 foot section.

The extension was in the forward end of the control room and created a new space for sonar. (TIRU was only lengthened 12.5 feet instead of 15.) The Conning Tower was renewed with an additional 5 foot section to accommodate the Mk 101 fire control system and Mk 37 director.

The Guppy III conversion was accomplished as a part of the Fleet Rehabilitation and Modernization (FRAM) program. These four-battery, four-engine boats became Guppy III. The "Northern Sail" was also added, as it was on other classes of Guppys, in order to get the bridge higher which allowed it to be manned in severe weather. TIRU retained its three engine arrangement.

PREAMBLE

A structural survey of the U.S.S. CLAMAGORE was conducted at her berth (afloat) at the Patriot's Point naval & Maritime Museum in Mount Pleasant, South Carolina. The purpose of this inspection is to ascertain the true condition of the vessel and to understand the issues impacting her long term preservation.

This walk-through survey, performed at the request of Mr. Bob Howard, entailed a cursory, walk-through visual inspection of the overall physical condition and appearance of the vessel, with focus on its structural integrity, firefighting requirements, de-watering systems, and conditions that could lead to serious injury.

Inspections of the outboard ballast and inboard fuel tank system, interior fuel and ballast tanks and voids were not done; this is a shipyard evolution requiring the gas-freeing of spaces with proper ventilation and manning to Code of Federal Regulation (29 CFR) requirements. Where possible, visual inspections from tank manhole covers was accomplished and limited inspection of voids that had been opened previously were carried out.

The following chapter, hopefully, will guide the reader in the overall characteristics of this unique class of stretched Balao-class submarine.

The body of this report shall include a textual format with embedded digital images in a deck-by-deck report of inspection outlining the conditions found, lighting, degree of cleanliness, structural condition and suitability as a space for public access.

Recommendations and observations (if needed) for each space will be included within the text in **bold** type face obviating the requirement for a separate 'Recommendations' section.

Recommendations in **bold red** type indicate a safety issue or danger to visiting public or crew.

VESSEL DATA

The designer's waterline is parallel to the base line. It is located 15' 00" above the base line and corresponds only approximately with the designed normal load and draft.

The forward perpendicular is 2' 02" forward at the intersection of the designer's waterline with the stem. The aft perpendicular is tangent to the stern profile, at the intersection with the after end of the designer's waterline. The mid-perpendicular is located half way between the end perpendiculars (6.5' forward of Frame # 69). The section at the mid-perpendicular is the mid-ship section.

The molded base line is 1 inch above the bottom of the keel. The datum line from which drafts are measured is at the bottom of the keel.

The designer's waterline is 18' 06" above the baseline.

The actual mean draft in surface normal conditions is 15' 11 1/2" and the trim is 5 3/4" by the stern.

SONAR DOMES

There are three BQG-4 sonar domes (PUFFS) located on the main deck centerline. These are designated No. 1, No. 2, and No. 3 from forward aft. No. 1 contains six SD-2 hydrophones and an AN/UQC transducer. No. 2 & No. 3 each contain six SD-1 hydrophones. No. 1 PUFF is located between 4" forward of Frame 20 and 10" aft of Frame 24. No. 2 is located between 14" forward of Frame 68 and 10" forward of Frame 72. No. 3 is located between 6" forward of Frame 119 and 16" forward of Frame 124.

The AN/BQR-2B fixed dome is located between Frames 6 to 14 centerline underneath the vessel with its underside on a line with the baseline. This dome contains an AN/UQC transducer centered at Frame 13 centerline and a BQM-1 test hydrophone.

RODMETER

The rodmeter or electro-magnetic log is located 14" forward of Frame 33, 5' 06" starboard of centerline. In its down position it extends 3' 04 1/2" below the shell, or 10 1/2" below the baseline of the vessel.

This appendage should be inspected prior to movement of vessel.

Specifications:

Displacement:

Surfaced:	1,731 tons
Length (overall):	322' 05 1/4"
Length between perpendiculars:	322' 01 1/4"
Extension of vessel beyond forward perpendicular:	04"
Extension of vessel beyond aft perpendicular:	None
Length of designer's waterline:	319' 10"
Breadth, molded, maximum at designer's waterline:	26' 00 1/2"
Breadth, extreme:	27' 04 1/8"

VESSEL DATA (cont.)

Depth, molded, amidships baseline to maindeck amidships:	23' 00 3/8"
Midship section is:	6.5' fwd. of Frame 69
Freeboard at bow:	9' 09"
Freeboard at stern at Frame 135:	3' 03"
Frame spacing (except from Frame 35 to Frame 62 & Frame 69 to Frame 105 where the spacing is 30"):	24"
Number of Frames:	143
Bottom of keel to molded baseline:	1"
Capacity of normal fuel oil tanks including clean oil tanks @ 95%:	57,846 gallons
Capacity of reserve fuel oil tanks (rated capacity):	62,474 gallons
Total capacity of fuel oil tanks:	120,320 gallons
Capacity of normal lubricating oil tanks @ 95%, sumps 75% Incl. main motor lube oil sumps @ 75%:	4,791 gallons
Capacity of reserve lubrication oil tank @ 95%:	1,848 gallons
Total capacity of lube oil tanks:	6,639 gallons
Capacity of potable water tanks:	8,246 gallons
Capacity of battery water tanks:	1,517 gallons
Inclination of shafts (down & aft):	0.1764"/ft.
Divergence of shafts, each shaft 0.5904 (outboard and aft):	1.1808"/ft
Area of rudder:	100 sq. ft.
Capacity of main ballast, fuel ballast & safety tanks, corrected to sea water for lead ballast and residual water:	562 tons
Capacity of variable ballast tanks incl. WRT and negative tanks:	178.17 tons

Heights above Normal Waterline

Highest point of fixed portion of vessel:	36' 06 1/2"
Center of anchor light forward:	17' 02 3/4"
Center of masthead light:	27' 09 3/4"
Center of searchlight:	19' 06 3/8"
Center of sidelights:	21' 04 1/8"
Center of anchor light aft:	15' 08 3/4"
Center of stern light:	14' 08 3/4"
Control room platform deck:	4' 02 3/8"
Conning tower platform:	5' 07 1/4"
Bridge platform:	26' 10 3/4"
Bridge tower hatch submerges:	20' 01 3/4"

Calculated Data

Tons per inch immersion:	12.8 tons
Area of water plane:	10,820 sq. ft.
C.G. of water plane:	0.98" fwd. of Fr. 69
Moment to change trim 1":	237 ft. tons
C.B. above bottom of keel:	9.43'
C.B. forward of Frame 69:	5.87'
Transverse metacenter above C.B.:	2.69'
Transverse metacentric height:	1.27'
Longitudinal metacenter above C.B.:	386.6
Longitudinal metacentric height:	367.2
Area of amidships section:	358 sq. ft.
Wetted surface:	13,650 sq. ft.

VESSEL DATA (cont.)

Ratio, length between perpendiculars to beam molded: 11.78
 Block coefficient (to 15' 11 1/2" W.L.): .514
 Prismatic coefficient (to 15' 11 1/2" W.L.): .626
 Midship section coefficient (to 15' 11 1/2" W.L.): .821
 Waterplane coefficient (to 15' 11 1/2" W.L.): .635
 Lead ballast: 12 tons

MAIN BALLAST TANKS (VENT PIPES INCLUDED)

Name	Location Frame	Cu.Ft.	Gallons	Tons Oil	Tons F.W.	Tons S.W.
1	25-35	1,729	12,933		48.03	49.40
2A & 2B	46-M1	1,527	11,422		42.42	43.62
2C & 2D	50-57	2,794	20,899		77.61	79.82
3A & 3B*	57-62	2,598	19,433		72.17	74.23
4A & 4B*	69-75	3,298	24,669		91.61	94.23
5A & 5B*	75-80	2,661	19,904		73.92	76.03
6A & 6B	80-85	2,334	17,458		64.83	66.69
6C & 6D	85-91	2,511	18,782		69.74	71.74
Safety	62-64	813	6,081		22.58	23.23
TOTAL		20,265	151,581		562.91	578.99

* Fitted for use as reserve fuel oil tanks.

NOTE: No deductions have been made for residual water or for lead ballast stowed in any of the main ballast tanks.

VARIABLE BALLAST TANKS

Name	Location Frame	Cu.Ft.	Gallons	Tons Oil	Tons F.W.	Tons S.W.
Aux.No. 1	64-69	1,077	8,057		29.92	30.77
Aux.No. 2	64-69	1,077	8,057		29.92	30.77
Negative	50-52	414	3,097		11.50	11.83
Fwd.trim	13-23	851	6,366		23.64	24.31
Fwd.W.R.T.	23-25	173	1,294		4.81	4.94
Aft trim	125-130	699	5,229		19.42	19.97
Aft W.R.T.	117-119	177	1,324		4.92	5.06
No.1A Var. Fuel Oil Tank	M3-50	884	6,614	20.54	24.56	25.26
No.1B Var. Fuel Oil Tank	M3-50	884	6,614	20.54	24.56	25.26
TOTAL		6,236	46,652	41.08	173.25	178.17

VESSEL DATA (cont.)

FUEL OIL TANKS

Name	Location Frame	Cu.Ft.	Gallons	Tons Oil	Tons F.W.	Tons S.W.
Normal No. 1	35-41	1,524	11,401	35.41	42.36	43.54
Normal No. 2	41-46	1,754	13,122	40.75	48.72	50.11
Normal No. 6	93-99	2,032	15,201	47.21	56.44	58.06
Normal No. 7	99-107	1,458	10,907	33.87	40.50	41.66
Collecting	91-93	400	2,993	9.30	11.11	11.43
Expansion	91-93	400	2,993	9.30	11.11	11.43
Clean Oil No. 1 (95 percent)	86-88 (Internal	82	611	1.90	2.28	2.34
Clean Oil No. 2 (95 percent)	97-99 (Internal	83	618	1.92	2.31	2.37
TOTAL (Normal)		7,733	57,846	179.66	214.83	220.94

RESERVE FUEL OIL TANKS (RATED CAPACITIES)

Name	Location Frame	Cu.Ft.	Gallons	Tons Oil	Tons F.W.	Tons S.W.
Fuel Ballast 3A & 3B	57-62	2,530	18,924	58.77	70.27	72.28
4A & 4B	69-75	3,220	24,089	74.81	89.44	92.00
5A & 5B	75-80	2,601	19,458	60.43	72.25	74.32
TOTAL (Reserve)		8,351	62,471	194.01	231.96	238.60
TOTAL(Maximum) (at 6.96 lbs./gal.)		16,084	120,317	373.67	446.79	459.54

LUBRICATING OIL TANKS

Name	Location Frame	Percent	Cu.Ft.	Gallons	Tons Oil	Tons F.W.
No. 1	76-77	95	161	1,201	4.13	4.47
No. 2	80-85	95	119	893	3.06	3.32
No. 3	107-109	95	139	1,037	3.56	3.86
Main eng.sump No.1	80-85	75	51	382	1.31	1.42
Main eng.sump No.2	80-85	75	51	382	1.31	1.42

VESSEL DATA (cont.)

LUBRICATING OIL TANKS - (Cont'd)

Name	Location	Percent	Cu.Ft.	Gallons	Tons Oil	Tons F.W.
	Frame					
Main eng.sump No. 3	91-96	75	51	382	1.31	1.42
Main eng.sump No. 4	91-96	75	51	382	1.31	1.42
Main motor L.O.sump	101-103	75	18	132	0.46	0.50
TOTAL (Normal)			641	4,791	16.45	17.83
Reserve L.O. No. 1	57-59	95	124	924	3.17	3.43
Reserve L.O. No. 2	57-59	95	124	924	3.17	3.43
TOTAL (Reserve)			248	1,848	6.34	6.86
TOTAL (Maximum) (at 7.67 lbs./gal.)			889	6,639	22.79	24.69

SANITARY TANKS 100% CAPACITY

Name	Location	Cu.Ft.	Gallons	S.W. Tons
	Frame			
No. 1	34-35	58	434	1.66
No. 2	76-77-1/2	90	673	2.57
No. 3	110-111	50	375	1.43
TOTAL		198	1,482	5.66

FWD. BATTERY FRESH WATER TANKS

Location		Pounds	Gallons	F.W. Tons
Frame	Side			
36-39	S	893	107	0.40
40-43	S	893	107	0.40
36-39	P	893	107	0.40
40-43	P	893	107	0.40
43-46	P	893	107	0.40
SUBTOTAL		4,465	535	2.00
48-51	S	768	92	0.34
48-52	P	1,002	120	0.45
SUBTOTAL		1,770	212	0.79
TOTAL (FWD)		6,235	747	2.79

VESSEL DATA (cont.)

(AFT) BATTERY FRESH WATER TANKS - Cont'd

Location		Pounds	Gallons	F.W. Tons
Frame	Side			
59-63	S	919	110	0.41
63-67	S	919	110	0.41
68-71	S	919	110	0.41
72-75	S	919	110	0.41
61-64	P	919	110	0.41
65-69	P	919	110	0.41
69-72	P	919	110	0.41
(AFT) SUBTOTAL		6,433	770	2.87

TOTAL (FWD & AFT) 12,668 1,517 5.66

SHIP'S FRESH WATER TANKS

Name	Location		Cu.Ft.	Gallons	F.W. Tons
	Frame	Side			
No. 1 Starboard	35-36		112	838	3.11
No. 2 Port	35-36		112	838	3.11
No. 1A Stbd.	M1-M3	S	439	3,285	12.20
No. 1B Port.	M1-M3	P	439	3,285	12.20
TOTAL			1,102	8,246	30.62

VARIABLE FUEL OIL TANKS (100% FULL)

Name	Location	Cu.Ft.	Gallons	Tons Oil	Tons F.W.	Tons S W
	Frame					
No. 1A Var. Fuel Oil Tank	M3-50	884	6,614	20.54	24.56	25.26
No. 1B Var. Fuel Oil Tank	M3-50	884	6,614	20.54	24.56	25.26
TOTAL		1,768	13,228	41.08	49.12	50.52

VESSEL DATA (cont.)

MISCELLANEOUS TANKS		Cu.Ft.	Gals.
Name	Location		
Hydraulic system supply & vent tank	Control room Frs. 47-48p	7.09	53
Reserve hydraulic oil tanks	Frs. 22-25P (3 tanks) Frs. 25-27P (2 tanks)	30.21	226
Torpedo alcohol	Frs. 22-238	6	45
Torpedo oil	Frs. 23-248	6	45
Vapor compressor L.O. tank (1)	Fwd. engineroom		10
Hydraulic system vent tank	Fwd. torp. room Aft. torp. room		2 5
Hydraulic system air tank	Radio room	5	
Hydraulic system leakage tank	Control room		5
Hydraulic system vent tank	Conning tower		2

PROPPELLING MACHINERY

(1) Diesel Engines - Main

Generator engines:

Manufacturer:

Type:

Number of cylinders:

R.P.M.:

Brake horsepower:

Number - 4

General Motors Corporation, Cleveland

Diesel Engine Division

Mechanical injection, 2 cycle, single acting,
oil cooled pistons, air starting, model
278-AS 8-3/4 by 10-1/2 inches N

16

750

1600

(2) Main Generators

Number:

Manufacturer:

Type:

4

General Electric Company, Schenectady, New York

Single structure, totally enclosed, separately
excited, self-ventilated, water-cooled air
cooling system, compensated type, short wound

VESSEL DATA (cont.)

CONFIDENTIAL

Ratings: Duty	Continuous Full Power	80 Percent Power	50 Percent Power
Volts	415	381	350
R.P.M.	750	675	600
R.W.	1100	880	550

(3) Main Control

Number: 2 (Split type)
 Manufacturer: General Electric Co. - Model 3W59B1
 Volts: 250-500 D.C.
 Amperes: 3000 AMPS - Continuous Duty
 (Operating Limits) 3600 for 90 min (overload)

(4) Main Motors

Number: 2
 Manufacturer: General Electric Company, Schenectady, New York
 Type: Double armature, enclosed, separately excited, self-ventilated through closed system with water-cooled air coolers, reversing, compensated type, compound wound

Ratings:		Armatures	-	2
Volts	- 415	No. of Poles	-	8
Amps	- 2650	R.P.M.	-	42 - 360
HP/Shaft	- 2700			
Time	- Cont.	Enclosure	- Watertight to shaft. Water proof above shaft.	

(5) Storage Batteries

Number: 4
 Number of cells each: 126
 Manufacturer: Exide Storage Battery Company
 Type: MW-65
 Voltage (open circuit): 261
 Ampere hours: 4340 at 1 hour rate at 1.265 sp.gr.

(6) Propellers

Number: 2
 Type: Adjustable - manganese bronze
 Number of Blades: 4
 Diameter: 7 feet 6 inches
 Pitch (Designed at .7R): 7.6 ft.
 Shaft diameter at propeller: 9 inches - line shaft 9 inches O.D. by 5-inch bore
 Weight of propeller & hub: 8744 lbs Port 2390 lbs

Reference:
 SS-203-1859638

Prairie Propeller - 4 blades - Details
 GERRY III Class SS351-416-425

For complete information and instruction concerning the propelling machinery, see the instruction books published by General Motor Corporation and the General Electric Company.

VESSEL DATA (cont.)

TORPEDO TUBES

There are two nests of fixed torpedo tubes for 21 inch or 19 inch torpedoes, one nest of six in the bow and one of four in the stern.

PRESSURE HULL CLOSURE PLATES

All closure plates are of 35 lb or 7/8" H.T.S. plate, have rounded corners (3" or 4" radius) and are welded flush with the pressure hull, using a continuous double-Vee butt weld.

Fr. 43-44	S	17" x 26-3/4"	Welded	Wardroom Passage: Way
Fr. 48-49	P	33-1/2" x 40-1/2"	Welded	Control Rm.
Fr. 72-74	P	32-1/4" x 26-3/4"	Welded	Crew's quarters
Fr. 85-87	C.L.	7'-4" x 5'-0"	Welded	Fwd engine rm.
Fr. 96-98	C.L.	7'-4" x 5'-0"	Welded	Aft engine rm.
Fr. 103-106	Amid.	5'-4" x 5'-5"	Welded	Maneuvering rm.

Reference Plans:

BUSHIPS No. 88-81101-804450 - Welded Type Hull Closure Plates.

BUSHIPS No. 88313-81101-781436 - Closing Plate Pressure Hull - Fwd Mach Comp

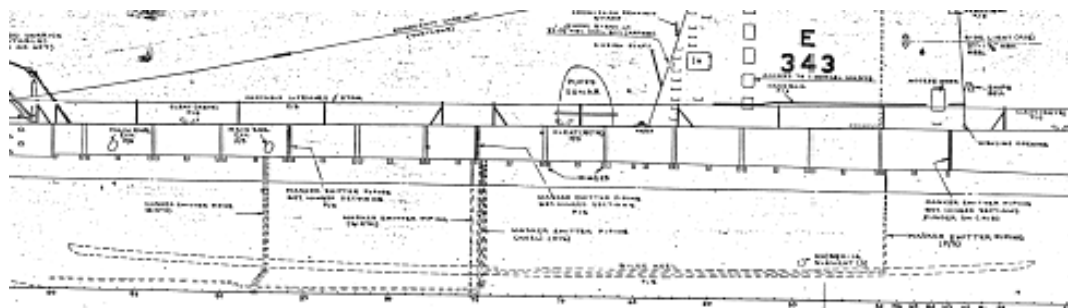
BUSHIPS No. 88313-81101-781437 - Closing Plate Pressure Hull - Aft Mach Comp

BUSHIPS No. 88346-845-1521610 - Compartment & Access - Modifications

BILGE KEELS

The bilge keels are of 17.85 pound plate. They are 15" deep and designed to follow the stream lines of the vessel as far as practicable from Frame 41 to Frame 99.

These were not inspected at time of survey being underwater.

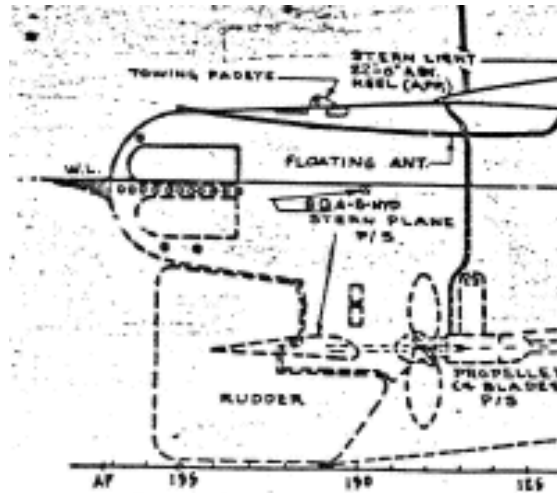


Bilge keel, located at near the bottom of the hull, arc fashion.

HULL INSPECTION EXTERIOR

RUDDER

The rudder is a built up structure of the balanced type. The cast steel frame is covered with 12.75 pound side plating (5/16") rabbetted and welded watertight. The inside is filled with white pine and vegetable pitch poured in hot. Waterline sections through the rudder are streamlined. The area of the rudder is approximately 100 square feet and its weight, including the rudder stock, is approximately 15,500 pounds.



Rudder and underwater running gear appendage adjacent to rudder.

The frame is bored through its axis for the rudder stock. Along the axis, the frame is made with three openings. The middle opening, at about the center of the rudder, takes a stern casting step which is fitted with a lignum vitae lined bearing for the rudder stock. The upper and lower openings, in which the rudder stock nuts are secured are filled with wood and tallow and closed with four 12.75 pound (5/16") portable plates which are secured with 1/2" diameter rolled naval brass screws.

The frame is bored above both nuts on tapers with the smaller diameters toward each other. The upper taper is fitted to the stock and keyed to it with two 1 1/4" x 1 3/4" keys 19" long which are secured to the stock. The lower taper is for a split composition M tapered bushing which the lower nut wedges against the stock.

The rudder stock nuts, the upper 8 3/4" I.D. and the lower 5 1/2" I.D., are each secured with a locking pin which is center punched to keep it in place. The rudder stock, which is 11' 4 3/8" long and weighs 2,342 pounds, extends up through the lignum vitae lined stern bearing and into the non-watertight hull structure to be fitted with the bolted halves of the steering crosshead which is keyed to the stock with two 1 1/2" x 2 1/4" keys 14 1/2" long. At the top of the rudder, hard-over steel stops cast on the rudder frame take up the stern post casting to limit the travel of the rudder to 38 degrees each side of the centerline.

The upper end of the stock is fitted with a thrust collar which places the weight of the rudder on a bearing race supported by the framing of the non-watertight stern. Any vertical movement of the rudder is limited by a fitted composition washer on the stock between the rudder frame and the underside of the stern casting step.

HULL INSPECTION EXTERIOR (cont.)

RUDDER (cont.)

The steering gear, when using the main sources or source of power (manual), is capable of moving the rudder between the angle of which the limit stops come into action. The steering gear is of the electro-hydraulic type and under the usual condition of steering by power the steering rams are operated by oil delivered by the main steering pump located in the after torpedo room.

The direction and amount of rudder movement is controlled by the position of the tilting box of the pump. The position of the tilting box is controlled by the following two arrangements:

- 1.) A size 5, A-end speed gear pump is provided on the conning tower steering stand. By operation of this steering pump by hand, oil is delivered to the control cylinders in the after torpedo room.
- 2.) A "jury rig" arrangement permits local control of the main steering pump by means of a manually operated lever attached to the mechanism which controls the pump stroke. The lever is portable and is removed and stowed nearby when not in use. When local control of the main steering pump in the after torpedo room is required, place the "jury rig" arrangement into operation by attaching the portable lever to the pump control mechanism, by opening the control cylinder bypass valve, by closing the hand and emergency cut-out valves in the main cut-out manifold, and by starting the steering motor with the three position snap switch installed adjacent to the motor controller cabinet. Movement of the attached lever as required for right or left rudder replaces the action supplied by the control cylinders during normal "power" steering and regulates the flow of oil from the main pump to the main rams by changing the position of the tilting box of the pump. The lever must be returned to neutral for holding the rudder at any desired position. A mechanical rudder angle indicator driven from the port steering ram connecting rod, is located in the after torpedo room.

There are four methods of steering the vessel, viz:

- a.) power (conning tower)
- b.) hand (conning tower)
- c.) emergency (control room)
- d.) "jury rig" (aft torpedo room)

The rudder (underwater) and steering appendage was not observed at the time of the survey. The rudder post and steering rams are locked in the fixed fore and aft position.

FORWARD BOW DIVE PLANES

The bow diving planes, located at frames # 16-17 port and starboard, are supported by separate stocks and connecting rods but are identical installations.

The cast steel plane frame is covered with 10 pound (1/4") steel plating, rabbetted and welded. The inside is filled with white pine and pitch and has about 730 pounds of lead fitted inside the forward edge to secure a balance in sea water around the axis of the stock. The area of each plane is 57 1/2 square feet and its weight, including lead ballast, is 5,420 pounds.

At about the center of the plane a steel tapered pin carries a cast nickel copper alloy spherical ball. The ball is held within a compositional seat in the end of the connecting rod, which lifts the plane on the 2" x 10 1/4" hinge pin from the horizontal to the rigged-in position. When in the rigged-in position the planes are brought up hard against rubber bumpers on the side of the

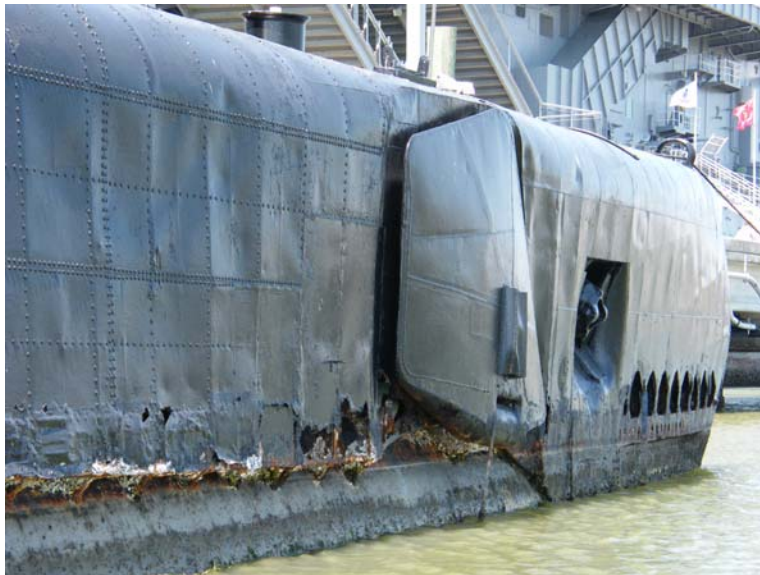
HULL INSPECTION EXTERIOR (cont.)

FOWARD BOW DIVE PLANES (cont.)

superstructure.



Detail of forward plane to starboard, showing wasted superstructure deck framing and face plating.



Forward plane to starboard, showing wasted superstructure deck framing and face plating.

The two bow planes appear to be in fair condition in that the hinges for both planes (what is visible) appear in tough condition. The foundations/bases for these planes are deteriorating badly. Additional reinforcement will be needed. There is interior degradation of the planes with wastage holes at the bottoms of both planes.

HULL INSPECTION EXTERIOR (cont.)

STERN DIVING PLANES

The stern diving planes are a pair of built-up structures, balanced on a common axis. The cast steel frame is covered with 10.2 pound plating (1/4"+), rabbetted and welded. The inside is filled with white pine and vegetable pitch poured in hot, except in way of the forward edge, which has about 1,700 pounds of lead fitted inside to secure a balance of sea water around axis of stock. Vertical sections through the planes are of airfoil shape. The area of each plane is 52 square feet and the total weight of both planes, including stock and lead, is 11,312 pounds.

The planes are carried on the ends of a horizontal athwartship stock 8' 02" long, which passes through two composition M bearings in the stern casting. The stock is fitted with composition sleeves in way of the stern casting bearings and the ends enter the frames of the planes on a taper carrying two horizontal 1 1/8" x 1 1/2" keys that are 11" long. A compositional thrust ring is carried on the stock on each side between the plane and the stern casting bearing. A vertical tapered key is fitted in each end of the stock to wedge and secure the planes onto the stock. Two cover plates, rabbetted into the frame of each plane, are fitted in way of the ends of the tapered keys, and secured with screws.

Both the tiller arm and cap are keyed to the stock at its center, between the two composition sleeves for the stern casting bearings. The tiller extends upward at a right angle to the plane of the diving planes. The hard rise and hard dive stops on the stern casting take up the forward and after side of the tiller arm to limit the travel of the planes to 27 degrees each side of the horizontal.

Both of these stern plane units are underwater and are in the slight up angle trim. Not observed at time of survey.

CONNING TOWER/SAIL

The conning tower is a built-up cylindrical shape 8' in diameter, mounted horizontally amidships on the strength hull. It is located between frames 49-56, and the length is 24' 00 3/4". The entire structure is made of special treatment steel (STS), and the ends are fitted with convex heads.



HULL INSPECTION EXTERIOR (cont.)



Maindeck access to sail with assorted shore power boxes and transformers.



Looking aft in sail just above maindeck. Notice careless storage of gear and paint.

HULL INSPECTION EXTERIOR (cont.)

CONNING TOWER/SAIL (cont.)

A 21 x 27 inch oval hatch provides access to the control room and a 25 inch diameter W.T. hatch access to the bridge via an access trunk and another 25inch diameter W.T. hatch. The hatch to the bridge is fitted with a contact maker to indicate the dogged condition for submerging.



Upper flat of sail, looking aft.



Conning station windshield.

The conning tower is designed to be a control and steering station for both submerged attack and surface cruising. This structure is in fair/good cosmetic and excellent structural shape.

Remove all debris, properly stow all shipboard items, remove paint and rags from space.

Properly fence off all sail access panels to prevent pigeon/wildlife from creating a home for themselves. Utilizing a firehose, clean all standing dirt/debris from sail.

Free-up drainage limber holes to prevent standing water and develop schedule of regular flushing of space.

HULL INSPECTION EXTERIOR (cont.)

SUPERSTRUCTURE OR MAINDECK

The superstructure deck, called the *main deck*, extends virtually from the tip of the bow to near the stern rudder/plane assembly. The deck is generally level on the centerline but with a marked camber on each side. Beginning from aft the deck rises very gradually in the direction of the bow, to a height approximately 10 feet above the waterline.

The superstructure or main deck is attached to the exterior hull by means of the framing and rounded sides forward and aft. Limber holes in the sides allow sea water to enter all the hollow spaces in the superstructure and the deck when diving, and drain off when the submarine is surfaced. The sonar dome is fitted forward followed by the tapered portion of the pressure hull gradually flaring to the full width pressure hull aft.



Foredeck profile, showing area forward of the sail.

The maindeck also has temporary outboard handrails/railings with lifelines fitted along the length of the deck facilitating passage from the access hatches. A painted semi-non-skid finish has been applied to the steel deck for footing; this is in relatively good condition with rust/scale at the perimeters of hardware and hatches.

Minor trip/fall hazards abound with the uneven decking throughout the length of the maindeck. Not suitable at this time for public access.

Lifelines are not suitable for public access without major modification that would spoil the lines of the vessel.

The foredeck features one of two main access scuttles with vertical ladder for access to the forward crew berthing/torpedo room.

HULL INSPECTION EXTERIOR (cont.)

SUPERSTRUCTURE OR MAINDECK (cont.)



Maindeck, aft, looking toward stern tubes.

The forward access hatch has much standing water with wasted/scaled deck covering. Design adequate drainage portals; repair as needed and prime/paint.

HULL INSPECTION EXTERIOR (cont.)

SUPERSTRUCTURE OR MAINDECK (cont.)



Hull fairing at bow to starboard, looking aft.



Overall view of port bow of CLAMAGORE, showing wasted plating for superstructure fairing.

The vessel's hull fairing forward has been intermittently immersed in standing warm salt water for many years. This has caused a failure of the vessel's paint coating system and resulting heavy rust scale of the hull plating and forward appendages. Much of the plating and structural members below the torpedo tubes is badly deteriorated and only a shipyard period can rectify this damage.

Ascertain scope of wastage to bow framing and hull scantlings at time of drydocking, repair as needed and install sacrificial anodes.

Properly sandblast hull to SSPC-10 Near White blast, prime and paint hull.

HULL INSPECTION EXTERIOR (cont.)

SUPERSTRUCTURE OR MAINDECK (cont.)

The superstructure deck forward and aft of the sail is in exceedingly poor condition. Much of the support foundation is rotted away with a crude attempt to strengthen the deck by the installation of wooden 4 x 4 and 2 x 4 planks.

This area is directly below maindeck and is a free-flooding space with limber holes cut into the exterior plating to facilitate drainage.. A forward anchor windlass and chain locker is fitted with an associated hawse pipe designed for a fluked anchor. Anchor and chain rode are aboard. Structural members support the maindeck and sail above. Also, there is associated piping and storage compartments for various operational gear (anchor windlass and warping capstans, etc.). Hinged steel deck plates allow limited access to this crawl space. At this time there are no structural issues outstanding, but structural members are rusted/scaled which demands attention.

There is significant corrosion occurring because of the following conditions:

- 1.) Pigeons have a major roost in this space with resultant damage to coating system due to acid related corrosion from standing guano.
- 2.) Standing water atop the pressure hull/ballast tankage due to blocked limber holes and standing dirt/debris.

Properly fence off all topside limber holes to prevent pigeon/wildlife from creating a home for themselves.

Utilizing a firehose, clean all standing dirt/debris from superstructure deck.

Free-up drainage limber holes to prevent standing water and develop schedule of regular flushing of space.

Properly sandblast superstructure deck to SSPC-10 Near-white blast, prime and paint.



Wasted mooring cleat foundation, typical of superstructure deck material condition.

HULL INSPECTION EXTERIOR (cont.)

SUPERSTRUCTURE OR MAINDECK (cont.)



Midship area of superstructure deck being crudely supported by 2 x 4 wood planks.

The deck between the public access paths, around the sail, and stern area is unsafe.

Properly template and replace all mooring cleat foundations as needed, immediately.

Properly template existing structure, fabricate and install new deck to historic standards.

UNDERWATER HULL

The hull bottom is freely eroding without benefit of an impressed cathodic system operational at time of survey; it is understood that Patriot's Point has engaged a contractor to design and install a new cathodic system.

The forward and aft torpedo tubes, being of bronze construction, are causing havoc galvanically with the surrounding steel structure. Much deterioration of forward and aft structure was observed at time of survey; this will require further inspection, fabrication and repair at time of drydocking. The area aft of the sail is suffering rust/scale on the exterior because of poor drainage on top of the fuel/ballast tanks.

HULL INSPECTION EXTERIOR (cont.)

UNDERWATER HULL (cont.)



Wasted structure around bronze torpedo tube.

Perform an ultrasonic inspection of the exterior fuel/ballast tankage at time of drydocking, crop out any plating with greater than 25% wastage and install new steel inserts.

Design, fabricate and install cover boxes over all ballast tank valve openings.

Design, fabricate and install cover boxes over all other through-hull openings from the pressure hull and fuel/ballast tankage.

Properly sandblast hull to SSPC-10 Near White blast, prime and paint hull.

Access hatches/escape scuttles both fore and aft (integral to the shell plating) have mildly wasted hinges and need new gaskets to be properly locked/secured.

Template, remove old wasted structure and renew with new scantlings the bow and stern fairing, foundations and shell plating around torpedo tubes.

HULL INSPECTION EXTERIOR (cont.)

TANK MANHOLES

The flat and flush type manholes are provided with 1/8" plant fiber gaskets except the fresh water tanks which have 1/8" sheet asbestos and the reduction gear oil tanks which have a 1/16" asbestos sheet gasket. The boiler-type manholes are provided with 7/8" x 11/16" rubber gaskets.

Bolted hatches and manholes on the ballast and fuel tanks have not been opened as part of this survey (although they may be opened to facilitate ventilation or periodically pumped with air to dewater tanks).

SOME standing oil and contaminated water have been pumped ashore. Tanks have not been inspected as this is strictly a drydock function where inspection is per 29 CFR for 'safe entry'. Gas freeing is a necessary prerequisite before entering any of these tanks.

HULL PLATING

Inward compression of plates on her superstructure and ballast tanks is evident in many areas of the topside hull; sure evidence of the long operational life of the vessel. Condition of the hull from the sheer to the waterline is cosmetically rough, as expected after many years of service. Steel railings and ladders are in need of maintenance on the exterior of the superstructure; replace the pins and secure new chains where appropriate. All of the foredeck anchor handling gear and anchor chain is housed and secured.

A cast/forged hawse pipes are well anchored to the stem for housing the anchor; the anchor cannot be dropped or operated at this time; the amount of chain in the chain locker is unknown.

The chain locker is free-flooding; it is assumed that there is an inordinate amount of rust/scale/mud present; this should be explored at time of drydocking.

Properly secure anchor in hawse as weldment beads holding anchor are failing.

The vessel's ballast tankage at the wind/waterline was ultrasonically tested at time of survey with the following results. Wind/waterline plating is 9# and 10# (7/32" & 1/4") mild steel plating throughout. Refer to 'Shell Plate Expansion Plans' for exact locations.

HULL WIND/WATERLINE, Starboard, Bow to Stern on 4' Centers

.130 .191 .195 .176 .156 .148 .067 .089 .178 .098 .200 .115 .211 .222 .194 .156 .136 .057 .167 .189 .099
.155 .222 .200 .206 .221 .209 .154 .130 .167 .156 .143 .122 .200 .136 .147 .167 .178 .111 .190 .126 .145
.090 .130 .167 .157 .126 .072 .083 .138 .089 .200 .145 .210 .178 .154 .167 .111 .122 .194 .156 .136 .221
.207 .209 .219 .155 .122 .100 .156 .121 .189 .154 .130 .167

HULL WIND/WATERLINE, Port, Bow to Stern on 4' Centers

.156 .143 .122 .200 .236 .147 .167 .178 .211 .149 .156 .234 .155 .132 .213 .141 .199 .188 .150 .145 .140
.146 .057 .144 .144 .150 .142 .063 .072 .069 .175 .054 .141 .137 .083 .157 .152 .151 .157 .143 .051 .052
.063 .041 .150 .050 .130 .167 .156 .143 .122 .200 .236 .147 .167 .178 .111 .149 .156 .134 .155 .132 .213
.141 .199 .188 .150 .145 .155 .147 .159 .133 .120 .075 .062

Due to low shell plate readings, often exceeding the 25% threshold, it is recommended that the vessel's waterline area in the splash zone be re-plated from bow to stern, port and starboard.

HULL INSPECTION EXTERIOR (cont.)

WATERTIGHT DOORS

The watertight doors are of built-up welded construction and tested originally to 200# per square inch hydraulic pressure on the 20" x 38" doors and 400# per square inch external pressure on the 30" D. doors. All doors are operated by a pair of crank handles located on each side of the door. The doors are further provided with an interlocking device which prevents the operation of the crank handles to lock the door until the door is closed, thereby insuring a portion of the locking dogs which will not interfere with the closing of the door at any time.

The bulkhead doors are held open by spring loaded latches on the adjacent structure. The door for the forward escape trunk can be closed from inside the vessel by means of extension shafts through the pressure hull. A pin in the quadrant of the operating arm for this inboard closing device, is used to hold the door in the open position. The bulkhead doors may be held in the closed position without the operation of the locking mechanism by a single dog mounted in the door with an operating handle on each side. These doors are in excellent shape and are intact; they can be closed. Excellent gaskets.

PUBLIC ACCESS BROWS

Two doors have been cut into CLAMAGORE's hull to facilitate public access to the forward and aft torpedo rooms; adequate railings and stairwells are fitted. Both utilize steel brows with adequate handrails with a small entry foyer that can be locked at each entrance/exit. Each access station has been cut through the exterior pressure hull with adequate non-skid intact, lighting installed and handrails provided. These public access brows are in good repair.



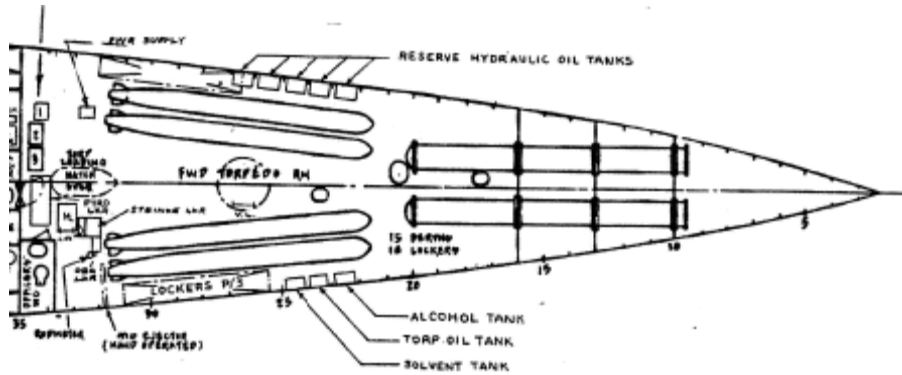
HULL INTERIOR

The interior of the vessel is divided into two main decks:

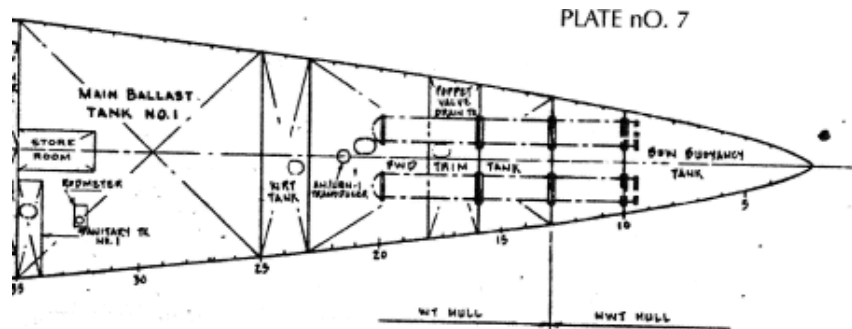
- a.) The Platform Deck, which is the top deck.
- b.) The Hold.

Only the 1974 INSURV report is extant and is not detailed as to the hull's structural condition. It is more concerned with equipment that could be of service to active fleet units. This report did state that the ship could not presently meet current operational needs because of outmoded communications and habitability conditions. Also, an expensive overhaul of her machinery would be necessary to correct deficiencies due to current safety operational guidelines. This report was instrumental in having the vessel stricken from the Naval Vessel Register in 1975.

FORWARD TORPEDO ROOM & HOLD SPACES



Forward Torpedo Room, Frames 0-35



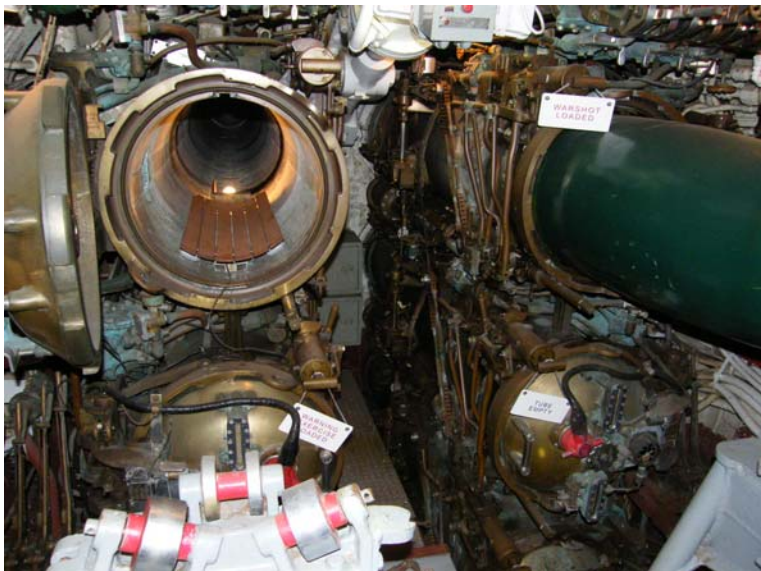
Hold, Frames 0-35.

HULL INTERIOR (cont.)

FORWARD TORPEDO ROOM (cont.)



Forward torpedo room, looking aft.



Forward torpedo tubes.

HULL INTERIOR (cont.)

FORWARD TORPEDO ROOM (cont.)



Interior of Forward Trim Tank.



Floor under main cabin sole of Torpedo Room, showing debris and loose stowage.

The following observations are made as to the condition of this space:

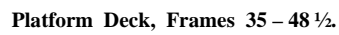
- 1.) Heavily rusted and scaled under main floors over forward trim tank.
- 2.) No standing water.
- 3.) Forward torpedo tubes do not appear to be leaking.
- 4.) Well lighted.

- 1.) **Renew transverse floor panels, several are loose, deteriorated and are in need of replacement.**
- 2.) **Replace loose or missing floor tiles.**

Pressure hull thickness gauge readings are as follows:

PORT	.675	.621	.590	.550	.622	.605
STBD	.623	.605	.678	.590	.555	.633

OFFICER'S COUNTRY & FORWARD BATTERY ROOM



- 1.) All spaces in excellent material and cosmetic condition.
- 2.) Well lighted.
- 3.) No standing water.
- 4.) Battery room contains empty batteries in original condition, very interesting space.

PORT	.643	.620	.655	.641	.590	.602
STBD	.622	.600	.612	.620	.633	.645

HULL INTERIOR (cont.)

OFFICER'S COUNTRY & FORWARD BATTERY ROOM (cont.)



Wardroom.



Watertight dogging door on interior passageway.

HULL INTERIOR (cont.)

OFFICER'S COUNTRY & FORWARD BATTERY ROOM (cont.)



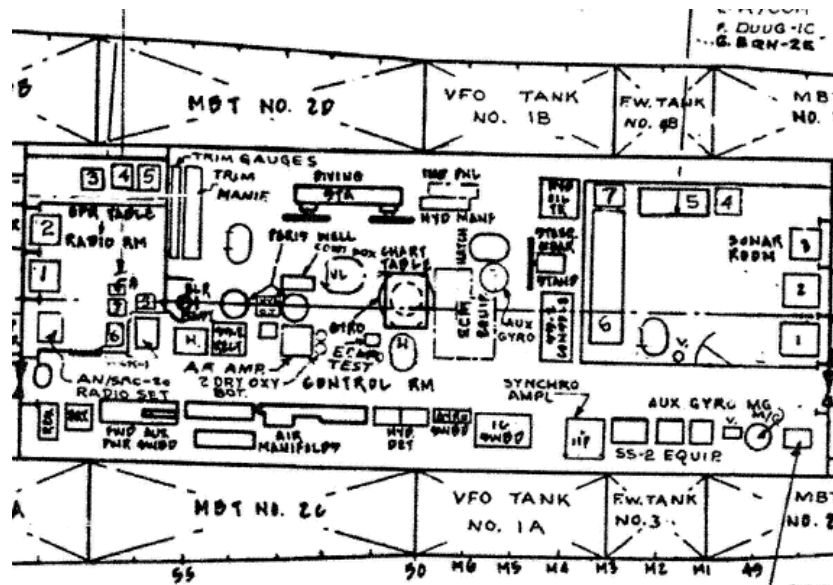
Forward Battery Room, looking forward to port. Largely original.



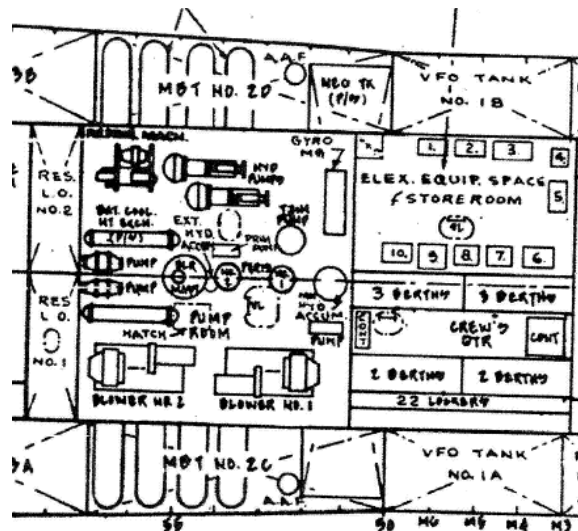
Forward Battery Room, looking aft to port.

HULL INTERIOR (cont.)

CONTROL ROOM, SONAR ROOM, PUMPROOM, BERTHING/STOREROOM



Platform Deck, Frames 47 – 58 ½.



Hold, Frames M3 – to Frame 58 ½.

The following observations are made as to the condition of this space:

- 1.) Well lighted in control room, not well lighted in sonar room and storeroom.
- 2.) Control room in good material and cosmetic condition.
- 3.) Sonar room and storeroom are dirty, rust/scale evident, possible PCB/oil contamination.
- 4.) Some standing water/oil in bilges (4-8") with heavily corroded bases of bulkheads. Standing water from leaks from periscope tube in conning tower.

HULL INTERIOR (cont.)

CONTROL ROOM, SONAR ROOM, STOREROOM (cont.)

Pressure hull thickness gauge readings are as follows:

PORT .602 .540 .625 .607 .670 .612
STBD .634 .600 .631 .560 .593 .545

- 1.) Properly seal periscopes from rainwater entry above.
- 2.) Remove and properly dispose of all standing hydraulic and lubrication oil in piping and sumps.



Control Room, helm station.



Sonar Room.

HULL INTERIOR (cont.)

CONTROL ROOM, SONAR ROOM, STOREROOM (cont.)



Standing oil in Pumproom.

HULL INTERIOR (cont.)

CREW'S GALLEY/MESSDECKS, STOREROOM & AFT BATTERY ROOM

The following observations are made as to the condition of this space:

- 1.) Well lighted in galley and mess spaces, not well lighted in battery/store room.
- 2.) All spaces in good material and cosmetic condition.
- 3.) Storeroom is dirty with rust/scale evident.

Pressure hull thickness gauge readings are as follows:

PORT .573 .580 .625 .641 .670 .668
STBD .642 .615 .634 .627 .638 .667

Platform & Hold, Frames 58 ½ to 77 ½.

HULL INTERIOR (cont.)

CREW'S GALLEY/MESSDECKS, STOREROOM & AFT BATTERY ROOM



Crew Messdeck.



Crew Galley.

HULL INTERIOR (cont.)

CREW'S GALLEY/MESSDECKS, STOREROOM & AFT BATTERY ROOM



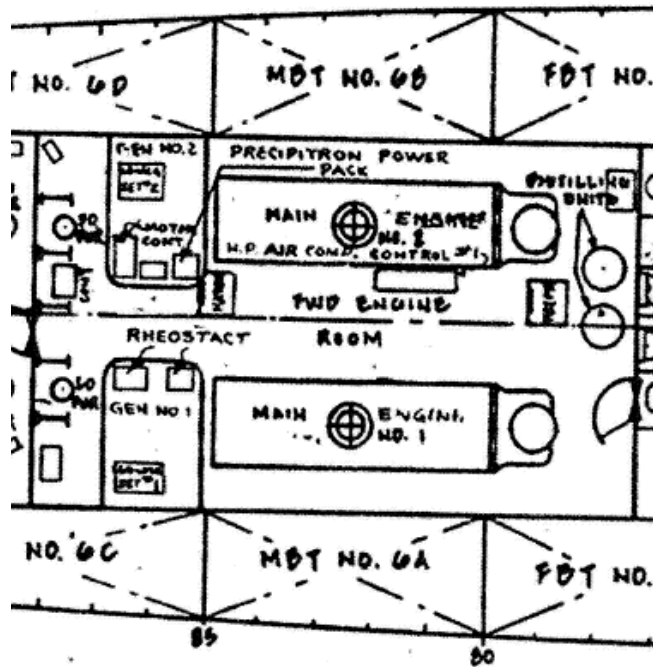
After Battery Room, looking forward to port.



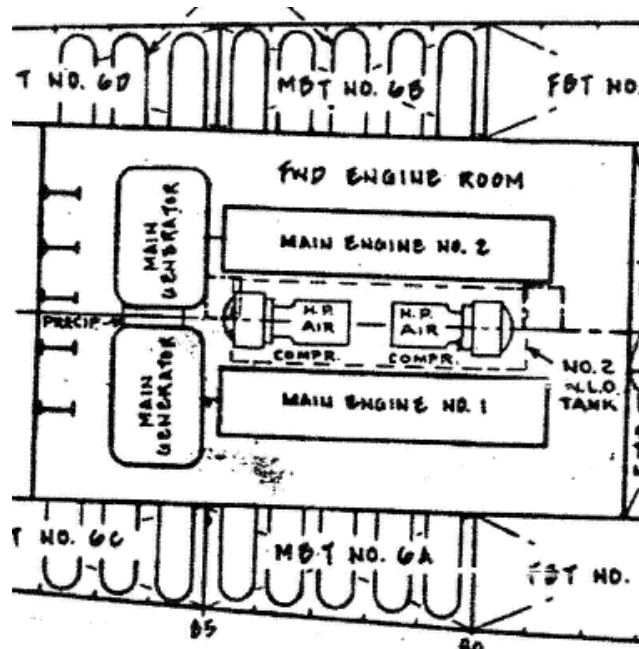
After Battery Room, looking aft.

HULL INTERIOR (cont.)

FORWARD ENGINEROOM



Platform, Forward Engine room, Frames 77 1/2 to 88.



Hold, Forward Engine room, Frames 77 1/2 to 88.

HULL INTERIOR (cont.)

FORWARD ENGINEROOM (cont.)

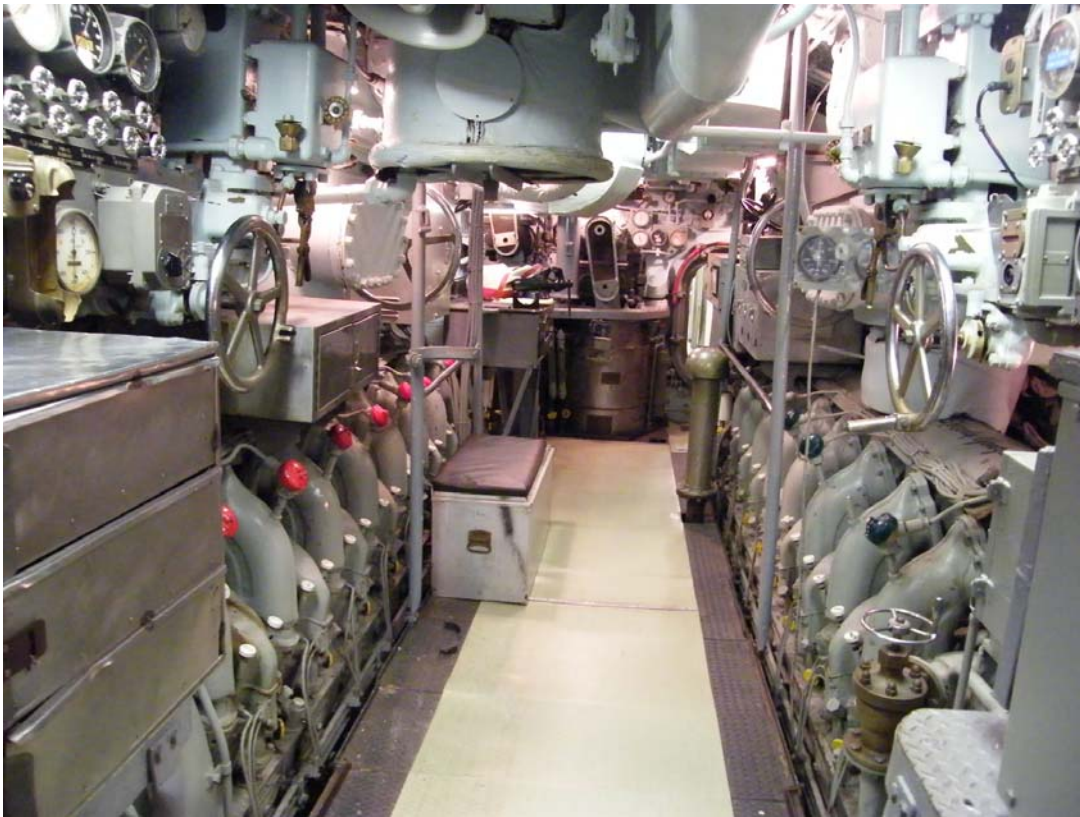
The following observations are made as to the condition of this space:

- 1.) Well lighted in upper engine room, not well lighted below.
- 2.) Upper engine room in good material and cosmetic condition.
- 3.) Lower engine room is dirty, heavy rust/scale evident, possible PCB/oil contamination.
- 4.) Some standing water/oil in bilges (3 to 4").
- 5.) Hatches to lower room needs locking devices.

Pressure hull thickness gauge readings are as follows:

PORT .597 .589 .634 .666 .675 .588
STBD .624 .653 .634 .634 .647 .650

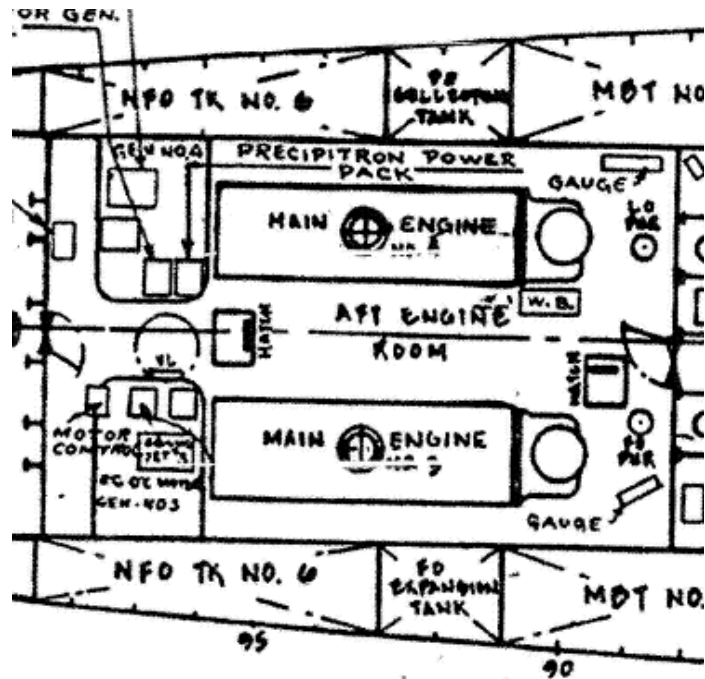
- 1.) Properly dispose of all standing oil from bilges and sumps.
- 2.) Consider cleaning, sanding and painting lower bilge space.
- 3.) Install proper lighting for bilge space.



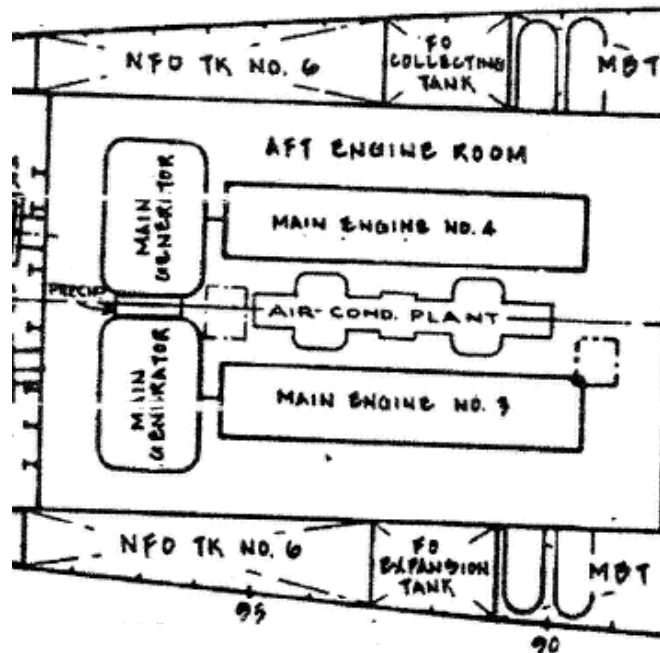
Forward Engine room, looking aft..

HULL INTERIOR (cont.)

AFTER ENGINEROOM



Platform Deck, After Engine room, Frames 87 1/2 to 98.



Hold, After Engine room, Frames 87 1/2 to 98.

HULL INTERIOR (cont.)

AFTER ENGINEROOM

The following observations are made as to the condition of this space:

- 1.) Well lighted in upper engine room, not well lighted below.
- 2.) Upper engine room in good material and cosmetic condition.
- 3.) Lower engine room is dirty, heavy rust/scale evident, possible PCB/oil contamination.
- 4.) Some standing oil in bilges.
- 5.) Hatches to lower room needs locking devices.

Pressure hull thickness gauge readings are as follows:

PORT .602 .592 .644 .635 .655 .608
STBD .600 .689 .695 .699 .723 .753

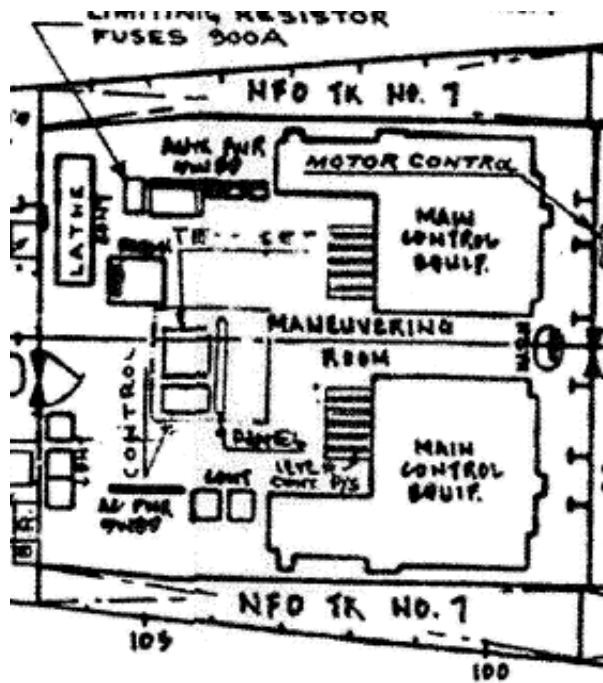
- 1.) Properly dispose of all standing oil from bilges and sumps.
- 2.) Consider cleaning, sanding and painting lower bilge space.
- 3.) Install proper lighting for bilge space.



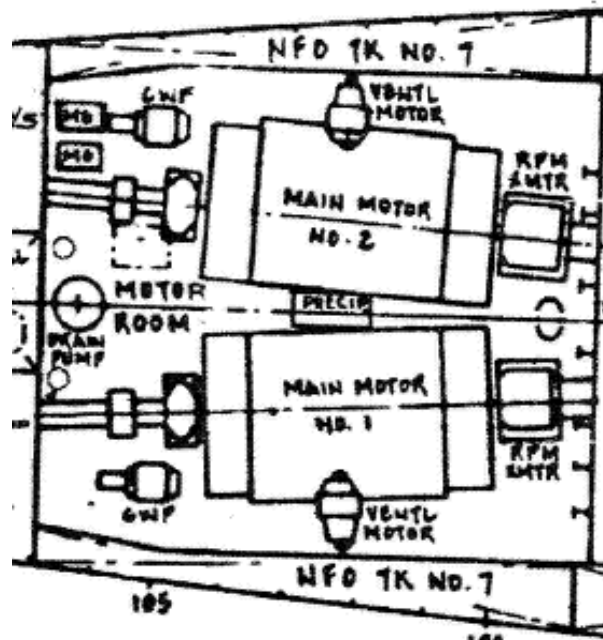
Aft Engine room, looking aft.

HULL INTERIOR (cont.)

MAIN PROPULSION & MOTOR CONTROL ROOM



Platform Deck, Motor Control Room, Frames 98 to 108.



Hold, Motor Control Room, Frames 98 to 108.

HULL INTERIOR (cont.)

MAIN PROPULSION & MOTOR CONTROL ROOM (cont.)

The following observations are made as to the condition of this space:

- 1.) Well lighted in upper room, no lighting below.
- 2.) Upper control room in good material and cosmetic condition.
- 3.) Lower motor room is dirty, heavy rust/scale evident, possible PCB/oil contamination.
- 4.) **Much standing water in bilges (12 to 18") with heavily corroded bases of bulkheads and foundations.**
- 5.) Hatches to lower room needs locking device.
- 6.) **Both shaft packing glands seeping water.**

Pressure hull thickness gauge readings are as follows:

PORT .623 .619 .645 .654 .556 .543
STBD .567 .544 .573 .639 .612 .601

- 1.) **Consider installation of exterior blanking seals while vessel is in water.**
- 2.) **At time of drydocking re-pack both shaft packing glands.**
- 3.) Lower motor room is dirty, heavy rust/scale evident, possible PCB/oil contamination.
- 4.) Properly de-scale, repair foundations as needed, sand, prime and paint lower space.
- 5.) Install proper lighting.



Platform Deck, Motor Control Room. Notice throttles and main panel.

HULL INTERIOR (cont.)

MAIN PROPULSION & MOTOR CONTROL ROOM (cont.)



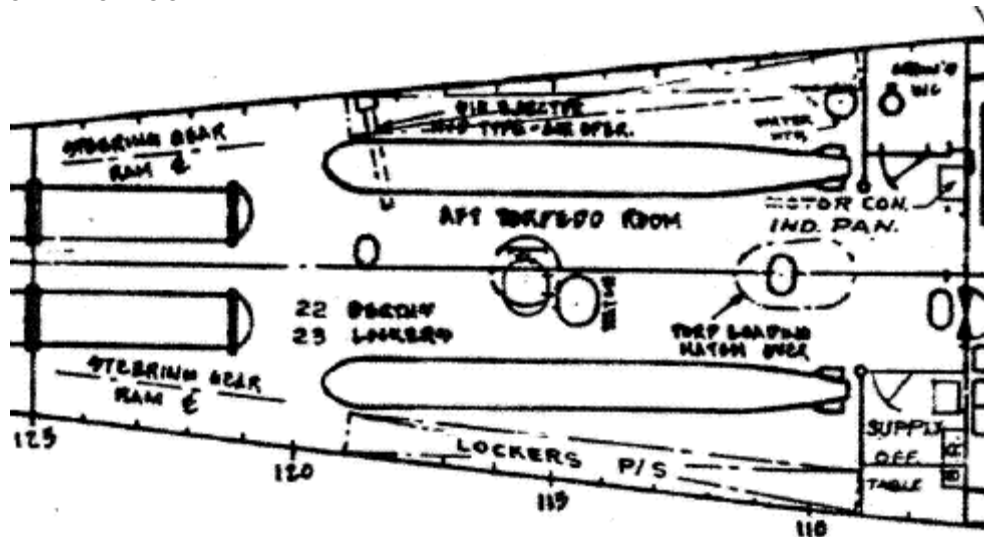
Port shaft packing gland in lower aft motor room. Showing weeping packing gland and standing water in bilges.



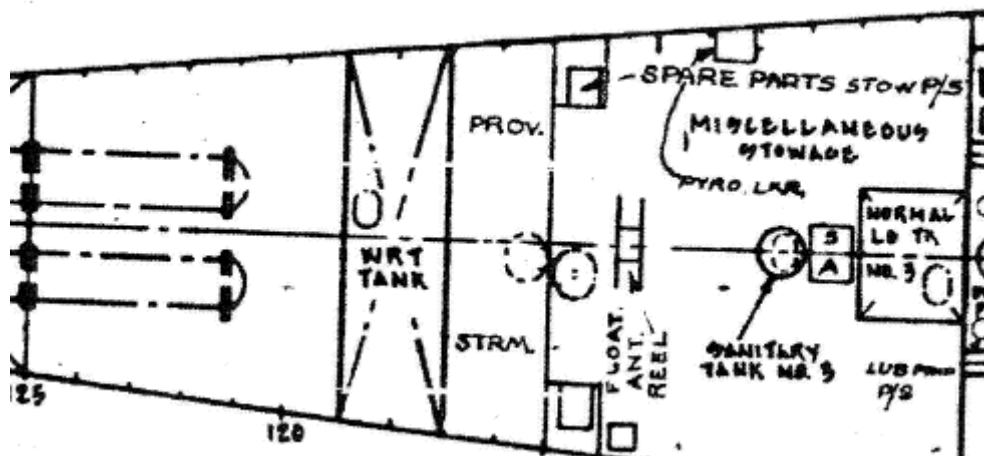
Standing water on centerline bilge of lower motor room.

HULL INTERIOR (cont.)

AFT TORPEDO ROOM



Aft Torpedo Room, Platform Deck, Frames 107 - 125.



Aft Torpedo Room, Hold, Frames 107 - 125

The following observations are made as to the condition of this space:

- 1.) Heavily rusted and scaled under main floors over after trim tank.
- 2.) After torpedo tubes do not appear to be leaking.
- 3.) Well lighted.
- 4.) Deck plates need proper securing to alleviate possible trip/fall condition.

Pressure hull thickness gauge readings are as follows:

PORT .612 .634 .675 .650 .643 .621
STBD .657 .656 .670 .630 .655 .635

HULL INTERIOR (cont.)

AFT TORPEDO ROOM (cont.)

- 1.) Consider properly sealing inboard door for surface buoy tube.
- 2.) Consider properly cleaning all bilge spaces in Storeroom, properly sand, prime and paint lower bilge spaces.
- 3.) Install proper lighting for lower bilge spaces.



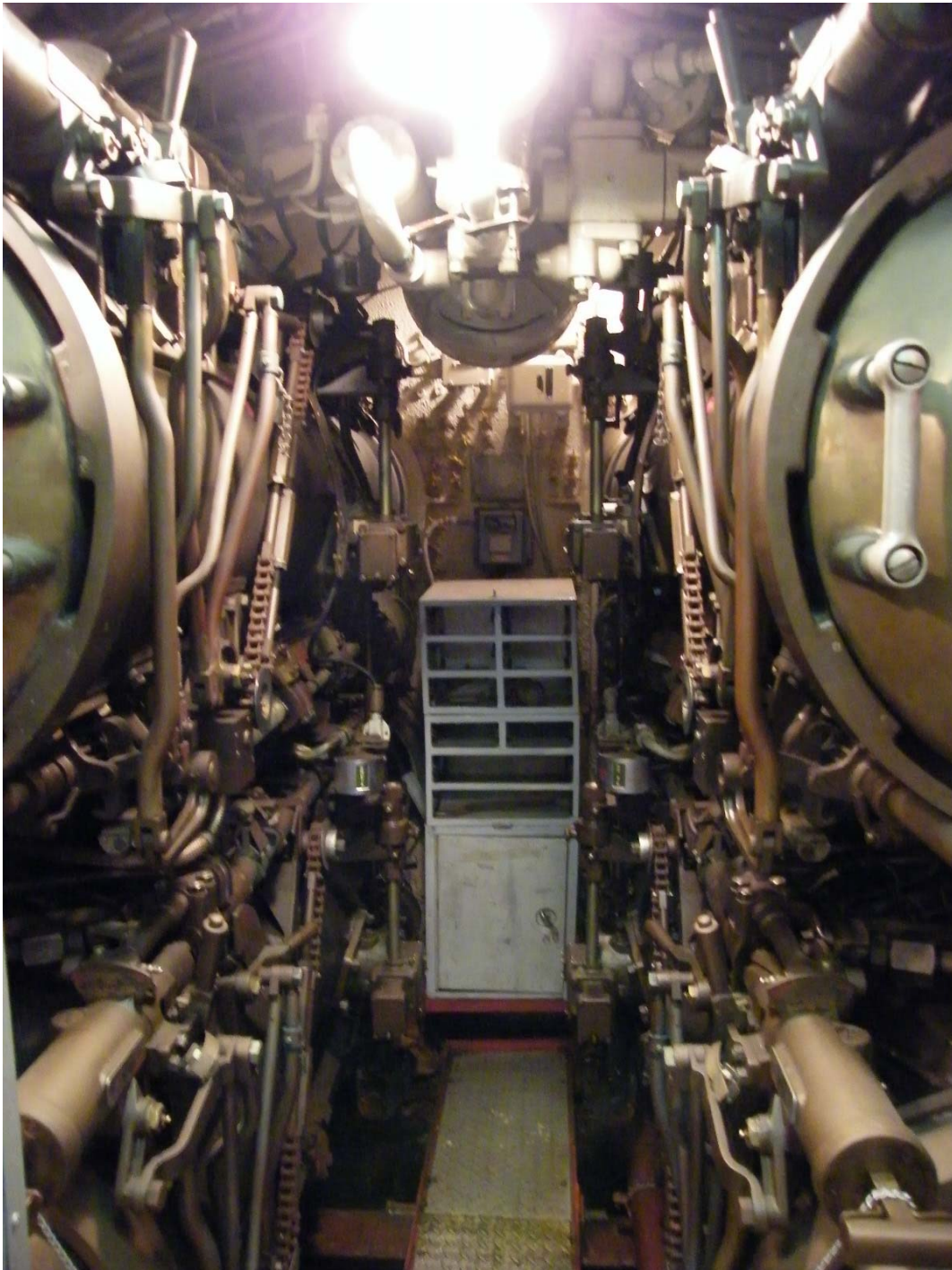
Aft Torpedo Room, looking aft.



Hold, Storeroom, formerly tank #7.

HULL INTERIOR (cont.)

AFT TORPEDO ROOM (cont.)



After bank of four torpedo tubes.

ELECTRONICS

The vessel has 440 Volt, 3 Phase, service capability at this time as most of the lighting circuits for the entire vessel are operable. The main control panels for these circuits are within each main machinery/engine room and in the main control room. All main power and load centers are well labeled and tagged and several ship's electricians have been going over all ship's service wiring and trunks prior to activation/inactivation of any additional circuitry. A shore power AC breaker box is mounted with appropriate shore cable rigged to the vessel.

Many of the boat's wiring harness to specialized equipment onboard has been severed as part of the "mothball" process.

All of the vessel's batteries are intact aboard.

Ship's wiring harness appears to be in good order and well preserved; although, much labeling has been removed during the decommissioning process.

VENTILATION

Currently, this system aboard is inoperable and ventilation is supplied by opening hatches and supplementary fans and natural ventilation.

The existing duct system is intact and in good repair; inspection will need to determine if there are PCB gasket issues.

The entire ventilation duct and filtration system will require cleaning.

Additional ventilation is needed for Hold spaces.

VESSEL HULL PRESERVATION/MANAGEMENT PLAN

No formal hull preservation/maintenance plan was presented during the inspection of this vessel. A hull maintenance program should be developed as a benchmark for scheduling ongoing repairs by utilizing ship's volunteer force (such as may exist) or contractors.

This is also a primary insurance underwriting concern. A well researched and complete maintenance program also provides successive management/personnel turn-overs with a superb research tool as to past work accomplished. The 'Standards for Historic Vessel Preservation Projects' issued by the Secretary of the Interior and the National Maritime Initiative may be of use in formulating such a plan.

FIREFIGHTING/SAFETY

The vessel, as previously mentioned, has adequate interior fire extinguishers. It is not known how familiar local fire department personnel are with the interior layout of this boat.

The Museum has stationed size I & II dry chemical extinguishers (all properly tagged) along all platforms within the passageways with one extinguisher being stationed between each pair of watertight doors. Emergency lighting is fitted throughout the vessel and is operable.

Ambulance and police service is not far away.

SUPPLEMENTAL RECOMMENDATIONS

The following additional recommendations are made:

1.) Remove old FREON and other gas cylinders throughout vessel.

2.) Shore Power System & Cables

This system has the following problems:

- a.) The shore cable box and cord should be fitted with protective lagging, fencing, or warning signs to ensure personnel and public are adequately protected,
- b.) Associated cable supports at railing topside need to be properly welded and secured to deck.

3.) Emergency Lighting

Emergency lighting is inoperable or has weak batteries in various areas of the below deck tour spaces.

4.) Insulation

Piping insulation in public access spaces will need attention as it has been disturbed/opened by past inspections and not put back to original shape.

5.) Safety Climbs

Climber safety rails need to be installed on any ladders leading out of lower storerooms and machinery spaces.

6.) Public Access/Watertight Hatches (Maindeck)

Both fore and aft hatches need to be refitted with proper gaskets installed.

7.) CO-2 Fire Bottles

Some of the vessel's fire extinguishers (particularly in lower engineroom spaces) are in need of recent inspection and tagging.

8.) Decking

Decking in areas of maindeck open to the public is slick and needs non-skid on centerline sections.

9.) Lifelines, Stanchions

Some of the lifeline stanchions need to be secured on maindeck.

SUPPLEMENTAL RECOMMENDATIONS (cont.)

10.) Switchboards

Proper shielding from public access all main switchboards is needed

Switchboard bus bars facing closest to the rear of the units are not labeled 'DANGER 440 VOLTS'; applicable voltage should be entered with red letters not less than 3/4" high.

11.) Lighting

Lenses, protective guards, and face plates were missing from many fluorescent and incandescent fixtures exposing naked bulbs or exposed, energized terminals. Repair/replace as needed.

12.) Electric Cables

Dead ended cables were not properly identified and isolated; properly identify and isolate these units throughout the ship. In general, the cabling on the weatherdecks and auxiliary engineering space has deteriorated. Cable jackets are deteriorated in many locations. Continue to identify and isolate/repair.

13.) Power Panels

The power panel in the main control room was missing components and has exposed component leads. Replace/repair.

14.) Asbestos Hazards

There are suspected asbestos hazards in all lower compartments identified throughout the ship. Confirmation/control measures are needed where suspect. Asbestos is present and the integrity of the covering is degraded. Develop working asbestos plan and use 29 CFR 1910, 1915 & 1926 as guides.

15.) Grab Rods

Grab rods need to be fitted where they would aid persons using ladders.

16.) Slip Resistant Treads

Slip resistant treads are degraded or missing at many areas throughout the vessel. Repair/replace as necessary

17.) Remove standing water and oil from all interior spaces. Inspect and clean electrics prior to lighting off any panels. Dispose of any waste oil and water according to Clean Water Act and Oil Pollution Act of 1990.

SUPPLEMENTAL RECOMMENDATIONS (cont.)

- 18.) Develop 'Safe Working Practices Plan' for lead, asbestos, confined spaces, air contaminants and safety standards for shipboard and shipyard employment. Designate 'Competent Person' and ensure this person is thoroughly versed/trained in these categories. Establish training program for volunteers and staff using OSHA guidelines. Much free assistance is provided by this government agency as regards methodology for training and compliance.
- 19.) Develop hull maintenance program.
- 20.) Develop 'Safe Working Practices Program' for safety and lifesaving.
- 21.) Establish an inspection program as required by 29 CFR 1915 and 1917.
- 22.) Install proper float alarms and instruct park personnel about emergency procedures with regard to a flooding event.



SUMMARY

CLAMAGORE has been in existence for 63 years and despite that is in fair material and structural condition. The topsides require cosmetic and structural attention, but these are the usual issues that all museum ships face. Her hull is the major question mark as her ballast tank system must be sorted out prior to her move to drydock.

An experienced crew with ability to fabricate gaskets, perform tap/die functions and be informed about the ballast tank system arrangement should be in place before any fuel/ballast tank hatches are removed. Removal of contaminated water/oil from her fuel/ballast tank system is paramount before an incident occurs.

The above will have to be sorted out prior to removal of mud around vessel as CLAMAGORE will be afloat at all stages of the tide after dredging.

Selective audio-gauging of her maindeck, bulkheads, platforms, and some side plating shows excessive plate wastage at the waterline; readings on the ballast tank skin plating and main pressure hull show only a greater than 60% loss throughout the vessel. There is minor compression of surface plating on the outer fuel/ballast tank skin at time of survey. The pressure hull is sound.

Care of her hull deserves immediate attention. Her topside paint system has failed and needs immediate remediation. Likewise, her superstructure deck is in trouble and immediate attention is needed there to prevent further degradation.

Drydocking and repair of the vessel is needed and should be a priority.

All interior ballast and fuel tank spaces were not inspected.

The Museum should develop a hull maintenance and repair program, and establish a proper training program for staff for flooding events, hazardous materials, air contaminants, confined space entry, lead, PCB and asbestos issues. This plan will provide the planning required for downstream restoration work.

The bottom line is that U.S.S. CLAMAGORE is an exceptional museum icon that many have come to see as incorporating some of the best in American material culture. She is the last of her breed.

A great boat.

Joseph Lombardi
Principal Surveyor

.NOTE: This yacht or workboat survey is issued by the undersigned who has exercised reasonable care in conducting a visual inspection of the accessible areas in connection with a marine survey of the subject vessel. All details and particulars in this report are believed to be true, but are not guaranteed accurate. All judgments, conclusions, and recommendations are expressions of opinion of the undersigned based upon his skill, training, and experience after a routine examination of the vessel and after discussions with owners or others familiar with the vessel. No part of this report is issued as an expressed or implied warranty of the condition of the vessel, of the value of the vessel or of the cost of any repairs. Unless specifically stated otherwise in this report, the undersigned has not removed fasteners, has not removed fixed structures or equipment, and has not disassembled hull or machinery for inspection or testing; therefore this report does not cover latent defects not readily discovered without such removal or disassembly. Unless specifically stated otherwise in this report, the undersigned has not operated the engines, machinery, equipment, or appurtenances. The undersigned has conducted his survey and issued this report for the sole use of the specified requesting party for an agreed fee based upon the intended use of the report and the legal liability of the undersigned; accordingly, others are not to use this report and not to rely upon the contents of this report without payment to the undersigned of an additional agreed fee based upon reevaluation of the same factors; further, the undersigned shall have no liability for consequential damages, no liability for personal injury damages, no liability for property loss damages, and no liability for punitive damages, all of which shall be deemed to have been knowingly and voluntarily waived upon use of this report; further, in no event shall the legal liability of the undersigned for this report ever exceed the fee paid by the requesting party for issuance of this report, regardless of the number of claims or suits and regardless of whether under theory of tort, contract, warranty, products, outrage, or otherwise.

APPENDIX III — **Geotechnical Reports**

**REPORT OF
GEOTECHNICAL EXPLORATION**

**Feasibility Study for
USS Clamagore Improvements and Relocation
Patriots Point Naval and Maritime Museum
Mount Pleasant, South Carolina
S&ME Project No. 1131-09-471**

Prepared For:

Patriots Point Naval & Maritime Museum
40 Patriots Point Road
Mount Pleasant, South Carolina 29464

Prepared By:



620 Wando Park Boulevard
Mt. Pleasant, South Carolina 29464

October 30, 2009



October 30, 2009

Patriots Point Naval & Maritime Museum
40 Patriots Point Road
Mount Pleasant, South Carolina 29464

Attention: Mr. Bob Howard, Director of Operations

Reference: **REPORT OF GEOTECHNICAL EXPLORATION**
Feasibility Study for USS Clamagore Improvements and Relocation
Patriots Point Naval and Maritime Museum
S&ME Project No. 1131-09-471

Dear Mr. Howard:

We have completed a geotechnical exploration for use in a feasibility study for the proposed relocation of the USS Clamagore at the Patriots Point Naval and Maritime Facility in Mount Pleasant, South Carolina. Our services were provided in general accordance with S&ME Proposal No. 31-09-072B, dated September 16, 2009. The purpose of our exploration was to evaluate the subsurface conditions at the site pertinent to the temporary support of the vessel as it is moved from its present berth to its proposed final location on land. This report presents our understanding of the planned construction, the site and subsurface conditions, and our geotechnical conclusions and recommendations.

PROJECT INFORMATION

We understand plans are to relocate the 322-ft long USS Clamagore from its present berth to adjacent land at the Patriots Point Naval and Maritime Facility. The proposed final location for the Clamagore is paved and presently used for parking. The vessel is presently resting on the mud river bottom. Three options are under consideration for relocation of the vessel in your feasibility study.

- A cofferdam will be constructed encompassing an area that traverses the existing shoreline and extends into the water. The vessel will be floated into the cofferdam, the cofferdam will be closed and then the water level raised in much the same way as a canal lock. The vessel will be moved to its final location once raised to a suitable elevation.
- A channel will be dredged from the vessel to the shore, with a trench excavated in the existing harbor bank and into the parking area. A pile-supported rail system will be constructed from the final location, through the trench and into the newly dredged channel. The vessel will then be floated to the rail system and winched to its final location.

Once the vessel is in its final location, permanent supports will be constructed around the rail system and it will be dismantled. We assume the temporary rail supports will be driven steel piles.

- A pile-supported crane trestle will be constructed from the land to the vessel location. Crane(s) will be used to lift and transport the vessel to its final location on land.

This project information was provided by Mr. Dwight Cathcart of the Dennis Corporation through email and telephone correspondence with Mr. Aaron Goldberg of our firm during March, September, and October 2009, our review of animation and renderings available on the Dennis Corporation website, and our visits to the site.

We used existing subsurface data that we collected previously¹ at the site for developing an understanding of the conditions on land. This exploration and use of existing data are for the purpose of a feasibility evaluation and are not adequate for preparation of design plans. Once the project moves into the design phase, we must be contacted to develop and implement the necessary geotechnical exploration and analysis for final design of any of the proposed methods.

METHODS OF EXPLORATION

Field Testing

As requested, we explored the subsurface conditions in the Cooper River with two soil test borings. The borings were performed from a barge to depths of about 83½ to 87 ft below the barge deck. Test locations were established in the field by estimating distances from existing site features. Coordinates for the test locations were obtained with the handheld GPS unit with submeter accuracy. The approximate test locations are shown on the Test Location Plan (Figure 1) in the Appendix. Boring elevations were estimated from published tide data. A more detailed description of our field testing procedures and the SPT Boring Logs are also included in the Appendix.

Laboratory Testing

Five representative soil samples were subjected to laboratory natural moisture content, grain size distribution, and/or Atterberg limits testing. This laboratory testing was performed in substantial accordance with applicable ASTM standards. The test results are presented on individual laboratory data sheets in the Appendix.

¹ Geotechnical Exploration, Landside Infrastructure Improvements Harbor Bank Erosion Control – Patriots Point, Mt. Pleasant, South Carolina, S&ME Project No. 1131-09-111, Project No. P-36-9530-PG and Proposed Flight Simulator, Patriots Point Naval & Maritime Museum, Mt. Pleasant, South Carolina, S&ME Project No. 1131-06-354

SITE AND SUBSURFACE CONDITIONS

Site Conditions

The Patriots Point Naval and Maritime Facility is located on the Cooper River in Mt. Pleasant, South Carolina. The facility presently consists of the Yorktown Visitor Building and associated parking on the land and the USS Yorktown and USS Clamagore in the Cooper River. The elevation difference of the surrounding marshes and the land is estimated to about 10 to 15 ft. The proposed permanent location for the USS Clamagore is currently a paved parking area south of the Visitor Building.

The site is known to be a former dredge spoil disposal area. On the high ground, fill likely exists from the ground surface to a depth of about 15 ft based upon the elevation difference of this site compared to the surrounding marshes.

Subsurface Conditions

Details of the subsurface conditions encountered by the borings and the previously performed soundings are shown on the logs in the Appendix. These logs represent our interpretation of the subsurface conditions based upon field data. Stratification lines on the sounding logs represent approximate boundaries between soil behavior types²; however, the actual transition may be gradual. The general subsurface conditions and their pertinent characteristics are discussed in the following paragraphs.

The over water exploration initially encountered 20 to 30 ft of very soft clayey silt. Beneath the silty clay layer, the subsurface conditions generally consisted of very loose to loose sand to the top of the Cooper Marl³. The marl was encountered at a depth of about 40 ft below the mudline, which corresponds to an elevation of about -48 ft-NAVD88. The marl continued to the deepest explored depth of about 83 ft below the mudline. The water depth at the boring locations ranged from a low of 0 ft at SPT-1 to over 9 ft at SPT-2 during our investigation. Water levels at the site vary with tidal changes.

The previously performed CPT soundings encountered 5 to 12 ft-thick layers of very soft to firm clay and very loose to medium dense sands to a depth of about 43 ft below grade. Based on our estimate that the ground surface elevation at our soundings was about +18 ft, the soils extend to an elevation of about -25 ft. Beneath the interbedded sands and clays, medium dense sands were encountered to the top of the Cooper Marl. The top of the Cooper Marl was encountered at depths of 70 to 73 ft below ground, which corresponds to top of marl elevations of -52 to -55 ft.

² Soil Behavior Type (SBT) shown on the CPT logs is calculated based on empirical correlations with tip resistance, sleeve friction, and pore pressure. A CPT log may define a soil based on its behavior as one type while its grain size and plasticity, the traditional basis for soil classification, may define it as a different type.

³ The Cooper Marl, locally referred to as “marl”, is an incompressible, thick (≥ 200 ft) stratum which underlies the area, and is typical the bearing stratum for deep foundations in the Charleston area.

The water depth at the sounding locations was measured 5 to 7 ft below grade.

CONCLUSIONS AND RECOMMENDATIONS

The conclusions and recommendations presented herein are based, in part, upon the data obtained during our subsurface exploration. During review of these recommendations, it should be kept in mind that with any previously filled site, unexpected and variable subsurface conditions (e.g., organic matter, buried debris or obstructions, etc.) may be encountered during construction. From our subsurface exploration, we have provided model soil profiles that can be used for wall design for the cofferdam method of relocation and axial compression and tension pile capacities for several pile types for the rail system and crane trestle methods. For permanent support of the vessel on land, we anticipate that the loads, load configuration, and the presence of the dredge spoil fill will require the vessel be supported on deep foundations.

Model Soil Profile for Cofferdam Method

Based on our understanding of the proposed cofferdam method, the containment walls will extend from the land to the water. The soil profile will change as the structure transitions from the land into the water. A model soil profile for the water is shown in Table 1. A model soil profile for the land is shown in Table 2. Lateral earth pressures exerted on the wall can be calculated using the values shown in Tables 1 and 2.

Table 1. Design Soil Parameters for Water Structures

Soil Layer	Top Elevation (ft)	Bottom Elevation (ft)	γ_{dry} (pcf)	γ_{sat} (pcf)	Drained Condition					Undrained Condition	
					ϕ' (degrees)	K_o	K_A	K_P	δ (degrees)	c (psf)	c_A (psf)
Clayey Silt	-4	-35	50	100	20	1	1	1	14	200	0.8c
Sand	-35	-48	85	110	28	0.53	0.36	2.77	14	-	-
Cooper Marl	-48	-79	75	110	44	1	1	1	14	3000	0.8c

Table 2. Design Soil Parameters for Land Structures

Soil Layer	Top Elevation (ft)	Bottom Elevation (ft)	γ_{dry} (pcf)	γ_{sat} (pcf)	Drained Condition					Undrained Condition	
					ϕ' (degrees)	K_o	K_A	K_P	δ (degrees)	c (psf)	c_A (psf)
Sand / Clay	+18	-25	40	100	20	1	1	1	14	360	0.8c
Sand	-25	-56	85	110	32	0.47	0.31	3.25	14	-	-
Cooper Marl	-56	-79	75	110	44	1	1	1	14	3000	0.8c

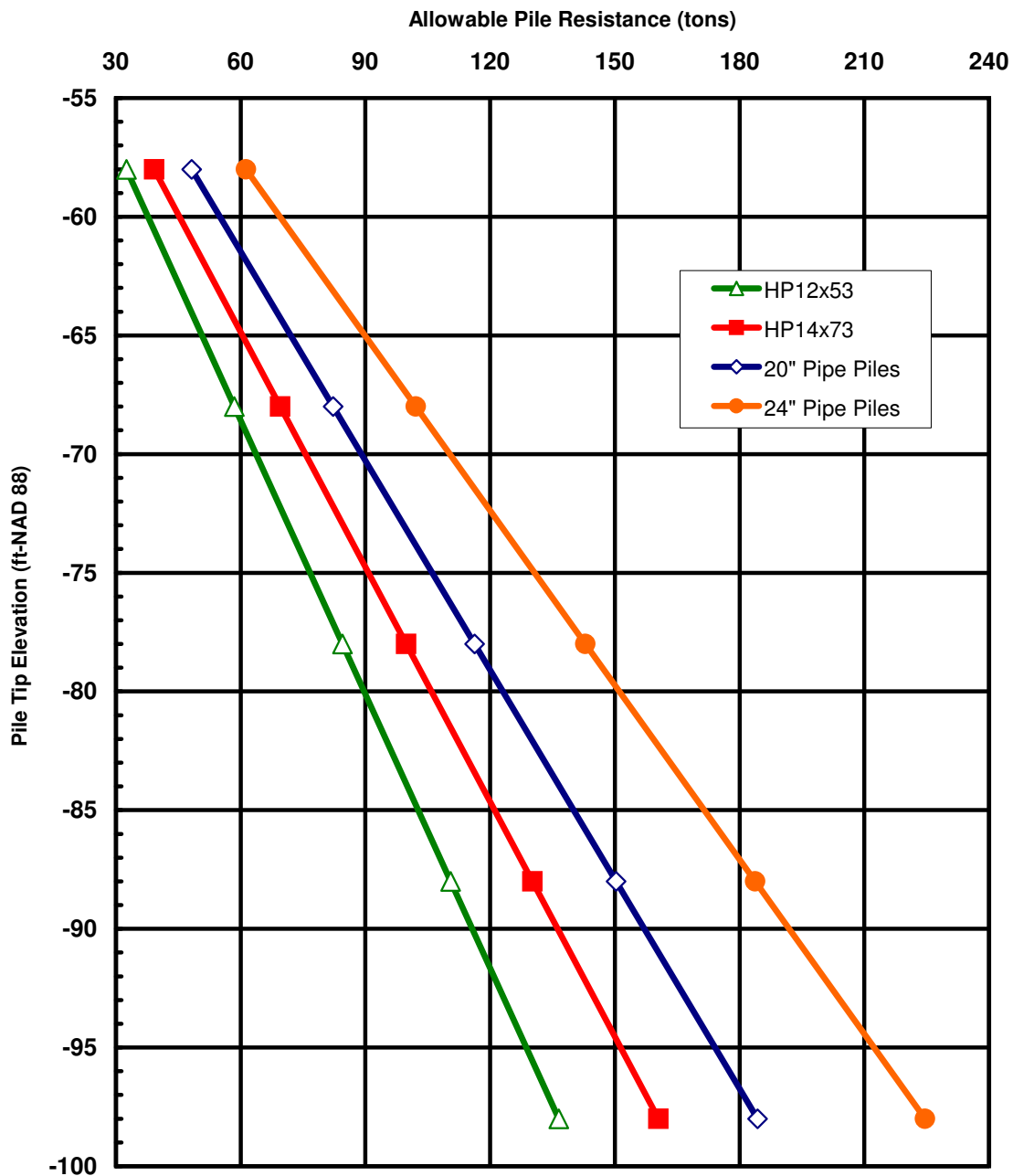
Soil properties are presented for both drained and undrained conditions to be used with long and short-term loading conditions, respectively. Both the drained and undrained cases should be evaluated to determine the critical design case.

Axial Pile Recommendations for the Rail and Trestle Methods

We recommend support of the rail system or crane trestle be achieved by installing driven piles. Figure A provides our recommended allowable axial capacities for steel HP12x53, HP14x73, 20-in. diameter pipe, and 24-in. diameter open-ended pipe piles.

An efficiency factor (to account for capacity reductions caused by group effects) of 1.0 should be used for center-to-center pile spacings of three pile diameters or more, which is the minimum recommended spacing. The structural capacity of the piles has not been considered in our analysis and should be checked by the Structural Engineer. The capacities shown in Figure A are based on the assumption that a pile load test program, as described below, will be implemented.

Driven pile capacities should be verified at the start of construction, before production piles are ordered, through dynamic pile testing with the use of a Pile Driving AnalyzerTM (PDA) (ASTM D4945). Dynamic testing is more economical than static load testing and will enable several piles to be quickly tested. We recommend that at least three piles, spaced equally along the length of the structure, be dynamically tested during restrike driving 5 days after installation to determine their capacity. An Engineering Technician working under the direction of the Geotechnical Engineer should monitor all pile driving to verify that the piles are encountering expected driving resistances and note any damage or other problems during installation.



NOTES:

- 1) The structural capacity of the piles has not been considered in our analysis and should be evaluated by the project structural engineer.
- 2) The allowable tensile capacity is approximately $\frac{2}{3}$ of the compressive capacity.
- 3) The minimum recommended pile tip elevation is -58 ft-NAVD 88 (10 ft into the marl).
- 4) The recommended minimum center-to-center pile spacing is 3 pile diameters.

Project No.: 1131-09-471
Date: October 2009



ALLOWABLE PILE RESISTANCE

USS Clamagore Relocation
Mount Pleasant, South Carolina

Figure A

LIMITATIONS OF REPORT

This report has been prepared in accordance with generally accepted geotechnical engineering practice for specific application to this project. The conclusions and recommendations contained in this report are based upon applicable standards of our practice in this geographic area at the time this report was prepared. No other warranty, express or implied, is made.

The analyses and recommendations submitted in this report are based, in part, upon data obtained from our subsurface exploration. The nature and extent of subsurface variations will not become evident until construction. If variations appear evident, then we should be given the opportunity to re-evaluate the recommendations of this report. In the event that any changes in the nature, design, or location of the proposed addition are planned, the conclusions and recommendations contained in this report will not be considered valid unless the changes are reviewed and conclusions modified or verified in writing.

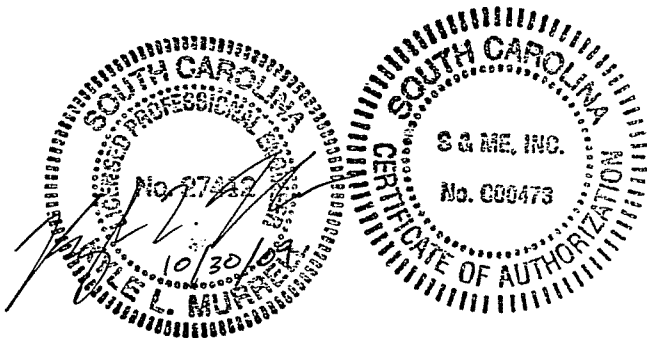
We recommend that S&ME be retained to review the final design plans and specifications to confirm that earthwork and foundation recommendations are properly interpreted and implemented.

CLOSURE

We appreciate the opportunity to be of service on this project. If you have any questions concerning this report, please call.

Sincerely,

S&ME, Inc.



Kyle L. Murrell, P.E.
Project Engineer

KLM/ADG

Handwritten signature of Aaron D. Goldberg, P.E.

Aaron D. Goldberg, P.E.
Senior Engineer

APPENDIX

Test Location Plan (Figure 1)

Site Location Plan (Figure 2)

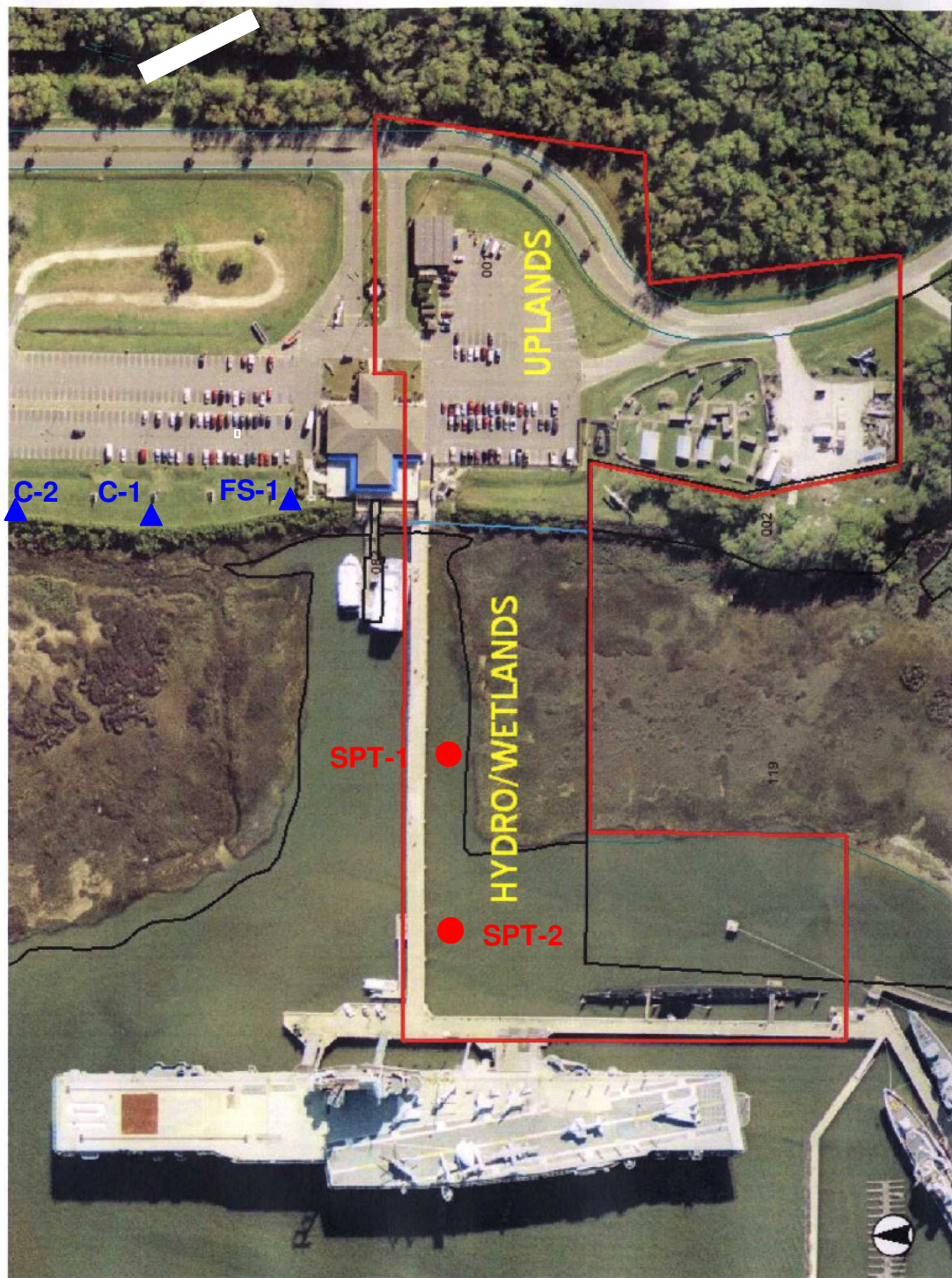
SPT Boring Logs

Previous CPT Sounding Logs

Field Testing Procedures

Laboratory Test Results

Laboratory Testing Procedures



SPT Test Location ●
Previous CPT Test Location ▲

This site plan was adapted by S&ME.
 Test locations are approximate.
 Do not use for estimation of distances or quantities.

Project No. 1131-09-471

October 2009

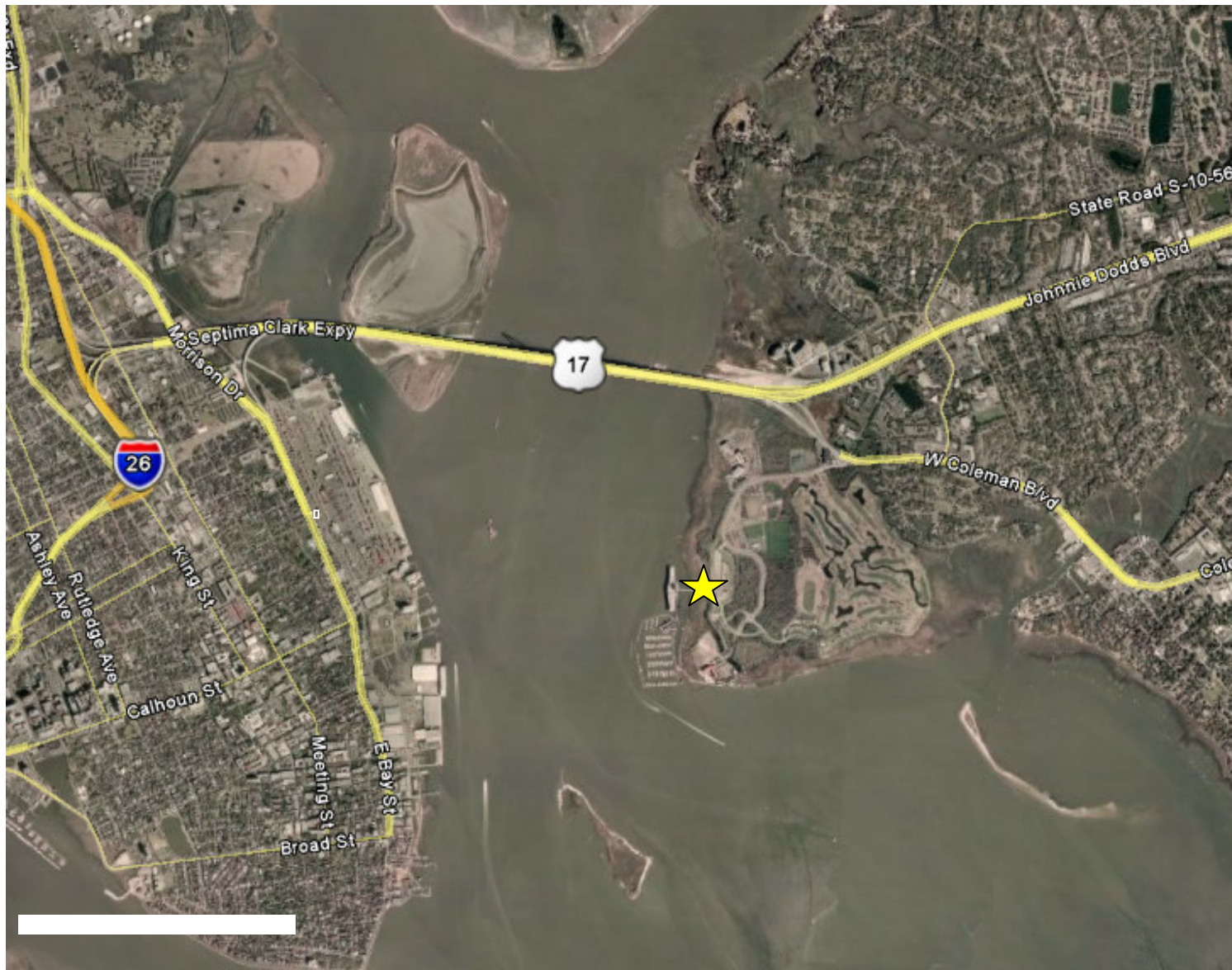
Not to Scale



TEST LOCATION PLAN

USS Clamagore Relocation
 Patriots Point
 Mount Pleasant, South Carolina

Figure 1



Site Location

Project No: 1131-09-471

Date: October 2009

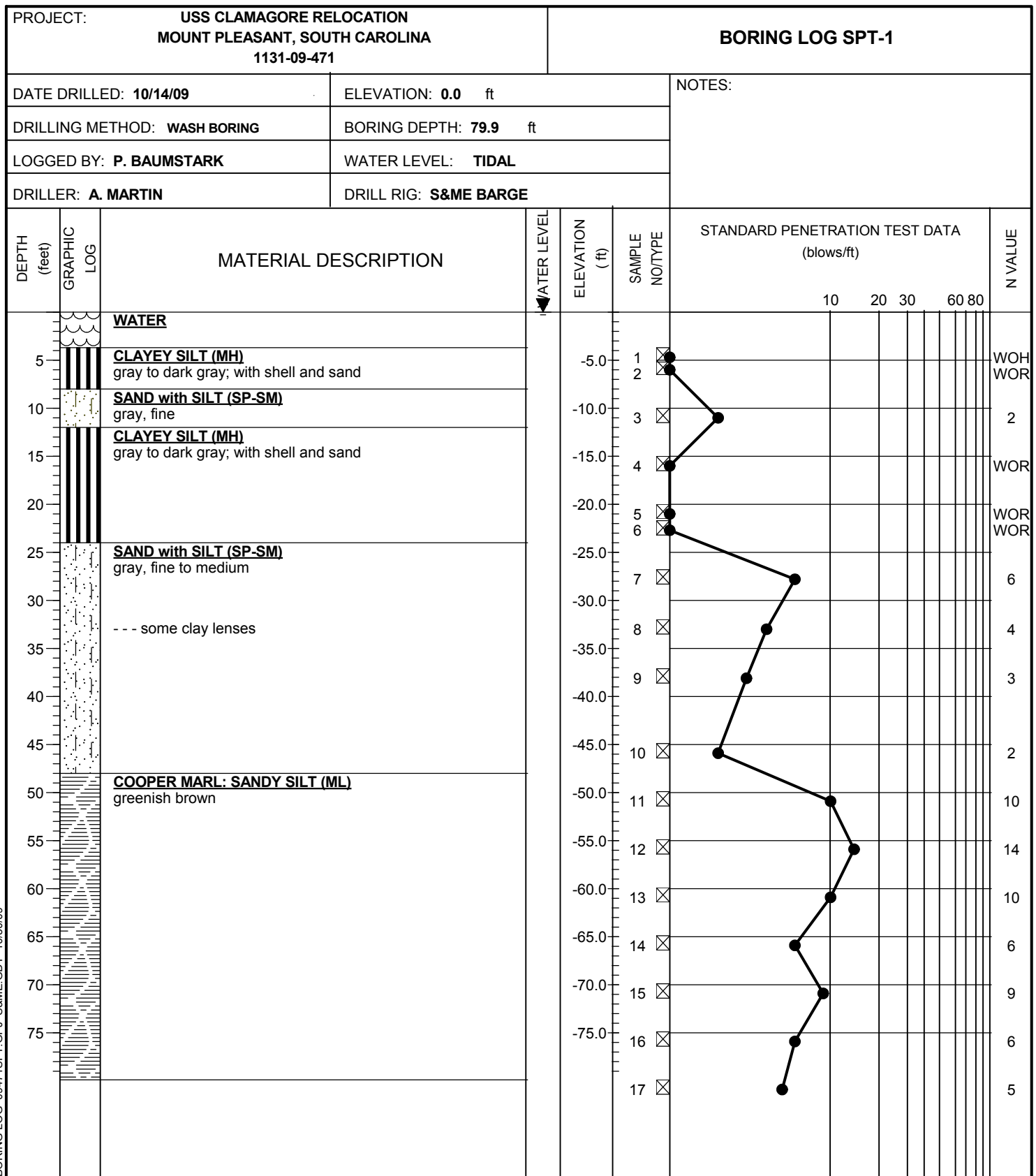
Not to Scale



SITE LOCATION PLAN

Patriots Point Naval and Maritime Facility
Mount Pleasant, South Carolina

Figure 2



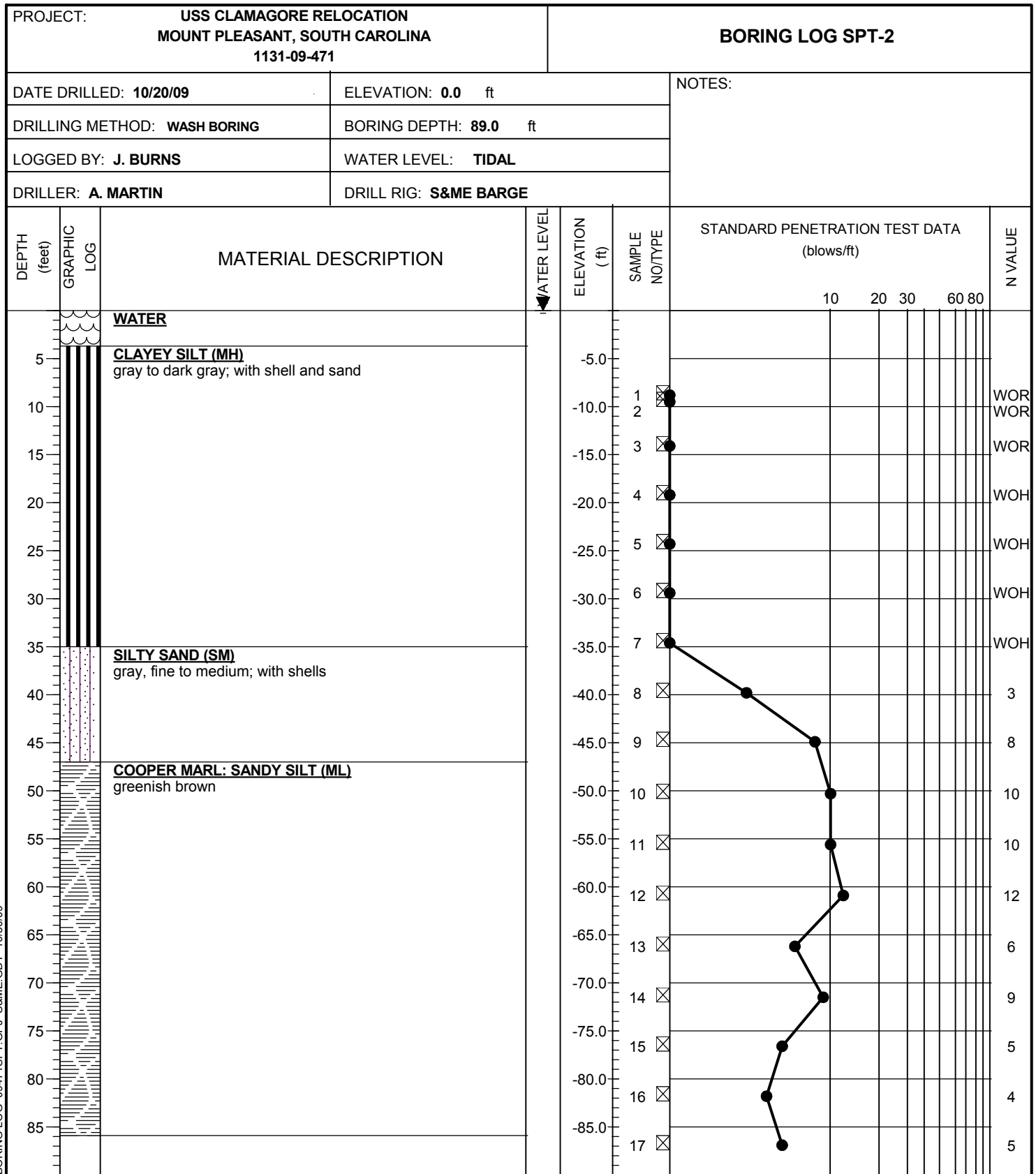
1. BORING AND SAMPLING IS IN ACCORDANCE WITH ASTM D-1586.
2. PENETRATION (N-VALUE) IS THE NUMBER OF BLOWS OF 140 LB. HAMMER FALLING 30 IN. REQUIRED TO DRIVE 1.4 IN. I.D. SAMPLER 1 FT.



S&ME

ENGINEERING • TESTING
ENVIRONMENTAL SERVICES

620 Wando Park Boulevard
Mt. Pleasant, SC



1. BORING AND SAMPLING IS IN ACCORDANCE WITH ASTM D-1586.
2. PENETRATION (N-VALUE) IS THE NUMBER OF BLOWS OF 140 LB. HAMMER FALLING 30 IN. REQUIRED TO DRIVE 1.4 IN. I.D. SAMPLER 1 FT.



S&ME

ENGINEERING • TESTING
ENVIRONMENTAL SERVICES

620 Wando Park Boulevard
Mt. Pleasant, SC

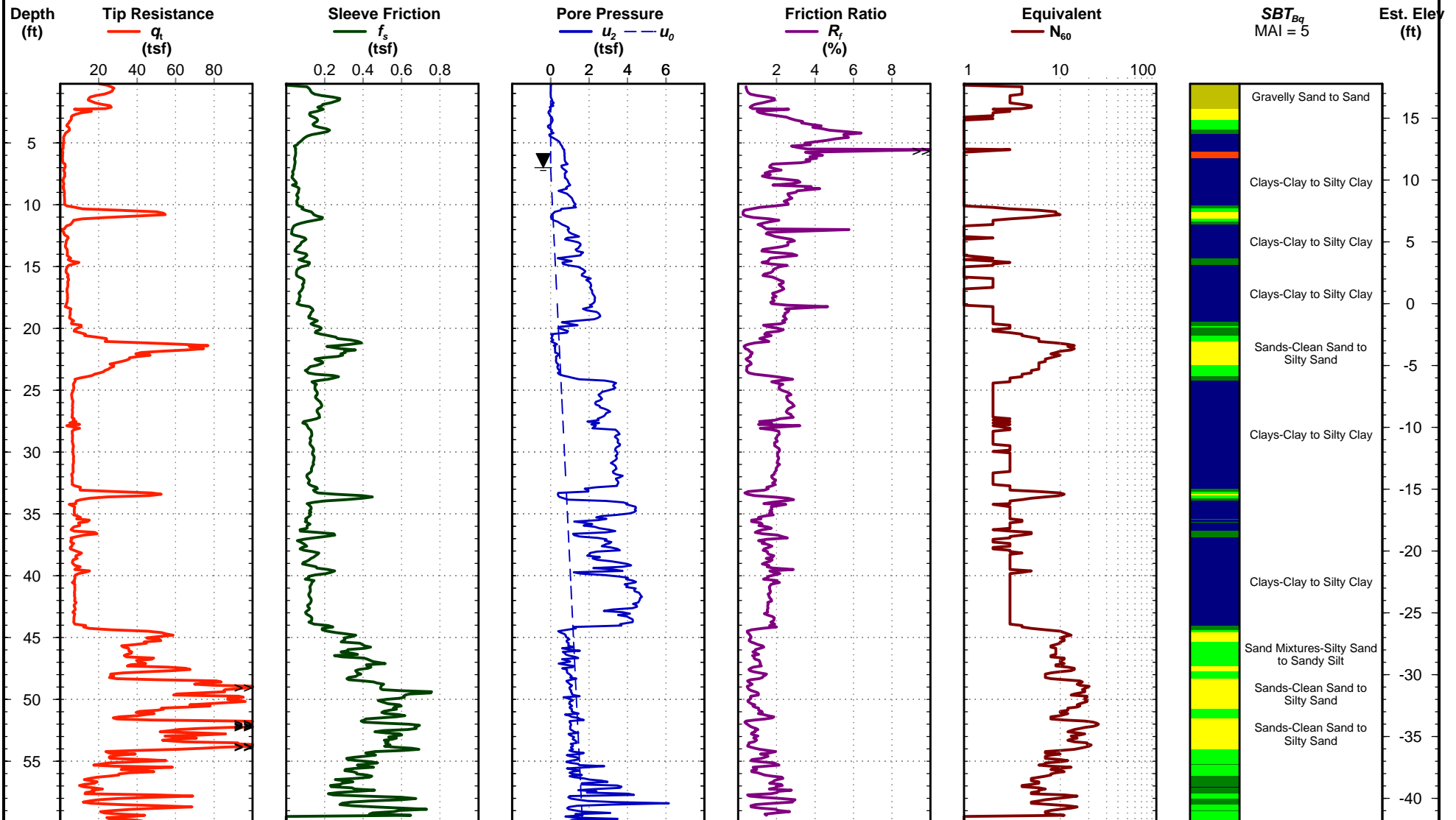


Proposed Flight Simulator
Mount Pleasant, SC
S&ME Project No: 1131-06-354

Cone Penetration Test FS-1

Date: May. 3, 2006
Estimated Water Depth: 7 ft
Rig/Operator: Andy Butch

Total Depth: 59.8 ft
Termination Criteria: Target Depth
Cone Size: 1.44



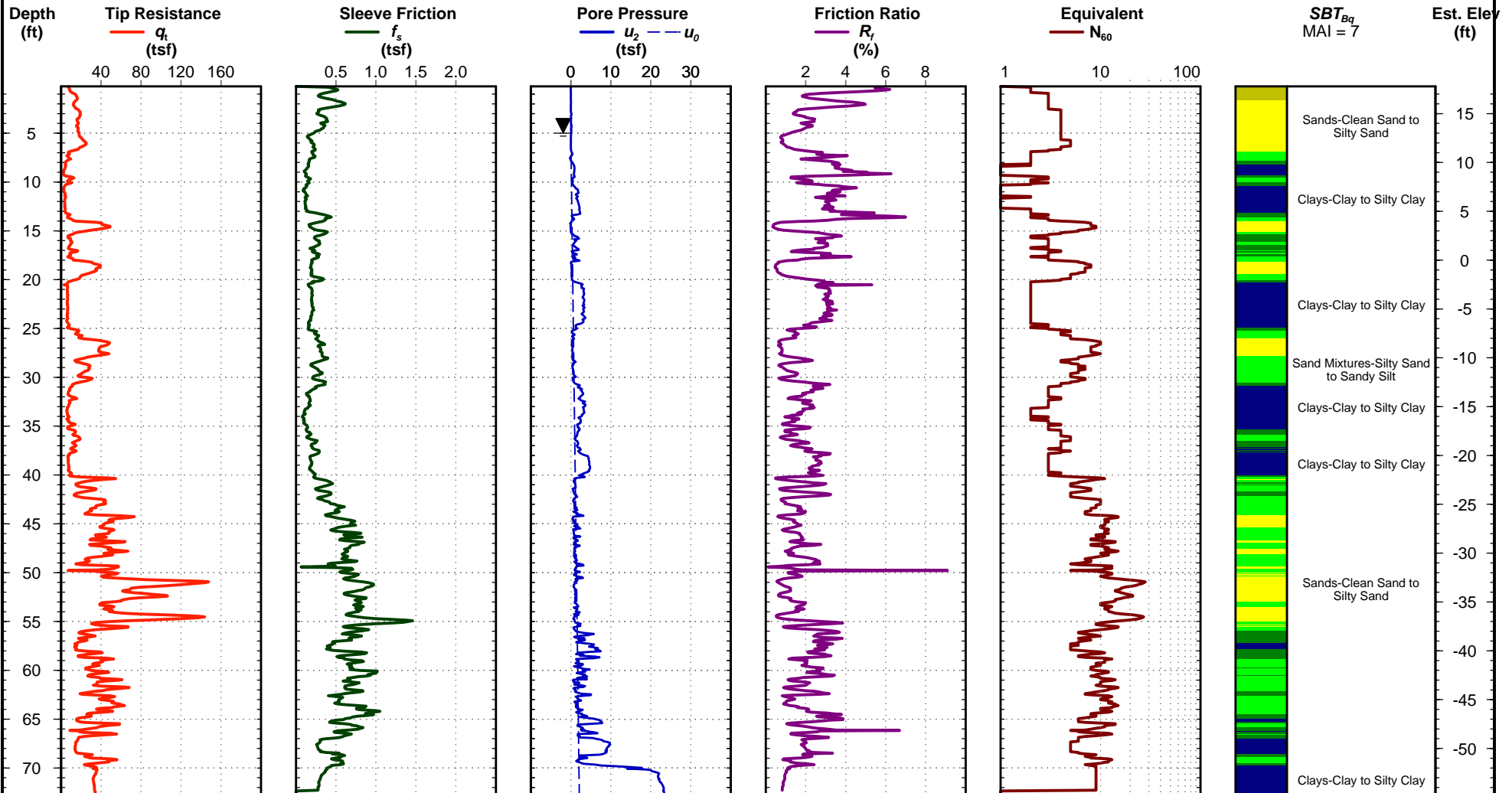


Cone Penetration Test

C-1

Date: Mar. 31, 2009
Estimated Water Depth: 5 ft
Rig/Operator: ATV / M. Cox

Total Depth: 72.7 ft
Termination Criteria: Target Depth
Cone Size: 1.75



C-1



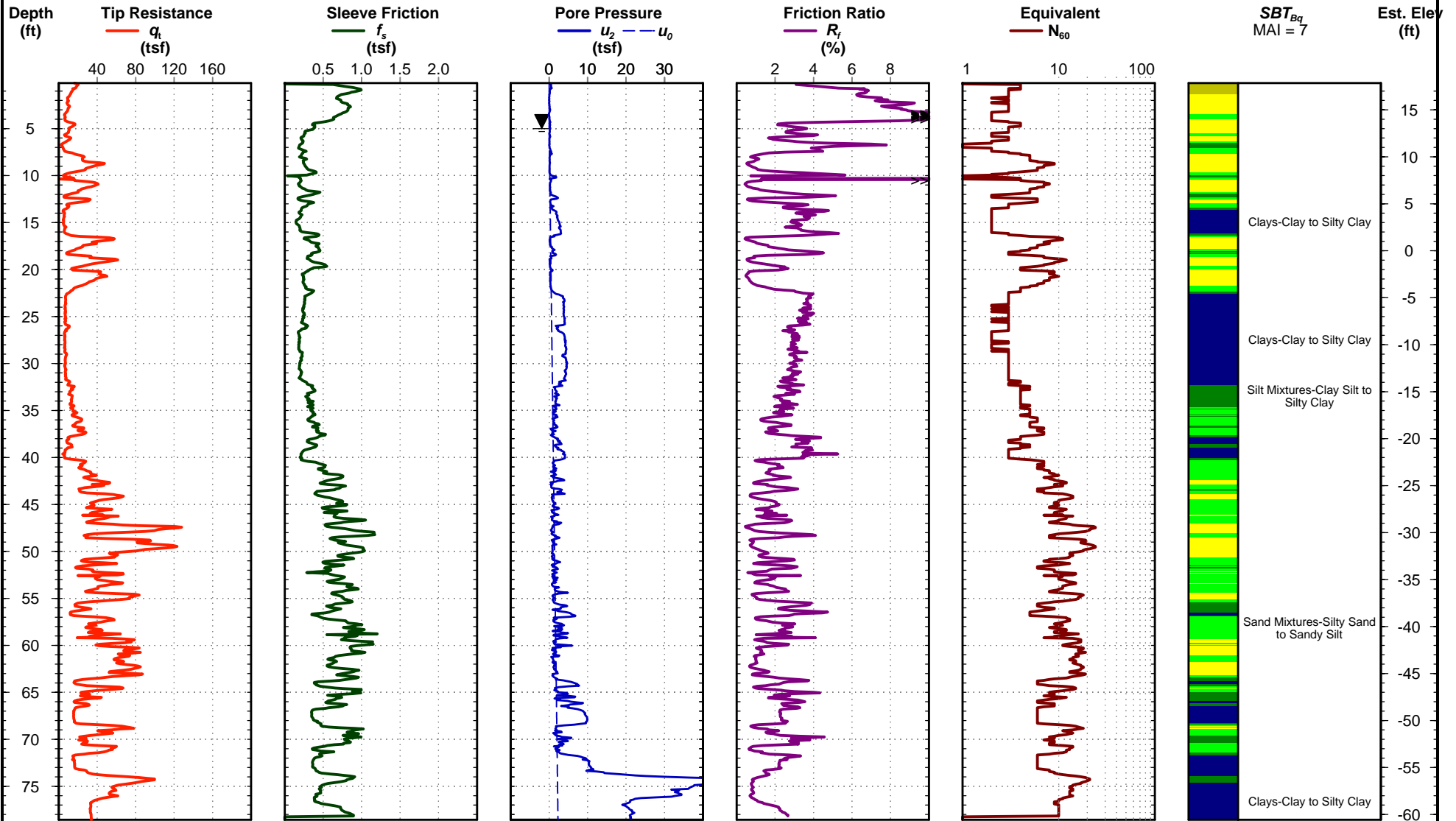
Landslide Infrastructure Improvements
Mt. Pleasant, SC
S&ME Project No: 1131-09-111

Cone Penetration Test

C-2

Date: Mar. 31, 2009
Estimated Water Depth: 5 ft
Rig/Operator: ATV / M. Cox

Total Depth: 78.6 ft
Termination Criteria: Target Depth
Cone Size: 1.75



C-2

FIELD TESTING PROCEDURES

Soil Test Borings

All boring and sampling operations were conducted in accordance with ASTM Designation D-1586. Initially, the borings were advanced by either mechanically augering or wash boring through the soils. Where necessary, a heavy drilling fluid is used below the water table to stabilize the side and bottom of the drill hole. At regular intervals soil samples were obtained with a standard 1.4-inch I.D., 2-inch O.D., split-barrel sampler. The sampler was first seated 6 inches to penetrate any loose cuttings and then driven an additional foot with blows of a 140 pound hammer falling 30 inches. The number of hammer blows required to drive the sampler the final foot is designated the "Standard Penetration Resistance." The penetration resistance, when properly evaluated, is an index to the soil strength.

Soil Classifications

Soil classifications provide a general guide to the engineering properties of various soil types and enable the engineer to apply his past experience to current problems. In our exploration, samples obtained during drilling operations are examined and visually classified according to color, texture, and relative density or consistency (based on standard penetration resistance). The consistency and relative density designations are as follows:

<u>SANDS</u>		<u>SILTS AND CLAYS</u>	
N (SPT)	Relative Density	N (SPT)	Consistency
0 - 4	Very Loose	0 - 2	Very Soft
5 - 10	Loose	3 - 4	Soft
11 - 30	Medium Dense	5 - 8	Firm
		9 - 15	Stiff
31 - 50	Dense	16 - 30	Very Stiff
50+	Very Dense	31 - 50	Hard
		50+	Very Hard

FIELD TESTING PROCEDURES

Cone Penetrometer Test (CPT) Sounding

The cone penetrometer test soundings (ASTM D 5778) were performed by hydraulically pushing an electronically instrumented cone penetrometer through the soil at a constant rate. As the cone penetrometer tip was advanced through the soil, nearly continuous readings of point stress, sleeve friction and pore water pressure were recorded and stored in the on-site computers. Using theoretical and empirical relationships, CPT data can be used to determine soil stratigraphy and estimate soil properties and parameters such as effective stress, friction angle, Young's Modulus and undrained shear strength.

The consistency and relative density designations, which are based on the cone tip resistance, q_t for sands and cohesive soils (silts and clays) are as follows:

<u>SANDS</u>		<u>SILTS AND CLAYS</u>	
Cone Tip Resistance, q_t (tsf)	Relative Density	Cone Tip Resistance, q_t (tsf)	Consistency
<20	Very Loose	<5	Very Soft
20 – 40	Loose	5 – 10	Soft
40 – 120	Medium Dense	10 – 15	Firm
		15 – 30	Stiff
120 – 200	Dense	30 – 60	Very Stiff
>200	Very Dense	>60	Hard

CPT Correlations

References are in parenthesis next to the appropriate equation.

General

p_a = atmospheric pressure (for unit normalization)

q_t = corrected cone tip resistance (tsf)

f_s = friction sleeve resistance (tsf)

$R_f = 100\% * (f_s/q_t)$

u_2 = pore pressure behind cone tip (tsf)

u_0 = hydrostatic pressure

$B_q = (u_2 - u_0)/(q_t - \sigma'_{v0})$

$Q_t = (q_t - \sigma'_{v0}) / \sigma'_{v0}$

$F_r = 100\% * f_s / (q_t - \sigma'_{v0})$










$I_c = ((3.47 - \log Q_t)^2 + (\log F_r + 1.22)^2)^{0.5}$

N-Value

$N_{60} = (q_t/p_a) / [8.5(1 - I_c/4.6)]$ (6)

(6) Jefferies, M.G. and Davies, M.P., (1993), "Use of CPTu to estimate equivalent SPT N60", ASTM Geotechnical Testing Journal, Vol. 16, No. 4

CPT Soil Classification Legend

Zone		Q _t /N	Description
1		2	Sensitive, Fine Grained
2		1	Organic Soils-Peats
3		1.5	Clays-Clay to Silty Clay
4		2	Silt Mixtures-Clayey Silt to Silty Clay
5		3	Sand Mixtures-Silty Sand to Sandy Silt
6		4.5	Sands-Clean Sand to Silty Sand
7		6	Gravelly Sand to Sand
8		1	Very Stiff Clay to Clayey Sand*
9		2	Very Stiff, Fine Grained*

(*) Heavily Overconsolidated or Cemented

Robertson's Soil Behavior Type (SBT), 1990			
Group #	Description	I _c	
		Min	Max
1	Sensitive, fine grained	N/A	
2	Organic soils - peats	3.60	N/A
3	Clays - silty clay to clay	2.95	3.60
4	Silt mixtures - clayey silt to silty clay	2.60	2.95
5	Sand mixtures - silty sand to sandy silt	2.05	2.60
6	Sands - clean sand to silty sand	1.31	2.05
7	Gravelly sand to dense sand	N/A	1.31
8	Very stiff sand to clayey sand (High OCR or cemented)	N/A	
9	Very stiff, fine grained (High OCR or cemented)	N/A	

Soil behavior type is based on empirical data and may not be representative of soil classification based on plasticity and grain size distribution.

Relative Density and Consistency Table			
SANDS		SILTS and CLAYS	
Cone Tip Stress, q _t (tsf)	Relative Density	Cone Tip Stress, q _t (tsf)	Consistency
Less than 20	Very Loose	Less than 5	Very Soft
20 - 40	Loose	5 - 15	Soft to Firm
40 - 120	Medium Dense	15 - 30	Stiff
120 - 200	Dense	30 - 60	Very Stiff
Greater than 200	Very Dense	Greater than 60	Hard

Sieve Analysis of Soils



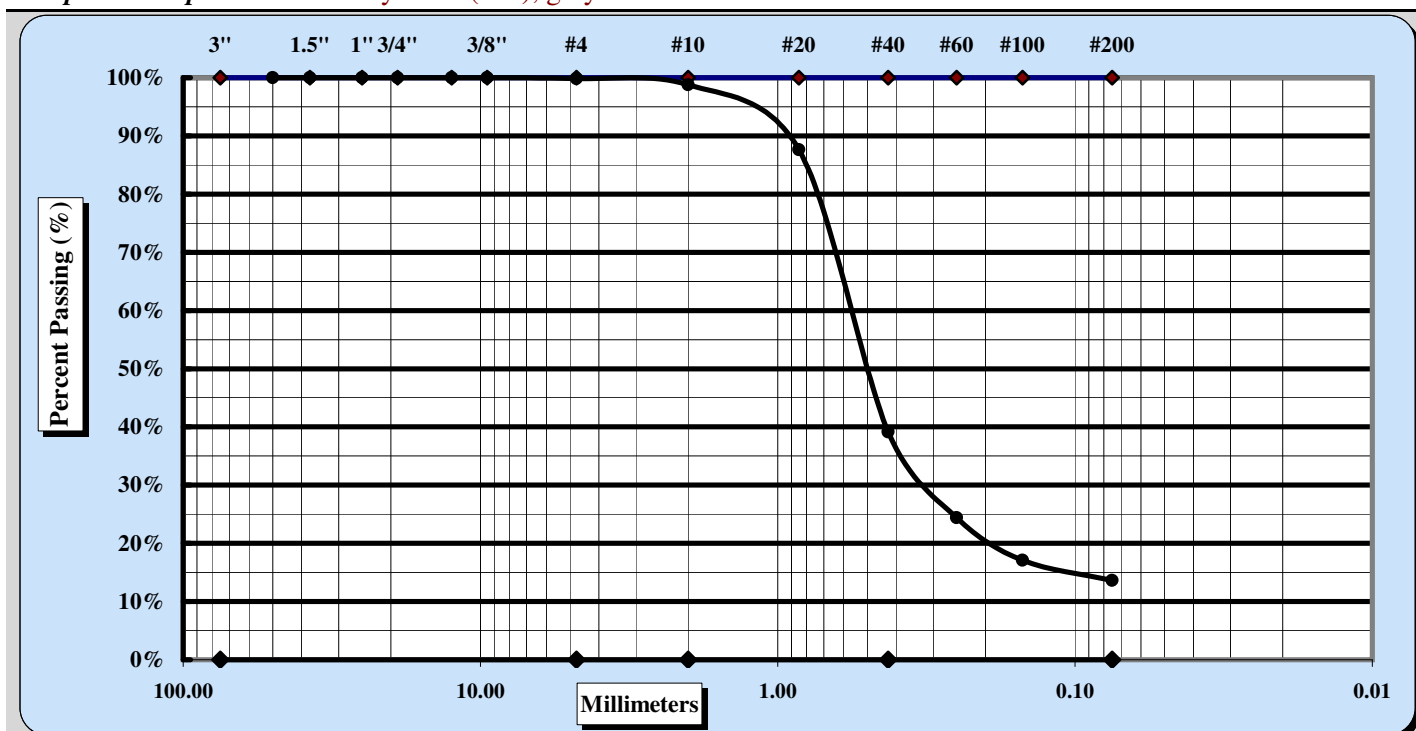
ASTM D 422

Quality Assurance

S&ME, Inc. - 620 Wando Park Blvd., Mt. Pleasant, SC 29464

Project #:	1131-09-471	Report Date:	10-29-09
Project Name:	USS Clamagore Relocation	Test Date(s):	10-22-09
Client Name:	Patriots Point Naval & Maritime Museum		
Client Address:	40 Patriots Point Boulevard, Mount Pleasant, SC		
Sample Id.	SPT-2	Type:	SS
		Sample Date:	10-21-09
Location:		Sample:	9
		Elevation:	38'

Sample Description: Silty Sand (SM), gray



Cobbles	< 300 mm (12") and > 75 mm (3")	Fine Sand	< 0.425 mm and > 0.075 mm (#200)
Gravel	< 75 mm and > 4.75 mm (#4)	Silt	< 0.075 and > 0.005 mm
Coarse Sand	< 4.75 mm and > 2.00 mm (#10)	Clay	< 0.005 mm
Medium Sand	< 2.00 mm and > 0.425 mm (#40)	Colloids	< 0.001 mm

Maximum Particle Size	2"	Coarse Sand	1.0%	Fine Sand	25.5%
Gravel	0.2%	Medium Sand	59.6%	Silt & Clay	13.6%
Liquid Limit	NA	Plastic Limit	NA	Plastic Index	NA
Specific Gravity	NA			Moisture Content	32.0%

Coarse Sand	1.0%	Medium Sand	59.6%	Fine Sand	25.5%
Description of Sand & Gravel Particles:		Rounded	<input type="checkbox"/>	Angular	<input type="checkbox"/>
Hard & Durable	<input type="checkbox"/>	Soft	<input type="checkbox"/>	Weathered & Friable	<input type="checkbox"/>

Notes / Deviations / References:

Kyle Murrell

Technical Responsibility

Signature

Project Engineer

Position

10/29/2009

Date

This report shall not be reproduced, except in full, without the written approval of S&ME, Inc.

Sieve Analysis of Soils



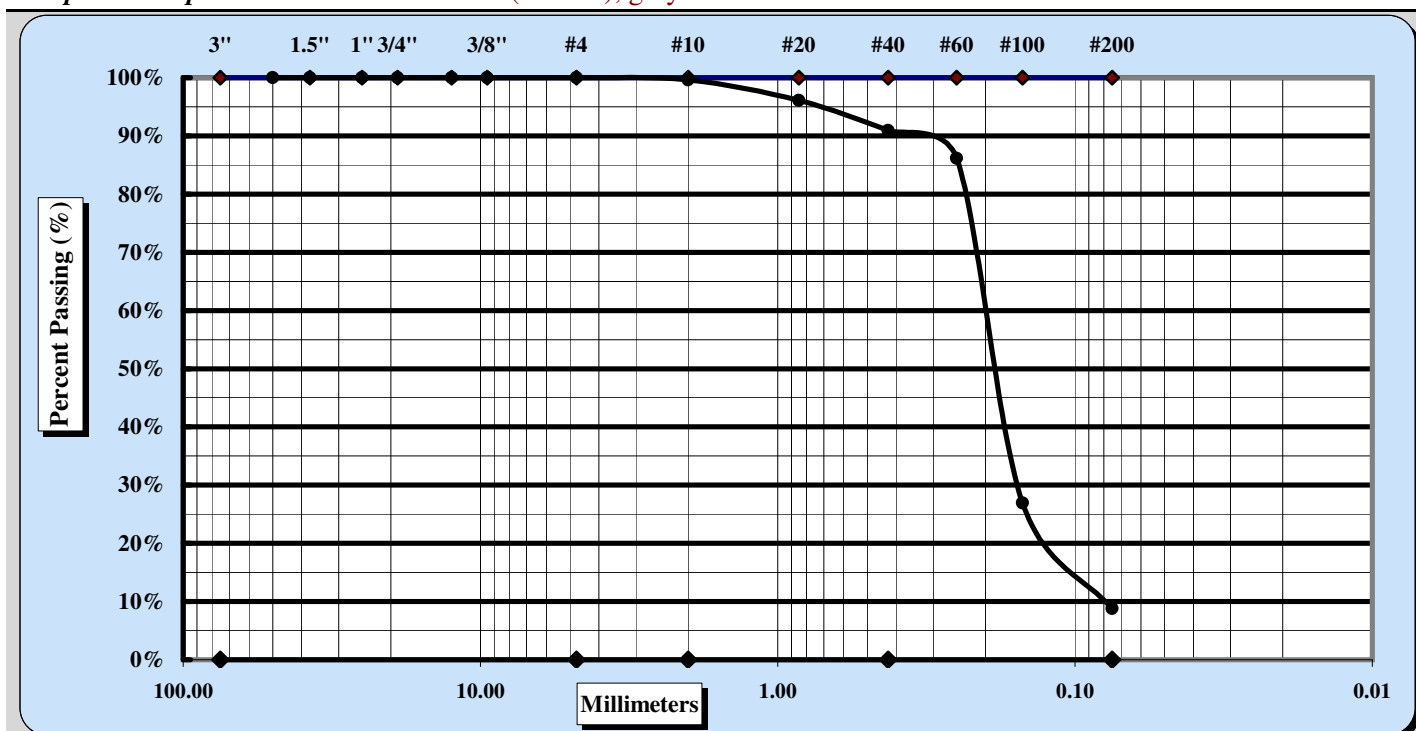
ASTM D 422

Quality Assurance

S&ME, Inc. - 620 Wando Park Blvd., Mt. Pleasant, SC 29464

Project #:	1131-09-471	Report Date:	10-29-09
Project Name:	USS Clamagore Relocation	Test Date(s):	10-22-09
Client Name:	Patriots Point Naval & Maritime Museum		
Client Address:	40 Patriots Point Boulevard, Mount Pleasant, SC		
Sample Id.	SPT-1	Type:	SS
		Sample Date:	10-21-09
Location:		Sample:	7
		Elevation:	31'

Sample Description: Sand with silt (SP-SM), gray



Cobbles	< 300 mm (12") and > 75 mm (3")	Fine Sand	< 0.425 mm and > 0.075 mm (#200)
Gravel	< 75 mm and > 4.75 mm (#4)	Silt	< 0.075 and > 0.005 mm
Coarse Sand	< 4.75 mm and > 2.00 mm (#10)	Clay	< 0.005 mm
Medium Sand	< 2.00 mm and > 0.425 mm (#40)	Colloids	< 0.001 mm

Maximum Particle Size	2"	Coarse Sand	0.4%	Fine Sand	82.1%
Gravel	0.0%	Medium Sand	8.7%	Silt & Clay	8.8%
Liquid Limit	NA	Plastic Limit	NA	Plastic Index	NA
Specific Gravity	NA			Moisture Content	22.4%

Coarse Sand	0.4%	Medium Sand	8.7%	Fine Sand	82.1%
Description of Sand & Gravel Particles:		Rounded	<input type="checkbox"/>	Angular	<input type="checkbox"/>
Hard & Durable	<input type="checkbox"/>	Soft	<input type="checkbox"/>	Weathered & Friable	<input type="checkbox"/>

Notes / Deviations / References:

Kyle Murrell

Technical Responsibility

Signature

Project Engineer

Position

10/29/2009

Date

This report shall not be reproduced, except in full, without the written approval of S&ME, Inc.

Sieve Analysis of Soils



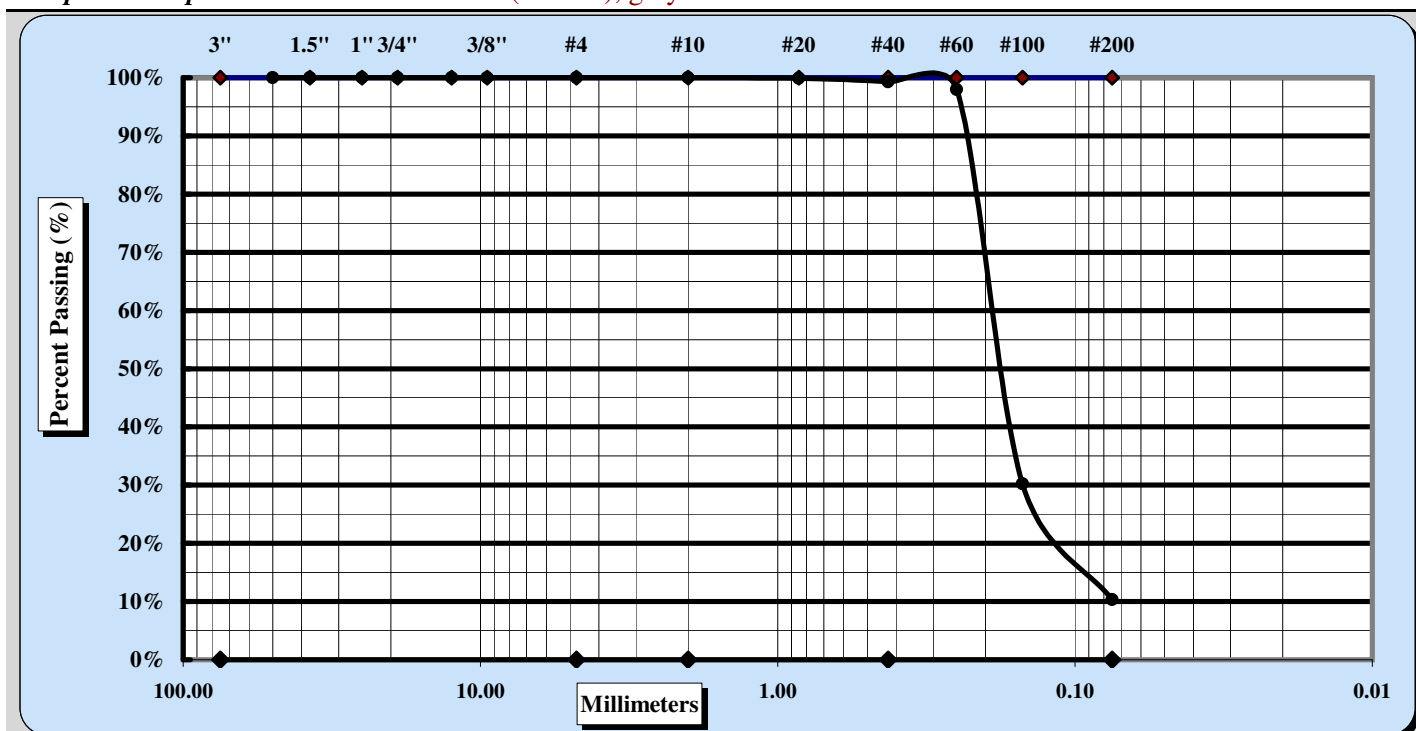
ASTM D 422

Quality Assurance

S&ME, Inc. - 620 Wando Park Blvd., Mt. Pleasant, SC 29464

Project #:	1131-09-471	Report Date:	10-29-09
Project Name:	USS Clamagore Relocation	Test Date(s):	10-22-09
Client Name:	Patriots Point Naval & Maritime Museum		
Client Address:	40 Patriots Point Boulevard, Mount Pleasant, SC		
Sample Id.	SPT-1	Type:	SS
		Sample Date:	10-21-09
Location:		Sample:	3
		Elevation:	11'

Sample Description: Sand with silt (SP-SM), gray



Cobbles	< 300 mm (12") and > 75 mm (3")	Fine Sand	< 0.425 mm and > 0.075 mm (#200)
Gravel	< 75 mm and > 4.75 mm (#4)	Silt	< 0.075 and > 0.005 mm
Coarse Sand	< 4.75 mm and > 2.00 mm (#10)	Clay	< 0.005 mm
Medium Sand	< 2.00 mm and > 0.425 mm (#40)	Colloids	< 0.001 mm

Maximum Particle Size	2"	Coarse Sand	0.0%	Fine Sand	89.0%
Gravel	0.0%	Medium Sand	0.7%	Silt & Clay	10.3%
Liquid Limit	NA	Plastic Limit	NA	Plastic Index	NA
Specific Gravity	NA			Moisture Content	33.2%

Coarse Sand	0.0%	Medium Sand	0.7%	Fine Sand	89.0%
Description of Sand & Gravel Particles:		Rounded	<input type="checkbox"/>	Angular	<input type="checkbox"/>
Hard & Durable	<input type="checkbox"/>	Soft	<input type="checkbox"/>	Weathered & Friable	<input type="checkbox"/>

Notes / Deviations / References:

Kyle Murrell

Technical Responsibility

Signature

Project Engineer

Position

10/29/2009

Date

This report shall not be reproduced, except in full, without the written approval of S&ME, Inc.

Liquid Limit, Plastic Limit, and Plastic Index



Another code

ASTM D 4318 ☒AASHTO T 89 ☐AASHTO T 90 ☐

Quality Assurance

S&ME, Inc. 620 Wando Park Boulevard Mt. Pleasant, SC 29464

Project #: **1131-09-471** Report Date: 10-29-09
 Project Name: USS Clamagore Relocation Test Date(s): 10-22-09
 Client Name: Patriots Point Naval & Maritime Museum
 Client Address: 40 Patriots Point Road, Mount Pleasant, SC

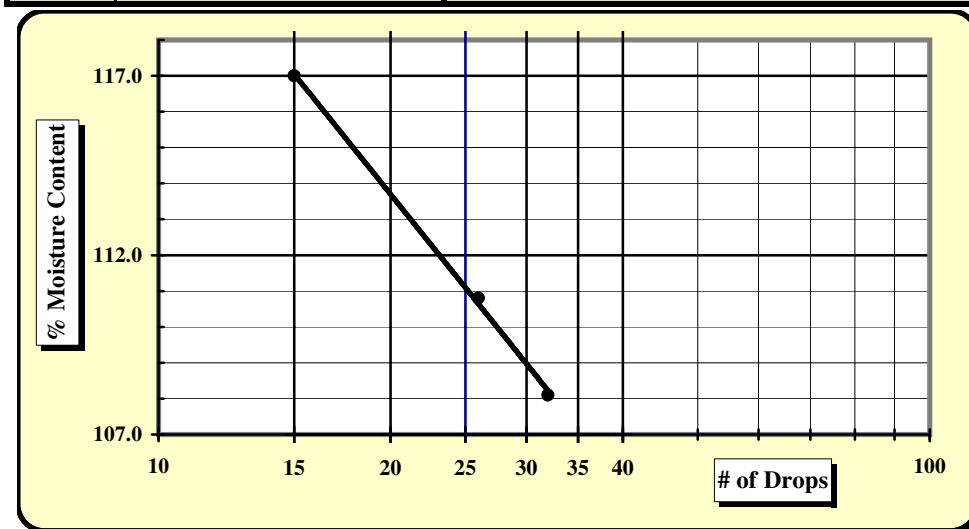
Boring #: 1 Sample #: 6 Sample Date: 10-21-09

Location: Offset: Elevation: 26'

Sample Description: Clayey Silt (MH), dark gray

Type and Specification	S&ME ID #	Cal Date:	Type and Specification	S&ME ID #	Cal Date:
Balance (0.01 g)	6002	9/13/2009	Grooving tool	6450	9/10/2009
LL Apparatus	6238	9/27/2009			
Oven	13796	8/25/2009			

Pan #	Tare #:	Liquid Limit						Plastic Limit		
		1	2	3	4	5	6	7	8	9
A	Tare Weight	21.12	21.42	21.60				21.19	21.39	
B	Wet Soil Weight + A	32.21	33.56	35.40				24.71	24.31	
C	Dry Soil Weight + A	26.45	27.18	27.96				23.43	23.23	
D	Water Weight (B-C)	5.76	6.38	7.44				1.28	1.08	
E	Dry Soil Weight (C-A)	5.33	5.76	6.36				2.24	1.84	
F	% Moisture (D/E)*100	108.1%	110.8%	117.0%				57.1%	58.7%	
N	# OF DROPS	32	26	15				Moisture Contents determined by ASTM D 2216		
LL	LL = F * FACTOR									
Ave.	Average							57.9%		



One Point Liquid Limit			
N	Factor	N	Factor
20	0.974	26	1.005
21	0.979	27	1.009
22	0.985	28	1.014
23	0.99	29	1.018
24	0.995	30	1.022
25	1.000		

NP, Non-Plastic ☐Liquid Limit **111**Plastic Limit **58**Plastic Index **53**Group Symbol **MH**Multipoint Method ☒One-point Method ☐Wet Preparation ☒ Dry Preparation ☐ Air Dried ☐ Estimate the % Retained on the #40 Sieve: 10%

Notes / Deviations / References:

ASTM D 4318: Liquid Limit, Plastic Limit, & Plastic Index of Soils

K. Gonzales

Technician Name

10/29/2009

Date

Kyle Murrell

Technical Responsibility

10/29/2009

Date

This report shall not be reproduced, except in full, without the written approval of S&ME, Inc.

Liquid Limit, Plastic Limit, and Plastic Index



Another code

ASTM D 4318



AASHTO T 89



AASHTO T 90



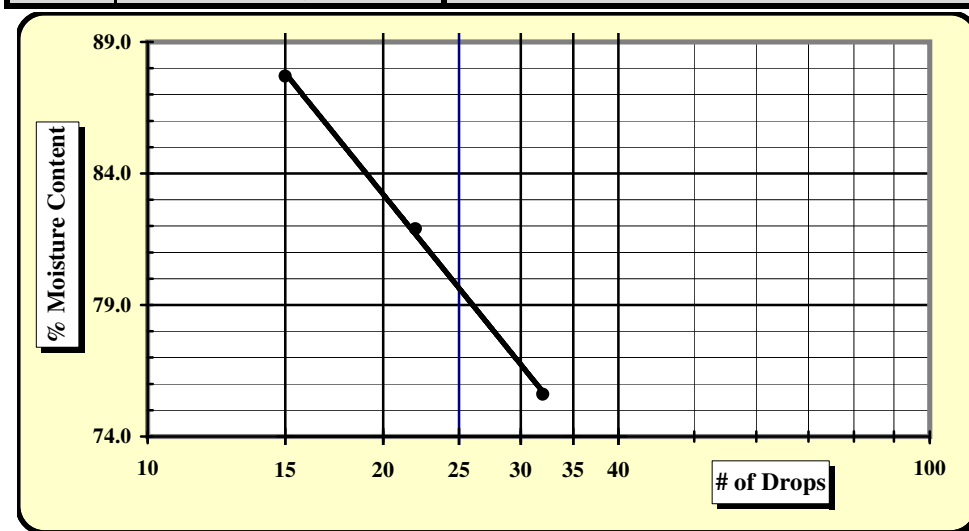
Quality Assurance

S&ME, Inc. 620 Wando Park Boulevard Mt. Pleasant, SC 29464

Project #:	1131-09-471	Report Date:	10-29-09
Project Name:	USS Clamagore Relocation	Test Date(s)	10-22-09
Client Name:	Patriots Point Naval & Maritime Museum		
Client Address:	40 Patriots Point Road, Mount Pleasant, SC		
Boring #:	2	Sample #:	5
Sample Date:		10-21-09	
Location:	Offset:	Elevation: 18'	
Sample Description:	Clayey Silt (MH), dark gray		

Type and Specification	S&ME ID #	Cal Date:	Type and Specification	S&ME ID #	Cal Date:
Balance (0.01 g)	6002	9/13/2009	Grooving tool	6450	9/10/2009
LL Apparatus	6238	9/27/2009			
Oven	13796	8/25/2009			

Pan #	Tare #:	Liquid Limit						Plastic Limit		
		1	2	3	4	5	6	7	8	9
A	Tare Weight	21.31	21.20	20.91				21.07	13.77	
B	Wet Soil Weight + A	36.97	37.84	40.15				24.16	17.61	
C	Dry Soil Weight + A	30.23	30.35	31.16				23.21	16.41	
D	Water Weight (B-C)	6.74	7.49	8.99				0.95	1.20	
E	Dry Soil Weight (C-A)	8.92	9.15	10.25				2.14	2.64	
F	% Moisture (D/E)*100	75.6%	81.9%	87.7%				44.4%	45.5%	
N	# OF DROPS	32	22	15				Moisture Contents determined by ASTM D 2216		
LL	LL = F * FACTOR									
Ave.	Average							45.0%		



One Point Liquid Limit			
N	Factor	N	Factor
20	0.974	26	1.005
21	0.979	27	1.009
22	0.985	28	1.014
23	0.99	29	1.018
24	0.995	30	1.022
25	1.000		

NP, Non-Plastic ☐Liquid Limit **80**Plastic Limit **45**Plastic Index **35**Group Symbol **MH**Multipoint Method ☒One-point Method ☐Wet Preparation ☒ Dry Preparation ☐ Air Dried ☐

Estimate the % Retained on the #40 Sieve: 10%

Notes / Deviations / References:

ASTM D 4318: Liquid Limit, Plastic Limit, & Plastic Index of Soils

K. Gonzales

Technician Name

10/29/2009

Date

K. Murrell

Technical Responsibility

10/29/2009

Date

This report shall not be reproduced, except in full, without the written approval of S&ME, Inc.

LABORATORY TESTING PROCEDURES

Grain Size Tests (ASTM D 1140 and ASTM D 422)

Grain size tests were performed to determine the soil particle size distribution. The amount of material finer than the #200 sieve was determined by washing the sample over that particular size sieve. The grain size distribution of the soil retained on the #200 sieve was then determined by passing the retained portion through a standard set of nested sieves.

Atterberg Limits Test (ASTM D-4318)

Atterberg Limits tests were performed to determine the soil plasticity characteristics. The soil plasticity index (PI) is representative of this characteristic and is bracketed by the liquid limit (LL) and the plastic limit (PL). The liquid limit is the moisture content at which the soil will flow as a heavy viscous fluid. The plastic limit is the moisture content at which the soil begins to lose its plasticity. The difference between the liquid limit and plastic limit is the plasticity index.

Natural Moisture Content Test (ASTM D 2216)

Moisture content tests were conducted to determine the ratio, expressed as a percentage, of the weight of water in a given amount of soil to the weight of the solid particles.

REVISED REPORT OF GEOTECHNICAL EXPLORATION

**Patriots Point Parking Lot Redesign
Mount Pleasant, South Carolina
S&ME Project No. 1131-09-139**

Prepared for:

Patriots Point Naval & Maritime Museum
40 Patriots Point Road
Mount Pleasant, South Carolina 29464

Prepared by:



620 Wando Park Boulevard
Mt. Pleasant, South Carolina 29464

July 10, 2009

July 10, 2009

Patriots Point Naval & Maritime Museum
40 Patriots Point Road
Mount Pleasant, South Carolina 29464

Attention: Mr. Bob Howard, Director of Operations

Reference: **REVISED REPORT OF GEOTECHNICAL EXPLORATION**
Patriots Point Parking Lot Redesign
Mount Pleasant, South Carolina
S&ME Project No. 1131-09-139

Dear Mr. Howard:

We have completed the Geotechnical Exploration for the proposed parking and roadway areas at the Patriots Point Naval & Maritime Museum in Mount Pleasant, South Carolina. Our services were provided in general accordance with S&ME proposal Nos. 31-09-081A and 31-09-081B dated April 3, 2009 and June 2, 2009, respectively. The purpose of these services was to evaluate the shallow subsurface conditions pertinent to site preparation and pavement design. This report presents our understanding of the proposed construction and the exploration data.

We initially issued our report for this project on May 11, 2009. Subsequent to that report, a meeting with Seamon Whiteside & Associates brought to light additional development issues that necessitate our additional services. This revised report encompasses our previous report, incorporated our additional services, and completely replaces our report dated May 11, 2009.

PROJECT INFORMATION

We understand plans are to redesign the parking area at Patriots Point in Mt. Pleasant, South Carolina. We understand the provided site plan is preliminary. However, in general, the site development will include new paved and grassed parking areas, access drives, and an open, grassed area. Finally, we understand new fill heights of about 2½ ft or less will be required to grade the project site.

This project information was provided by Mr. William O'Neal, E.I.T. and Mr. Stuart Whiteside, P.E. with Seamon Whiteside & Associates (SWA) in telephone conversations, e-mails, and two meetings at SWA's office with Ms. Tracey Turner, P.E., Ms. Meredith L. Eichelberger, E.I.T., and Mr. Aaron D. Goldberg, P.E. of our firm between April 1 and July 1, 2009.

METHODS OF EXPLORATION

Field Testing

Subsurface conditions at the site were explored by performing 17 cone penetration test (CPT) soundings to depths ranging from 10 to 48 ft. To further explore the near surface soils 4-ft hand-auger borings were performed adjacent to each sounding location. In addition, two 4-ft hand-auger borings were performed in the proposed bio-swale areas. To explore the area underneath the existing parking areas and roadways, 12 asphalt cores and 4-ft hand-auger borings were performed within the employee and bus parking area, general admission parking area, and the old Patriots Point Road. Test locations were established in the field by S&ME personnel estimating distances and right angles from existing site features. The test locations are presented on the Test Location Plan in the Appendix.

In a CPT sounding (ASTM D 5778), an electronically instrumented cone penetrometer is hydraulically pushed through the soil to measure point stress, pore water pressure, and sleeve friction. The CPT data is used to determine soil stratigraphy and to estimate soil parameters such as preconsolidation stress, friction angle, and undrained shear strength. Sounding C-1 was stopped at a depth of about 17 ft in soft to firm clay and a pore pressure dissipation test was performed.

The hand auger borings were performed by manually turning a steel auger into the ground. The soils encountered were classified in the field by a Geotechnical Professional using the Unified Soil Classification System (USCS). A more detailed description of our field testing procedures, the CPT sounding logs, and Hand Auger Boring Logs are included in the Appendix.

Laboratory Testing

We performed 200 sieve wash testing on the soils excavated from each bioswale area to determine if infiltration testing should be performed. We understand that it is generally preferable to test the soil below the bottom of the proposed bioswale area; therefore, we tested soils at a depth of approximately 3 ft within the hand-auger borings. All laboratory testing was performed in general accordance with ASTM standards. Laboratory testing procedures and a Laboratory Data Summary are included in the Appendix.

SITE AND SUBSURFACE CONDITIONS

Site Conditions

The project site is located to the east of the existing Patriots Point Naval & Maritime Museum in Mt. Pleasant, South Carolina. The site is bound by the Charleston Harbor and Patriots Point Naval and Maritime Museum to the west, Marine Road to the south, the intersection of Patriots Point Boulevard and Patriots Point Road to the north, and Patriots Point Boulevard to the east.

At the time of our exploration, the western portion of the site is wooded and the eastern portion is currently occupied by the Patriots Point Naval & Maritime Museum. In general, the ground elevations on the wooded east side of the site are approximately 4 ft higher than those on the west.

Existing Pavement Conditions

While observing the site, it was noted that the existing pavements were cracked. We observed some joint separation with vegetation growing through some of these areas.

The pavement at our test locations consisted of an aggregate base course overlain by an asphaltic concrete surface course. The average thickness of the base and surfaces courses was 2.3 in. and 5.1 in., respectively. The pavement component thickness at each test location is presented in Table 1 below:

Table 1. Pavement Thickness

Core Name	Asphalt Surface Course Thickness (in.)	Aggregate Base Thickness (in.)
B-1	1	3
B-2	1	5
B-3	1.25	4.75
B-4	1.75	4.25
B-5	2.5	5.5
B-6	3	0
B-7	2.5	3.5
B-8	3	5
B-9	3	9
B-10	3	9
B-11	3.5	8.5
B-12	2.5	3.5
Average	2.3	5.1

Subsurface Conditions

Details of the subsurface conditions encountered by the soundings and hand-auger borings are shown on the logs in the Appendix. These logs represent our interpretation of the subsurface conditions based upon field data. Stratification lines on the logs represent approximate boundaries between soil types; however, the actual transition may be gradual. The general subsurface conditions and their pertinent characteristics are discussed in the following paragraphs.

The exploration in the non-pavement areas initially encountered 0 to 3 in. of organic laden topsoil. The hand-auger borings within the existing pavement areas encountered approximately 1 to 3½ in. of asphalt pavement underlain by 0 to 9 in. of aggregate base course. Below the pavement materials, relatively “clean” sandy fill to a depth of 2 to 4 ft below the existing ground surface.

Beneath these surface materials the soundings encountered erratically uncontrolled fill consisting of interbedded layers of sand, clayey sand, shell hash, and slightly sandy clay and silt. Although difficult to differentiate from native soils, fill consisting of a loose and soft mixture of sand silt and clay extends to a depth of about 15 ft. All the soundings except C-2, C-3, C-10, and C-17 were terminated within this layer. Below the fill, the exploration, except soundings C-10 and C-17, encountered a medium dense sand layer to a depth of about 18 ft. Soft clay was encountered below the sand to a depth of 26 to 28 ft below the existing ground surface (C-10 was terminated within this layer). Beneath the clay layer, the exploration encountered alternating layers of soft to firm clay and loose to medium dense sand to the final exploration depth of 48 ft.

Subsurface water was measured upon completion of the soundings and hand-auger borings at a depth of about 1 to 6 ft below the existing ground surface. Subsurface water was not encountered in the 4-ft hand-auger borings at locations C-1, C-4, C-5, C-7, C-13, C-14, C-17, and all of the pavement area borings except B-5 and B-8. Subsurface water levels at the site will fluctuate during the year due to such things as seasonal, tidal, and climatic variations and with construction activity in the area.

CONCLUSIONS AND RECOMMENDATIONS

The analyses and recommendations submitted herein are based, in part, upon data obtained from our subsurface exploration. The nature and extent of subsurface variations will not become evident until construction. If variations appear evident, then we should be retained to re-evaluate the recommendations of this report. In the event that any changes in the nature, design or location of the proposed expansion are planned, the conclusions and recommendations contained in this report shall not be considered valid unless the changes are reviewed by us, and the conclusions are modified or verified in writing. This is particularly important if the fill heights will be greater than those assumed in this report. We recommend that S&ME, Inc. be retained to review the final design plans and specifications to confirm that earthwork and foundation recommendations are properly interpreted and implemented.

Hereafter, we present a general assessment, engineering assessment with more detail, and recommendations for various areas of the site identified on Figure 1.

General Assessment

For your convenience, our recommendations are summarized in outline form below. This brief summary should not be used for design or construction purposes without reviewing the more detailed information presented in the remainder of the report.

1. After consulting with SWA, it was decided not to proceed with the bioswale option since the site soils were expected to have a very low permeability based upon our grainsize testing and field classification.
2. The thick uncontrolled dredge spoil underlying the site will undergo consolidation with the addition of the proposed new fill at the ground surface. We estimate that approximately 2 in. of settlement will occur over the next 4 years from the addition of each 1 ft of new fill added.
3. In order to reduce post-construction settlement, the site should be surcharged for 6 months with a temporary embankment of fill of approximately 1 ft for every 1 ft of permanent fill. The surcharging would pre-consolidate the site, which would reduce post construction settlements of pavements and utilities. Otherwise, settlement as described above should be accounted for in design.
4. Positive site drainage should be established to handle storm water runoff. To help with this the base course should be extended beyond the limits of the pavement areas into ditches or a stormwater management area prior to utility construction.
5. Near surface dredge spoil soils provide poor pavement support and poor drainage. We recommend the new parking and roadway pavements be supported on at least 2 ft and 3 ft of well-compacted controlled fill, respectively.
6. If underground utilities will be located in areas containing new fill, they should be designed to withstand the predicted settlement or a surcharge program should be implemented to pre-consolidate the areas.
7. The existing pavement areas contain about 2 to 4 ft of relatively clean soils. It appears the soils can be reused during construction. Normal field quality control testing should be performed to confirm as for any other fill source.

The primary geotechnical considerations will be subgrade evaluation and stabilization, and fill placement and long-term settlement. Since these are very dependent upon final grades, S&ME should be retained to review the final design and specifications.

The following presents our geotechnical recommendations regarding site preparation, subgrade stabilization, and pavement recommendations. During review of these recommendations, it should be kept in mind that subsurface conditions will vary between test locations, and, as with any previously developed site, unexpected subsurface conditions will be encountered. These variable conditions can normally be handled during construction by field engineering evaluation.

Engineering Assessment

Site Preparation

Site preparation should begin with establishing positive site drainage to help drain wet areas and handle storm water runoff. Gravity drained surface ditches should be excavated as deep as practical and as far in advance of general clearing and grading operations as possible. If sufficient fall is not available, ditches should be tied to sumps and pumped.

Following site drainage improvements, site preparation should continue with the removal of unsuitable surface materials. This should include clearing and grubbing of all vegetation and roots, stripping organic laden topsoil, removing or milling asphalt pavements, removing crushed stone, and undercutting unsuitable surface soils from the proposed parking and roadway areas. Stumps and taproots should be completely removed from the construction areas, and the resulting voids should be backfilled with well-compacted controlled fill.

Prior to fill placement, the exposed subgrade in the proposed parking and roadway areas should be evaluated by the Geotechnical Engineer. This evaluation should include probing and in some instances proofrolling with light equipment under the observation of the Geotechnical Engineer. Areas that pump or rut excessively should be stabilized or undercut as directed by the Geotechnical Engineer. Undercutting should be observed by the Geotechnical Engineer to confirm that all unsuitable materials are removed and that suitable materials are not over-excavated.

The exploration encountered approximately 15 ft of highly variable, fill at the site. Where fill heights are low, these soils are generally not suitable for pavement support and undercutting will be necessary. Careful subgrade evaluation will be very important, and undercutting portions of the site should be expected. The extent and depth of any undercutting will be dependent on final grades, the weather conditions during construction, the aggressiveness of the earthwork schedule, site drainage, and the grading contractor's means and methods.

Stabilization Measures

We recommend the new parking and roadway pavements be supported on at least 2 ft and 3 ft of well-compacted controlled fill, respectively. Depending on final grades, some existing soils will need to be undercut and replaced with well-compacted controlled fill. If the subgrade is adequately stable, fill should be placed and compacted as recommended in the "Controlled Fill" section of this report. If the subgrade is only marginally stable, an 18 to 24-inch thick bridge lift of relatively dry granular soil should be placed. The bridge lift should be pushed full depth from higher, stable areas over unstable ones using light, tracked equipment. Highly unstable areas may require the use of a geotextile fabric or geogrid and possibly 18 to 24 in. of crushed No. 57 stone.

Settlement

As mentioned previously, we estimate that approximately 2 in. of settlement will occur over the next 4 years from the addition of each 1 ft of new fill placed on site. This could potentially cause “potholes” and “birdbaths” within the proposed pavement areas. Also, grassed areas containing new fill could be susceptible to settlements leading to ponded water in these areas. Underground utilities should be designed to that they can handle the predicted settlement or the following surcharge program should be implemented.

Surcharging

Total post-construction static settlement of the areas requiring over 1 ft of fill can be reduced to 2 in. or less by surcharging the areas with extra fill (in addition to the fill required for final grading). This surcharge embankment will pre-consolidate the underlying dredge spoil. Once the soils have consolidated sufficiently, the surcharge can be removed and the site can be constructed at the planned grade. During surcharging, we should perform weekly to bi-weekly settlement monitoring to determine when sufficient settlement has occurred.

For areas receiving over 1 ft of new permanent fill, our analysis indicates that a surcharge height of 1 ft (in addition to the fill required for final grading) for every 1 ft of planned fill left in place for 6 months will reduce total post-construction settlement to 2 in. or less. Differential settlement may be more than half of the total settlement. Due to the uncontrolled fill, if planned fill heights are greater than 4 ft, or if the estimated waiting periods are not feasible for the construction schedule, the surcharge height may need to be increased.

The crest of the surcharge should extend a minimum of 10 ft beyond the edge of the proposed parking area, where feasible. If the surcharge fill will be used in other areas as controlled fill, it should meet the requirements for controlled fill material. Otherwise, any sandy soil having a moist unit weight of at least 110 pcf may be used. The surcharge fill may simply be dumped and spread with a dozer until the required surcharge height is obtained; compaction is not necessary.

To monitor the rate and magnitude of site settlement, settlement plates should be installed within the surcharged areas prior to fill placement. Protection (from any movement) of the settlement plates during construction is imperative. If the settlement plates are disturbed, the data collected becomes useless. Fill soils should be methodically hand placed and compacted in areas above and immediately surrounding the settlement plates. Fill soils should not be dumped in the immediate areas of the settlement plates. Settlement plate locations should be barricaded after completion of filling to protect the plates from being disturbed or destroyed.

Upon completion of fill placement, the site should be allowed to consolidate until settlement plate data, as interpreted by the Geotechnical Engineer, indicates that the remaining post-construction settlement due to the planned fill will be acceptable. Settlement plate readings should be taken weekly to bi-weekly throughout the surcharge period.

Wick Drains

Our analysis indicates, a 6-ft triangular wick spacing with no additional surcharge will take about 6 months to settle leaving less than 2 in. of long-term settlement. It should be noted that the embankment should be overbuilt by a foot or so to account for the weight of the base course and asphalt and settlement that occurs. This will leave a small amount of fill to be removed after settlement has occurred and the site is cut to subgrade. The wick drains should be installed to a minimum depth of 30 ft below the existing ground surface. A drainage layer of at least 12 in. of “clean” sand with no more than 5% fines should be placed prior to wick drain installation.

Bioswale Areas

As previously mentioned, laboratory 200 sieve wash testing was performed in the areas where the bioswales were proposed. The soils encountered had a percent finer than the 200 sieve of 81 to 96 %. Based on our experience with similar soils, the soils at this site are not “freely draining” and infiltration rates would likely be less than 0.25 in./hr. Based on conversations with SWA, typically a design value of 1.5 in/hr or higher is needed to get positive results on the infiltration calculations. Therefore, no other analysis or testing was performed for the bioswale areas.

Excavations

The majority of the excavations required for this project will be in uncontrolled dredge spoil. It is extremely important that all excavations be sloped or shored in strict compliance with the most recent local, state, and federal governing regulations including OSHA (29 CFR Part 1926) excavation trench safety standards.

Stockpiles should be placed well away from the edge of the excavation and their height should be controlled so they do not surcharge the sides of the excavation. The responsibility for excavation safety and stability of temporary construction slopes and shoring should lie solely with the contractor. This information is provided only as a service and under no circumstance should we be assumed responsible for construction site safety.

Controlled Fill

Controlled fill material should be cohesionless soil containing no more than 15% fines (material passing the No. 200 sieve) by weight and having a maximum dry density of at least 105 pcf as determined by a laboratory modified Proctor compaction test (ASTM D 1557). The soil should be relatively free of organics, deleterious matter, and elongated or flat particles susceptible to degradation. All fill should be placed in uniform lifts of 10 in. or less (loose measure) and compacted to at least 95% of the modified Proctor maximum dry density.

Fill placement should be observed by a qualified Materials Technician working under the direction of the Geotechnical Engineer. In addition to this visual evaluation, the Technician should perform a

sufficient amount of in-place field density tests to confirm that the required degree of compaction is being attained.

The existing fill soils in the wooded dredge spoil area and the grassy areas around the site are not suitable for use as controlled fill. These soils should be undercut from the pavement areas where necessary and at least 10 ft beyond the pavement limits. Undercut soils should be disposed of off site or in landscaped areas.

The soils in the top 2 to 4 ft under the existing pavements appear to be suitable as controlled fill. Test must be run at the time of construction to check their suitability.

Pavement Design Recommendations

We have performed pavement design analyses for new flexible asphalt pavements using the *AASHTO Guide for Design of Pavement Structures* and associated literature. The pavements may be supported on new well-compacted controlled fill provided our site preparation, subgrade stabilization, and controlled fill recommendations are followed.

Based on our experience, local well-compacted controlled fill will provide a California Bearing Ratio (CBR) of at least 10 percent; therefore, 10 percent was used in our pavement design. This CBR value should be confirmed with laboratory testing during construction.

Traffic data was not provided. We assume the parking areas will be subject to automobiles and an occasional heavy truck or tour bus. Roadway areas will be subjected to car and heavy bus traffic. The roadway and bus parking areas should have at least 3 ft of well-compacted controlled fill, and the car parking areas should have a minimum of 2 ft of well-compacted controlled fill. Our recommended minimum pavement section for the proposed parking and roadway areas is shown in the following table.

MATERIAL	FLEXIBLE PAVEMENT		RIGID PAVEMENT	
	Roadways/ Bus Parking	Car Parking Areas	Heavy Duty	Standard Duty
Asphaltic Concrete Surface Course (SCDOT Type C)	3 in.	2 in.	-	-
Graded Aggregate Base Course (marine limestone)	8 in.	6 in.	-	-
Portland Cement Concrete ($f'_c = 4000$ psi)	-	-	6 in.	5 in.
Controlled Fill	3 ft	2 ft	3 ft	2 ft

Based on our analysis, the recommended roadway pavement section has an allowable traffic volume of about 1,825,000 ESAL¹ over a 15-year design life.

Subgrade evaluation and stabilization should be performed according to the recommendations previously discussed. The new graded aggregate base course should be compacted to at least 100% of the maximum dry density as determined by the modified Proctor compaction test (ASTM D 1557). To confirm that the base course has been uniformly compacted, in-place field density tests should be performed by a qualified Materials Technician and the area should be methodically proofrolled under their evaluation. The thickness should not be deficient in any area by more than ½ in. The asphalt pavement thickness should not be deficient by more than ¼ in. in any area.

A rigid pavement section is recommended in loading areas such as trash dumpsters. We also recommend rigid pavements be used in areas subjected to repeated lateral loading (turning, stopping, starting) such as any bus drop off areas.

All materials and workmanship should meet the minimum requirements of South Carolina Department of Transportation's (SCDOT) *Standard Specifications for Highway Construction*, 2007 Edition.

The performance of pavements will be dependent upon a number of factors including subgrade conditions at the time of paving, rainwater runoff, and traffic. Adequate drainage of the pavement subgrade will be critical to pavement performance, as accumulation of water in the subgrade soils and pavement base course will significantly decrease the useful life of the pavement. Finished grades of the pavement should be higher than the surrounding grades, and the base course should be extended beyond the pavement to the drainage areas to prevent water from pooling in the pavement base materials. Landscaping islands should be designed so that they do not pond water.

Pavement design typically has relatively low factors of safety; therefore, it will be very important that the specifications are followed closely during pavement construction. Our analysis was based on a 15-year design life; however, some isolated areas could require repair in a shorter period of time.

Recommendations for Each Development Area on Site

Refer to the Test Location Plan in the Appendix for the approximate location of each area.

Area 1

Area 1 is the location of the proposed general admission parking and entrance road. Currently the area is a wooded undeveloped dredge spoil pit. Planned fill heights of up to 2½ ft are

¹ Equivalent 18-kip single axle load. For example, a legally-loaded tandem axle tractor-trailer has an ESAL of up to 2.5, while a passenger car has an ESAL of approximately 0.0002

planned to bring this area up to final grade. The planned fill will induce up to 5 in. of settlement. The predicted settlement should be allowed to occur before paving. This could be accomplished with the use of wick drains or a surcharge of 2½ ft. The roadway areas should have at least 3 ft of well-compacted controlled fill, and the car parking areas should have a minimum of 2 ft of well-compacted controlled fill.

Area 2

Area 2 is the proposed bus drive through and parking area. It is currently occupied by a portion of the wooded area and the existing old Patriots Point Road, and the existing employee and bus parking areas. The area will require less than 1 ft of new fill to bring it up to planned grade; therefore, no remedial action is required for the existing pavement areas. If no new fill is required in the existing pavement areas, the pavement can be overlaid. If fill is required or the pavement is not reused, pavements should be completely removed from the area before filling. In areas without existing pavement, dredge spoil soils should be undercut so that at least 3 ft of well-compacted controlled fill will be in the roadways and bus parking areas, and the car parking areas should have a minimum of 2 ft of well-compacted controlled fill.

Area 3

Area 3 is the future grass parking area. This area is currently occupied by the northwestern portion of the wooded area and a portion of the existing Patriots Point Road. Fill heights will be up to 3 ft in this area. Since no buildings or pavements are planned for the area, it is not necessary to wick or surcharge. There are existing utilities in the area that will be overlaid by the fill. They must be relocated. It should be noted that the area will continue to gradually settle up to about 6 in. with time (years). As such, maintenance may be needed from time to time to fix depressions that may develop.

Area 4

Area 4 is planned to be a grassed area for future development. The area is presently occupied by general admission parking and a grassy knoll between the parking area and the old Patriots Point Road. Based on the grading plan, the existing parking lot will be cut up to 3 ft. The soils removed from this area appear to be suitable for use as controlled fill. During removal of these soils, a layer of at least 6 in. of well compacted controlled fill should be left over the dredge material to provide a more stable surface. Since there are no immediate plans for pavements or buildings in this area, there is no need to wick or surcharge. It should be noted that the area will continue to gradually settle with time (years). As such, maintenance may be needed from time to time to fix depressions that may develop.

Area 5

Area 5 is the location of the proposed new museum building. It is currently occupied by temporary office space, parking and drive areas, and some grassy areas. Final floor elevations for the planned building will be approximately 2 ft above the existing ground surface. The

current plans have the museum construction to be performed last. Plans are also for the building to be constructed on deep foundations bypassing the dredge spoil. With both of these in mind, the area need not be wicked or surcharged. The proposed fill should be placed about 6-in. above proposed final grade and allowed to sit until construction of the museum.

LIMITATIONS OF REPORT

This report has been prepared in accordance with generally accepted geotechnical engineering practice for specific application to this project. The conclusions and recommendations contained in this report are based upon applicable standards of our practice in this geographic area at the time this report was prepared. No other warranty, express or implied, is made.

The analyses and recommendations submitted in this report are based, in part, upon the data obtained from the subsurface exploration. The nature and extent of variations between the borings will not become evident until construction. If variations appear evident, then we will re-evaluate the recommendations of this report. In the event that any changes in the nature, design, or location of the proposed parking and roadway areas are planned, the conclusions and recommendations contained in this report will not be considered valid unless the changes are reviewed and conclusions modified or verified in writing.

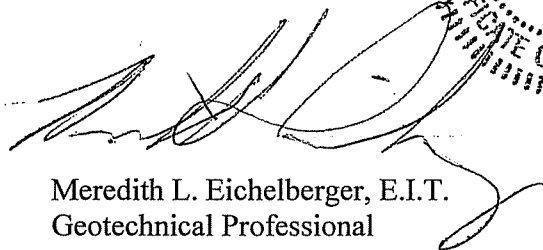
We recommend that S&ME be provided the opportunity to review the final design plans and specifications in order that earthwork and foundation recommendations are properly interpreted and implemented.

CLOSURE

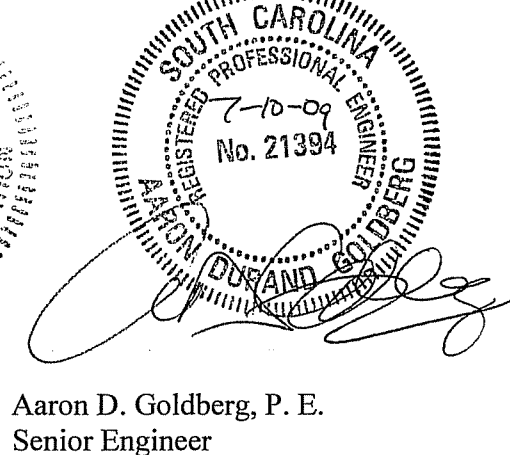
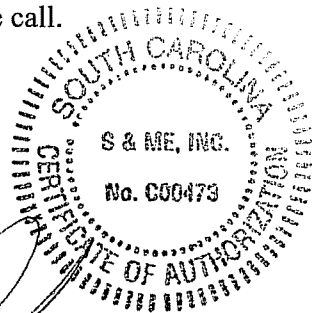
We appreciate the opportunity to be of service on this project. If you have any questions concerning this report, please call.

Sincerely,

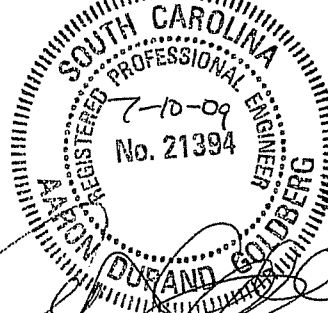
S&ME, Inc.



Meredith L. Eichelberger, E.I.T.
Geotechnical Professional



Aaron D. Goldberg, P. E.
Senior Engineer



MLE/ADG/acl

APPENDIX

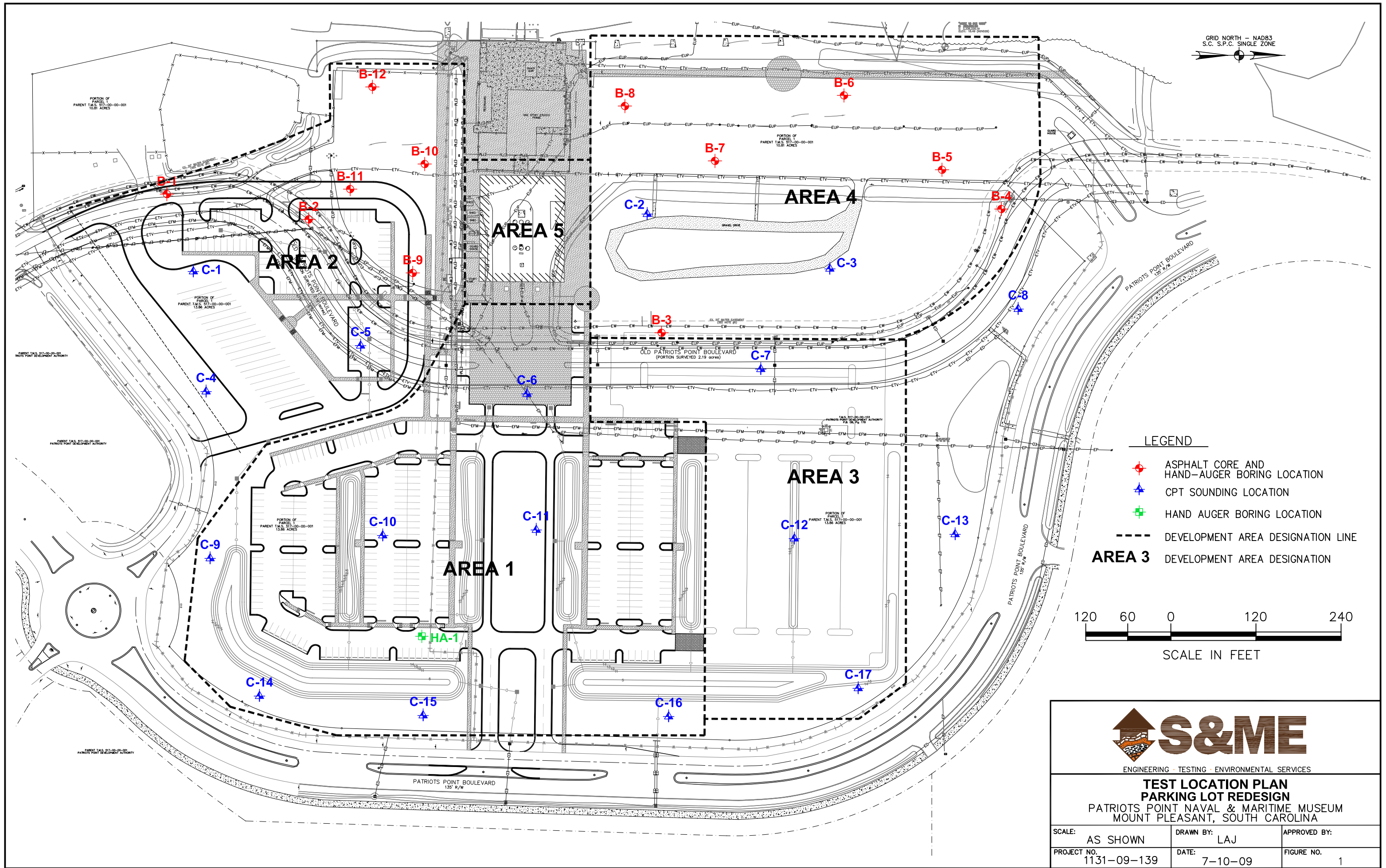
Test Location Plan

CPT Sounding Logs

Hand-Auger Boring Logs

Laboratory Results Summary

Field and Laboratory Testing Procedures





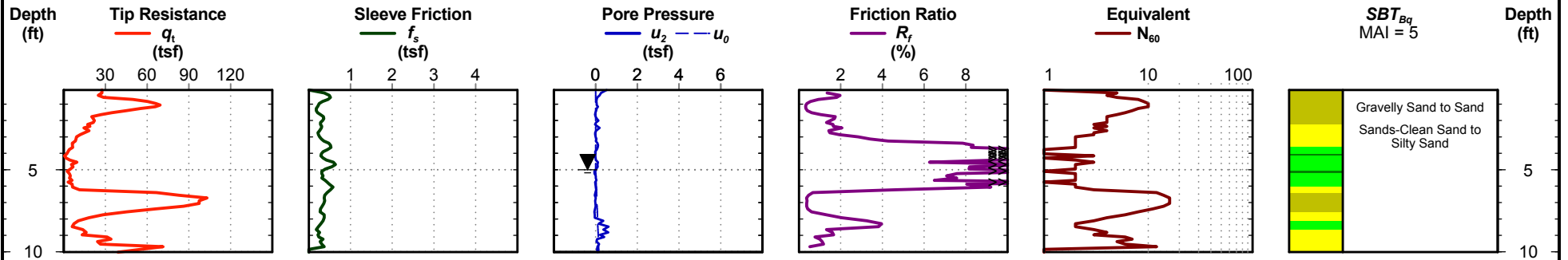
Patriots Point Parking Lot Redesign
Mt. Pleasant, SC
S&ME Project No: 1131-09-139

Cone Penetration Test

C-1

Date: Apr. 21, 2009
Estimated Water Depth: 5 ft
Rig/Operator: Gyrotrac/A. Feix

Total Depth: 10.0 ft
Termination Criteria: Target Depth
Cone Size: 1.44



C-1

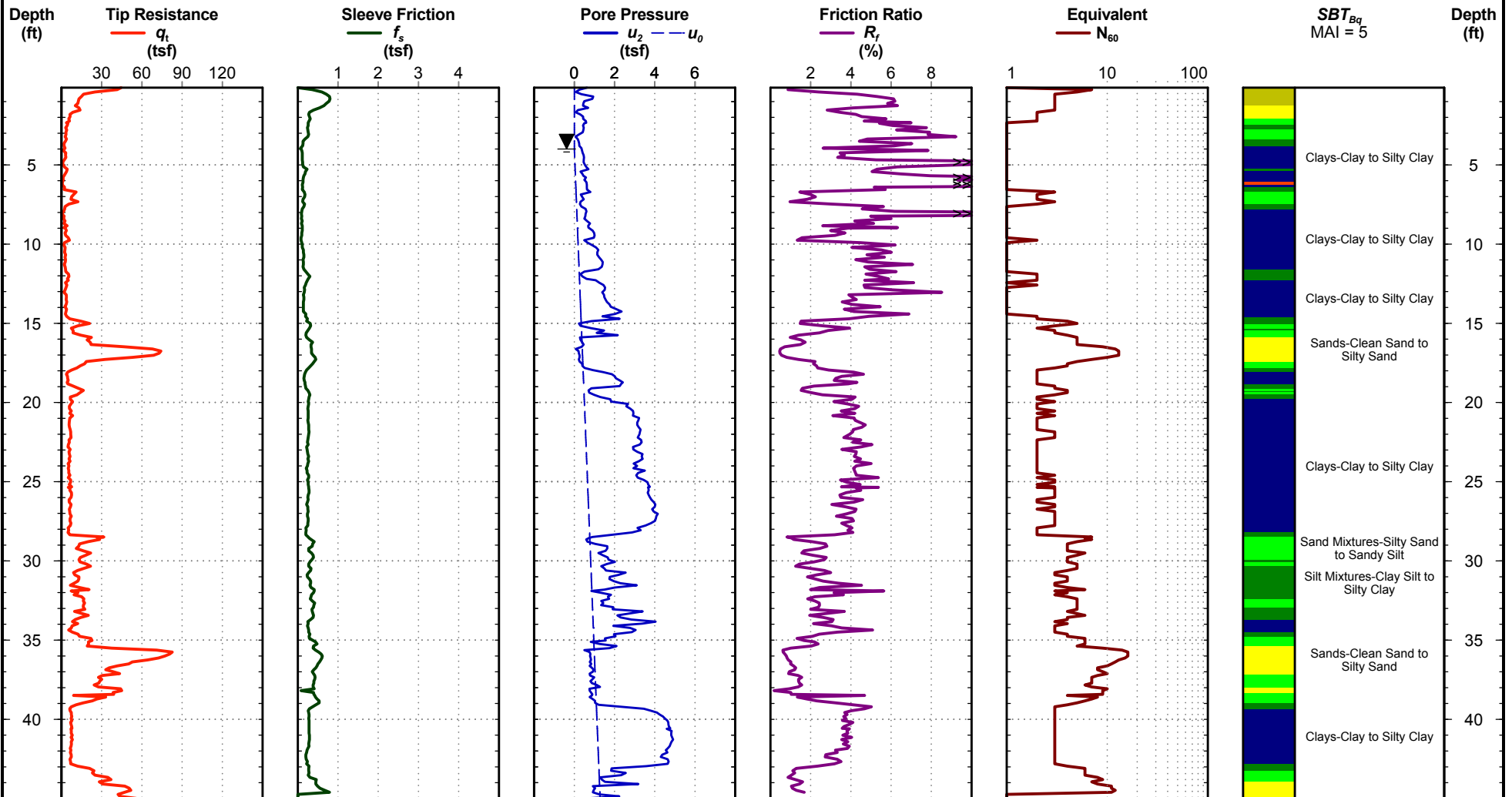


Cone Penetration Test

C-2

Date: Apr. 21, 2009
Estimated Water Depth: 4 ft
Rig/Operator: Gyrotrac/A. Feix

Total Depth: 45.0 ft
Termination Criteria: Target Depth
Cone Size: 1.44



C-2

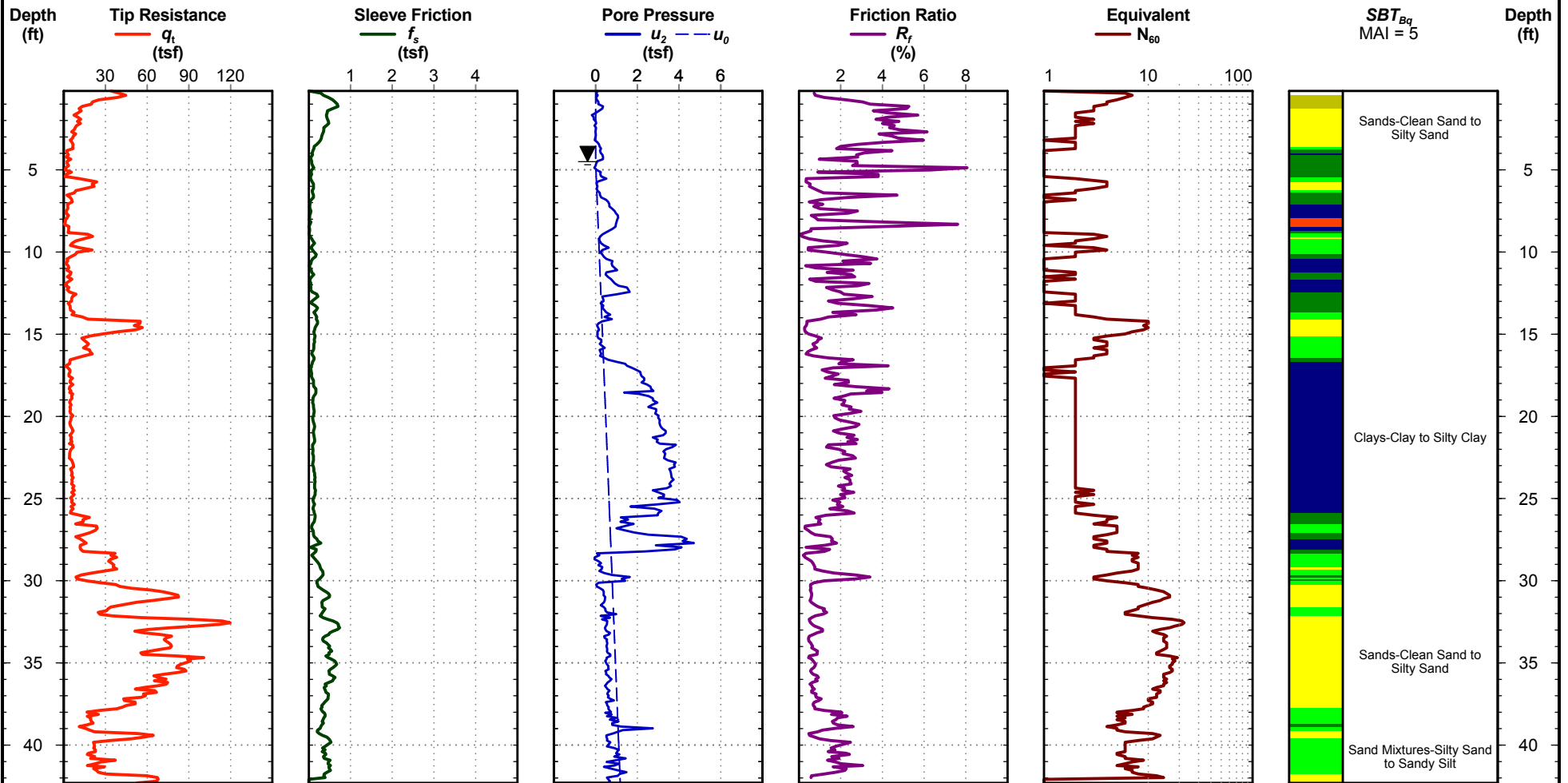


Cone Penetration Test

C-3

Date: Apr. 21, 2009
Estimated Water Depth: 4.5 ft
Rig/Operator: Gyrotrac/A. Feix

Total Depth: 42.3 ft
Termination Criteria: Target Depth
Cone Size: 1.44



C-3



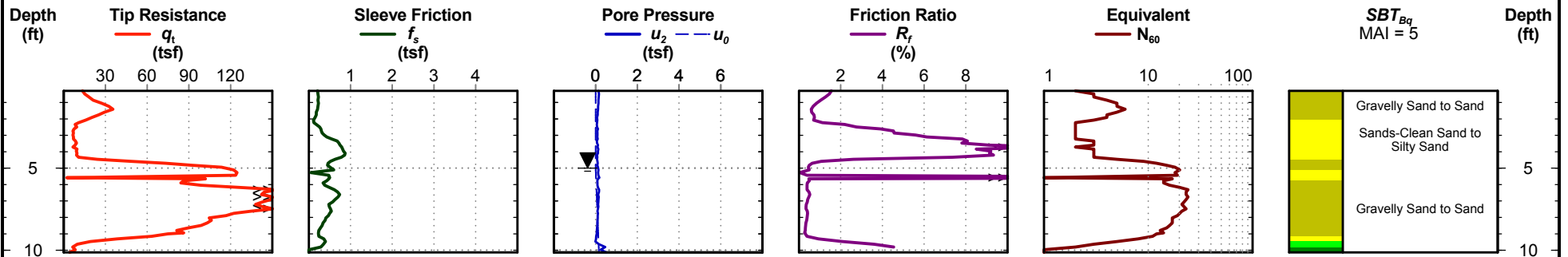
Patriots Point Parking Lot Redesign
Mt. Pleasant, SC
S&ME Project No: 1131-09-139

Cone Penetration Test

C-4

Date: Apr. 21, 2009
Estimated Water Depth: 5 ft
Rig/Operator: Gyrotrac/A. Feix

Total Depth: 10.1 ft
Termination Criteria: Target Depth
Cone Size: 1.44



C-4



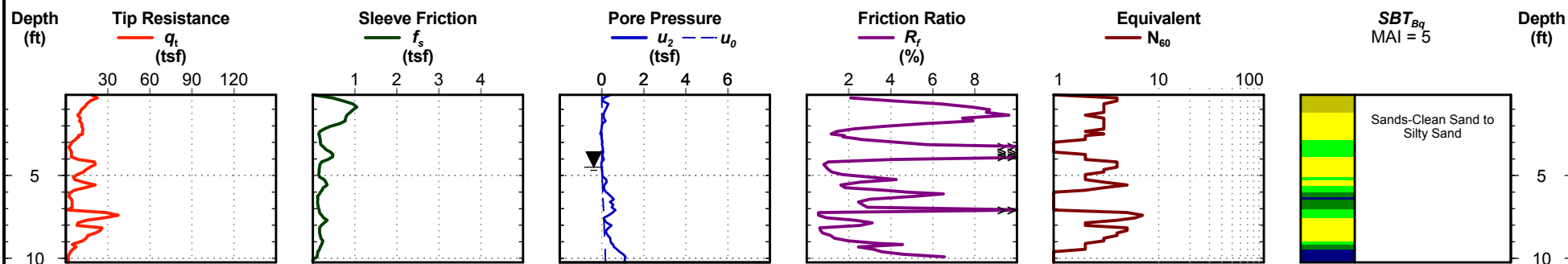
Patriots Point Parking Lot Redesign
Mt. Pleasant, SC
S&ME Project No: 1131-09-139

Cone Penetration Test

C-5

Date: Apr. 21, 2009
Estimated Water Depth: 4.5 ft
Rig/Operator: Gyrotrac/A. Feix

Total Depth: 10.3 ft
Termination Criteria: Target Depth
Cone Size: 1.44



C-5



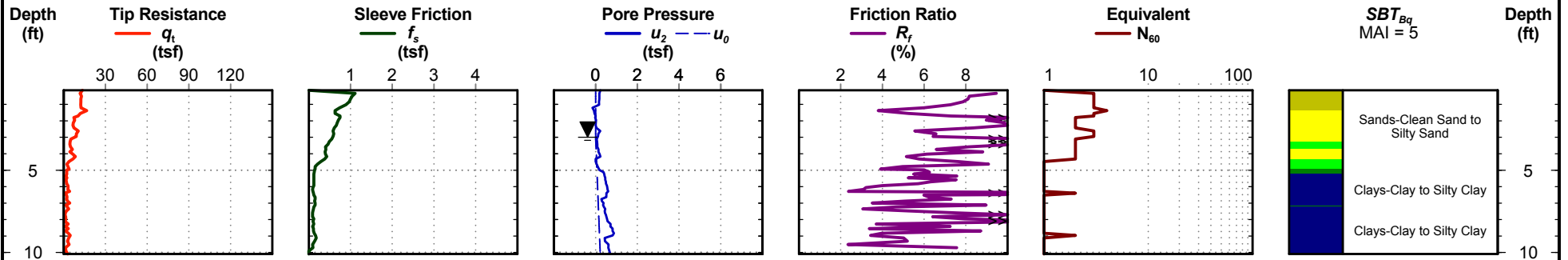
Patriots Point Parking Lot Redesign
Mt. Pleasant, SC
S&ME Project No: 1131-09-139

Cone Penetration Test

C-6

Date: Apr. 21, 2009
Estimated Water Depth: 3 ft
Rig/Operator: Gyrotrac/A. Feix

Total Depth: 10.1 ft
Termination Criteria: Target Depth
Cone Size: 1.44



C-6



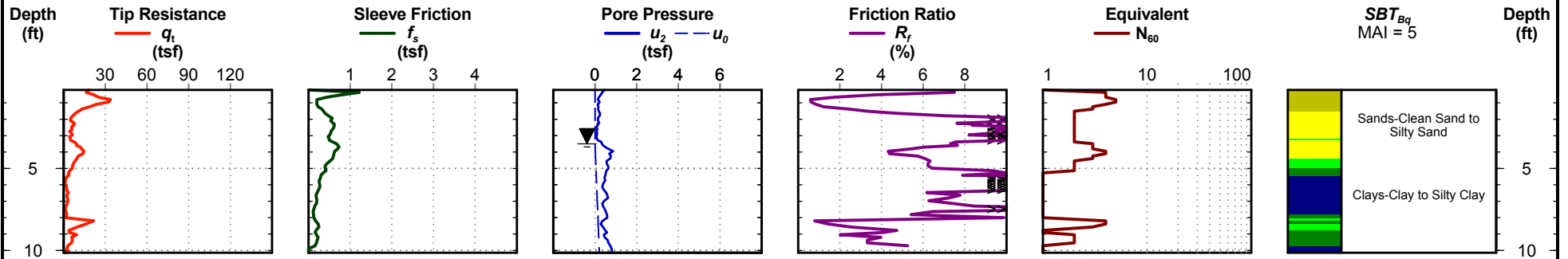
Patriots Point Parking Lot Redesign
Mt. Pleasant, SC
S&ME Project No: 1131-09-139

Cone Penetration Test

C-7

Date: Apr. 21, 2009
Estimated Water Depth: 3.5 ft
Rig/Operator: Gyrotrac/A. Feix

Total Depth: 10.1 ft
Termination Criteria: Target Depth
Cone Size: 1.44



C-7



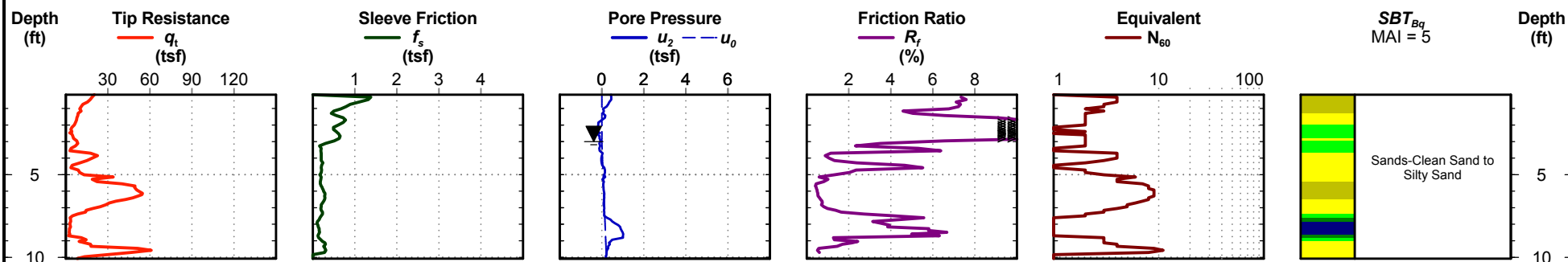
Patriots Point Parking Lot Redesign
Mt. Pleasant, SC
S&ME Project No: 1131-09-139

Cone Penetration Test

C-8

Date: Apr. 21, 2009
Estimated Water Depth: 3 ft
Rig/Operator: Gyrotrac/A. Feix

Total Depth: 10.1 ft
Termination Criteria: Target Depth
Cone Size: 1.44



C-8



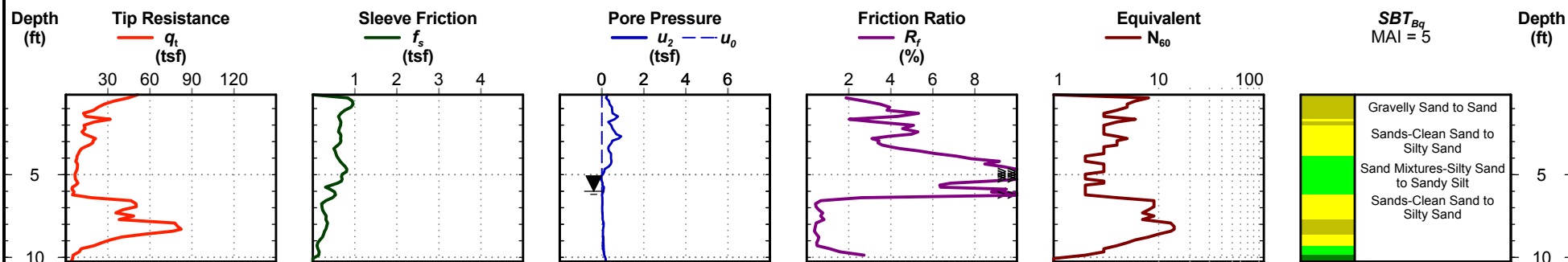
Patriots Point Parking Lot Redesign
Mt. Pleasant, SC
S&ME Project No: 1131-09-139

Cone Penetration Test

C-9

Date: Apr. 21, 2009
Estimated Water Depth: 6 ft
Rig/Operator: Gyrotrac/A. Feix

Total Depth: 10.3 ft
Termination Criteria: Target Depth
Cone Size: 1.44



C-9

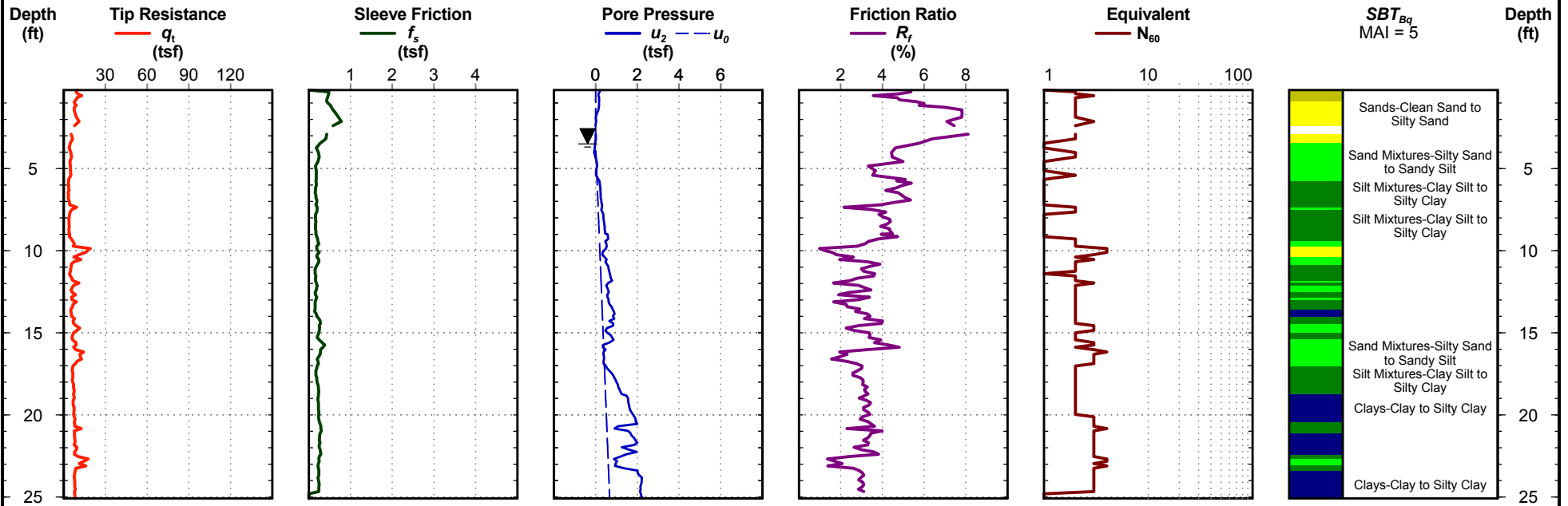


Patriots Point Parking Lot Redesign
Mt. Pleasant, SC
S&ME Project No: 1131-09-139

Cone Penetration Test C-10

Date: Apr. 21, 2009
Estimated Water Depth: 3.5 ft
Rig/Operator: Gyrotrac/A. Feix

Total Depth: 25.1 ft
Termination Criteria: Target Depth
Cone Size: 1.44



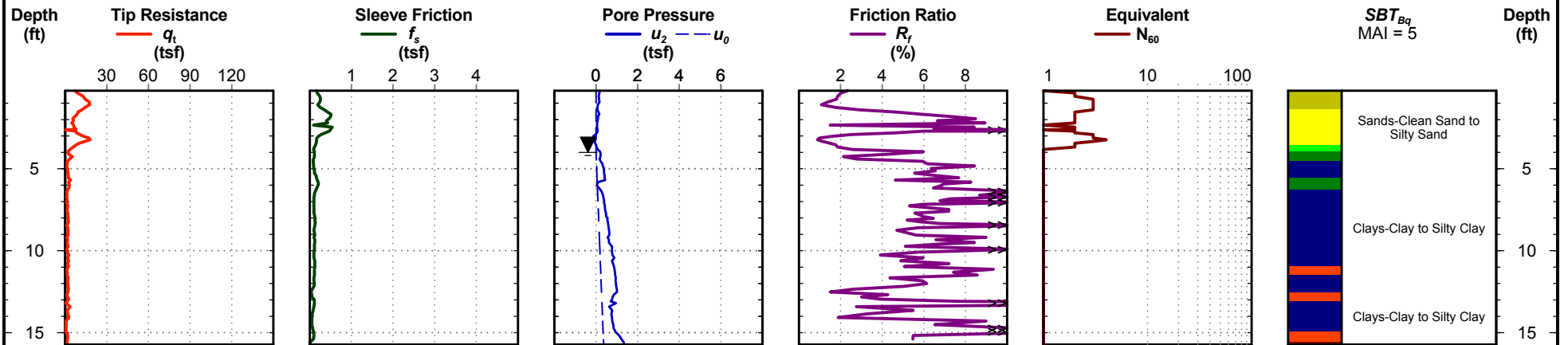


Patriots Point Parking Lot Redesign
Mt. Pleasant, SC
S&ME Project No: 1131-09-139

Cone Penetration Test C-11

Date: Apr. 21, 2009
Estimated Water Depth: 4 ft
Rig/Operator: Gyrotrac/A. Feix

Total Depth: 15.7 ft
Termination Criteria: Target Depth
Cone Size: 1.44



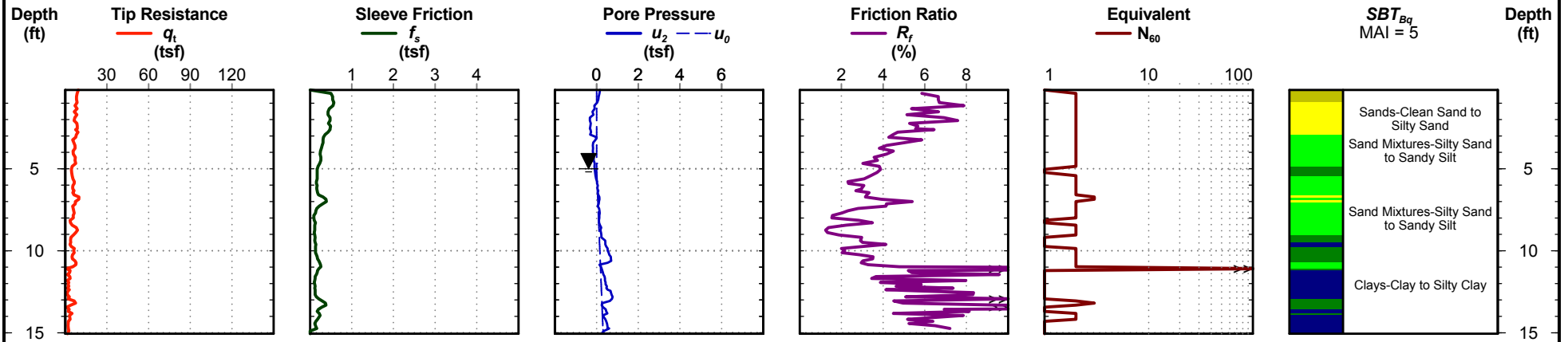


Patriots Point Parking Lot Redesign
Mt. Pleasant, SC
S&ME Project No: 1131-09-139

Cone Penetration Test C-12

Date: Apr. 21, 2009
Estimated Water Depth: 5 ft
Rig/Operator: Gyrotrac/A. Feix

Total Depth: 15.1 ft
Termination Criteria: Target Depth
Cone Size: 1.44



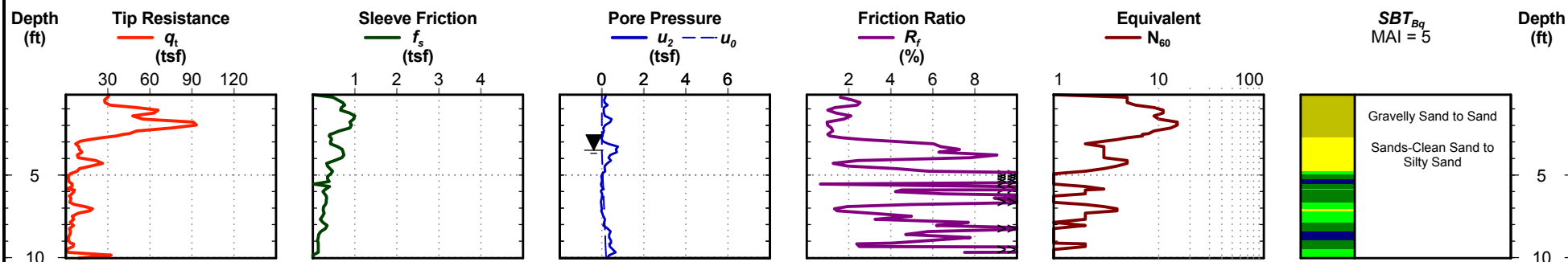


Patriots Point Parking Lot Redesign
Mt. Pleasant, SC
S&ME Project No: 1131-09-139

Cone Penetration Test C-13

Date: Apr. 21, 2009
Estimated Water Depth: 3.5 ft
Rig/Operator: Gyrotrac/A. Feix

Total Depth: 10.0 ft
Termination Criteria: Target Depth
Cone Size: 1.44



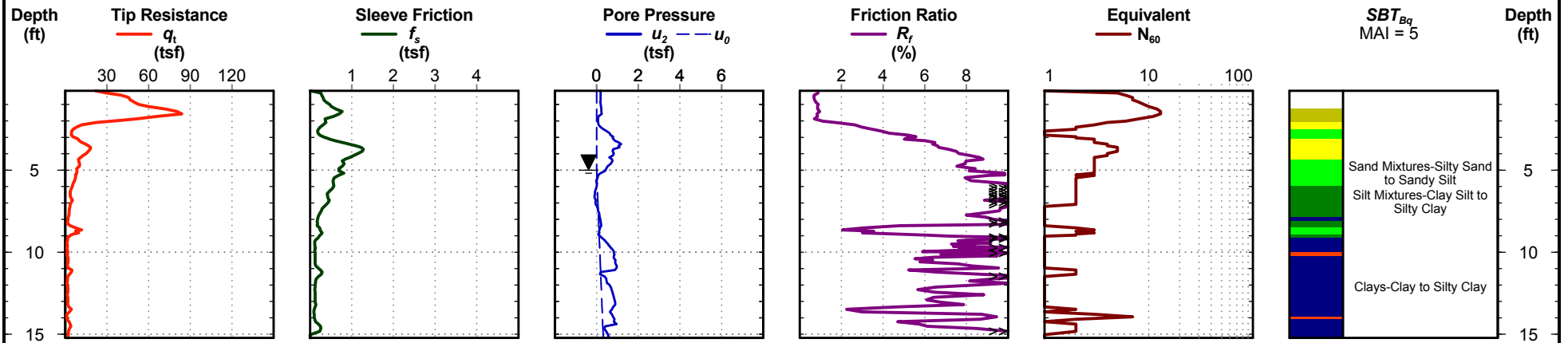


Patriots Point Parking Lot Redesign
Mt. Pleasant, SC
S&ME Project No: 1131-09-139

Cone Penetration Test C-14

Date: Apr. 21, 2009
Estimated Water Depth: 5 ft
Rig/Operator: Gyrotrac/A. Feix

Total Depth: 15.2 ft
Termination Criteria: Target Depth
Cone Size: 1.44



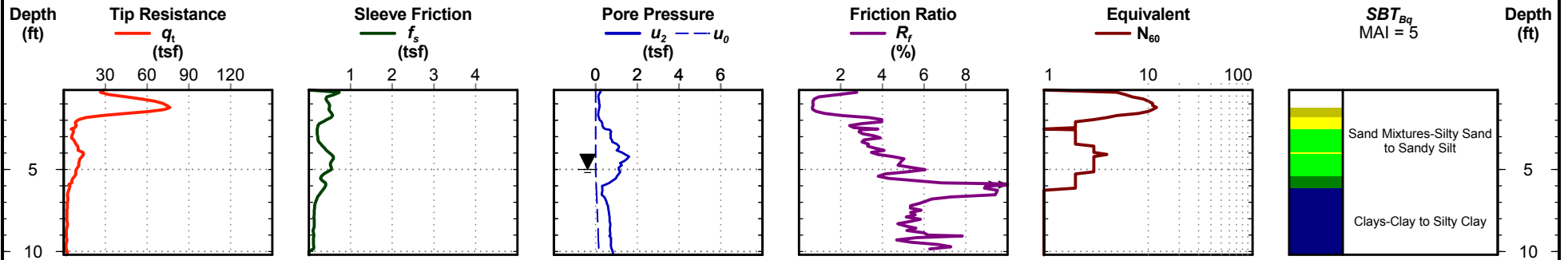


Patriots Point Parking Lot Redesign
Mt. Pleasant, SC
S&ME Project No: 1131-09-139

Cone Penetration Test C-15

Date: Apr. 21, 2009
Estimated Water Depth: 5 ft
Rig/Operator: Gyrotrac/A. Feix

Total Depth: 10.2 ft
Termination Criteria: Target Depth
Cone Size: 1.44



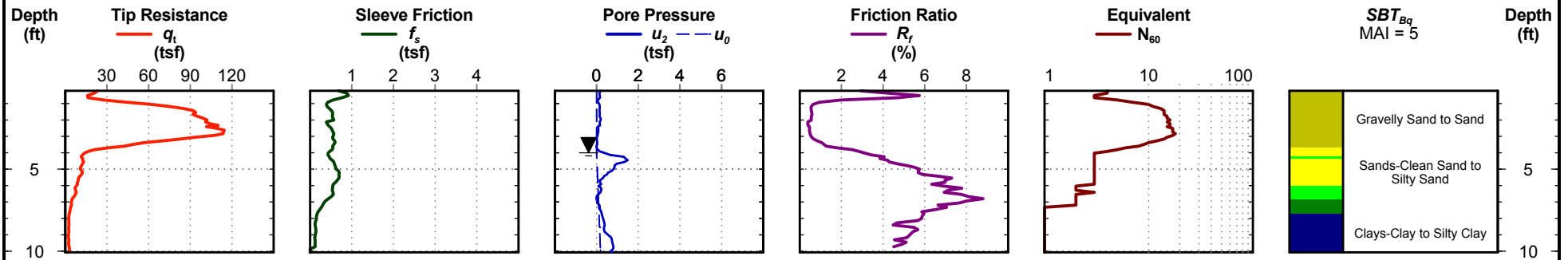


Patriots Point Parking Lot Redesign
Mt. Pleasant, SC
S&ME Project No: 1131-09-139

Cone Penetration Test C-16

Date: Apr. 21, 2009
Estimated Water Depth: 4 ft
Rig/Operator: Gyrotrac/A. Feix

Total Depth: 10.1 ft
Termination Criteria: Target Depth
Cone Size: 1.44



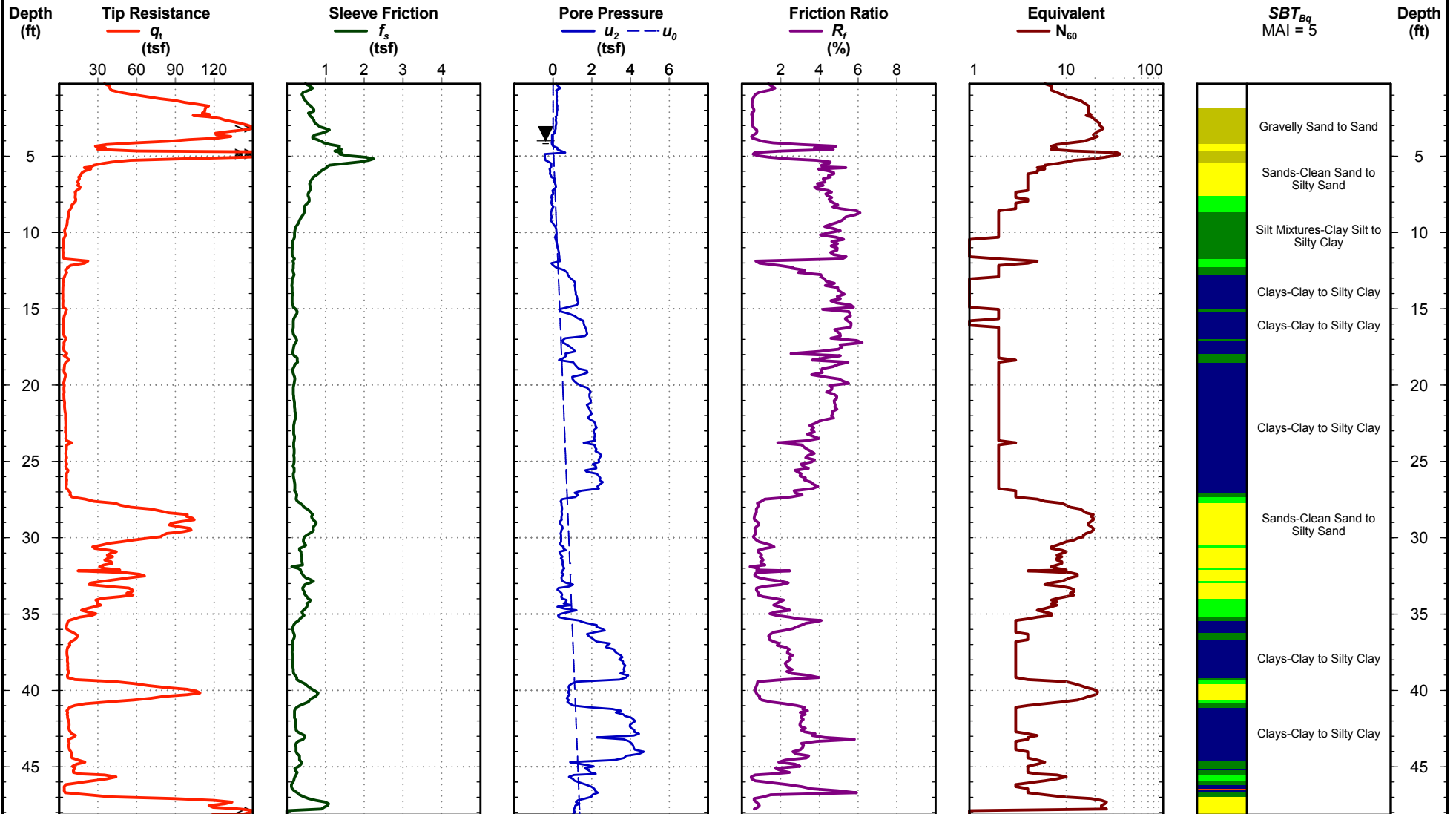



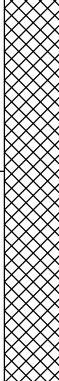

Patriots Point Parking Lot Redesign
Mt. Pleasant, SC
S&ME Project No: 1131-09-139

Cone Penetration Test C-17

Date: Apr. 21, 2009
Estimated Water Depth: 4 ft
Rig/Operator: Gyrotrac/A. Feix

Total Depth: 48.2 ft
Termination Criteria: Target Depth
Cone Size: 1.44




PROJECT: PATRIOTS POINT PARKING LOT REDESIGN MOUNT PLEASANT, SOUTH CAROLINA 1131-09-139				HAND AUGER BORING LOG: B-1	
DATE STARTED: 6/19/09		DATE FINISHED: 6/19/09		NOTES:	
SAMPLING METHOD: HAND AUGER		PERFORMED BY: M. EICHELBERGER			
WATER LEVEL: NOT ENCOUNTERED AT TIME OF BORING					
DEPTH (feet)	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION (ft)	WATER LEVEL	DYNAMIC CONE PENETRATION RESISTANCE
		ASPHALT= 1 INCH BASE COURSE= 3 INCHES FILL: SLIGHTLY SILTY SAND (SP-SM) light brown, fine, moist; with shell			
1		--- separation fabric		-	
2		FILL: CLAYEY SILT (CL) dark bluish gray, moist		-	
3				-	
4				-	
HAND AUGER BORING TERMINATED AT 4 FEET.					









PROJECT: PATRIOTS POINT PARKING LOT REDESIGN MOUNT PLEASANT, SOUTH CAROLINA 1131-09-139				HAND AUGER BORING LOG: B-2	
DATE STARTED: 6/19/09		DATE FINISHED: 6/19/09		NOTES:	
SAMPLING METHOD: HAND AUGER		PERFORMED BY: M. EICHELBERGER			
WATER LEVEL: NOT ENCOUNTERED AT TIME OF BORING					
DEPTH (feet)	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION (ft)	WATER LEVEL	DYNAMIC CONE PENETRATION RESISTANCE
		ASPHALT= 1 INCH			
		BASE COURSE= 5 INCHES			
1		FILL: SLIGHTLY SILTY SAND (SP-SM) light brown, fine, moist; with shell		-	
2		--- separation fabric			
3		FILL: CLAYEY SILT (CL) dark bluish gray, moist		-	
4				-	
HAND AUGER BORING TERMINATED AT 4 FEET.					









PROJECT: PATRIOTS POINT PARKING LOT REDESIGN MOUNT PLEASANT, SOUTH CAROLINA 1131-09-139				HAND AUGER BORING LOG: B-3	
DATE STARTED: 6/19/09		DATE FINISHED: 6/19/09		NOTES:	
SAMPLING METHOD: HAND AUGER		PERFORMED BY: M. EICHELBERGER			
WATER LEVEL: NOT ENCOUNTERED AT TIME OF BORING					
DEPTH (feet)	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION (ft)	WATER LEVEL	DYNAMIC CONE PENETRATION RESISTANCE
1		<u>ASPHALT= 1.25 INCHES</u>		-	
		<u>BASE COURSE= 4.75 INCHES</u>			
		<u>FILL: SLIGHTLY SILTY SAND (SP-SM)</u> light brown, fine, moist; with shell			
2				-	
3				-	
4		<u>FILL: SILTY SAND (SM)</u> dark bluish gray, fine, moist; with clay nodules and chell		-	

PROJECT: PATRIOTS POINT PARKING LOT REDESIGN MOUNT PLEASANT, SOUTH CAROLINA 1131-09-139				HAND AUGER BORING LOG: B-3		
DATE STARTED: 6/19/09		DATE FINISHED: 6/19/09		NOTES:		
SAMPLING METHOD: HAND AUGER		PERFORMED BY: M. EICHELBERGER				
WATER LEVEL: NOT ENCOUNTERED AT TIME OF BORING						
DEPTH (feet)	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION (ft)	WATER LEVEL	DYNAMIC CONE PENETRATION RESISTANCE	
		HAND AUGER BORING TERMINATED AT 4.5 FEET.				

PROJECT: PATRIOTS POINT PARKING LOT REDESIGN MOUNT PLEASANT, SOUTH CAROLINA 1131-09-139				HAND AUGER BORING LOG: B-4	
DATE STARTED: 6/19/09		DATE FINISHED: 6/19/09		NOTES:	
SAMPLING METHOD: HAND AUGER		PERFORMED BY: M. EICHELBERGER			
WATER LEVEL: NOT ECNOUNTERED AT TIME OF BORING					
DEPTH (feet)	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION (ft)	WATER LEVEL	DYNAMIC CONE PENETRATION RESISTANCE
		ASPHALT= 1.75 INCHES			
		BASE COURSE= 4.25 INCHES			
1		<u>FILL: SLIGHTLY SILTY SAND (SP-SM)</u> light brown, fine, moist; with shell		-	
2		<u>FILL: SILTY SAND (SM)</u> dark bluish gray, fine, moist; with clay nodules and shell - - - separator fabric		-	
3		<u>FILL: CLAYEY SILT (CL)</u> dark bluish gray, moist		-	
4		HAND AUGER BORING TERMINATED AT 4 FEET.		-	












PROJECT: PATRIOTS POINT PARKING LOT REDESIGN MOUNT PLEASANT, SOUTH CAROLINA 1131-09-139				HAND AUGER BORING LOG: B-5	
DATE STARTED: 6/19/09		DATE FINISHED: 6/19/09		NOTES:	
SAMPLING METHOD: HAND AUGER		PERFORMED BY: M. EICHELBERGER			
WATER LEVEL: 3.51 FEET AT TIME OF BORING					
DEPTH (feet)	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION (ft)	WATER LEVEL	DYNAMIC CONE PENETRATION RESISTANCE
1		<u>ASPHALT= 2.5 INCHES</u>		-	
		<u>BASE COURSE= 5.5 INCHES</u>			
2		<u>FILL: SLIGHTLY SILTY SAND (SP-SM)</u> light brown, fine, moist; with shell		-	
3		<u>FILL: SILTY SAND (SM)</u> brown to dark brown organic stained, fine, moist; with trace organics		-	
4		<u>FILL: CLAYEY SILT (CL)</u> bluish gray, saturated			
		HAND AUGER BORING TERMINATED AT 4 FEET.		-	



ENGINEERING • TESTING
ENVIRONMENTAL SERVICES







620 WANDO PARK BLVD.
MT. PLEASANT, SOUTH CAROLINA

PROJECT: PATRIOTS POINT PARKING LOT REDESIGN MOUNT PLEASANT, SOUTH CAROLINA 1131-09-139				HAND AUGER BORING LOG: B-6	
DATE STARTED: 6/19/09		DATE FINISHED: 6/19/09		NOTES:	
SAMPLING METHOD: HAND AUGER		PERFORMED BY: M. EICHELBERGER			
WATER LEVEL: NOT ENCOUNTERED AT TIME OF BORING					
DEPTH (feet)	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION (ft)	WATER LEVEL	DYNAMIC CONE PENETRATION RESISTANCE
		<u>ASPHALT= 3 INCHES</u>			
		<u>CONCRETE= 1.5 INCHES</u>			
1		<u>FILL: SLIGHTLY SILTY SAND (SP-SM)</u> light brown and gray, fine, moist; with shell		-	
2					
3		<u>FILL: CLAYEY SILT (ML)</u> bluish gray, moist		-	
4		HAND AUGER BORING TERMINATED AT 4 FEET.		-	









PROJECT: PATRIOTS POINT PARKING LOT REDESIGN MOUNT PLEASANT, SOUTH CAROLINA 1131-09-139				HAND AUGER BORING LOG: B-7	
DATE STARTED: 6/19/09		DATE FINISHED: 6/19/09		NOTES:	
SAMPLING METHOD: HAND AUGER		PERFORMED BY: M. EICHELBERGER			
WATER LEVEL: NOT ENCOUNTERED AT TIME OF BORING					
DEPTH (feet)	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION (ft)	WATER LEVEL	DYNAMIC CONE PENETRATION RESISTANCE
		<u>ASPHALT= 2.5 INCHES</u>			
		<u>BASE COURSE= 3.5 INCHES</u>			
		<u>FILL: SLIGHTLY SILTY SAND (SP-SM)</u> light brown, fine, moist; with shell			
1		<u>FILL: SILTY SAND (SM)</u> brown to dark brown organic stained, fine, moist; trace organics		-	
2				-	
3		<u>FILL: CLAYEY SILT (CL)</u> bluish gray, moist		-	
4				-	
HAND AUGER BORING TERMINATED AT 4 FEET.					



PROJECT: PATRIOTS POINT PARKING LOT REDESIGN MOUNT PLEASANT, SOUTH CAROLINA 1131-09-139				HAND AUGER BORING LOG: B-8	
DATE STARTED: 6/19/09		DATE FINISHED: 6/19/09		NOTES:	
SAMPLING METHOD: HAND AUGER		PERFORMED BY: M. EICHELBERGER			
WATER LEVEL: 3 FEET AT TIME OF BORING					
DEPTH (feet)	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION (ft)	WATER LEVEL	DYNAMIC CONE PENETRATION RESISTANCE
	■	<u>ASPHALT= 3 INCHES</u>			
	●●●●●	<u>BASE COURSE= 5 INCHES</u>			
1	⊗⊗⊗⊗⊗	<u>FILL: SLIGHTLY SILTY SAND (SP-SM)</u> light brown, fine, moist; with shell		-	
2	⊗⊗⊗⊗⊗	<u>FILL: SILTY SAND (SM)</u> dark grayish brown, fine, moist		-	
3	⊗⊗⊗⊗⊗	<u>FILL: SAND (SP)</u> bluish gray, fine, saturated		▽	
	⊗⊗⊗⊗⊗	<u>FILL: SILTY SAND (SM)</u> dark brown, organic stained, fine, saturated			
4		HAND AUGER BORING TERMINATED AT 4 FEET.		-	

PROJECT: PATRIOTS POINT PARKING LOT REDESIGN MOUNT PLEASANT, SOUTH CAROLINA 1131-09-139				HAND AUGER BORING LOG: B-9	
DATE STARTED: 6/19/09		DATE FINISHED: 6/19/09		NOTES:	
SAMPLING METHOD: HAND AUGER		PERFORMED BY: M. EICHELBERGER			
WATER LEVEL: NOT ENCOUNTERED AT TIME OF BORING					
DEPTH (feet)	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION (ft)	WATER LEVEL	DYNAMIC CONE PENETRATION RESISTANCE
		<u>ASPHALT= 3 INCHES</u>			
		<u>BASE COURSE= 9 INCHES</u>			
1		<u>FILL: SLIGHTLY SILTY SAND (SP-SM)</u> light brown, fine, moist; with shell		-	
2		<u>FILL: SILTY SAND (SM)</u> bluish gray, fine, moist; with shell		-	
3		<u>FILL: CLAYEY SILT (CL)</u> dark bluish gray to black, moist		-	
4				-	
HAND AUGER BORING TERMINATED AT 4 FEET.					






PROJECT: PATRIOTS POINT PARKING LOT REDESIGN MOUNT PLEASANT, SOUTH CAROLINA 1131-09-139				HAND AUGER BORING LOG: B-10	
DATE STARTED: 6/19/09		DATE FINISHED: 6/19/09		NOTES:	
SAMPLING METHOD: HAND AUGER		PERFORMED BY: M. EICHELBERGER			
WATER LEVEL: NOT ENCOUNTERED AT TIME OF BORING					
DEPTH (feet)	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION (ft)	WATER LEVEL	DYNAMIC CONE PENETRATION RESISTANCE
		<u>ASPHALT= 3 INCHES</u>			
		<u>BASE COURSE= 9 INCHES</u>			
1		<u>FILL: SLIGHTLY SILTY SAND (SP-SM)</u> light brown, fine, moist; with shell		-	
		<u>FILL: SILTY SAND (SM)</u> bluish gray, fine, moist; with shell			
2		<u>FILL: SILTY SAND (SM)</u> dark brown, fine, moist; with crushed stone and organics		-	
		--- separation fabric			
3		<u>FILL: CLAYEY SILT (CL)</u> dark bluish gray to black, moist		-	
4				-	
HAND AUGER BORING TERMINATED AT 4 FEET.					



ENGINEERING • TESTING
ENVIRONMENTAL SERVICES

620 WANDO PARK BLVD.
MT. PLEASANT, SOUTH CAROLINA

PROJECT: PATRIOTS POINT PARKING LOT REDESIGN MOUNT PLEASANT, SOUTH CAROLINA 1131-09-139				HAND AUGER BORING LOG: B-11	
DATE STARTED: 6/19/09		DATE FINISHED: 6/19/09		NOTES:	
SAMPLING METHOD: HAND AUGER		PERFORMED BY: M. EICHELBERGER			
WATER LEVEL: NOT ENCOUNTERED AT TIME OF BORING					
DEPTH (feet)	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION (ft)	WATER LEVEL	DYNAMIC CONE PENETRATION RESISTANCE
		<u>ASPHALT= 3.5 INCHES</u>			
		<u>BASE COURSE= 8.5 INCHES</u>			
1		<u>FILL: SILTY SAND (SM)</u> gray, fine, moist; with shell		-	
2		HAND AUGER BORING REFUSAL AT 2 FEET.		-	

PROJECT: PATRIOTS POINT PARKING LOT REDESIGN MOUNT PLEASANT, SOUTH CAROLINA 1131-09-139				HAND AUGER BORING LOG: B-12	
DATE STARTED: 6/19/09		DATE FINISHED: 6/19/09		NOTES:	
SAMPLING METHOD: HAND AUGER		PERFORMED BY: M. EICHELBERGER			
WATER LEVEL: NOT ENCOUNTERED AT TIME OF BORING					
DEPTH (feet)	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION (ft)	WATER LEVEL	DYNAMIC CONE PENETRATION RESISTANCE
1		<u>ASPHALT= 2.5 INCHES</u>		-	
		<u>BASE COURSE= 3.5 INCHES</u>			
2		<u>FILL: SLIGHTLY SILTY SAND (SP-SM)</u> light brown, fine, moist; with shell		-	
3		<u>FILL: SILTY SAND (SM)</u> gray, fine, moist; with shell		-	
4		<u>FILL: CLAYEY SILT (CL)</u> dark bluish gray to black, moist		-	
HAND AUGER BORING TERMINATED AT 4 FEET.					

PROJECT: PATRIOTS POINT PARKING LOT REDESIGN MOUNT PLEASANT, SOUTH CAROLINA 1131-09-139				HAND AUGER BORING LOG: C-1	
DATE STARTED: 4/29/09		DATE FINISHED: 4/29/09		NOTES:	
SAMPLING METHOD: HAND AUGER		PERFORMED BY: N. DUNCAN			
WATER LEVEL: NOT ENCOUNTERED AT TIME OF BORING					
DEPTH (feet)	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION (ft)	WATER LEVEL	DYNAMIC CONE PENETRATION RESISTANCE
1		<u>POSSIBLE FILL: SAND (SP)</u> gray, fine, dry <u>POSSIBLE FILL: SILTY SAND (SM)</u> tan/gray, fine, dry; with shell fragments	-		
2		- - - tan, moist; with shell and clay	-		
3		<u>POSSIBLE FILL: SANDY CLAY (CL)</u> brown/gray, fine, moist	-		
4		HAND AUGER BORING TERMINATED AT 4 FEET.	-		








PROJECT: PATRIOTS POINT PARKING LOT REDESIGN MOUNT PLEASANT, SOUTH CAROLINA 1131-09-139				HAND AUGER BORING LOG: C-2	
DATE STARTED: 4/28/09		DATE FINISHED: 4/28/09		NOTES:	
SAMPLING METHOD: HAND AUGER		PERFORMED BY: N. DUNCAN			
WATER LEVEL: 3.5 FEET AT TIME OF BORING					
DEPTH (feet)	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION (ft)	WATER LEVEL	DYNAMIC CONE PENETRATION RESISTANCE
1		<u>POSSIBLE FILL: SILTY SAND (SM)</u> gray, fine, dry; with gravel and organics - - - brown, moist	-	-	
2		<u>POSSIBLE FILL: SANDY CLAY (CL)</u> brown and gray, fine, moist	-	-	
3			-	-	
4				-	
HAND AUGER BORING TERMINATED AT 4 FEET.					









S&ME
ENGINEERING • TESTING
ENVIRONMENTAL SERVICES


620 WANDO PARK BLVD.
MT. PLEASANT, SOUTH CAROLINA

PROJECT: PATRIOTS POINT PARKING LOT REDESIGN MOUNT PLEASANT, SOUTH CAROLINA 1131-09-139				HAND AUGER BORING LOG: C-4	
DATE STARTED: 4/27/09		DATE FINISHED: 4/27/09		NOTES:	
SAMPLING METHOD: HAND AUGER		PERFORMED BY: N. DUNCAN			
WATER LEVEL: NOT ENCOUNTERED AT TIME OF BORING					
DEPTH (feet)	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION (ft)	WATER LEVEL	DYNAMIC CONE PENETRATION RESISTANCE
		<u>ORGANIC LADEN TOPSOIL= 3 INCHES</u>			
1		<u>POSSIBLE FILL: SILTY SAND (SM)</u> brown, fine, moist --- gray/brown, loose, moist; with some shell		-	
2		<u>CLAYEY SAND (SC)</u> brown, fine, moist		-	
3				-	
4				-	
HAND AUGER BORING TERMINATED AT 4 FEET.					

PROJECT: PATRIOTS POINT PARKING LOT REDESIGN MOUNT PLEASANT, SOUTH CAROLINA 1131-09-139				HAND AUGER BORING LOG: C-5	
DATE STARTED: 4/28/09		DATE FINISHED: 4/28/09		NOTES:	
SAMPLING METHOD: HAND AUGER		PERFORMED BY: N. DUNCAN			
WATER LEVEL: NOT ENCOUNTERED AT TIME OF BORING					
DEPTH (feet)	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION (ft)	WATER LEVEL	DYNAMIC CONE PENETRATION RESISTANCE
1		<u>POSSIBLE FILL: SAND (SP)</u> gray, dry; with shell and organics <u>POSSIBLE FILL: SILTY SAND (SM)</u> gray, fine, dry; with shell		-	
		<u>POSSIBLE FILL: CLAYEY SAND (SC)</u> gray/brown, fine, moist		-	
2		<u>POSSIBLE FILL: SANDY CLAY (CL)</u> gray/brown, fine, moist		-	
		<u>POSSIBLE FILL: SILTY SAND (SM)</u> brown, fine, moist		-	
3		<u>POSSIBLE FILL: SANDY CLAY (CL)</u> brown, fine, moist		-	
4		HAND AUGER BORING TERMINATED AT 4 FEET.		-	




PROJECT: PATRIOTS POINT PARKING LOT REDESIGN MOUNT PLEASANT, SOUTH CAROLINA 1131-09-139				HAND AUGER BORING LOG: C-6			
DATE STARTED: 4/28/09		DATE FINISHED: 4/28/09		NOTES:			
SAMPLING METHOD: HAND AUGER		PERFORMED BY: N. DUNCAN					
WATER LEVEL: 3.5 FEET AT TIME OF BORING							
DEPTH (feet)	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION (ft)	WATER LEVEL	DYNAMIC CONE PENETRATION RESISTANCE		
		<u>ORGANIC LADEN TOPSOIL= 3 INCHES</u>					
1		<u>POSSIBLE FILL: SILTY SAND (SM)</u> tan/brown, fine, moist; with shell		-			
2		<u>POSSIBLE FILL: CLAYEY SAND (SC)</u> brown, fine, moist		-			
3		<u>POSSIBLE FILL: SANDY CLAY (CL)</u> gray/brown, fine, moist		-			
4		--- saturated					
		HAND AUGER BORING TERMINATED AT 4 FEET.		-			



PROJECT: PATRIOTS POINT PARKING LOT REDESIGN MOUNT PLEASANT, SOUTH CAROLINA 1131-09-139				HAND AUGER BORING LOG: C-7	
DATE STARTED: 4/28/09		DATE FINISHED: 4/28/09		NOTES:	
SAMPLING METHOD: HAND AUGER		PERFORMED BY: N. DUNCAN			
WATER LEVEL: NOT ENCOUNTERED AT TIME OF BORING					
DEPTH (feet)	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION (ft)	WATER LEVEL	DYNAMIC CONE PENETRATION RESISTANCE
1		<u>ORGANIC LADEN TOPSOIL= 2 INCHES</u>	-	-	
2		<u>POSSIBLE FILL: CLAYEY SAND (SC)</u> brown, fine, moist			
3		<u>POSSIBLE FILL: SANDY CLAY (CL)</u> brown, fine, moist			
4		HAND AUGER BORING TERMINATED AT 4 FEET.			


PROJECT: PATRIOTS POINT PARKING LOT REDESIGN MOUNT PLEASANT, SOUTH CAROLINA 1131-09-139				HAND AUGER BORING LOG: C-8	
DATE STARTED: 4/29/09		DATE FINISHED: 4/29/09		NOTES:	
SAMPLING METHOD: HAND AUGER		PERFORMED BY: N. DUNCAN			
WATER LEVEL: 3 FEET AT TIME OF BORING					
DEPTH (feet)	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION (ft)	WATER LEVEL	DYNAMIC CONE PENETRATION RESISTANCE
1		<u>POSSIBLE FILL: CLAYEY SAND (SC)</u> brown, fine, moist; with trace organics - - - no organics	-	-	
2		<u>POSSIBLE FILL: SANDY CLAY (CL)</u> gray and brown, fine, moist	-	-	
3		- - - saturated			
4		HAND AUGER BORING TERMINATED AT 4 FEET.	-		




PROJECT: PATRIOTS POINT PARKING LOT REDESIGN MOUNT PLEASANT, SOUTH CAROLINA 1131-09-139				HAND AUGER BORING LOG: C-10			
DATE STARTED: 4/23/09		DATE FINISHED: 4/23/09		NOTES: fc= fines content			
SAMPLING METHOD: HAND AUGER		PERFORMED BY: R. BOLLER					
WATER LEVEL: 1.5 FEET AT TIME OF BORING							
DEPTH (feet)	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION (ft)	WATER LEVEL	DYNAMIC CONE PENETRATION RESISTANCE		
1		<u>POSSIBLE FILL: SAND (SP)</u> light reddish brown, fine, moist		-			
2		<u>POSSIBLE FILL: SANDY SILT (ML)</u> dark gray to reddish brown mottled, fine, saturated		▽			
3		--- fc= 91% --- gray		-			
4		HAND AUGER BORING TERMINATED AT 4 FEET.			-		

PROJECT: PATRIOTS POINT PARKING LOT REDESIGN MOUNT PLEASANT, SOUTH CAROLINA 1131-09-139				HAND AUGER BORING LOG: C-11			
DATE STARTED: 4/23/09		DATE FINISHED: 4/23/09		NOTES: fc= fines content			
SAMPLING METHOD: HAND AUGER		PERFORMED BY: R. BOLLER					
WATER LEVEL: 3 FEET AT TIME OF BORING							
DEPTH (feet)	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION (ft)	WATER LEVEL	DYNAMIC CONE PENETRATION RESISTANCE		
1		<u>POSSIBLE FILL: SANDY SILT (ML)</u> dark gray to reddish brown mottled, fine, moist		-			
2				-			
3		- - - dark gray, saturated; fc= 81%					
4		HAND AUGER BORING TERMINATED AT 4 FEET.		-			



PROJECT: PATRIOTS POINT PARKING LOT REDESIGN MOUNT PLEASANT, SOUTH CAROLINA 1131-09-139				HAND AUGER BORING LOG: C-12	
DATE STARTED: 4/23/09		DATE FINISHED: 4/23/09		NOTES: fc= fines content	
SAMPLING METHOD: HAND AUGER		PERFORMED BY: R. BOLLER			
WATER LEVEL: 1 FEET AT TIME OF BORING					
DEPTH (feet)	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION (ft)	WATER LEVEL	DYNAMIC CONE PENETRATION RESISTANCE
1		<u>ORGANIC LADEN TOPSOIL= 1 INCH</u> <u>POSSIBLE FILL: SANDY SILT (ML)</u> dark gray to grayish blue, saturated; with decaying roots			
2				-	
3		--- dark gray; fc= 81%		-	
4				-	
HAND AUGER BORING TERMINATED AT 4 FEET.					






PROJECT: PATRIOTS POINT PARKING LOT REDESIGN MOUNT PLEASANT, SOUTH CAROLINA 1131-09-139				HAND AUGER BORING LOG: C-13	
DATE STARTED: 4/29/09		DATE FINISHED: 4/29/09		NOTES:	
SAMPLING METHOD: HAND AUGER		PERFORMED BY: N. DUNCAN			
WATER LEVEL: NOT ENCOUNTERED AT TIME OF BORING					
DEPTH (feet)	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION (ft)	WATER LEVEL	DYNAMIC CONE PENETRATION RESISTANCE
1		<u>ORGANIC LADEN TOPSOIL= 2 INCHES</u>			
		<u>POSSIBLE FILL: SILTY SAND (SM)</u> tan/brown, fine, moist		-	
		<u>POSSIBLE FILL: CLAYEY SAND (SC)</u> brown, fine, moist		-	
2		<u>POSSIBLE FILL: SANDY CLAY (CL)</u> gray/brown, fine, moist		-	
		<u>POSSIBLE FILL: SILTY SAND (SM)</u> gray, fine, moist		-	
3		<u>POSSIBLE FILL: SANDY CLAY (CL)</u> brown/gray, fine, moist		-	
4		HAND AUGER BORING TERMINATED AT 4 FEET.		-	

PROJECT: PATRIOTS POINT PARKING LOT REDESIGN MOUNT PLEASANT, SOUTH CAROLINA 1131-09-139				HAND AUGER BORING LOG: C-14	
DATE STARTED: 4/29/09		DATE FINISHED: 4/29/09		NOTES:	
SAMPLING METHOD: HAND AUGER		PERFORMED BY: N. DUNCAN			
WATER LEVEL: NOT ENCOUNTERED AT TIME OF BORING					
DEPTH (feet)	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION (ft)	WATER LEVEL	DYNAMIC CONE PENETRATION RESISTANCE
		<u>ORGANIC LADEN TOPSOIL= 3 INCHES</u>			
1		<u>POSSIBLE FILL: SILTY SAND (SM)</u> tan/brown, fine, moist		-	
2				-	
3		<u>POSSIBLE FILL: SANDY CLAY (CL)</u> dark gray, fine, moist --- gray		-	
4				-	
HAND AUGER BORING TERMINATED AT 4 FEET.					







PROJECT: PATRIOTS POINT PARKING LOT REDESIGN MOUNT PLEASANT, SOUTH CAROLINA 1131-09-139				HAND AUGER BORING LOG: C-15	
DATE STARTED: 4/23/09		DATE FINISHED: 4/23/09		NOTES: fc= fines content	
SAMPLING METHOD: HAND AUGER		PERFORMED BY: R. BOLLER			
WATER LEVEL: 2.5 FEET AT TIME OF BORING					
DEPTH (feet)	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION (ft)	WATER LEVEL	DYNAMIC CONE PENETRATION RESISTANCE
1		ORGANIC LADEN TOPSOIL= 1 INCH POSSIBLE FILL: SILTY SAND (SM) reddish brown to brown, fine, moist		-	
		POSSIBLE FILL: SAND (SP) light yellowish brown, fine, moist		-	
2		POSSIBLE FILL: SANDY SILT (ML) light gray to reddish brown mottled, moist, fine		-	
		--- saturated		▽	
3		--- gray; fc= 85%		-	
		--- dark gray			
4		HAND AUGER BORING TERMINATED AT 4 FEET.			

PROJECT: PATRIOTS POINT PARKING LOT REDESIGN MOUNT PLEASANT, SOUTH CAROLINA 1131-09-139				HAND AUGER BORING LOG: C-16			
DATE STARTED: 4/23/09		DATE FINISHED: 4/23/09		NOTES: fc= fines content			
SAMPLING METHOD: HAND AUGER		PERFORMED BY: R. BOLLER					
WATER LEVEL: 1.5 FEET AT TIME OF BORING							
DEPTH (feet)	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION (ft)	WATER LEVEL	DYNAMIC CONE PENETRATION RESISTANCE		
1		<u>POSSIBLE FILL: SANDY SILT (ML)</u> dark brownish gray, fine, moist		-			
2		--- reddish brown to gray mottled; saturated		▽			
3		--- dark gray --- fc= 96%		-			
4		HAND AUGER BORING TERMINATED AT 4 FEET.			-		

PROJECT: PATRIOTS POINT PARKING LOT REDESIGN MOUNT PLEASANT, SOUTH CAROLINA 1131-09-139				HAND AUGER BORING LOG: C-17			
DATE STARTED: 4/29/09		DATE FINISHED: 4/29/09		NOTES:			
SAMPLING METHOD: HAND AUGER		PERFORMED BY: N. DUNCAN					
WATER LEVEL: NOT ENCOUNTERED AT TIME OF BORING							
DEPTH (feet)	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION (ft)	WATER LEVEL	DYNAMIC CONE PENETRATION RESISTANCE		
		<u>ORGANIC LADEN TOPSOIL= 3 INCHES</u>					
1		<u>POSSIBLE FILL: CLAYEY SAND (SC)</u> brown, soft, fine, moist		-			
2				-			
3		<u>POSSIBLE FILL: SANDY CLAY (CL)</u> gray/brown, fine, moist		-			
4				-			
		HAND AUGER BORING TERMINATED AT 4 FEET.					

PROJECT: PATRIOTS POINT PARKING LOT REDESIGN MOUNT PLEASANT, SOUTH CAROLINA 1131-09-139				HAND AUGER BORING LOG: HA-1	
DATE STARTED: 4/23/09		DATE FINISHED: 4/23/09		NOTES: fc= fines content	
SAMPLING METHOD: HAND AUGER		PERFORMED BY: R. BOLLER			
WATER LEVEL: 2.5 FEET AT TIME OF BORING					
DEPTH (feet)	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION (ft)	WATER LEVEL	DYNAMIC CONE PENETRATION RESISTANCE
1		ORGANIC LADEN TOPSOIL= 1 INCH POSSIBLE FILL: SILTY SAND (SM) reddish brown, fine, moist		-	
2		POSSIBLE FILL: SANDY SILT (ML) light gray, fine, moist		-	
3		--- gray, saturated --- fc= 88%			
4		HAND AUGER BORING TERMINATED AT 4 FEET.			

PROJECT: PATRIOTS POINT PARKING LOT REDESIGN MOUNT PLEASANT, SOUTH CAROLINA 1131-09-139				HAND AUGER BORING LOG: HA-2	
DATE STARTED: 4/23/09		DATE FINISHED: 4/23/09		NOTES: fc= fines content	
SAMPLING METHOD: HAND AUGER		PERFORMED BY: R. BOLLER			
WATER LEVEL: 1 FEET AT TIME OF BORING					
DEPTH (feet)	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION (ft)	WATER LEVEL	DYNAMIC CONE PENETRATION RESISTANCE
1		ORGANIC LADEN TOPSOIL= 1 INCH POSSIBLE FILL: SANDY SILT (ML) reddish brown to gray mottled, fine, moist		▽	
2		--- saturated		-	
3		--- dark gray; fc= 90%		-	
4		--- dark gray; fc= 90%		-	
HAND AUGER BORING TERMINATED AT 4 FEET.					

**Summary of Laboratory Test Data
Patriots Point Parking Lot Redesign
Mt. Pleasant, South Carolina
S&ME Job No. 1131-09-139**

Sample Location	Sample Depth (feet)	Passing 200 Sieve (%)
HA-1	3.0	88
HA-2	3.0	90
C-10	3.0	91
C-11	3.0	81
C-12	3.0	81
C-15	3.0	85
C-16	3.0	96

FIELD TESTING PROCEDURES

Cone Penetrometer Test (CPT) Sounding

The cone penetrometer test soundings (ASTM D 5778) were performed by hydraulically pushing an electronically instrumented cone penetrometer through the soil at a constant rate. As the cone penetrometer tip was advanced through the soil, nearly continuous readings of point stress, sleeve friction and pore water pressure were recorded and stored in the on-site computers. Using theoretical and empirical relationships, CPT data can be used to determine soil stratigraphy and estimate soil properties and parameters such as effective stress, friction angle, Young's Modulus and undrained shear strength.

The consistency and relative density designations, which are based on the cone tip resistance, q_t for sands and cohesive soils (silts and clays) are as follows:

<u>SANDS</u>		<u>SILTS AND CLAYS</u>	
Cone Tip Resistance, q_t (tsf)	Relative Density	Cone Tip Resistance, q_t (tsf)	Consistency
<20	Very Loose	<5	Very Soft
20 – 40	Loose	5 – 10	Soft
40 – 120	Medium Dense	10 – 15	Firm
		15 – 30	Stiff
120 – 200	Dense	30 – 60	Very Stiff
>200	Very Dense	>60	Hard

CPT Correlations

References are in parenthesis next to the appropriate equation.

General

p_a = atmospheric pressure (for unit normalization)

q_t = corrected cone tip resistance (tsf)

f_s = friction sleeve resistance (tsf)

$R_f = 100\% * (f_s/q_t)$

u_2 = pore pressure behind cone tip (tsf)

u_0 = hydrostatic pressure

$B_q = (u_2 - u_0)/(q_t - \sigma_{v0})$

$Q_t = (q_t - \sigma_{v0}) / \sigma'_{v0}$

$F_r = 100\% * f_s / (q_t - \sigma_{v0})$










$I_c = ((3.47 - \log Q_t)^2 + (\log F_r + 1.22)^2)^{0.5}$

N-Value

$$N_{60} = (q_t/p_a) / [8.5(1 - I_c/4.6)] \quad (6)$$

(6) Jefferies, M.G. and Davies, M.P., (1993), "Use of CPTu to estimate equivalent SPT N60", ASTM Geotechnical Testing Journal, Vol. 16, No. 4

CPT Soil Classification Legend

Zone	Q _p /N	Description
1		2 Sensitive, Fine Grained
2		1 Organic Soils-Peats
3		1.5 Clays-Clay to Silty Clay
4		2 Silt Mixtures-Clayey Silt to Silty Clay
5		3 Sand Mixtures-Silty Sand to Sandy Silt
6		4.5 Sands-Clean Sand to Silty Sand
7		6 Gravelly Sand to Sand
8		1 Very Stiff Clay to Clayey Sand*
9		2 Very Stiff, Fine Grained*

(*) Heavily Overconsolidated or Cemented

Robertson's Soil Behavior Type (SBT), 1990			
Group #	Description	I _c	
		Min	Max
1	Sensitive, fine grained	N/A	
2	Organic soils - peats	3.60	N/A
3	Clays - silty clay to clay	2.95	3.60
4	Silt mixtures - clayey silt to silty clay	2.60	2.95
5	Sand mixtures - silty sand to sandy silt	2.05	2.60
6	Sands - clean sand to silty sand	1.31	2.05
7	Gravelly sand to dense sand	N/A	1.31
8	Very stiff sand to clayey sand (High OCR or cemented)	N/A	
9	Very stiff, fine grained (High OCR or cemented)	N/A	

Soil behavior type is based on empirical data and may not be representative of soil classification based on plasticity and grain size distribution.

Relative Density and Consistency Table			
SANDS		SILTS and CLAYS	
Cone Tip Stress, qt (tsf)	Relative Density	Cone Tip Stress, qt (tsf)	Consistency
Less than 20	Very Loose	Less than 5	Very Soft
20 - 40	Loose	5 - 15	Soft to Firm
40 - 120	Medium Dense	15 - 30	Stiff
120 - 200	Dense	30 - 60	Very Stiff
Greater than 200	Very Dense	Greater than 60	Hard

LABORATORY TESTING PROCEDURES

Grain Size Tests (ASTM D 1140 and ASTM D 422)

Grain size tests were performed to determine the soil particle size distribution. The amount of material finer than the #200 sieve was determined by washing the sample over that particular size sieve. The grain size distribution of the soil retained on the #200 sieve was then determined by passing the retained portion through a standard set of nested sieves.