REQUEST FOR QUALIFICATIONS

DATE ISSUED: July 07, 2023

CITY OF SOUTHPORT

REQUEST FOR QUALIFICATIONS

FOR:

Shoreline Stabilization Project – Schematic Design and Permitting Services

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DUE DATE / TIME:
August 16, 2023 @ 3:00 PM

Deadline for Inquiries	**August 9, 2023 @ 5:00 PM**
Time and Date Set for Submittal	**August 16, 2023 @ 3:00 PM**
Notice of Selection	**September 1, 2023**

REQUEST FOR QUALIFICATIONS (RFQ)

FOR

Shoreline Stabilization Project - Schematic Design and Permitting Services

INFORMATION AND INSTRUCTIONS

I. GENERAL INFORMATION

A. The City of Southport ("Southport") (http:/www.cityofsouthport.com) seeks professional consulting services, from qualified firms, licensed to do business in North Carolina, to provide professional coastal engineering and environmental permitting services to assist the City of Southport with the selection of a shorefront improvement plan and pursuit of State and Federal environmental permits that will allow for the construction of the selected plan.
B. The Statement of Qualifications ("SOQ") must be received by the Assistant City Manager at 1029 N. Howe Street, Southport, NC 28461 by the date and times listed on the cover page of this RFQ.
C. Questions pertaining to the selection process should be directed to Southport Assistant City Manager, Dorothy Dutton at ddutton@cityofsouthport.com .
D. Southport shall not be held responsible for any oral instructions. Any changes, or clarifications, to this Request for Qualifications ("RFQ") will be in the form of an addendum, which will be furnished to all registered RFQ holders.
E. Southport reserves the right to reject any or all SOQ's, to waive any informality or irregularity in any SOQ received, and to be the sole judge of the merits of the respective SOQ received.
F. Questions regarding this RFQ may be directed to Dorothy Dutton via email at ddutton@cityofsouthport.com and shall be received no later than five (5) business days prior to the opening date to allow for the timely preparation and posting of addenda. Questions received, and the decisions regarding each question, shall be set forth in a written addendum. No oral interpretations shall be made to any respondent as to the meaning of any portion of the RFQ documents.
G. Any addenda to this RFQ will be posted on the Town's website. Therefore, all interested respondents should check the website from now through procurement opening. It is the sole responsibility of the respondent to be knowledgeable of all addenda related to this procurement.
H. The consulting firm will be selected based on qualifications and other factors. Refer to **Section III.C.**
I. The City does not discriminate on the basis of race, color, sex, national origin, religion, age, or disability. Any contractors or vendors who provide services, programs or goods for the City are expected to fully comply with the City's non-discrimination policy.

II. ANTICIPATED SCOPE OF WORK

The City of Southport, a coastal North Carolina community of approximately 4000, is seeking professional coastal engineering services for the restoration and stabilization of approximately 4,000 ft of City shoreline. The current phase of the project is expected to include evaluation of existing, conceptual stabilization alternatives, assisting the City with a desired plan selection, and seeking State and federal permits for the selected shorefront stabilization alternative.

The following scope of services is suggested at this time. If variations to this scope are suggested by the respondent, they should be clearly identified in the response submitted by the consultant.

A. Evaluate Existing Project Plan / Plan Selection Confirmation:

1. Evaluate the stabilization options proposed for the site in the report entitled, "Southport, NC, Site Conditions and Analysis for Shoreline Improvement Project," dated May 2019, as well as other supporting documentation included as "Attachments" to this RFQ.
2. Working with City staff, select 3 options to be advanced to conceptual design.
3. Provide estimates of the probable material quantities relative to the current conditions, as documented in the February 2023 survey conducted by McKim & Creed, and an estimate of the probable construction cost of each of the 3 options.
4. Visit the site to confirm current site conditions through observations.
5. Use the current and expected future site conditions to evaluate the appropriateness of the original design of the three (3) project options noted above.
6. Present the findings to City staff and the Board of Aldermen (Board) and seek the selection of a preferred plan to advance to Schematic Design and Permitting phases of the project.

B. Sand Source Identification:

1. Identify, and obtain samples of, a suitable number of candidate upland local sand sources that could be potentially used for the sand fill component of the project.
2. Provide an analysis of each sample to determine its suitability to meet project goals.
3. Collect a suitable number of native beach sediment samples from along the Southport shorefront for comparison to candidate sources, compatibility analyses, and permit submittal.
4. Review physical sand samples, inspect laboratory analyses for representative samples and perform requisite beach compatibility analyses to support identification of the most suitable source.

C. Schematic Level Design:

1. Following selection of a preferred plan by the City (Refer to Section II.A.6., above), develop a schematic-level design sufficient to support the formulation of the Coastal Area Management Act (CAMA) major permit application.

2. Consider available physical, environmental, and cultural resources data for development of the schematic-level design.
3. Develop sufficient details regarding the project plan to support a permit application and agency review. This will include schematic layout drawings and details of structures, beach fill, marsh restoration, etc., as appropriate.
4. Update the preliminary opinion of probable cost of construction, if necessary.

D. **<u>Permit Pre-Application Meeting:</u>**

1. Coordinate and participate in a permit pre-application meeting with the State of North Carolina Division of Coastal Management (NCDCM) and USACE in Wilmington, NC.
2. Prepare all required preliminary project details and distribute to permitting agencies prior to the meeting.

E. **<u>CAMA Major Permit:</u>**

1. Prepare the Coastal Area Management Act (CAMA) major permit application for submittal to the State of North Carolina Division of Coastal Management (NCDCM), including permit application forms, project narrative, and required notifications.
2. Respond to Agency comments and requests for additional information regarding the permit application. These responses will be formulated based on available information prepared during previous tasks.
3. Provide supporting documentation to permitting agencies to facilitate review of the permit application. Documentation is expected to include, but may not be limited to,:
    a. A Biological Assessment for submittal to USACE Regulatory to fulfill the requirements as outlined under Section 7(c) of the Endangered Species Act of 1973, as amended.
    b. An Essential Fish Habitat Assessment for submittal to the National Marine Fisheries Service.

III. <u>STATEMENT OF QUALIFICATIONS SELECTION CRITERIA</u>

A. Interested firms must submit a Statement of Qualifications (SOQ) that addresses the following evaluation criteria. Respondents are encouraged to organize their submissions in such a way as to follow the general evaluation criteria listed below. Information included within the SOQ will be used to evaluate your firm as part of any criteria regardless of where that information is found within the SOQ. Information obtained from the SOQ, and from any other relevant source, may be used in the evaluation and selection process. The project proposal must outline the firm's qualifications and describe the process planned to provide the deliverables listed above. Proposals should include team members, past relevant project experience, knowledge and awareness of the City of Southport and any other commonly included information with such studies. It is the City's intent to make the selection after reviewing the qualifications of each submitting firm.

B. **REQUIRED INFORMATION:**

All qualifications statements shall include the following information, at minimum:

1. Cover Letter (1-page)
2. Tab A: Proposed Scope of Services / Approach
3. Tab B: Project Experience
4. Tab C: Project Schedule
5. Appendix A: Key Personnel Resumes
6. Appendix B: Professional References
7. ~~Fee Proposal~~ Unit Cost List (separate sealed envelope).

COVER LETTER

The cover letter shall not exceed one (1) page and shall contain, at minimum, the following information: Company name of the primary consultant and any planned sub-consultants as well as the contact names, addresses, phone numbers and email addresses for each primary consultant and sub-consultant. The cover letter should also identify the project manager with associated contact information.

TAB A- PROPOSED SCOPE OF SERVICES / APPROACH

Describe the firm's approach to performing the required services in the Anticipated Scope of Work described above. Supplement the Anticipated Scope of Work as necessary to adequately meet the desired goals of the City. Identify how your firm plans to utilize internal or external consultants or sub-consultants to complete the project.

TAB B- PROJECT EXPERIENCE

Identify at least two (2) but no more than three (3) similar projects where you were the Primary Consultant. Demonstrate the experience of your firm, including all sub-consultants, on similar projects. The projects submitted should demonstrate that the consultant and/or the team have performed the same or similar type of services to be considered relevant.

TAB C – PROJECT SCHEDULE

Describe the project timeline for completion. The proposed project schedule should illustrate the firm's capability to meet schedule requirements. Provide a Project Work Plan/schedule showing key project milestones and deliverables. The schedule shall demonstrate the firm's ability to meet the designated milestones.

Appendix A – EXPERIENCE OF KEY PERSONNEL

For each key person identified, list their length of time with the firm and at least two comparable projects in which they have played a primary role. There are no limitations on the number of key positions the firm may provide. However, at a minimum the firm must provide the primary consultant, or project manager, and at least one (1) person from each sub-consultant identified, if applicable. Resumes should provide information for key staff (no company profiles) and should not include general firm information. Provide an organizational chart at the end of this tab, chart may be submitted in 11"X17". The chart should depict the project team organization, lines of authority and primary responsibilities of team members. Clearly indicate superior/subordinate reporting relationships. Provide names of each position and identification of firm or sub-consultant.

Appendix B – PROFESSIONAL REFERENCES

The SOQ should include a minimum of three (3) professional references, with contact information. The references should be projects performed by the consultant in small-to-medium sized municipalities, preferably in North Carolina.

Separate Sealed Envelope – ~~FEE PROPOSAL~~ UNIT COST LIST

~~A cost proposal addressing the elements of the work to be performed. This proposal shall be in sufficient detail to include the task, number of hours, unit hourly rates and total proposal. The consultant shall indicate all costs that are considered necessary for the completion of the project. One cost proposal shall be submitted. It shall be submitted in a separate sealed envelope.~~ The City requests unit price information at the time qualifications are received and will thereafter negotiate a lump sum contract for those services at a fair and reasonable fee with the best qualified firm.

C. Qualifications Criteria: A rating system will be utilized by Southport to score and rank each proposal. Respondents are encouraged to keep their proposals concise and to include a minimum of marketing materials. At a minimum, each proposal must address the following criteria:

Item	Evaluation Criteria	Maximum Points
1	General Information & Relevant Firm Experience	20
2	Team Staff Experience and Qualifications	20
3	Project Understanding and Method of Approach	30
4	Schedule	20
5	Fee Proposal and Other Factors	10
	Total Possible Points	**100**

IV. SUBMITTAL REQUIREMENTS

A. The SOQ shall include a one-page cover letter plus a maximum of ten (10) pages (front and back) to address the SOQ criteria specified in Section III. Table of Contents, section divider pages, and Appendices A and B do not count toward the total page count. Resumes for each key team member shall be limited to no more than two pages. Resumes shall be attached as Appendix A.

B. Qualifications must be placed in a sealed envelope clearly marked "Response to RFQ for

“**Shoreline Stabilization Project – Schematic Design and Permitting Services**” and five (5) hard copies and (1) electronic copy (complete electronic copy of the qualifications package on a USB Drive using a searchable ".pdf" file format) of the Statement of Qualifications and Appendix A must be **submitted to the City of Southport Assistant City Manager, 1029 N. Howe Street, Southport, NC 28461 by August 16, 2023 at 3:00 pm local time.**

C. Failure to comply with the following criteria may be grounds for disqualifications: Receipt of submittal by the specified cut-off date and time; The number of originals and/or copies of the submittal specified; or Adherence to maximum page requirements.

D. Adherence to the maximum page criteria is critical; each page side with criteria information will be counted. Pages shall be generally 8-1/2" x 11" paper. A maximum of two (2) pages may be on 11" x 17" size paper.

V. SELECTION PROCESS AND SCHEDULE

A. Reviewers for Southport will evaluate each Statement of Qualifications ("SOQ") according to the above criteria. A short-list of finalists will be developed based on qualification packages received and the above considerations. Fee proposals of the short-listed finalists will be opened and reviewed prior to selection. The City of Southport may elect to meet with any, all, or none of the consultants prior to selection. Following these steps, Southport will select and notify the selected firm. Those firms not selected for further consideration will be notified as well.

B. The following tentative schedule has been prepared for this project. Firms interested in this project must be available on the interview meeting date, if an interview is held.

1. SOQ's due: August 16, 2023 @ 3:00 PM
2. Firms notified of Selection: September 1, 2023

C. Southport will enter into negotiations with the selected firm. Upon Board of Alderman's approval, it is anticipated that the professional services contract will be executed by the City Manager by the end of September 2023. Southport reserves the right to terminate the selection process at any time.

VI. ATTACHMENTS

Attachment A: *"Southport, NC, Site Conditions and Analysis for Shoreline Improvement Project," dated May 2019.*

Attachment B: *Preliminary Concept plans, SOUTHPORT, NC SHOREFRONT IMPROVEMENT PLAN, 3/18/2019*

Attachment C: *City of Southport Board of Alderman Workshop February 27, 2023 - SHORELINE IMPROVEMENT PROJECT*

Attachment D: *An Archaeological Reconnaissance and Remote-Sensing Survey Along the Cape Fear River Waterfront at Southport, Brunswick County, North Carolina, Submittal Date, 4 June 2023*

Attachment E: *CONDITION SURVEY - PLAN VIEW OF SOUTHPORT SHORELINE IMPROVEMENT PREPARED FOR OLSEN ASSOCIATES, INC. SOUTHPORT, BRUNSWICK COUNTY, NORTH CAROLINA, FEBRUARY 9, 2023*

ATTACHMENT A

Southport, NC
Site Conditions and Analysis for Shoreline Improvement Project

Southport City Shoreline Improvement Project
Brunswick County, NC

Prepared by:

Olsen Associates, Inc.
2618 Herschel Street
Jacksonville, FL 32204
(904) 387-6114
olsen-associates.com

May 2019

Prepared for:

City of Southport,
North Carolina

Southport, NC
Site Conditions and Analysis
for Shoreline Improvement Project

Southport City Shoreline Improvement Project
Brunswick County, NC

May 2019

Report Submitted to:
City of Southport, North Carolina

Report Submitted by:
Olsen Associates, Inc.
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Site Conditions and Analysis
for Shoreline Improvement Project

Southport City Shoreline Improvement Project
Brunswick County, NC

May 2019

Report Submitted to:
City of Southport, North Carolina

Report Submitted by:
Olsen Associates, Inc.
2618 Herschel Street
Jacksonville, FL 32204
(904) 387-6114

1.0 INTRODUCTION

This report provides the background information and a description of existing site conditions along the Southport, NC shorefront to support the need and scope of a planned comprehensive shorefront restoration and stabilization project. The project is intended to address chronic shoreline erosion and the need for increased shore protection along about 4,000 feet of Cape Fear River shorefront. The purpose of this report is to provide (1) relevant information for understanding site conditions and the required scope of an improvement project and (2) design criteria to be considered in the design of the selected improvement plan. All elevations herein are referenced to the North American Vertical Datum of 1988 (NAVD88[1]) and all horizontal coordinates are referenced to the North Carolina State Coordinate System, North American Datum of 1983 (NAD83), unless specifically noted.

[1] NAVD88 = North American Vertical Datum of 1988. This is an absolute vertical datum to which variable datums such as those defined by tide levels can be referenced and inter-compared.

1.1 Problem Statement

The Southport, NC Cape Fear River shorefront beach is highly eroded due to long-term effects of storm related wind waves, waves generated from both recreational boat and commercial boat and ship traffic, and the effects of the ongoing increase in average water level (i.e., sea level rise). The erosional effect of these forces has increased over time due to (1) an increase in sea level, (2) an increase in size and frequency of recreational boat traffic in the area, and (3) an increase in the size and frequency of the commercial boats and ships that use the Wilmington Harbor Federal Navigation Channel. Anticipated future increases in both sea level and the size and frequency of ship traffic in an expanded Federal navigation channel will further exacerbate the erosional stress along the Southport shorefront. To date, only limited, localized shore protection works have been implemented in an attempt to protect upland development and infrastructure situated along the shorefront from coastal flooding and wave impacts. The disparate shore protection approaches implemented to date have provided a satisfactorily level of reliable protection to the entire shorefront. Moreover, the efforts have contributed to a reduction in the available accessible dry beach resulting in loss of recreational space and beach habitat.

Presently, the City of Southport desires to implement a comprehensive restoration and stabilization project along about 4,000 feet of Cape Fear River shorefront. The shorefront general faces southward with a general west to east alignment. The precepts for restoration and stabilization of the shorefront are,

1) enhance protection of upland development (public and private) against storm waves and water levels and boat and ship wave impacts;
2) maximize beach access and use opportunities to the extent practicable;
3) incorporate existing shoreline and habitat conditions in the restoration plan;
4) consider potential effects of future sea level rise and increased size and frequency of recreational and commercial vessel traffic; and
5) plan and design for minimum future maintenance.

The intended project plan will include combinations of beach fill, structural stabilization, and salt marsh restoration and expansion.

1.2 Preferred Project Plan

The preferred project plan is a combination of shore and marsh stabilization measures accompanied with beach and marsh restoration. The project will restore recreation and habitat conditions and reduce the potential for impacts and infrastructure damage along the Southport shorefront. Restoring and stabilization a beach and marsh area seaward of the existing Southport shorefront infrastructure will increase the distance between upland development and the shoreline and reduce, through increase wave breaking and dissipation, the amount of wave energy and wave uprush that reaches the current shoreline location.

To meet the project goal of incorporating existing shoreline conditions into the plan, to the extent possible, the scope of shore and marsh (i.e., living shoreline) restoration are focused on those areas where either of these approaches are expected to have the highest likelihood of success and longevity. That is, along areas of the Southport shorefront where nearshore water depths may prohibit successful implementation of a living shoreline approach, sand beach and dune restoration is the preferred protection method. Given the elevated wave conditions along the entire project shoreline, structural stabilization of varying forms is necessary for areas of both beach/dune as well as marsh restoration. Historical and current shoreline conditions clearly demonstrate the impacts associated with the high wave energy along this entire shoreline. Future expansions of the Wilmington Harbor Federal Navigation Channel and the associated increase in frequency and size of boats and ship traffic will only exacerbate the erosional stress along the Southport shoreline.

Sheets 1 and **2** of **4** in **Appendix A** depict existing conditions along the Southport shorefront. In general, the existing shorefront is highly eroded and most of the upland is protected by various shore-hardening structures such as revetments, bulkheads, and walls. Along the westernmost 800 ft of the 4,000 ft Southport shorefront, the remnants of a sand beach remains. This beach is highly eroded and evidence of frequent over-topping is observed along its entire length. Another alternative to revetments and bulkhead is located along the easternmost 650 feet of the Southport shorefront. Here, although most of the upland is protect by bulkheads also, the walls are fronted by a stable spartina marsh. The stability of the marsh is provided mostly by the effects of a rip-rap rock sill along the riverside perimeter of the marsh. Also, along most of the shorefront, the nearshore and lower intertidal area is littered with rock and concrete rubble debris. The source of this debris appears to be past failed shore protection efforts that were constructed of undersized materials not suitable for the wave climate or, with materials that have degraded overtime and reduced in size.

Sheet 3 of **4** depicts the preferred plan and proposed improvements associated with the restoration and stabilization plan along the Southport shoreline. Comparison of the existing and proposed improvements highlight the beach restoration and stabilization measures for the westernmost 2,200 feet of the Southport shorefront. The beach restoration and stabilization features will be located along those areas of the shorefront that are currently characterized by existing beach, low-crested bulkheads, rip-rap revetments of various designs and elevation, and a relative deep nearshore area, compared to the more eastern area of the shorefront. The deeper nearshore area allows larger waves to reach the shoreline, thereby requiring robust structural stabilization to ensure that the beach fill will remain in place during most conditions. The proposed beach berm elevation will have a crest elevation of about +4 feet with a dune ridge located along the landward extent that will have a crest elevation of up to about +6 feet, where possible. The beach will have a fronting slope of about 1V:11H, which will emulate the existing beach conditions. It is expected that the beach fill slope will meet the existing nearshore grade at about -6 feet, on average. **Sheet 4** of 4 in **Appendix A** includes typical cross-sections for each of the proposed structure, beach, and marsh project features.

The beach fill will be stabilized by nine (9) rip-rap breakwaters that will be "tuned" to offer the greatest protection to the beach and upland and allow design beach fill dimensions to be maintained on a more or less consistent basis. The two (2) westernmost breakwaters will be completely detached from the restored shoreline. The remaining seven (7) breakwaters will be integrated into the beach fill where the distance between the existing bulkheads and -6 ft elevation is narrowest. The crest elevation of the breakwaters will be set at +4 ft, to accommodate the existing tide and wave climate and about +1 ft of anticipated increase in the average water level due to sea level rise.

A living shoreline approach, with rip-rap rock sill and expansion of the existing marsh areas will be implemented along the easternmost 1,800 feet of the project shoreline. This area is characterized by low-crested bulkheads fronted by a nearshore area that is higher in elevation with scattered marsh grasses. Along the easternmost 650 feet, marsh grasses are more established and widespread due to the presence of an existing rip-rap rock sill. The goal along this entire 1,800 ft reach of shoreline will be to establish a marsh grass area similar to the existing conditions along the easternmost 650 feet and install and rehabilitate a rip-rap sill along the entire area. Based upon existing sill conditions, the proposed sill will have a crest elevation that varies between +1 and +2 ft, NAVD88.

The shore-perpendicular groin located at the eastern project limit will also be rehabilitated through the replacement of displaced stone. The foot print of this structure will not be expanded.

The project scope will also include the removal of as much intertidal and nearshore debris and rubble as possible. It is expected that most of the debris above the mean low tide elevation can be removed. The debris will either be placed against the toe of existing bulkheads and covered with sand fill or removed from the site and disposed of at an approved upland disposal area.

Beach fill sand will be sourced from various local upland sites. Sand similar to existing conditions in average grain size, grain size distribution, shell content, and fines content will be selected for use. Although this is not an oceanfront beach, the sand source will need to be similar to typical beach sand found on the oceanfront and lower Cape Fear River to provide the required beach fill configuration and performance necessary for project success.

1.3 Site Location

The City of Southport lies along the western bank of the Cape Fear River in Brunswick County, NC. The shoreline is situated approximately three miles from the mouth of the river at the intersection of the Atlantic Intracoastal Waterway (ICWW). **Figure 1** shows the location of the City of Southport along the river as well as its approximate regional location along the southeastern coast of North Carolina.

The project shoreline extends approximately 4,000 feet from the Southport Yacht Basin (representing the westernmost area of the shoreline) to a low relief stone structure near Bonnet's Creek to the east. The shoreline faces south-southeast with Battery Island approximately 0.5 miles across the Cape Fear River.

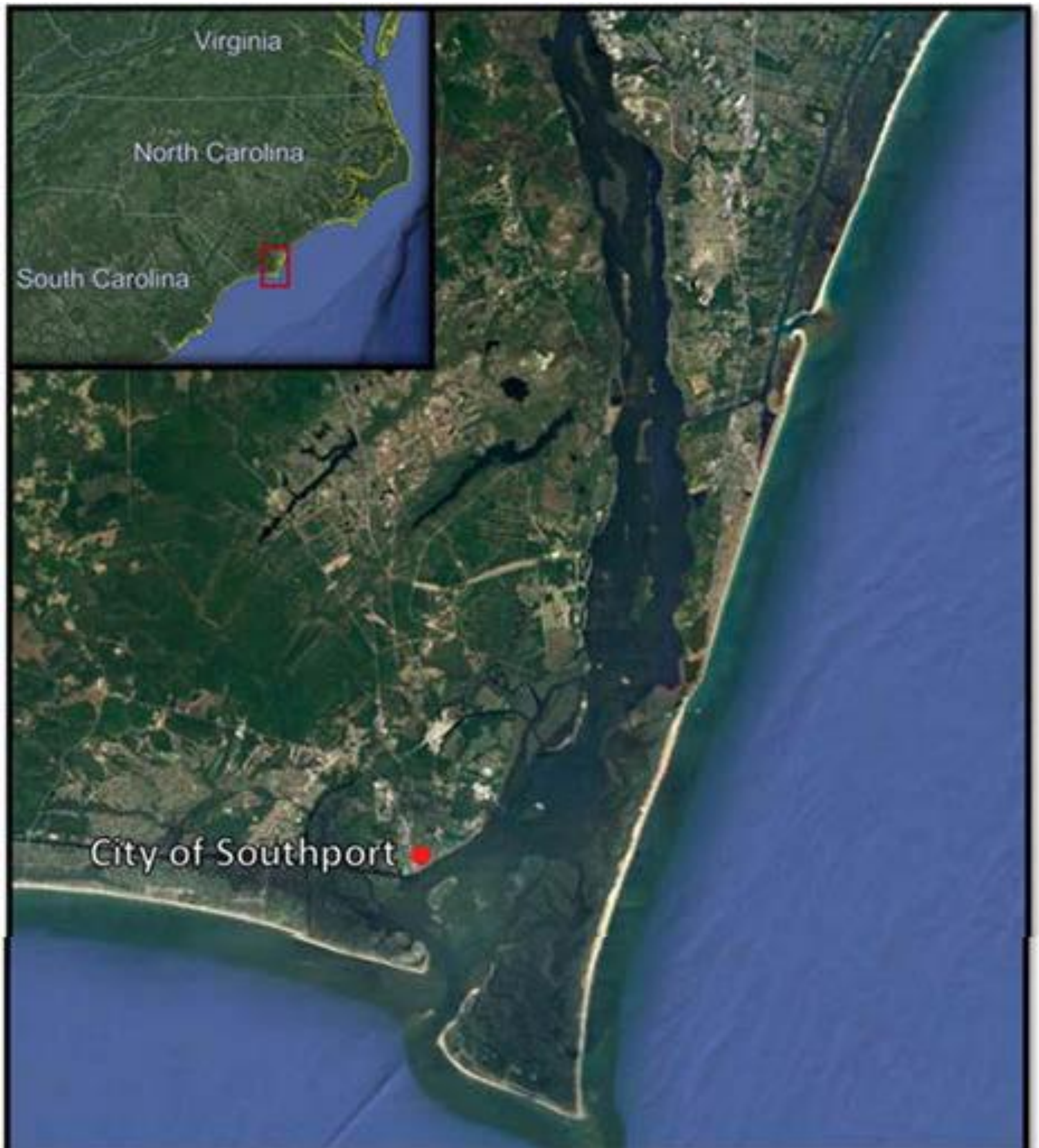

Figure 1: Location map depicting the Cape Fear River and the location of the City of Southport in Brunswick County, NC (images: Google).

2.0 CURRENT SHORELINE CONDITIONS

A review of the current shoreline conditions on 30 May 2018 provided a foundational understanding of the character and configuration of the modern shoreline. The Southport shorefront is characterized by multiple distinct conditions and features, including segments of sandy beach, rock revetments, vertical walls of various construction, and spartina marsh protected by a low rock sill. The unique condition of each section of the shoreline provides a different basis for selection of improvement approaches for each. **Figure 4** provides an aerial view of the current Southport shoreline, surrounding features, and six distinct sections of the shoreline that represent differing conditions. Typical characteristics and conditions of each of these are discussed below.

Figure 2: Aerial view of Southport, NC shoreline between the ICWW and Bonnets Creek (Image: September 2017).

Section 1 – Sand Beach

Beginning at the southwest edge of the shoreline, near the Southport Yacht Basin, the shoreline is defined by an elevated wooden platform. This structure includes a shore- perpendicular vertical wooden wall that acts as a de-facto sand retaining structure. It appears that this structure limits the amount of sand that is transported from the Southport beach to the yacht basin. The condition of the wooden wall is unknown.

The first section of the shoreline, continuing northeast for approximately 800 feet towards the wastewater pumping station, is comprised of a low sand beach. This is the only remaining area of the Southport shoreline that resembles a typical sand beach. Common berm elevations along the sand beach vary from about +3.0 to +3.5 feet, relative to the NAVD88 vertical datum. The typical beach slope varies from about 1V:10H at the western end of the beach to a milder 1V:20H slope to the east near the pumping station. The distance between the waterline and the edge of upland infrastructure, (i.e., West Bay Street) also varies from west to east. At the western end of the beach section, the widest area is about 190 feet. At the eastern end, the narrowest, the waterline is only about 57 feet from the edge of the road. Two stormwater outfalls are located along this reach of shoreline and sit approximately 240 feet and 410 feet from the southwestern edge of the beach, at an elevation of +2.9 feet and +4.1 feet (NAVD88), respectively. Several wooden private piers are also located along this shoreline section. One complete pier extends from an undeveloped parcel approximately 100 feet from the berm to a depth of -7 feet. A damaged pier along with numerous derelict piles, remain along the beach as well. Approximately 500 feet along the shoreline a scattered area of rubble lies in depths ranging from -0.8 feet and -5.0 feet. **Figure 3** shows three representative photos of this section of the project taken on 30 May 2018.

Figure 3: Condition photographs of Reach 1"Sand Beach" along Southport City shoreline. Top Left – looking east from the edge of the wooden platform. Top Right – looking west from near the pumping station. Bottom – near beach midpoint looking east with scattered rubble in the intertidal zone.

Section 2 – US Army Corps of Engineers Revetment

Just east of the sand beach section is a rock revetment constructed in 2013 by the U.S. Army Corps of Engineers (USACE). This revetment, roughly 280 feet long, is intended to protect a public utility wastewater lift/pump station located adjacent to the Southport shorefront. As of March 2011, chronic erosion and beach loss had placed the pumping station within 20 feet of the shoreline which prompted the USACE project. The revetment has a surveyed crest elevation ranging from +5.0 to +6.0 feet. The armor stone design criteria called for two layers of 600 to 1,100 lb granite stones with an average diameter is about 1.7 ft. **Figure 4** shows a typical design cross-section for the revetment taken from the USACE report (USACE, 2013). The eastern end of the revetment is tied into a vinyl bulkhead that runs in front of the Cape Fear Restaurant and the Riverside Motel. A public boardwalk is located on the south (i.e., river side) of the pumping station. There is no beach seaward of the revetment and the intertidal area fronting the structure contains a large amount of scattered rocks and debris which limit access and use at low tide. **Figure 5** shows three photos that describe the condition of the revetment and its terminus into the vinyl bulkhead.

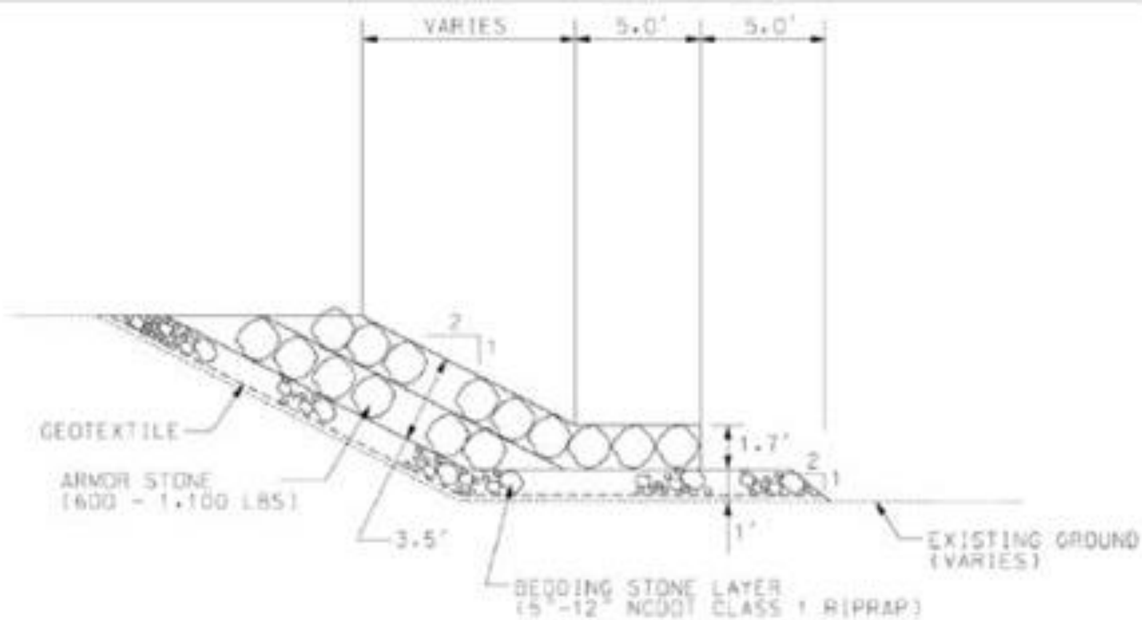

Figure 4: Design specifications for typical section view of USACE revetment taken from USACE Project Report (May 2013).

Figure 5: Photographs of the rock revetment protecting the wastewater pumping station (30 May 2018) Top Left – view facing east of the revetment and beach with the Wilmington Cape Fear Pilots Association in the background. Top Right – close-up view of the revetment and the transition to the vinyl wall. Bottom – view facing west from the vinyl wall of the revetment with pumping station in the background.

Section 3 – Bulkhead Protection

Immediately east of the USACE revetment is approximately 630 feet of shoreline (i.e., Section 3) that is protected by low elevation vertical bulkheads. These bulkheads form the portion of the shorefront occupied by the Wilmington Cape Fear Pilots Association, the Riverside Motel, the Cape Fear River Restaurant and Lounge, and the city owned Waterfront Park. This section consists of both private and public land. From the intersection with the revetment, a 235 feet section of vinyl bulkhead appears to have been recently installed fronting the private property. The following 425 feet is composed of a newly place timber bulkhead along the public parking lot and Waterfront Park. Typical elevations at the top of the bulkhead range from +5.7 to +6.2 feet. At ground level, behind the vinyl bulkhead, there are areas where material has been lost, reducing the structural integrity of the bulkhead. The eastern edge of the bulkhead terminates into the upland near the beginning of another stone revetment.

The shoreline in front of the bulkhead is sandy with mixed rubble of various composition including varying sized concrete, rocks, and relic piles. Seaward of the timber bulkhead, fronting the parking lot, there is a stormwater outfall. Similar to the beach fronting the revetment, this area provides no space to recreate. The area is highly susceptible to impacts from wind waves and boat and ship generated waves. **Figure 6** presents photos of the bulkhead including the upland erosion and the various rubble at the foot of the structure.

Figure 6: Photographs of the typical bulkhead sections (30 May 2018). Left – the transition between the vinyl section and wooden section with eroded upland fill. Right – typical rubble found at the foot of the structures along with the stormwater outfall.

Section 4 – Revetment

Near the eastern end of Waterfront Park, the shore fronting timber bulkhead gives way to a rock revetment that extends approximately 650 feet, where it meets another vinyl bulkhead. The revetment varies in height with a crest elevation of +10.0 feet south of the fishing pier. This area is setback approximately 50 feet from the edge of E. Bay St. and vegetated. The remaining portion of the revetment (east of the fishing pier) abuts the sidewalk adjacent to E Bay St. with a crest elevation ranging from +7.0 to +13.4 feet. The revetment slope is typically about 1V:2.5H but it appears that recent storm activity has resulted in significant reworking and slumping of some areas of the revetment slope. The slumping is likely related to the use of undersized armor stone for the local wave climate and too steep of a slope for the rock that was used. A narrow beach does exist seaward of the revetment but is exposed only during low tides. The narrow beach and sandy bottom nearshore is again littered with various debris and rocks. Just east of the fishing pier a stormwater outfall is tied into the revetment at an elevation of +6.1 feet. A unique set of large rocks also lie in the intertidal zone. These rocks appear to be manmade blocks of concrete or tabby, a type of concrete made from shell, lime, and sand that was popular prior to the widespread use of modern cement. Based on historical photographs it appears these rocks have eroded significantly in the last five years. **Figure 7** presents a panoramic view of the revetment taken from the fishing pier. The property along the steep revetment is publicly owned by the City of Southport.

Figure 7: Panoramic view of the steep revetment abutting E. Bay St. with Oceanfront Park on the left and tabby stones in the foreground.

Section 5 – Residential Vinyl Bulkheads

The end of the revetment meets a vinyl bulkhead at the intersection of the first private parcel to the east. The following 11 parcels are privately owned and are fronted by bulkheads, primarily vinyl, with typical elevations between +4.9 and +5.4 feet. Seaward of the first 580 feet of the bulkheads there is a narrow sandy bottom exposed during low tides. This area is cluttered with relic pilings and various small sized rocks. Proceeding eastward from the pier at 314 E. Bay St., the area fronting the bulkheads has emergent salt marsh vegetation. The presence of the vegetation provides additional protection to the upland from wave action. An old culvert debris field of rocks is also present seaward of the empty lot between 318 and 402 E. Bay St. **Figure 8** shows two photographs representing the intertidal zone fronting the bulkheads seaward of the homes.

Figure 8: Photographs of the intertidal zone fronting the vinyl bulkhead.
Top – facing west showing the debris in the sandy beach with the steep revetment in the background.
Bottom – facing east with the row of houses on the left showing the various rubble in the intertidal zone.

Section 6 – Marsh Sill

The final section of the Southport shoreline, roughly 720 feet in length, is primarily characterized by low-crested vinyl bulkheads fronted by marsh grasses and a low-crest rock sill. The rock sill is about 420 feet in length, beginning just east of 410 East Bay Street and extending westward. The sill is offset from the bulkhead about 50 feet, on average. The crest elevation of the sill varies from about 0 to +1.0 ft, NAVD88. The western end of this beach section is located at a relic shore-perpendicular rock groin. The combination of the rock sill and associated marsh creates a successful proto-type “living shoreline” condition for this reach of shoreline. Within this section the shoreline fronting the Kingsley Street Park Fishing Pier (a public park) does not have a bulkhead. The park is protected by the marsh sill, scattered rubble, and vegetation. **Figure 9** provides two photographs taken from the Kingsley Park Pier showing the marsh sill, the vinyl bulkheads, and the conditions at the park.

Figure 9: Photographs taken from the Kingsley Fishing Pier on 30 May 2018. Top – facing west showing the rock sill, marsh grass, vinyl wall, and protection along the park. Bottom – facing easts showing the pier and the rock sill.

3.0 SITE PHYSICAL CHARACTERISTICS AND DESIGN CONDITIONS

3.1 Tides and Tidal Datums

The tidal datums for Southport are listed in **Table 1**. The astronomical tides along the shoreline are primarily semi-diurnal with a mean rang of approximately 4.3 feet.

Table 1: Tidal levels and datums at Southport, NC.

Datum	Elevation (ft-NAVD)
Mean Higher High Water (MHHW)	1.95
Mean High Water (MHW)	1.62
North American Vertical Datum of 1988 (NAVD)	0.00
National Geodetic Vertical Datum 1929 (NGVD)	-0.42
Mean Sea Level (MSL)	-0.46
Mean Tide Level (MTL)	-0.50
Mean Low Water (MLW)	-2.63
Mean Lower Low Water (MLLW)	-2.78

3.2 Sea Level Rise

When developing a shoreline project, it is critical to account for future sea level rise (SLR) to ensure design criteria are suitable for the lifetime of the project. However, estimating the appropriate amount of SLR over the planning period is difficult. SLR estimates can vary significantly for long-term (greater than 30 years) planning horizons. There are many different opinions in the scientific community regarding the amount of SLR that will occur in the future. In North Carolina, the State has issued guidance to the Coastal Resources Commission (CRC) to limit planning for SLR to 30 years with the opportunity to update expectations every five years thereafter. The purpose of this is to prevent the possibly unnecessary expenditure of public funds for infrastructure projects that may not be needed over a longer period. Rather, NC is implementing an adaptive approach to SLR by planning for 30 years and adjusting or responding as may be required in the future after observations of impeding rise are made.

For the City of Southport, the most recent update to the North Carolina Sea Level Rise Assessment Report dated March 2015 (CRC, 2015), provides the most specific recommendations and incorporates data from the Intergovernmental Panel on Climate Change (IPCC), the USACE, and the National Oceanic and Atmospheric Administration (NOAA). The NOAA data is specifically of interest as it includes measurements from a tide gauge that was installed on the Southport Fishing Pier. **Figure 10** shows the record of that tide gauge along with the historic rate of SLR. These data allow for a detailed assessment of the relative sea level rise (RSLR), which includes the rate of land subsidence, along the Southport shoreline. The development of projected RSLR from each of these sources is beyond the scope of this report. Here, the final results of the CRC Report will be presented.

Three estimates of future RSLR, specific to Southport, are presented in the CRC Report. The first estimate is based on the historic trend provided by physical measurements of tides. The past rate of increase is extrapolated 30 years in accordance with CRC guidance. To account for expected increases in the rate of SLR, two other estimates were presented using data from the most recent IPCC scenario-based projections. The lower projection is based on IPCC's conservative estimate for future greenhouse gas emissions. The higher projection is determined using the high greenhouse gas emissions scenario. **Table 2** summarizes the results for the City of Southport.

Table 2: Change in sea level at Southport, NC in the year 2045 from three estimates.

Tide Gauge Projections (inches)		IPCC Low Estimate (inches)		IPCC High Estimate (inches)	
Mean	Range	Mean	Range	Mean	Range
2.4	1.9-2.8	5.9	3.7-8.2	6.9	4.4-9.4

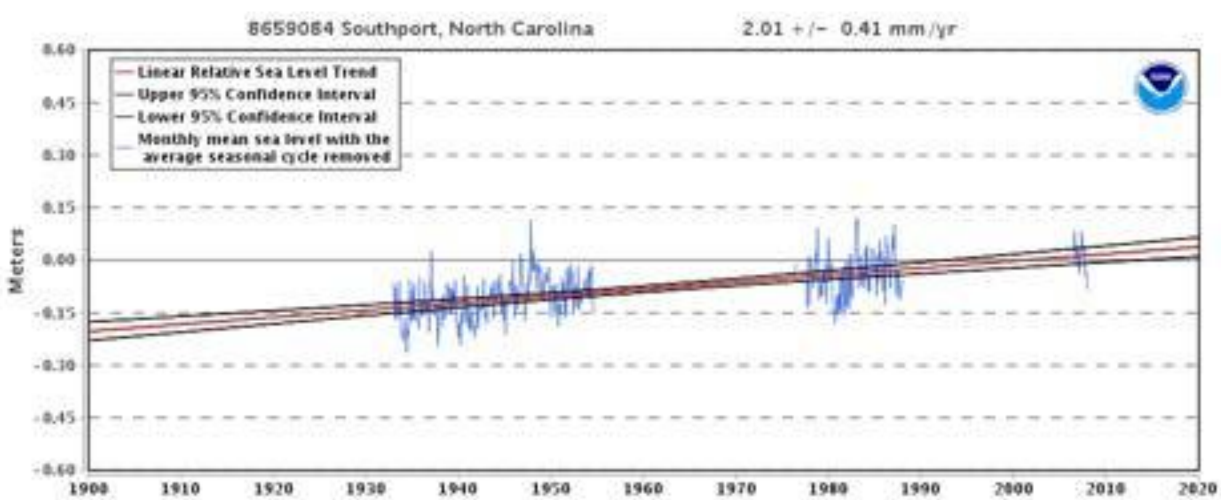

Figure 10: Sea level rise trend based on data recorded by the Southport Fishing Pier tide gauge.

Specific guidance regarding SLR planning is not available. Rather, communities typically select their own approach for considering SLR through considerations of risk tolerance, funding availability, planning horizon, ability to implement adaptive management, and opportunity for periodic re-analysis of conditions, among others. However, failure to plan for rising seas will result in a project design that is inadequate and susceptible to future environmental impacts.

3.3 Wind Climate

Waves along the Southport shoreline are primarily generated by wind forcing and arrive from a north-northeast fetch or a south-southeast fetch. Understanding the wind conditions is the first step in determining the types of waves that are important to designing future improvements to the shoreline. A wind rose summarizing wind speeds and directions, based on 17 years of hourly wind data from the Brunswick County Airport is shown in **Figure 11**. The Brunswick County Airport is located three miles west of the City shoreline. The wind data suggest that the frequently occurring winds are directed generally from the southwest and the north directions. However, throughout the year winds originate from all directions.

Extreme winds at the Southport shoreline are generally associated with coastal storms such as hurricanes and tropical storms during the late summer and fall and nor'easters that typically occur during the fall and winter months. The wind record from the Brunswick County Airport was evaluated to determine extreme wind values for design considerations based on the northeast fetch and the southeast fetch.

Examining the northeast quadrant (all winds from 000^o – 090^o) the yearly maximum wind value was determined for all seventeen years. These values were then used in a Generalized Extreme Value (GEV) distribution to determine probabilistic wind conditions over the north-northeast fetch. The same process was applied to winds coming from the southeast quadrant (090^o – 180^o) for the south-southeast fetch. **Table 3** list the percent annual chance of occurrence and equivalent return period of predicted wind speeds over the two dominant fetches approaching the Southport shoreline.

Table 3: Predicted probabilistic wind speeds for the two dominant fetches based on data from the Brunswick County International Airport.

% Annual Chance of Occurrence	Equivalent Return Period (years)	NNE Fetch Wind Speed (mph)	SSE Fetch Wind Speed (mph)
50	2	24.6	20.3
10	10	33.9	27.2
5	20	37.4	29.8
2	50	42.0	33.2
1	100	45.5	35.7
0.2	500	49.4	41.6

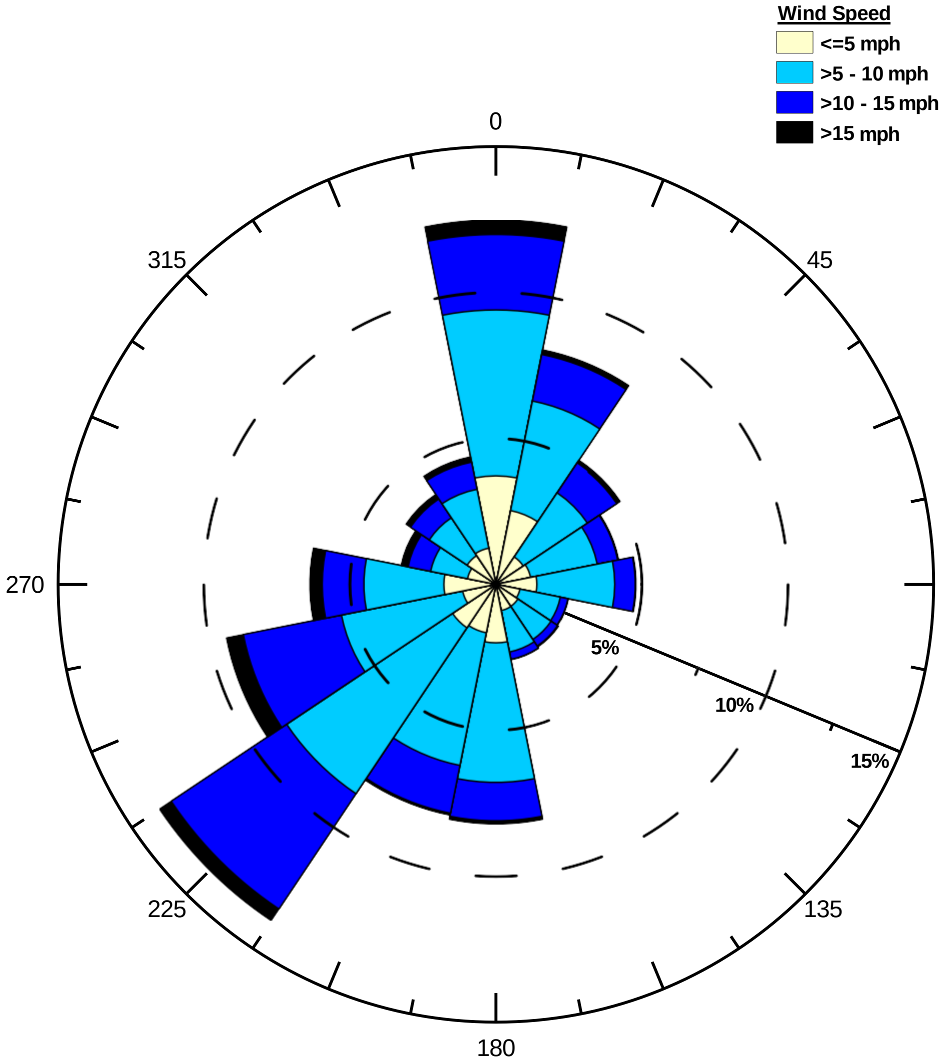

Figure 11: Wind rose for Brunswick County Airport, demonstrating the historic wind field near the Southport shoreline.

3.4 Waves

Waves experienced along the Southport shoreline are primarily generated by local winds and commercial ship traffic. The waves contribute to erosion of the shoreline and can exacerbate event-based flooding. The size of the waves that reach the shoreline are dependent upon wind speed, the distance across the water fronting the shoreline (i.e. fetch), the water depth at the shoreline, and the size and speed of the ships that travel the river.

The maximum probable wave heights that can impact the shoreline are evaluated below. The maximum waves are assumed to be associated with statistically significant wind events and the largest ships that pass the area. A more detailed description of the development of these wave events is provided in **Appendix B**.

3.4.1 Wind Generated Waves

Based on the analysis of the wind conditions near the Southport shoreline, maximum probable wind-wave heights can be determined by the Fetch-Limited method. In this method, wave heights are limited by fetch length, wind speed, and water depth across the length of the fetch. Fetch length is a measure of the distance over which wind is "working" (blowing over) the surface of a body of water. For Southport, two fetch "windows" along the Cape Fear River affect the shoreline and are shown in **Figure 12**.

The south-southeast fetch of 3.2 miles provides a more shore perpendicular direction to much of the City shoreline, allowing wind generated waves to impact the shoreline directly. The north-northeast fetch of 4.2 miles would generate waves that arrive at the shoreline at a very oblique angle. However, for completeness and allowing for the most conservative estimate, both fetch-limited wave conditions are evaluated as though they are normally incident to the shoreline.

Fetch limited wave height (H) and wave period (T) values were calculated following guidance in the Shore Protection Manual (USACE, 1984). The windspeeds based on various return periods presented in **Section 3.3** were used as the inputs for the wave height development. An average depth of 16.8 feet was determined from the local bathymetry across the NNE fetch. An average depth of 30.9 feet was determined from the local bathymetry across the SSE fetch.

Expected maximum wave heights for various sustained wind speeds and probabilistic still water levels were computed. The results are presented in **Table 4** for the NNE fetch and in **Table 5** for the SSE fetch. These results suggest that the height of wind waves that approach the shoreline can vary significantly depending upon the input conditions.

Table 4: Maximum predicted fetch-limited wave height under various wind and water level conditions for the NNE fetch.

% Annual Chance of Occurrence	Equivalent Return Period (years)	Stillwater Flood Level (ft, NAVD88)	Avg. Depth over Fetch (ft)	Wind Speed (MPH)	Wave Height (ft)	Wave Period (s)
50 yr wind with no flood elevation			16.8	33.2	2.4	2.9
10	10	4.6	21.4	27.2	2.0	2.7
2	50	7.6	24.4	33.2	2.5	2.9
1	100	9.2	26.0	35.7	2.7	3.0
0.2	500	12.5	29.3	41.6	3.3	3.2

Table 5: Maximum predicted fetch-limited wave height under various wind and water level conditions for the SSE fetch.

% Annual Chance of Occurrence	Equivalent Return Period (years)	Stillwater Flood Level (ft, NAVD88)	Avg. Depth over Fetch (ft)	Wind Speed (MPH)	Wave Height (ft)	Wave Period (s)
50 yr wind with no flood elevation			30.9	33.2	2.2	2.7
10	10	4.6	35.5	27.2	1.7	2.5
2	50	7.6	38.5	33.2	2.2	2.7
1	100	9.2	40.1	35.7	2.4	2.8
0.2	500	12.5	43.4	41.6	2.9	3.0

Figure 12: Location map depicting the location of the Southport shoreline in Brunswick County, NC and the fetch length across different fetch windows.

3.4.2 Ship Wakes

Ship-generated wave impacts are a consistent occurrence along the Southport shoreline. As a ship passes in the navigation channel, waves are generated that propagate to, and impact the shoreline. These waves are generated as a ship moves through water and the bow of the hull displaces the water through which it is moving. This builds up pressure in front of the ship which increases flow velocities around the ship midsection. One can think of it as the water moving past the ship at a faster rate than the surrounding water, creating a lower pressure across the midsection of the ship. This low pressure, high velocity flow then passes the stern where it encounters slower moving water, which builds up pressure at the stern. The water surface around the ship responds to these pressure gradients, raising the water level at the bow and stern and lowering it along the midsection. This creates two sets of waves: symmetrical diverging waves that propagate obliquely off the port and starboard of the ship, and transverse waves that propagate in the direction of the ship (see **Figure 13**). As the transverse wave passes the shoreline, a large drawdown of water is created in the trough, the size of which is accentuated by the presence of crests in front and behind the drawdown. Drawdown is followed by a dramatic change in water level as the crests of the transverse and diverging waves arrive at the shoreline.

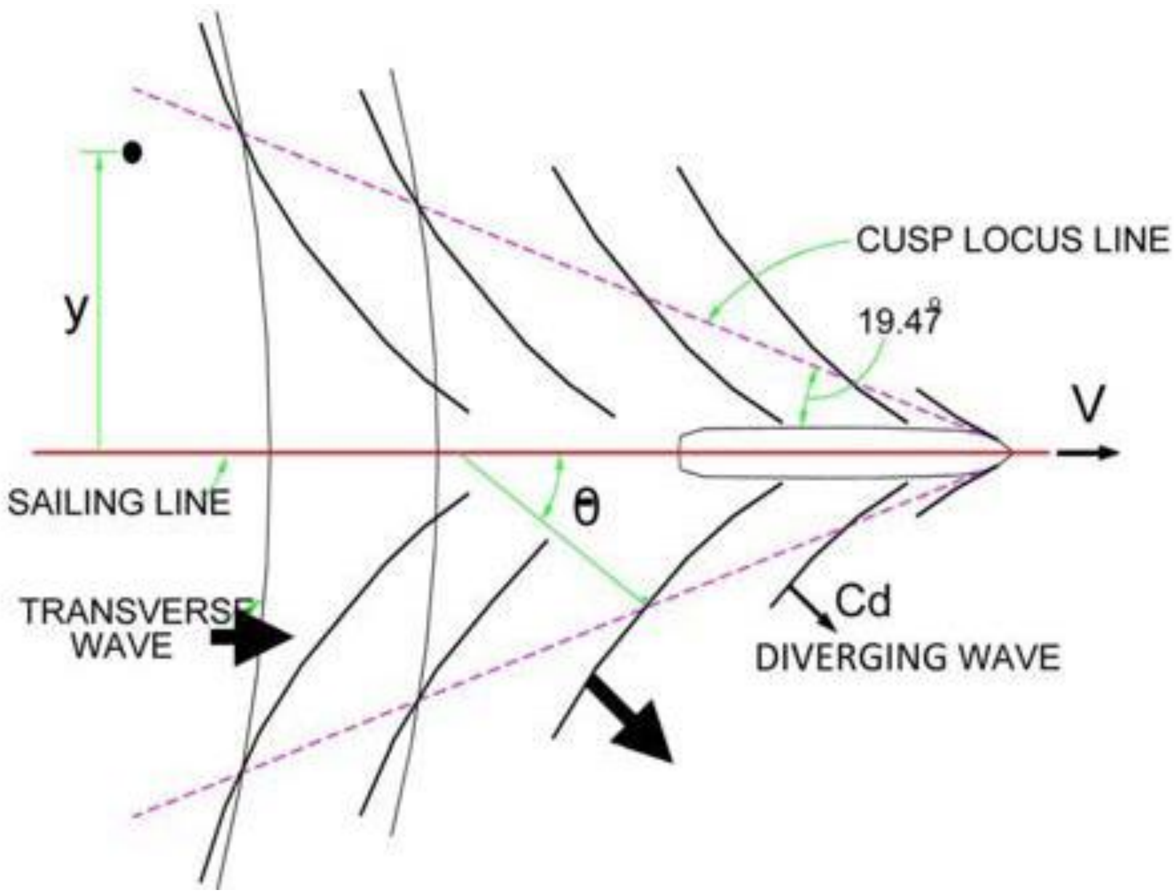

Figure 13: Sample ship-generated wave pattern for deep water (from *Kriebel et al* (2003)).

Based on inputs conditions for the area, a ship generated wave height of 3.4 feet is possible for the largest ships. This wave represents the most conservative estimate for ship generated waves based on large vessels that are limited to the Cape Fear Federal Navigation Channel. However, the variation of ship generated wakes that impact the Southport shoreline extends from these estimates down to personal watercraft traveling much closer the shoreline. Overall, the rate of wave energy from ship wakes and the size of those wakes is increasing. This further emphasizes the need for shoreline improvements that will reduce erosion from increased wave energy.

3.5 Storm Effects

This section discusses the methodology and results of analyses employed to predict cumulative storm water levels along the Southport shoreline. Cumulative storm water levels were predicted by evaluating the effects of storm surge, wave setup, and wave height (crest elevation).

3.5.1 Storm History

Southport has been affected by a number of damaging storms/hurricanes in the past, **Table 6** summarizes the number of storms passing within 25 and 100 nautical miles of the project area since 1842. These extreme events represent the potential for significant coastal damage.

Table 6: Hurricane/Tropical Storm history in the vicinity of Southport NC (1842 -2018).[2]

Category[3]	**Radius from Southport, NC**	
	25 nm	**100 nm**
Tropical Storm	19	61
Category 1	8	34
Category 2	5	15
Category 3	2	7
Category 4	2	3
Category 5	0	0
Total	36	120

[2] Historic hurricane data from NOAA Office for Coastal Management
[3] Saffir-Simpson hurricane scale.

As Category 4 storms, Diana in 1984 and Helene in 1958, represent the two most powerful storms that have passed within 25 nautical miles of Southport. However, in terms of direct impact and damages, the Saffir-Simpson scale is not the best measure. Other major factors, such as the storm track and the prevailing tide conditions, influence the local impacts. To understand more fully the impacts of storm events, specific measures of local impacts must be investigated.

3.5.2 Storm Water Levels

Storm surge, as defined as the super-elevation of the mean water level during a storm event, is primarily caused by wind shear stress, Coriolis contributions, barometric pressure anomalies, rainfall, local bathymetry, shoreline configuration, and astronomical tides. The rate of occurrence of various storm surges at a given location is expressed as the "return period" (T_R). Return periods are typically computed by a combination of numerical modeling and historical record. The return period has an inverse relationship with the probability that the event will be exceeded in any one year. For example, a 100-year surge has a 0.01 or 1% chance of being experienced or exceeded in any one year.

FEMA storm surge estimates for various return periods are listed in **Table 7** and plotted as **Figure 14**. Included in **Figure 14** is an expanded interpretation of the storm surge estimates which include the highest estimate for Relative Sea Level Rise as described in **Section 3.2**.

Table 7: Predicted storm surge elevations for various return periods.

Return Period (Years)	FEMA 2008 Flood Insurance Study Predicted Storm Surge Elevation (ft-NAVD)	FEMA 2018 Flood Insurance Study Predicted Storm Surge Elevation (ft-NAVD)
500	11.4	12.5
100	8.7	9.2
50	7.6	-
10	4.6	-

The high-water levels and wave action associated with hurricanes represent a significant source of damage to the Southport shoreline. **Table 8** list significant hurricane activity that impacted Southport over the last 65 years along with noted storm surge elevations and are also plotted in **Figure 14**.

Table 8: Measured maximum water elevations for major storm events.

Hurricane (Years)	Year	High Water Mark (ft)[4]	Recorded Water Elevation (ft NAVD88)[5]
Hazel	1954	12.2	
Connie	1955	5.0	
Diane	1955	5.4	
Ione	1955	5.8	
Donna	1960	6.7	
Fran	1996	-	3.9
Matthew	2017	-	7.4
Florence	2018	-	7.1

[4] High water mark data from U.S. Department of Commerce, Technical Paper No. 48, "Characteristics of the Hurricane Storm Surge," (1963) was converted to NAVD88 based on referenced water levels from the same storm cited in the FEMA FIS for Brunswick County dated August 2018.
[5] Referenced water elevation from USGS Flood Event Viewer.

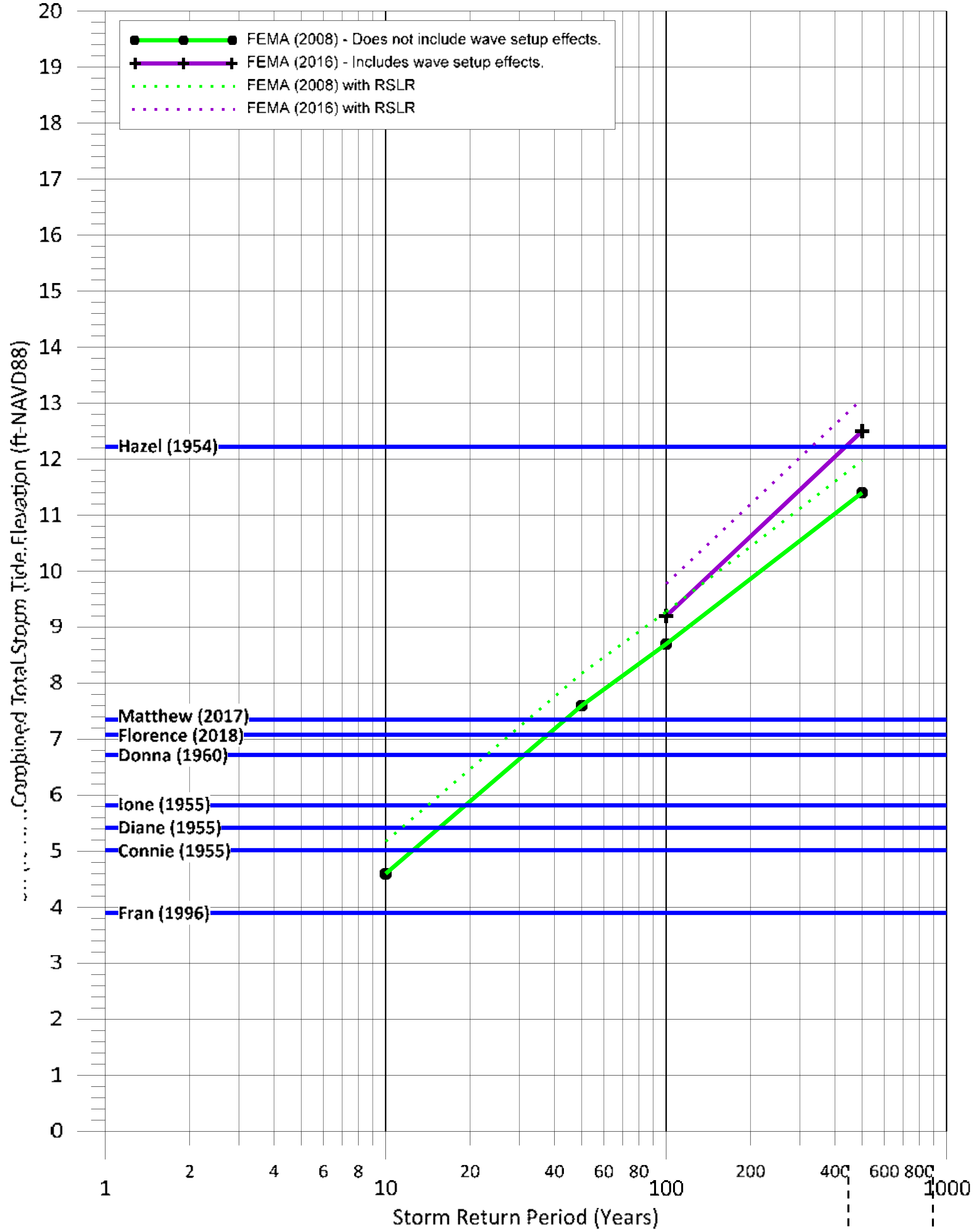

Figure 14: FEMA storm surge predictions with historic storm levels along the Southport shoreline.

4.0 PROJECT ALTERNATIVES

The alternatives described below represent a range of scenarios that could be implemented to address the shoreline protection and improvement goals of the City of Southport. In addition to fulfilling NEPA requirements, analysis of the No Action and action alternatives described below represent a broad range of potential outcomes and associated environmental effects that could occur as project implementation.

No Action

The no action alternative would maintain current shoreline conditions. As discussed earlier, this would include frequent impacts to the shorefront and adjacent upland infrastructure due to wind, storm, and vessel traffic waves. Along the western end of the Southport shoreline, frequent flooding would continue and continued sand losses from the sand beach would likewise threaten loss of a portion of East Bay Street at the western terminus of the USACE rock revetment. Recreational access would remain limited along the entire shorefront due to the absence of a subaerial sand beach area and the presence of widespread rubble across the nearshore area. The No-Action alternative would not meet the community goals of increase shorefront protect and recreational public access to the shorefront areas.

Option 1: Breakwaters with Stems & Sand Fill / Sill with Marsh (Preferred Alternative)

Option 1 consists of two major components. These are (1) sand fill stabilization by a series of breakwaters with and without stems along the western two-thirds of the Southport shorefront and (2) enhancement and extension of the marsh area and rock sill along the eastern one-third of the shorefront. The combination of sand fill and breaker will significantly increase shore protection and recreational space and provide a more natural transition between the upland and the river. The marsh and sill features will enhance shore project along the private area and be consistent with similar existing conditions along the far eastern area of the shorefront that have proven to prove a high level of protection from flooding and waves. **Sheet 3** in **Appendix A** shows a planview drawing of Option 1. Given the anticipated success of this project approach compared to others discussed below, the City of Southport has selected Option 1 at the preferred approach.

Option 2: Breakwaters with Sand Fill / Sill with Marsh

Option 2 is a variation of Option 1 without stems behind any breakwaters. This change lowers the overall cost by reducing the amount of stone required. However, without the stems, the sand in the lee of the breakwaters would be expected to be less stable especially during significant storm events. The reduced sand stability and an increased potential for sand loss during storm events would be expected to increase future beach maintenance efforts and costs.

The loss of sand from the beach may also have an undesired effect of increasing sand transport to the Southport Yacht Basin which could increase the need for dredging maintenance.

Option 3: Breakwaters with Stems & Sand Fill / Revetment / Sill with Marsh

Option 3 consists of three major components. These are (1) sand fill stabilization by a series of breakwaters with and without stems, (2) a section of revetment abutting the most seaward shoreline adjacent to the Riverside Motel, and (3) enhancement and extension of the marsh area and rock sill along the eastern one-third of the shorefront. The addition of the revetment within the stabilized sand section changes the protection method by removing two breakwaters and the accompanying sand fill. This approach reduces the overall cost but removes recreational space and moves the wave energy dissipation closer to the upland area.

Option 4: Breakwaters with Sand Fill / Revetment / Sill with Marsh

Option 4 is a variation of Option 3 without stems behind any breakwaters. Again, this change lowers the overall cost by requiring less sand fill and rock placement. However, as discussed for Option 2, a decrease in the stability of the sand fill behind the breakwaters is expected.

Option 5: Revetment / Sill with Marsh

Option 5 is a major variation from the previous alternatives and consists of two major components. These are (1) a properly sized revetment, similar to the USACE project protecting the pump house, that extends east from the current revetment to the private homes and (2) enhancement and extension of the marsh area and rock sill along the eastern one-third of the shorefront. The revetment design would include considerations for future sea level rise, increased ship wakes from larger commercial vessels, and a design storm condition. The revetment would protect the upland but would not create a significant buffer from the upland infrastructure and prevent access to the water’s edge where the revetment is located.

Option 6: Protected Beach / Revetment / Sill with Marsh

Option 6 included the same components of Option 5 with the addition of enhancements to the sandy beach on the western end of the shoreline. The protected beach would include a short extension of the USACE revetment to prevent continued flanking, breakwaters to reduce the wave energy, and beach fill. This approach provides the same adequate protection to the upland in Option 5 while providing some enhancement to the current section of sandy shoreline.

5.0 REFERENCES

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Appendix A

Existing Condition and Project Alternatives

Sheet 1: Existing Conditions
Sheet 2: Existing Conditions
Sheet 3: Preferred Option
Sheet 4: Typical Sections

NOTES:

1. DESIGN SHORELINE = -1.5' FT NAVD88.
2. BEACH SLOPE IS ASSUMED TO BE 1V:11H WITH UPPER BEACH OF +4 FT, NAVD88

SCALE

0 150 300 FEET

REVISIONS				
LTR	DESCRIPTION	BY	DATE	APPRVD

olsen associates, inc.
coastal engineering
2618 Herschel Street
Jacksonville, FL 32204
Tel. (904) 387-6114
COA 0001468

SOUTHPORT, NC
SHOREFRONT IMPROVEMENT PLAN

EXISTING CONDITIONS

DRAWN BY: DATE:

CHECKED BY: CJC 06/xx/2019

SHEET 1 of 4

DATE: 06/xx/2019

REVISED BY: DATE:

NOTES:

1. DESIGN SHORELINE = −1.5' FT NAVD88.
2. BEACH SLOPE IS ASSUMED TO BE 1V:11H WITH UPPER BEACH OF +4 FT, NAVD88

SCALE

0 150 300 FEET

REVISIONS				
LTR	DESCRIPTION	BY	DATE	APPRVD

olsen associates, inc.
coastal engineering
2618 Herschel Street
Jacksonville, FL 32204
Tel. (904) 387-6114
COA 0001468

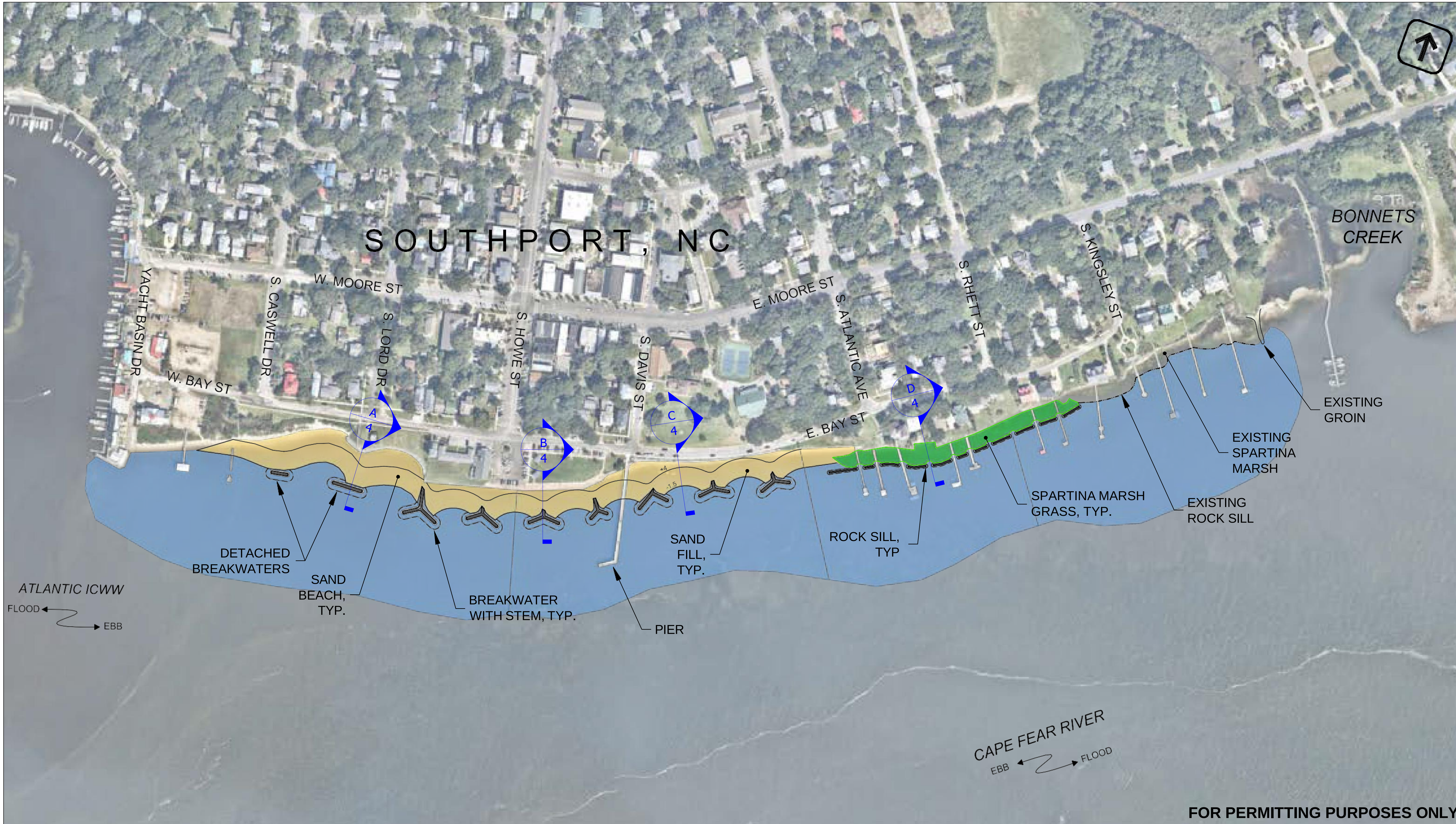
SOUTHPORT, NC
SHOREFRONT IMPROVEMENT PLAN

EXISTING CONDITIONS

DRAWN BY: ML DATE: 06/xx/2019

CHECKED BY: CGC DATE: 06/xx/2019

SHEET 2 of 4



FOR PERMITTING PURPOSES ONLY

NOT FOR CONSTRUCTION

NOTES:

1. DESIGN SHORELINE = −1.5' FT NAVD88.
2. BEACH SLOPE IS ASSUMED TO BE 1V:11H WITH UPPER BEACH OF +4 FT, NAVD88

SCALE

0 150 300 FEET

REVISIONS				
LTR	DESCRIPTION	BY	DATE	APPRVD

olsen associates, inc.
coastal engineering
2618 Herschel Street
Jacksonville, FL 32204
Tel. (904) 387-6114
COA 0001468

SOUTHPORT, NC
SHOREFRONT IMPROVEMENT PLAN
OPTION 1
BREAKWATERS WITH STEMS &
SAND FILL / SILL WITH MARSH

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DATE: 06/xx/2019
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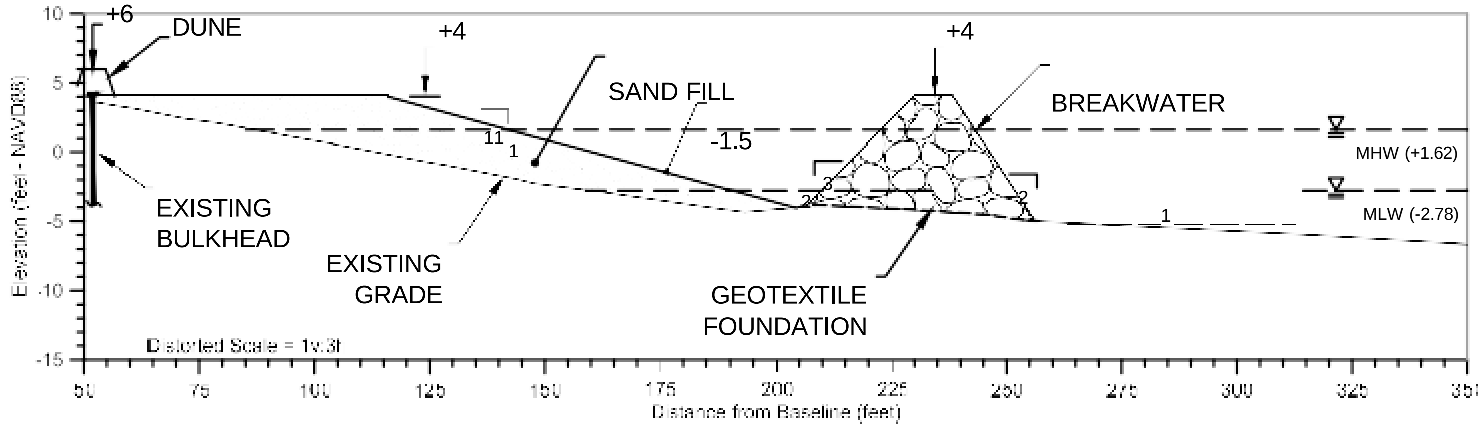
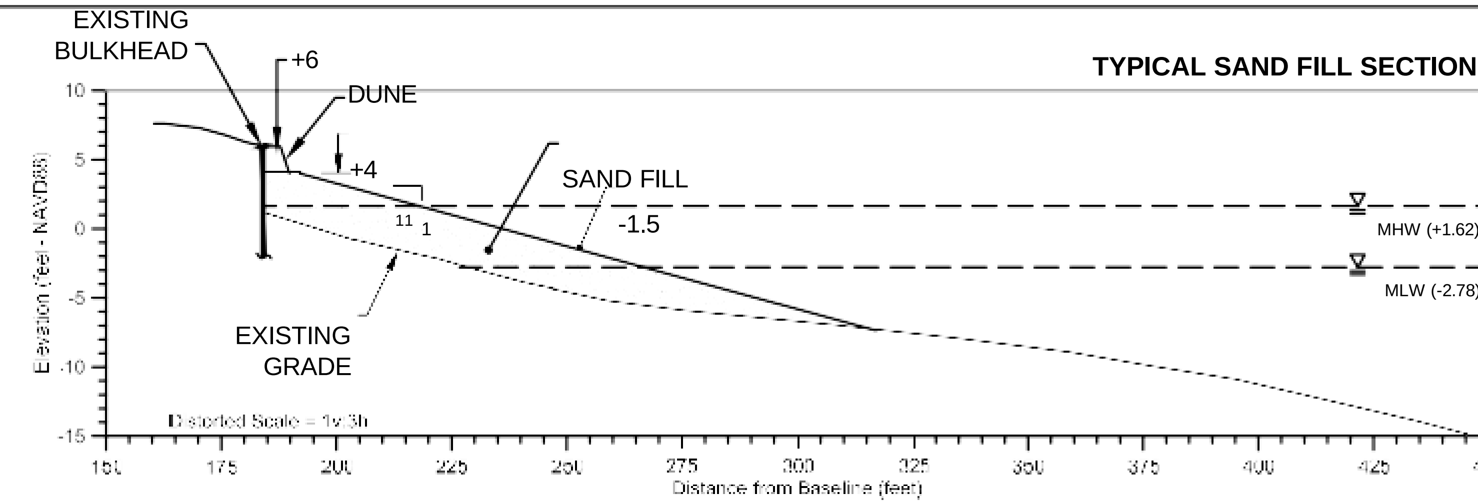
SHEET 3 of 4

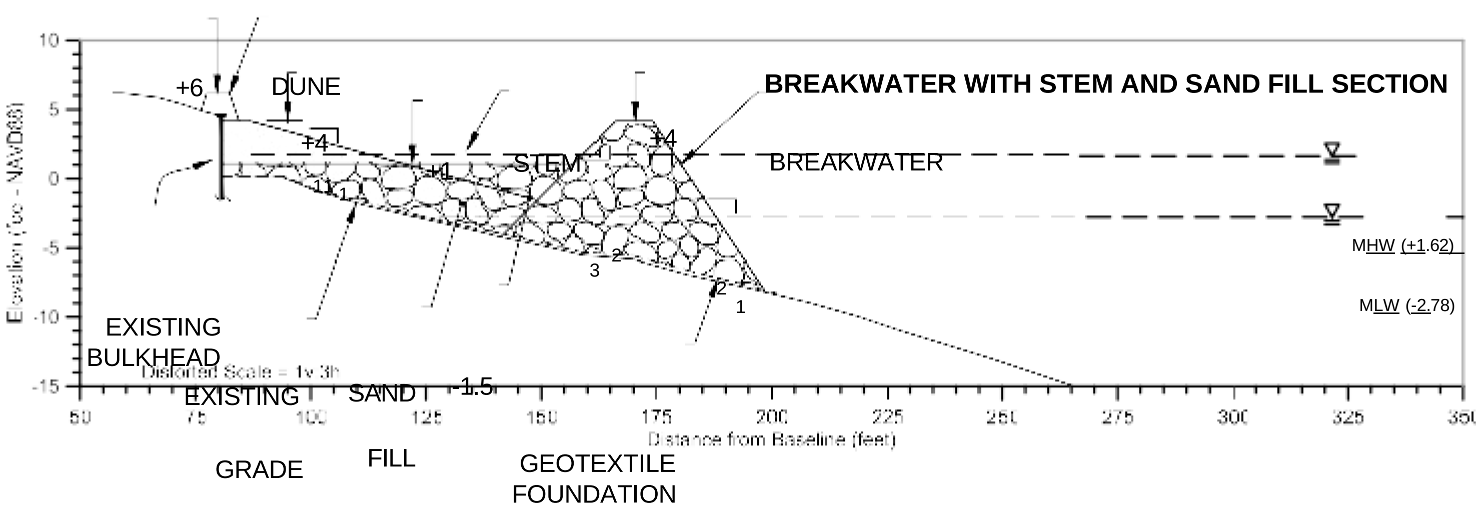
TYPICAL BREAKWATER WITH SAND FILL SECTION



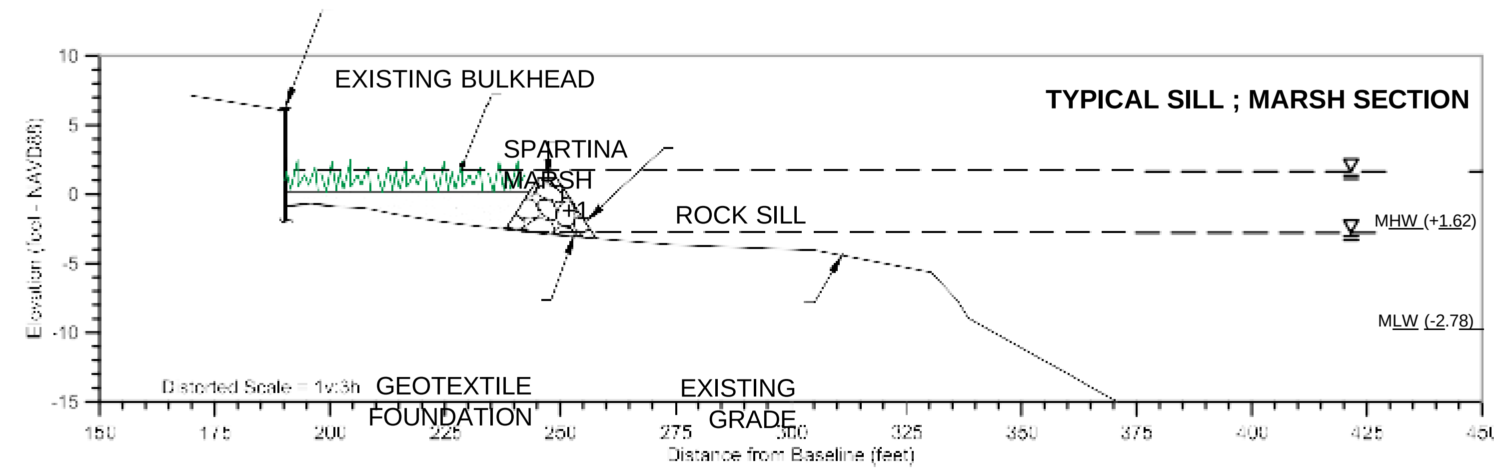
TYPICAL SAND FILL SECTION



BREAKWATER WITH STEM AND SAND FILL SECTION



TYPICAL SILL ; MARSH SECTION



1. DESIGN SHORELINE = -1.5' FT NAVD88
2. BEACH SLOPE IS ASSUMED TO BE 1V:11H WITH UPPER BEACH OF +4 FT NAVD88

NOTES:

FOR PERMITTING PURPOSES ONLY
NOT FOR CONSTRUCTION

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CHECKED BY:	CGC	DATE:	05/xx/2019
REVISED BY:		DATE:	

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REVISIONS				
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SOUTHPORT, NC
SHOREFRONT IMPROVEMENT PLAN

TYPICAL SECTIONS

SHEET 4 of 4

Appendix B

Development of Representative Wave Characteristics

Wind Generated Waves
and
Ship Wakes

WIND GENERATED WAVES

Based on the analysis of the wind conditions near the Southport shoreline, maximum probable wind-wave heights can be determined by the Fetch-Limited method. In this method, wave heights are limited by fetch length, wind speed, and water depth across the length of the fetch. Fetch length is a measure of the distance over which wind is “working” (blowing over) the surface of a body of water. For Southport, two fetch “windows” along the Cape Fear River affect the shoreline and are shown in **Figure B-1**.

The south-southeast fetch of 3.2 miles provides a more shore perpendicular direction to much of the City shoreline, allowing wind generated waves to impact the shoreline directly. The north-northeast fetch of 4.2 miles would generate waves that arrive at the shoreline at a very oblique angle. However, for completeness and allowing for the most conservative estimate, both fetch-limited wave conditions are evaluated as though they are normally incident to the shoreline.

Fetch limited wave height (H) and wave period (T) values were calculated using Equation 3-39 and 3-40 from the Shore Protection Manual (USACE, 1984):

$$\frac{gH}{U_A^2} = 0.283 \tanh\left[0.530\left(\frac{gd}{U_A^2}\right)^{\frac{3}{4}}\right] \tanh\left\{\frac{0.00565\left(\frac{gF}{U_A^2}\right)^{\frac{1}{2}}}{\tanh\left[0.530\left(\frac{gd}{U_A^2}\right)^{\frac{3}{4}}\right]}\right\}$$

$$\frac{gT}{U_A} = 7.54 \tanh\left[0.833\left(\frac{gd}{U_A^2}\right)^{\frac{3}{8}}\right] \tanh\left\{\frac{0.0379\left(\frac{gF}{U_A^2}\right)^{\frac{1}{3}}}{\tanh\left[0.833\left(\frac{gd}{U_A^2}\right)^{\frac{3}{8}}\right]}\right\}$$

where F is the fetch length, d is the average depth of water over which the fetch is acting, g is gravity, and U_A is the wind stress factor (adjusted windspeed) defined relative to the surface wind speed (U_S) by: $U_A = 0.71 U_S^{1.23}$.

Figure B-1: Location map depicting the location of the Southport shoreline in Brunswick County, NC and the fetch length across different fetch windows.

The windspeeds based on various return periods presented in **Section 3.3** were used as the inputs for the wave height development. An average depth of 16.8 feet was determined from the local bathymetry across the NNE fetch. An average depth of 30.9 feet was determined from the local bathymetry across the SSE fetch.

Expected maximum wave heights for various sustained wind speeds and probabilistic still water levels were computed. The results are presented in **Table B-1** for the NNE fetch and in **Table B-2** for the SSE fetch. These results suggest that the height of wind waves that approach the shoreline can vary significantly depending upon the input conditions.

Table B-1: Maximum predicted fetch-limited wave height under various wind and water level conditions for the NNE fetch.

% Annual Chance of Occurrence	Equivalent Return Period (years)	Stillwater Flood Level (ft, NAVD88)	Avg. Depth over Fetch (ft)	Wind Speed (MPH)	Wave Height (ft)	Wave Period (s)
50 yr wind with no flood elevation			16.8	33.2	2.4	2.9
10	10	4.6	21.4	27.2	2.0	2.7
2	50	7.6	24.4	33.2	2.5	2.9
1	100	9.2	26.0	35.7	2.7	3.0
0.2	500	12.5	29.3	41.6	3.3	3.2

Table B-2: Maximum predicted fetch-limited wave height under various wind and water level conditions for the SSE fetch.

% Annual Chance of Occurrence	Equivalent Return Period (years)	Stillwater Flood Level (ft, NAVD88)	Avg. Depth over Fetch (ft)	Wind Speed (MPH)	Wave Height (ft)	Wave Period (s)
50 yr wind with no flood elevation			30.9	33.2	2.2	2.7
10	10	4.6	35.5	27.2	1.7	2.5
2	50	7.6	38.5	33.2	2.2	2.7
1	100	9.2	40.1	35.7	2.4	2.8
0.2	500	12.5	43.4	41.6	2.9	3.0

SHIP WAKES

Ship-generated wave impacts are a consistent occurrence along the Southport shoreline. As a ship passes in the navigation channel, waves are generated that propagate to, and impact the shoreline. These waves are generated as a ship moves through water and the bow of the hull displaces the water through which it is moving. This builds up pressure in front of the ship which increases flow velocities around the ship midsection. One can think of it as the water moving past the ship at a faster rate than the surrounding water, creating a lower pressure across the midsection of the ship. This low pressure, high velocity flow then passes the stern where it encounters slower moving water, which builds up pressure at the stern. The water surface around the ship responds to these pressure gradients, raising the water level at the bow and stern and lowering it along the midsection. This creates two sets of waves: symmetrical diverging waves that propagate obliquely off the port and starboard of the ship, and transverse waves that propagate in the direction of the ship (see **Figure B-2**). As the transverse wave passes the shoreline, a large drawdown of water is created in the trough, the size of which is accentuated by the presence of crests in front and behind the drawdown. Drawdown is followed by a dramatic change in water level as the crests of the transverse and diverging waves arrive at the shoreline.

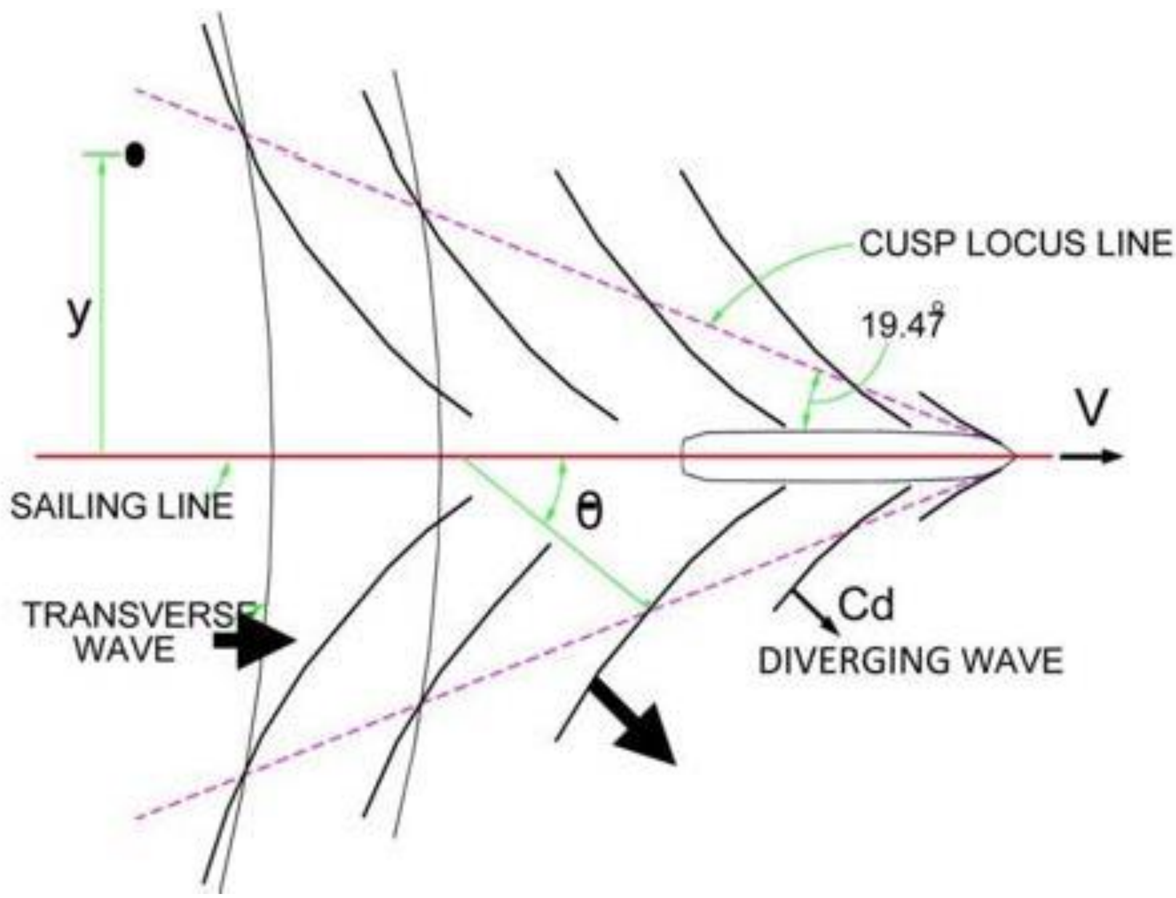

Figure B-2: Sample ship-generated wave pattern for deep water (from *Kriebel et al* (2003)).

The maximum wave height (H) experienced at the shoreline as a ship passes (combining the transverse and divergent waves into a single record) can be determined from the equation adapted from *Kriebel et al* (2003):

$$\frac{gH}{V^2} = \beta(F_* - 0.1)^2 \left(\frac{y}{L}\right)^{-\frac{1}{3}}$$

where H=wave height, $F_* = F_L exp\left(\alpha \frac{d}{T}\right)$, $\alpha = 2.35(1 - C_b)$, and

$\beta = 1 + 8tanh^3\left(0.45\left(\frac{L}{L_e} - 2\right)\right)$.

Additionally, d is the channel depth, L is the vessel length, T is the vessel draft, b is the beam width, y is the distance from the sailing line, V is the vessel speed, $C_b = \frac{\forall}{LBT}$ is the vessel clock coefficient, ∀ is the vessel displacement, L_e is the vessel entrance length (defined as the length from bow to the start of the parallel middle-body of the hull), and $F_L = \frac{V}{\sqrt{gL}}$ is the length-based Froude number of the vessel. The block coefficient characterizes the amount of volume occupied by the vessel relative to its nominal dimensions – length, beam, and draft.

In this investigation, the design condition was based upon Panamax ship dimensions (i.e., 106 feet beam, 39.5 feet draft, and 965 feet length with a displacement of 80,000 tons). Several Panamax sized ships call on the Port of Wilmington and pass the Southport shoreline. The entrance length of the ship is defined as 20% of the ship length or 193 feet. The design ship speed is assumed to be 15 knots. Observed ship speeds in the Savannah River suggest that common ship speeds in the Federal navigation channels vary between about 10 and 15 knots (USACE, 2006). Here, we will assume the upper end of the range for computation of wave heights.

Figure B-3 illustrates the assumed shape and dimensions for the vessel and channel used for these calculations. There is a strong dependence on the channel depth to ship draft ratio, d/T and wave heights at the shoreline. Higher water levels (i.e., larger water depths) result in smaller wave heights at the shoreline for ships of equal sizes and speeds. Based on that relationship a channel depth based on current Mean Lower Low Water (MLLW) conditions is used to determine the wave ship wake condition. The nearest distance from the shoreline to the sailing line is 1,200 ft.

Based on these inputs a ship generated wave height of <u>3.4 feet</u> is possible for the largest ships. This wave represents the most conservative estimate for ship generated waves based on large vessels that are limited to the Cape Fear Federal Navigation Channel. However, the variation of ship generated wakes that impact the Southport shoreline extends from these estimates down to personal watercraft traveling much closer the shoreline. Overall, the rate of wave energy from ship wakes and the size of those wakes is increasing. This further emphasizes the need for shoreline improvements that will reduce erosion from increased wave energy.

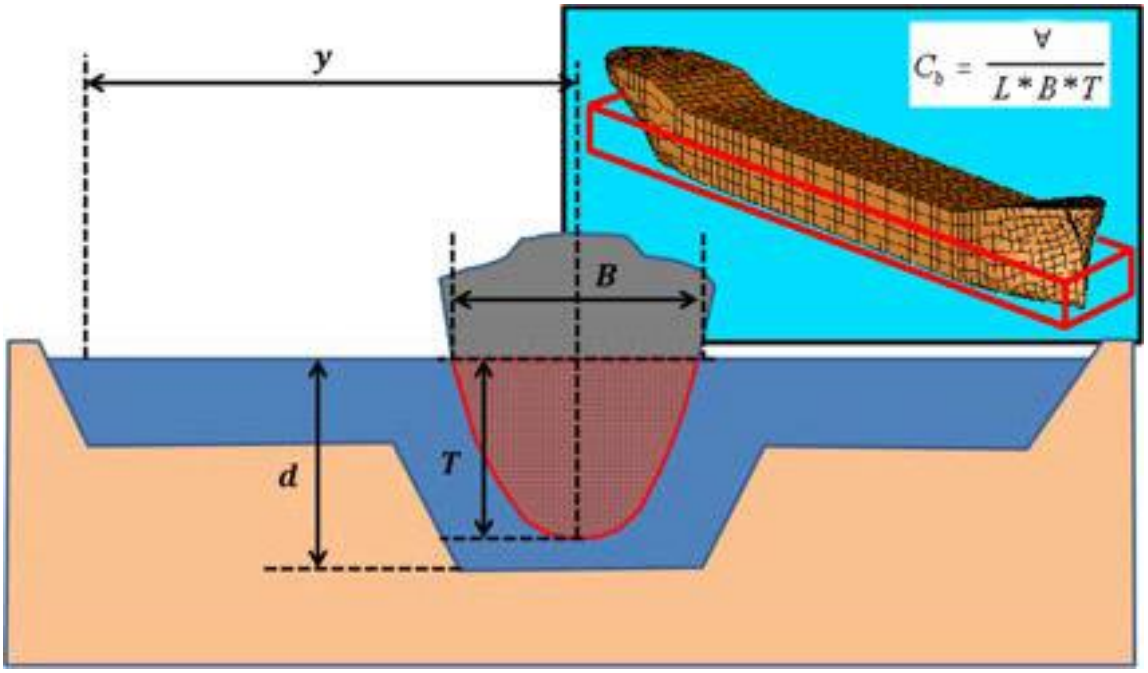

Figure B-3: Schematic showing typical vessel and channel dimensions used in calculations. Inset is adapted from *Kriebel et al* (2003).

REFERENCES

Kriebel, D., Seelig, W., Judge, C., "Development of a Unified Description of Ship-Generated Waves," Proc. PIANC USA Annual Meeting 2003, Protland, OR

Maynord, S.T. (USACE, 2006), "Ship Forces on the Shoreline of the Savannah Harbor Project," Report, USACE Engineering Research and Develepment Center, Coastal and Hydraulics Laboratory (ERDC/CHL), Vicksburge MS.

U.S. Army Corps of Engineers, (USACE, 1984), "Shore Protection Manual", Coastal Engineering Research Center, Vicksburg, MS.

ATTACHMENT B

EXISTING
GROIN

EXISTING
SPARTINA
MARSH

EXISTING
ROCK SILL

PIER

PRELIMINARY - CONCEPT

NOTES:

SCALE

0 150 300 FEET

olsen

ML

03/18/2019

1. DESIGN SHORELINE = −1.5' FT NAVD88.
2. BEACH SLOPE IS ASSUMED TO BE 1V:11H WITH UPPER BEACH OF +4 FT, NAVD88

REVISIONS				
LTR	DESCRIPTION	BY	DATE	APPRVD

associates, inc.
coastal engineering
2618 Herschel Street
Jacksonville, FL 32204
Tel. (904) 387-6114
COA 0001468

SOUTHPORT, NC
SHOREFRONT IMPROVEMENT PLAN

EXISTING CONDITIONS

DRAWN BY: DATE:

CHECKED BY: CGC

SHEET 1 of 8

NOTES:

1. DESIGN SHORELINE = −1.5' FT NAVD88.
2. BEACH SLOPE IS ASSUMED TO BE 1V:11H WITH UPPER BEACH OF +4 FT, NAVD88

SCALE

0 150 300 FEET

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SOUTHPORT, NC
SHOREFRONT IMPROVEMENT PLAN

EXISTING CONDITIONS

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SHEET 2 of 8

DATE: 03/18/2019
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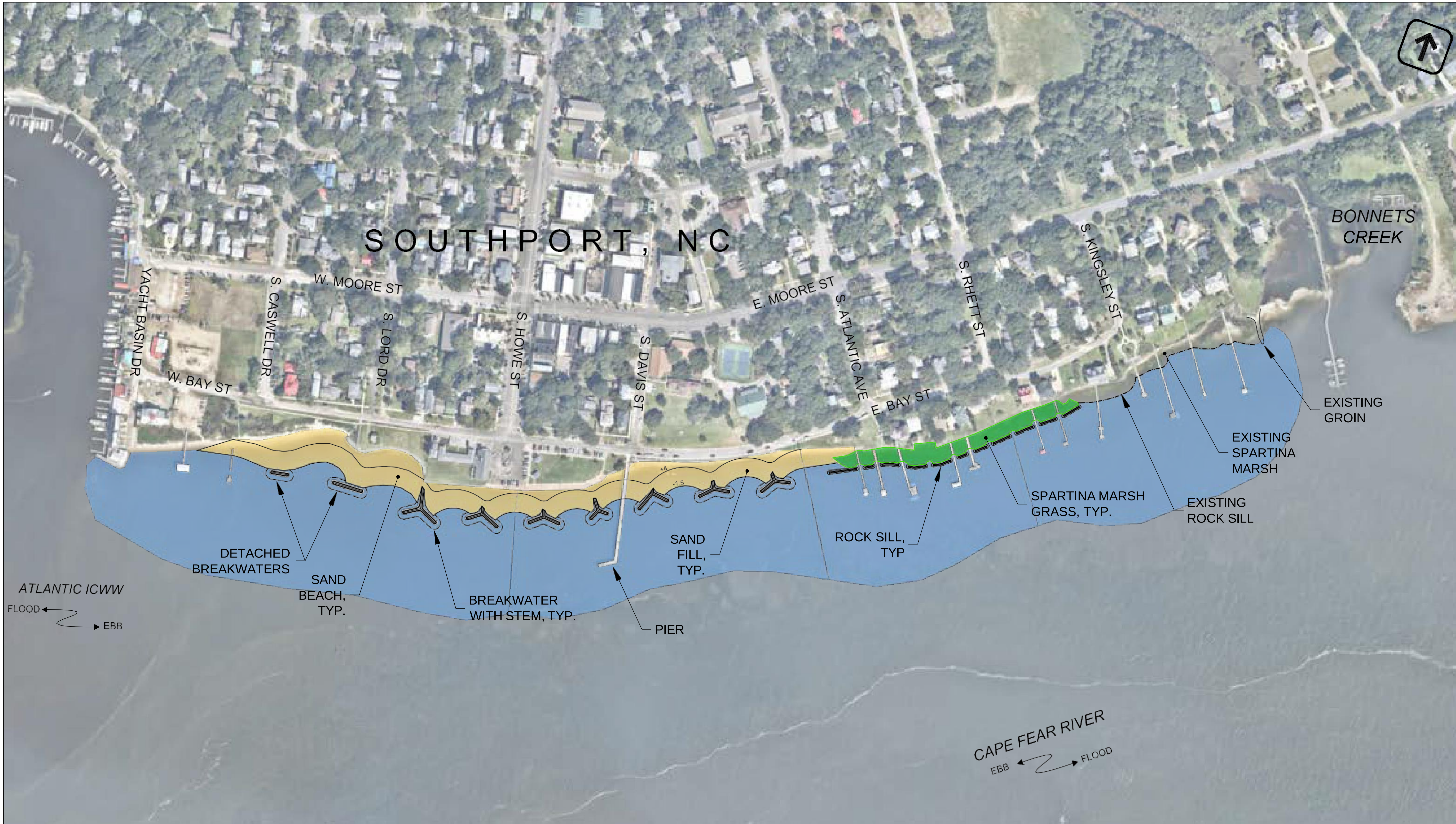

PRELIMINARY - CONCEPT

NOTES:

1. DESIGN SHORELINE = -1.5' FT NAVD88.
2. BEACH SLOPE IS ASSUMED TO BE 1V:11H WITH UPPER BEACH OF +4 FT, NAVD88

SCALE

0 150 300 FEET

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SOUTHPORT, NC
SHOREFRONT IMPROVEMENT PLAN
OPTION 1
BREAKWATERS WITH STEMS &
SAND FILL / SILL WITH MARSH

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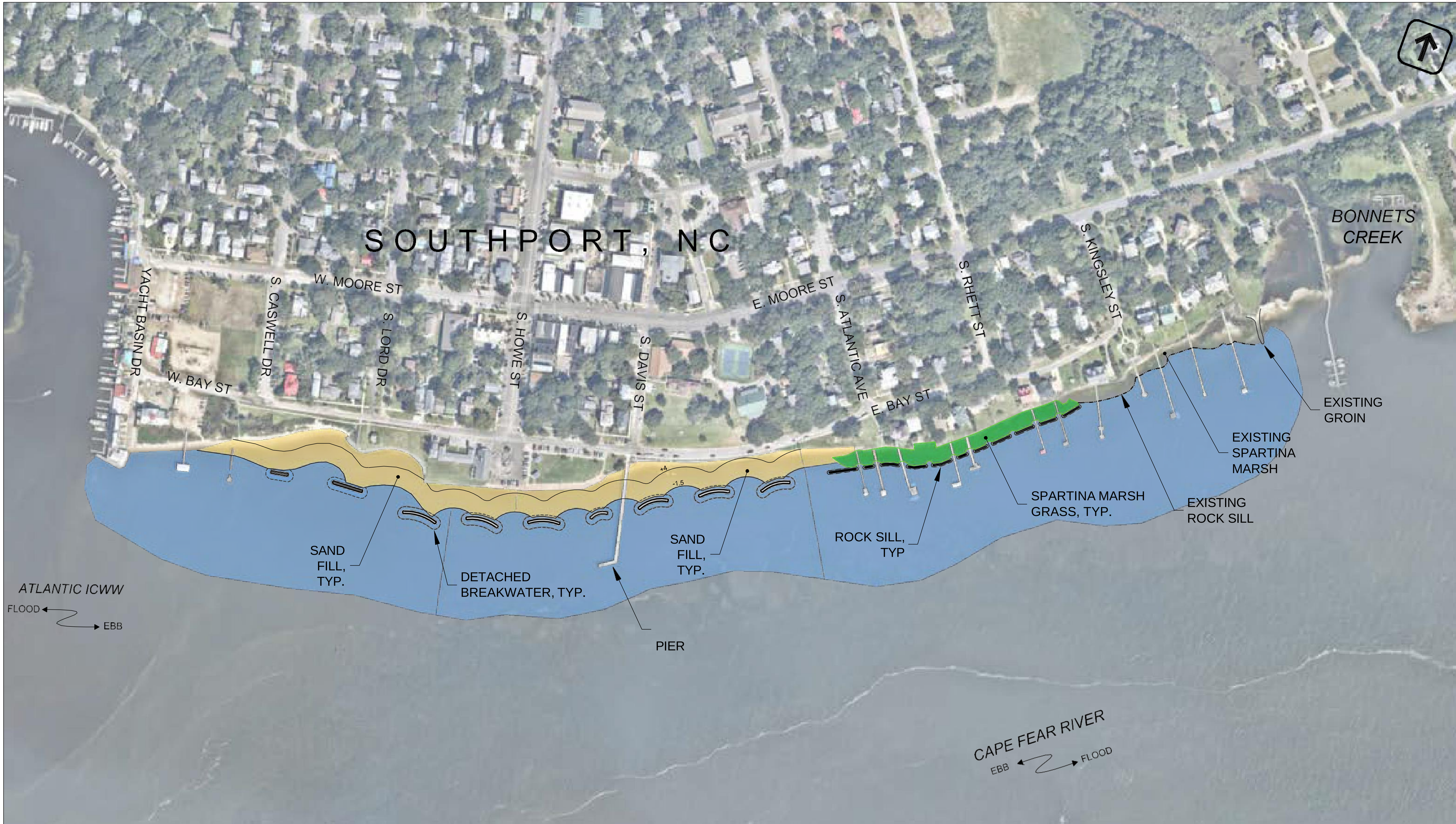
SHEET 3 of 8



PRELIMINARY - CONCEPT

NOTES:
1. DESIGN SHORELINE = -1.5' FT NAVD88.
2. BEACH SLOPE IS ASSUMED TO BE 1V:11H WITH UPPER BEACH OF +4 FT, NAVD88

SCALE

0 150 300 FEET

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SOUTHPORT, NC
SHOREFRONT IMPROVEMENT PLAN
OPTION 2
BREAKWATERS WITH SAND FILL / SILL WITH MARSH

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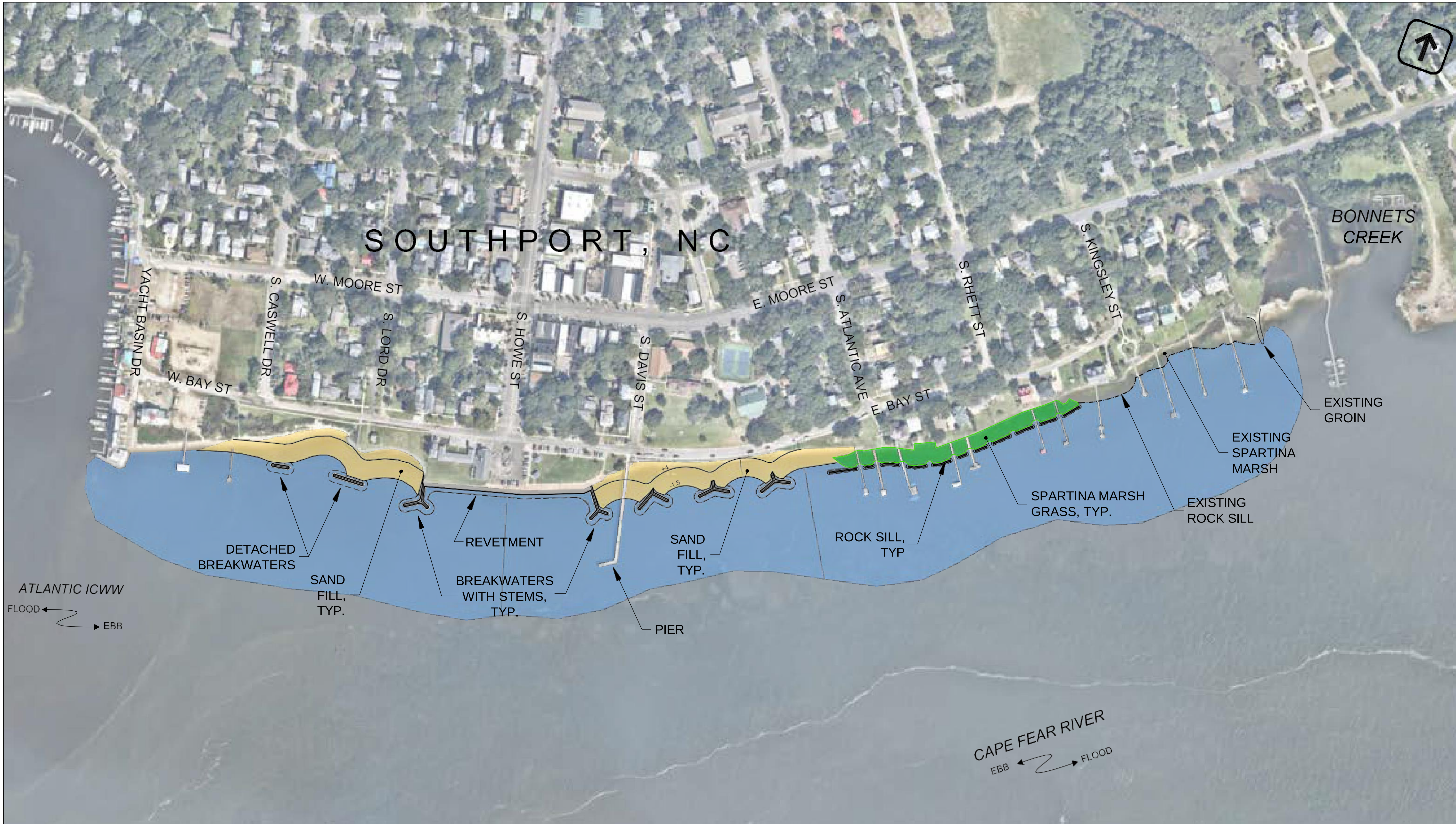
REVISED BY: DATE:

SHEET 4 of 8



PRELIMINARY - CONCEPT

NOTES:
1. DESIGN SHORELINE = -1.5' FT NAVD88.
2. BEACH SLOPE IS ASSUMED TO BE 1V:11H WITH UPPER BEACH OF +4 FT, NAVD88

SCALE

0 150 300 FEET

REVISIONS				
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SOUTHPORT, NC
SHOREFRONT IMPROVEMENT PLAN
OPTION 3
BREAKWATERS WITH STEMS & SAND FILL / REVETMENT / SILL WITH MARSH

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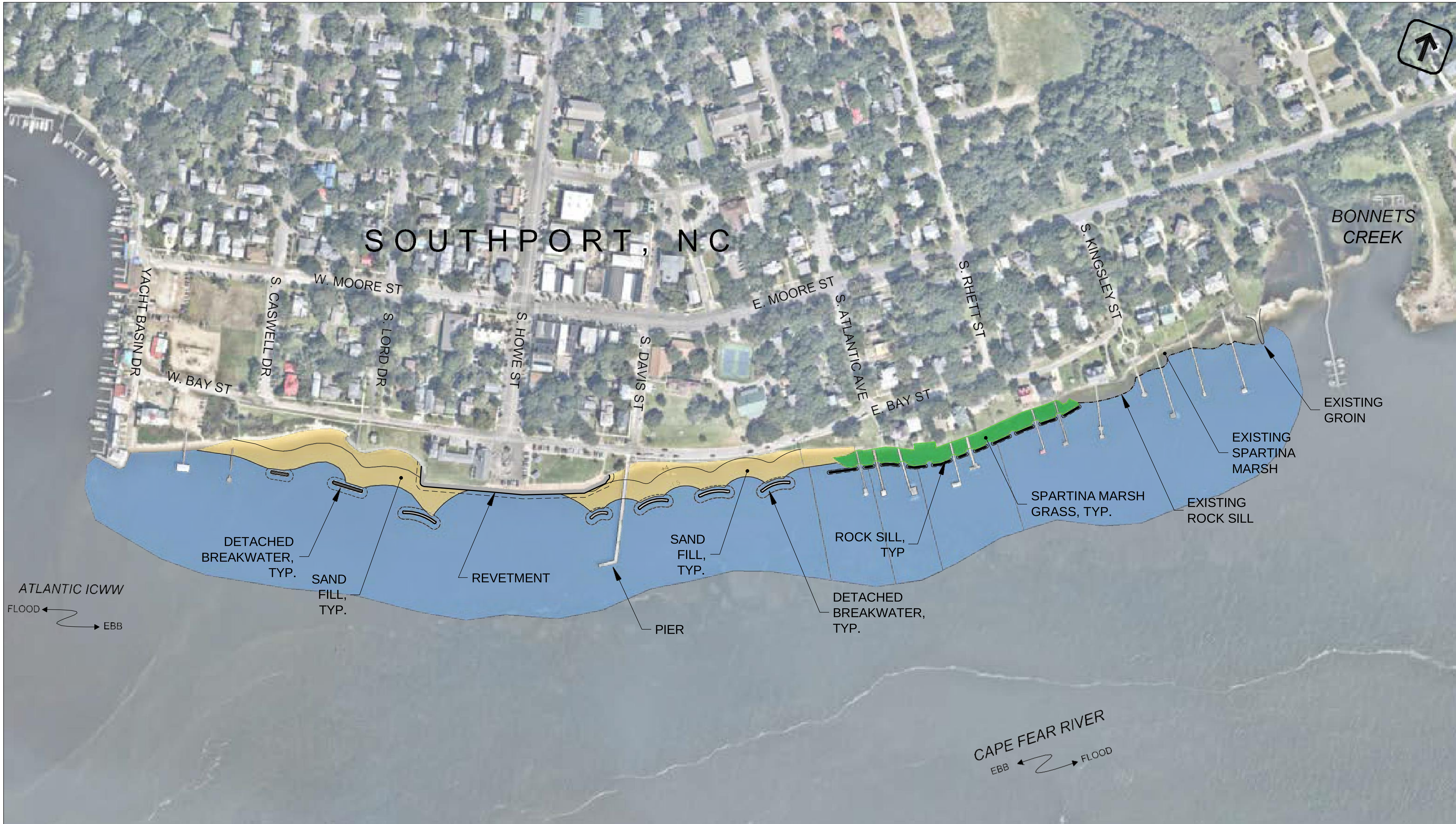
SHEET 5 of 8



PRELIMINARY - CONCEPT

NOTES:
1. DESIGN SHORELINE = −1.5' FT NAVD88.
2. BEACH SLOPE IS ASSUMED TO BE 1V:11H WITH UPPER BEACH OF +4 FT, NAVD88

SCALE

0 150 300 FEET

REVISIONS				
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SOUTHPORT, NC
SHOREFRONT IMPROVEMENT PLAN
OPTION 4
BREAKWATERS WITH SAND FILL / REVETMENT / SILL WITH MARSH

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SHEET 6 of 8

SOUTHPORT NC

W. MOORE ST

BONNETS CREEK

EXISTING GROIN

EXISTING SPARTINA

MARSH

SPARTINA MARSH GRASS, TYP.

EXISTING ROCK SILL

REVETMENT

REVETMENT

ROCK SILL, TYP

ATLANTIC ICWW

FLOOD

EBB

PIER

ADD / ENHANCE REVETMENTS

PRELIMINARY - CONCEPT

NOTES:

1. DESIGN SHORELINE = -1.5' FT NAVD88.
2. BEACH SLOPE IS ASSUMED TO BE 1V:11H WITH UPPER BEACH OF +4 FT, NAVD88

SCALE

olsen

LTR	DESCRIPTION	BY	DATE	APPRVD

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coastal engineering
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Jacksonville, FL 32204
Tel: (904)387-6114
COA 0001468

SHOREFRONT IMPROVEMENT PLAN
OPTION 5

REVETMENT ADD / ENHANCE ONLY

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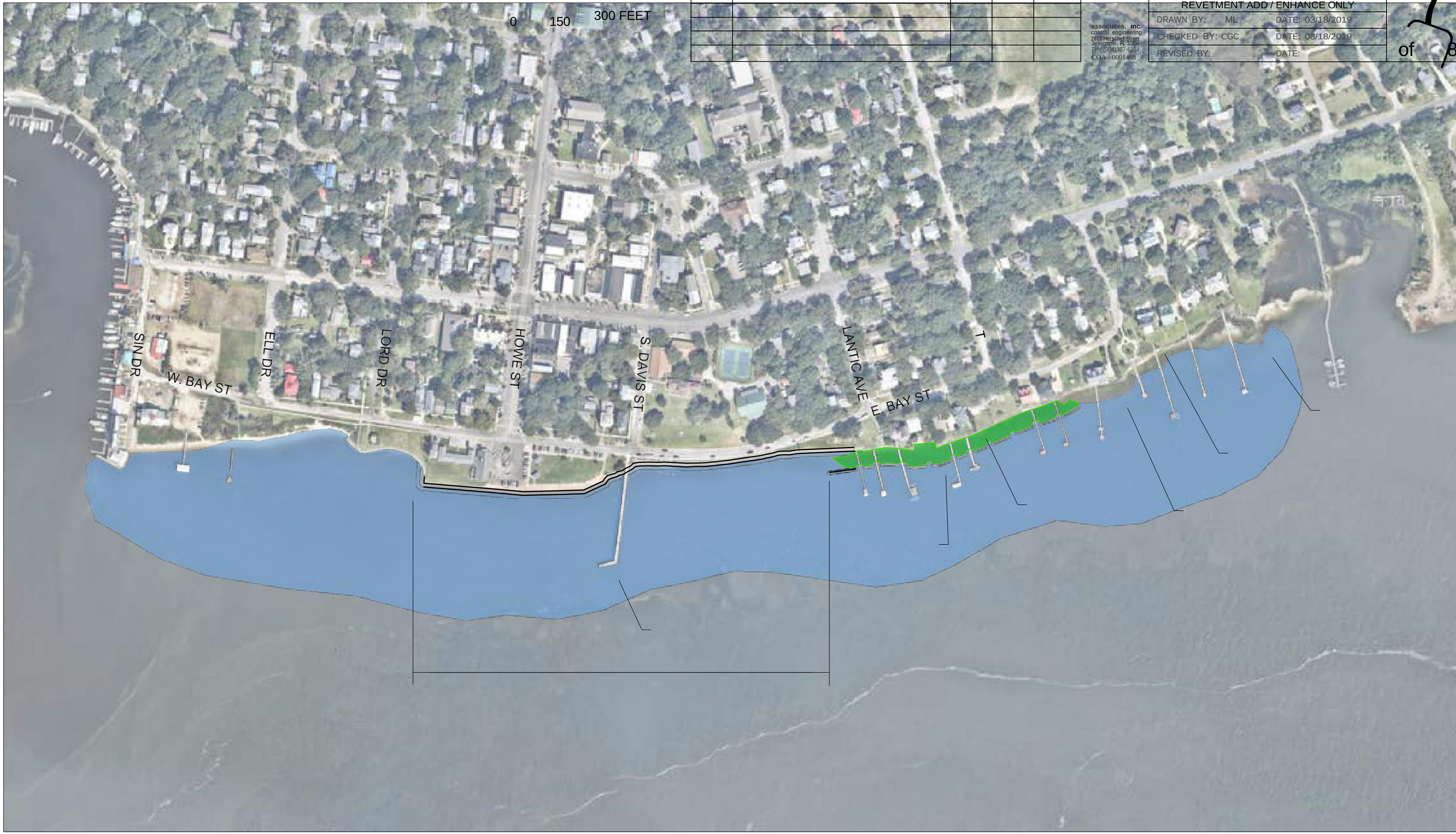
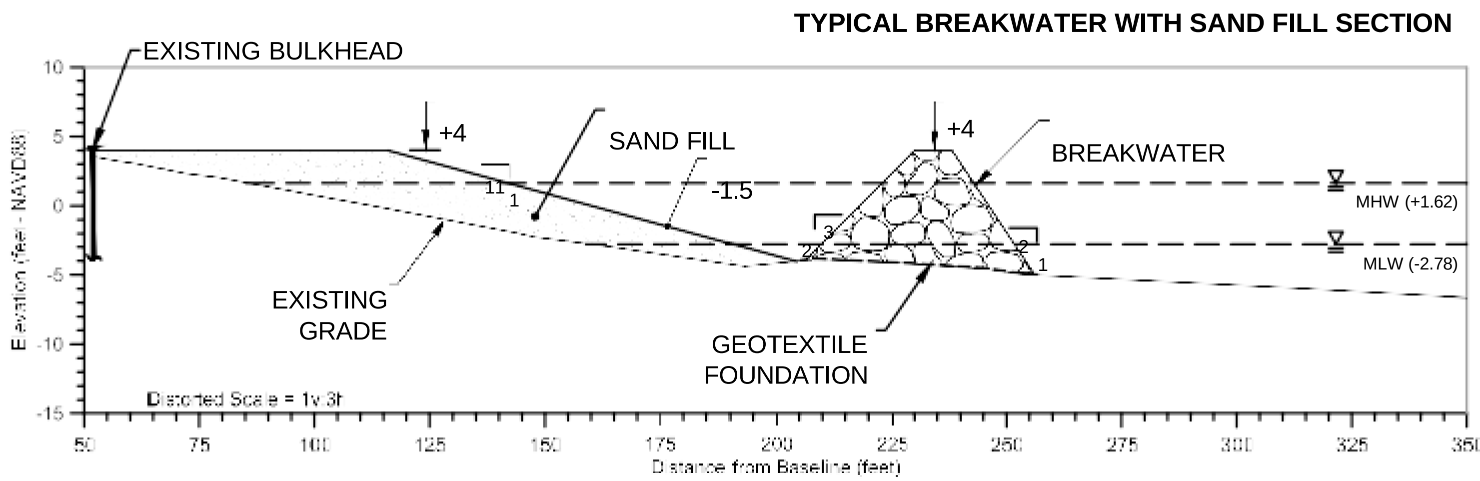
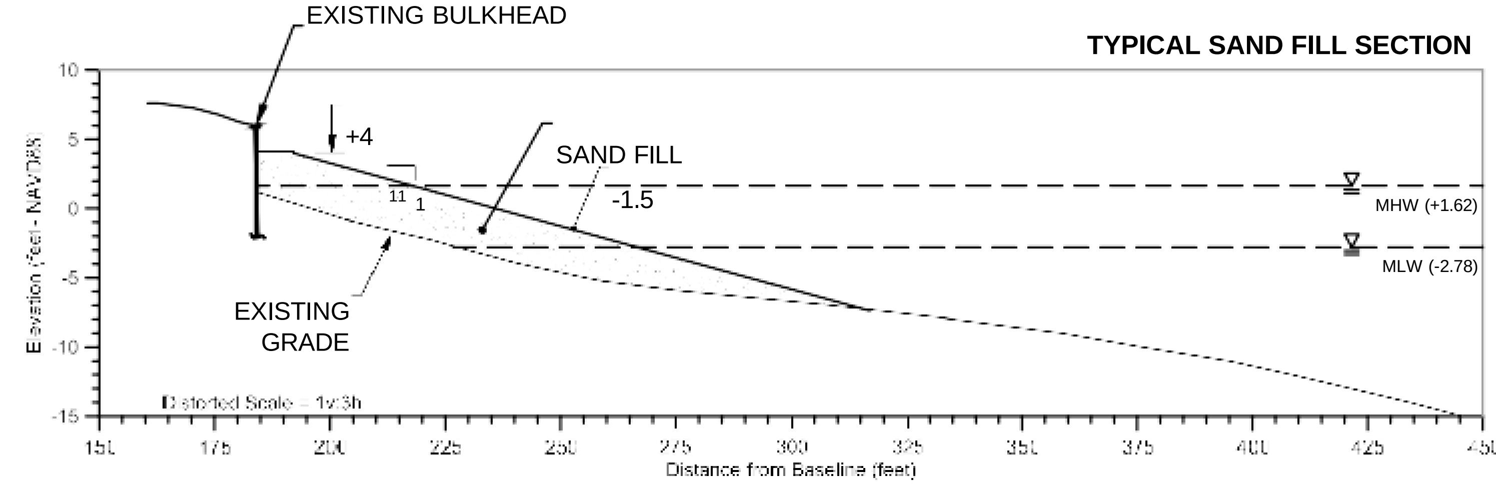
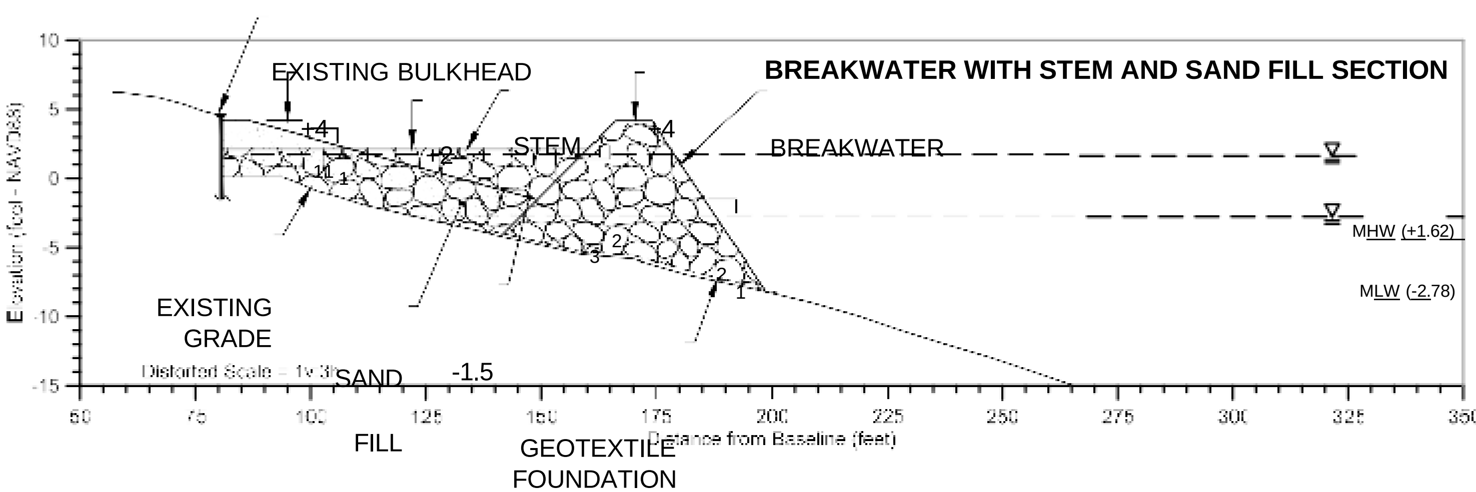
REVISED BY:	DATE:

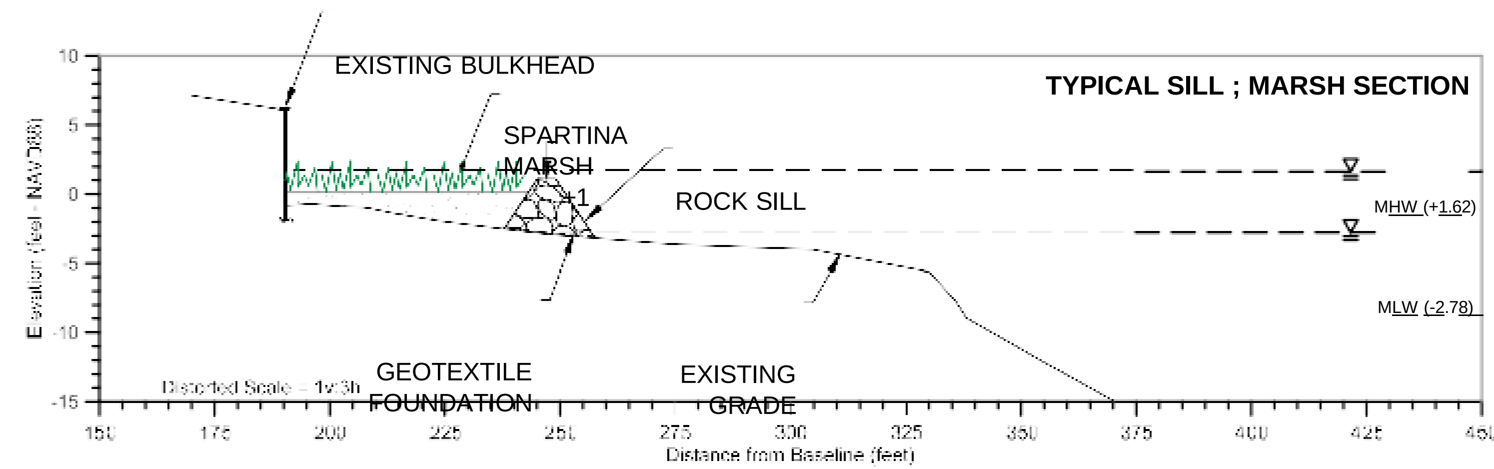
7 of 8

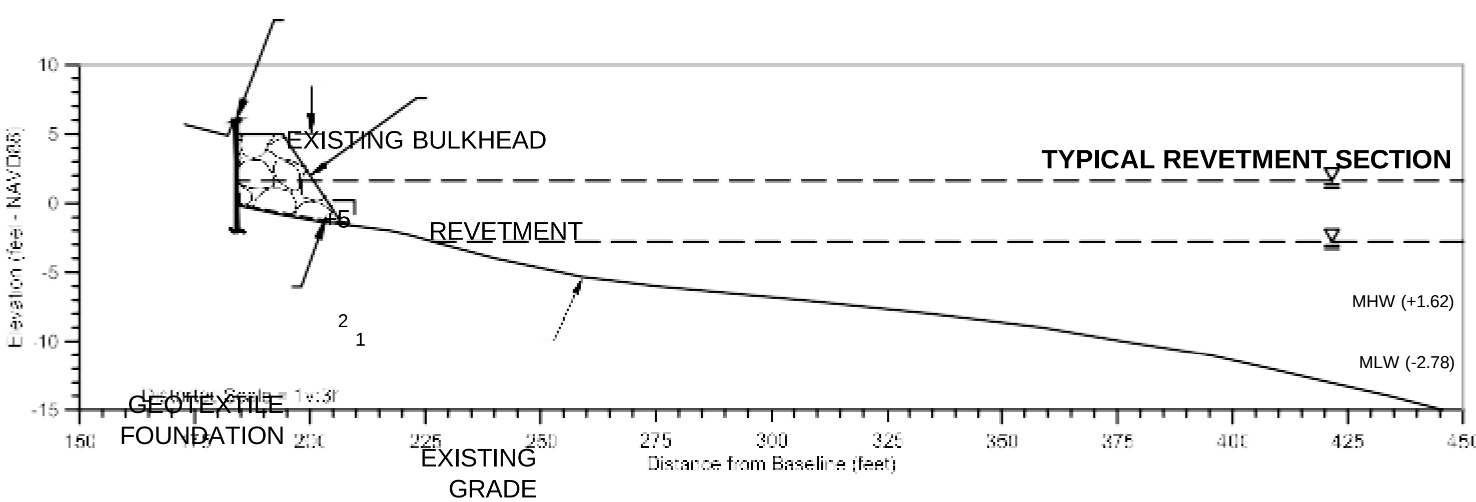












1. DESIGN SHORELINE = -1.5' FT NAVD88
2. BEACH SLOPE IS ASSUMED TO BE 1V: 1H WITH UPPER BEACH OF +4 FT NAVD88

NOTES:

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PRELIMINARY - CONCEPT

SOUTHPORT, NC SHOREFRONT IMPROVEMENT PLAN TYPICAL SECTIONS	SHEET 8 of 8

ATTACHMENT C

City of Southport

Board of Alderman Workshop

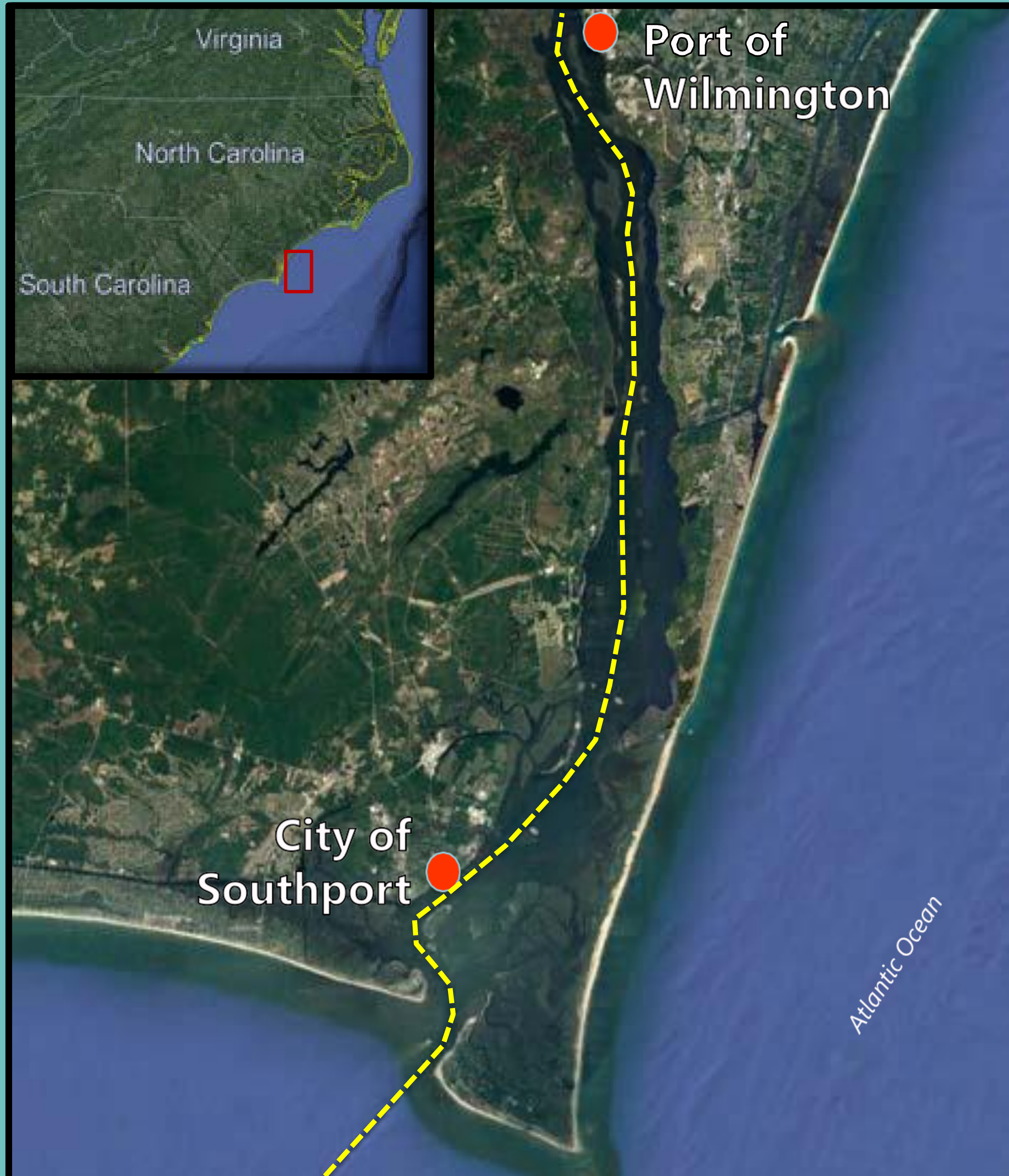
February 27, 2023

SHORELINE IMPROVEMENT PROJECT

Chris Creed, P.E.

olsen associates, inc.

ccreed@olsen-associates.com


Virginia
North Carolina
South Carolina
Port of
Wilmington
City of
Southport
Atlantic Ocean

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NOTES:

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LTR	REVISIONS DESCRIPTION	BY	DATE	APPRVD

olsen

EXISTING CONDITIONS

SHBET

1

Southport N.C. Established 1792

Existing Conditions

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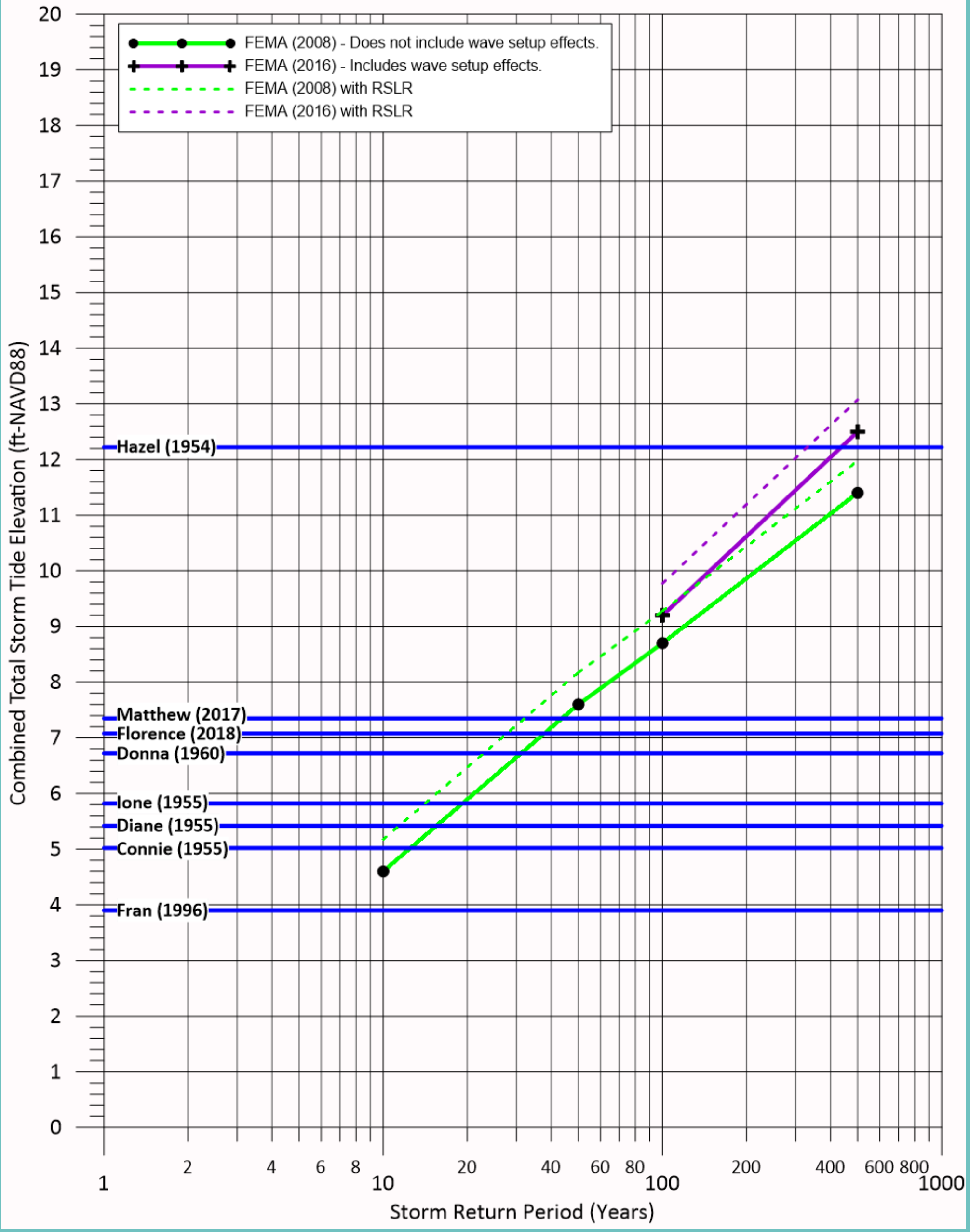
Site Conditions / Considerations

- Highly Eroded Shoreline (4,000 ft +/-) (widespread armoring)
- High Erosional Stress
  - Storm surge
  - Wind waves
  - Ship/boat generated waves
- Future Port of Wilmington Expansion
  - Channel deepening
  - Increase in ship size and frequency
- Sea Level Rise (SLR)



Storm Surge Predictions

Dominant Wind Wave Fetches

Table 9. Relative sea level rise by 2045 considering potential increased rates of sea level rise (RCP 2.6 which is the lowest greenhouse gas emission scenario, combined with vertical land movement at each tide gauge).*

Station	RCP 2.6 + VLM RSLR in 30 years, inches			
	Mean	Low	High	95% CI
Duck	7.1	4.8	9.4	2.3
Oregon Inlet	6.3	3.9	8.7	2.4
Beaufort	6.5	4.2	8.7	2.3
Wilmington	5.8	3.5	8.0	2.3
Southport	5.9	3.7	8.2	2.3

*Note: Projections were rounded to the nearest tenth of an inch.

Table 10. Relative sea level rise by 2045 considering potential increased rates of sea level rise (RCP 8.5 which is the highest greenhouse gas emission scenario, combined with vertical land movement at each tide gauge).

Station	RCP 8.5 + VLM RSLR in 30 years, inches			
	Mean	Low	High	95% CI
Duck	8.1	5.5	10.6	2.5
Oregon Inlet	7.3	4.7	9.9	2.6
Beaufort	7.5	5.0	10.0	2.5
Wilmington	6.8	4.3	9.3	2.5
Southport	6.9	4.4	9.4	2.5

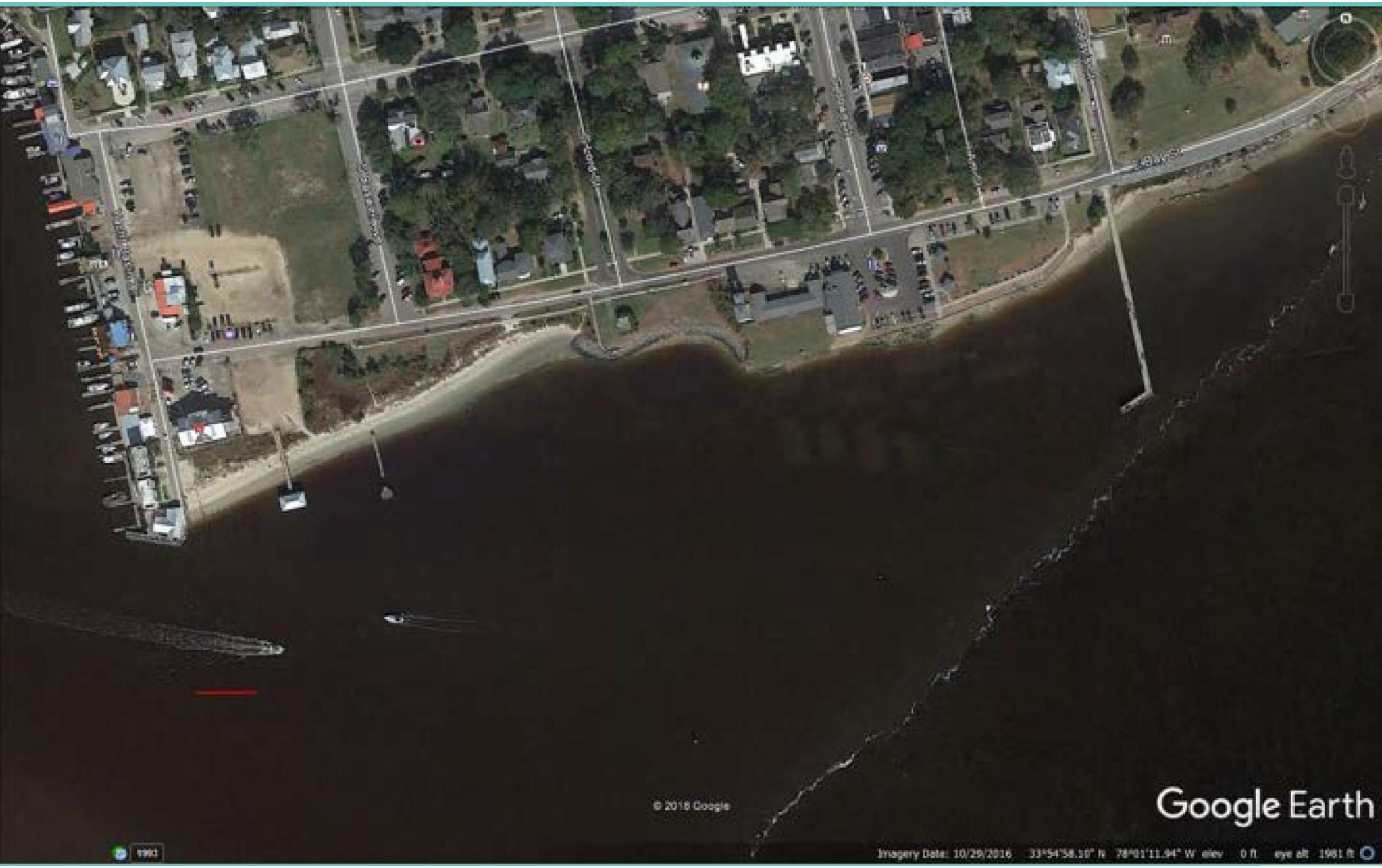
*Note: Projections were rounded to the nearest tenth of an inch.

Established 1792 Southport N.C.

Sea Level Rise

olsen associates, inc. Coastal Engineering

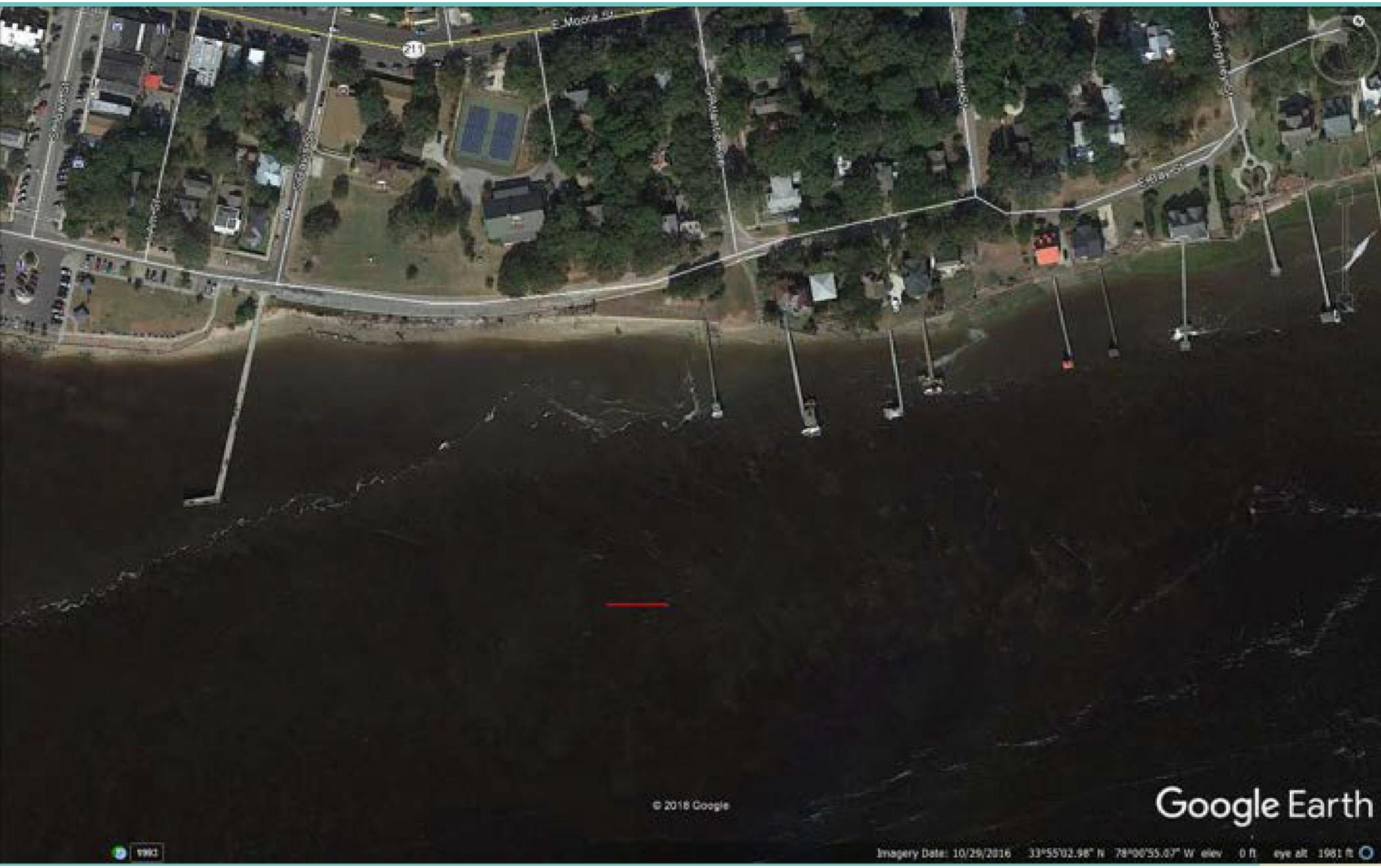

ICWW
Section 1
Section 2
Section 3
Section 4
Section 5
Section 6
Bonnets Creek
Federal Navigation Setback Line
Cape Fear River



Sections 1, 2 and 3

Section 2

Section 3



Sections 4 and 5

Section 4

Southport N.C. Established 1792

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Section 5

Sections 5 and 6

olsen associates, inc.

Section 6

NOTES:
1. DESIGN SHORELINE = -1.0' FT NAVD88.
2. BEACH SLOPE IS ASSUMED TO BE ... WITH UPPER BEACH O

SCALE
0 150 300 FEET

REVISIONS				
LTR	DESCRIPTION	BY	DATE	APPRVD

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SHEET

EXISTING CONDITIONS

DRAWN BY: ML DATE: 03/18/2019
CHECKED BY: EOC DATE: 03/18/2019
REVISED BY: DATE:

2 of 8

Shoreline Sections

olsen
associates, inc.

Federal Navigation Channels

Project Goals

- Comprehensive shoreline stabilization
- Protect shoreline and upland from…
  - Continued erosion and loss of land
  - Ship generated waves (existing and future)
  - Sea level rise (SLR) and increase frequency and magnitude of flooding
- Enhance and protect environmental resources of the area
- Increase the recreational value (access and use)
- Improve and expand ‘living shoreline’ features

Project Approach

- **Develop Project Scope for Current Conditions**
- **Develop Alternatives based on City constraints**
  - Funding limitations from Port of Wilmington grant
  - Spectrum of ‘Green to Gray’ Solutions
- **Incorporate existing shoreline protection**
  - USACE constructed revetment
  - Living shoreline protection adjacent to private homes

Previously Proposed Alternatives

- No Action
- Option 1: T-groins / Sand Beach/ Living Shoreline
- Option 2: Breakwaters / Sand Beach / Living Shoreline
- Option 3: Revetment / Living Shoreline

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NOTES:
1. [illegible]
2. [illegible]

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REVISIONS				
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OPTION 1
BREAKWATERS WITH STEMS & SAND FILL / SILL WITH MARSH

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Option 1

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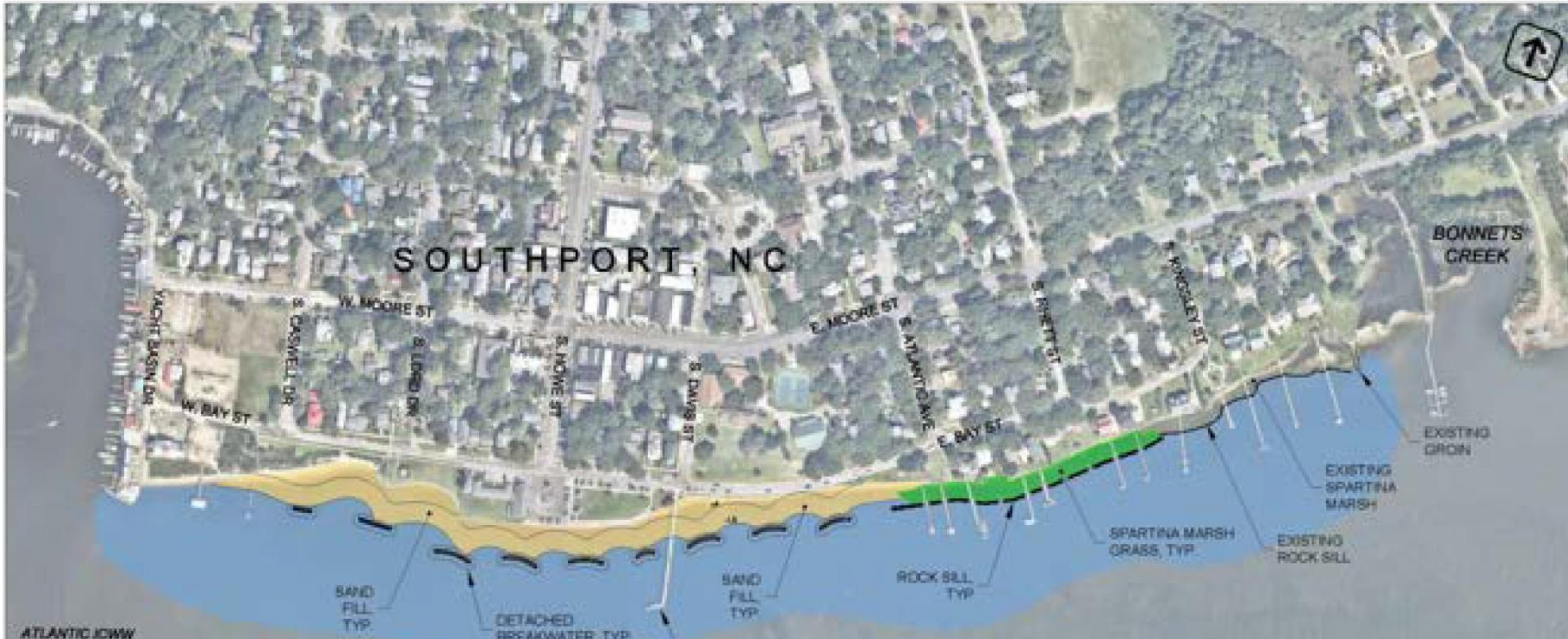

NOTES:
1. DESIGN SHORELINE = [illegible] FT NAVD88.
2. BEACH SLOPE IS ASSUMED TO BE [illegible] WITH UPPER BEACH OF [illegible]

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REVISIONS				
LTR	DESCRIPTION	BY	DATE	APPRVD

olsen

SOUTHPORT, NC
SHOREFRONT IMPROVEMENT PLAN
OPTION 2
BREAKWATERS WITH SAND FILL / SILL WITH MARSH

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CHECKED BY: [illegible]	DATE: [illegible]
REVISED BY:	DATE:

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or .e:

Option 2

olsen
associat.es, inc.

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NOTES:
1. [illegible]
2. [illegible]

SCALE
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REVISIONS				
LTR	DESCRIPTION	BY	DATE	APPRVD

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OPTION 5
REVETMENT ADD / ENHANCE ONLY
DRAWN BY: ML DATE: [illegible]
CHECKED BY: [illegible] DATE: [illegible]
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SHEET
7
of 8

Option 3

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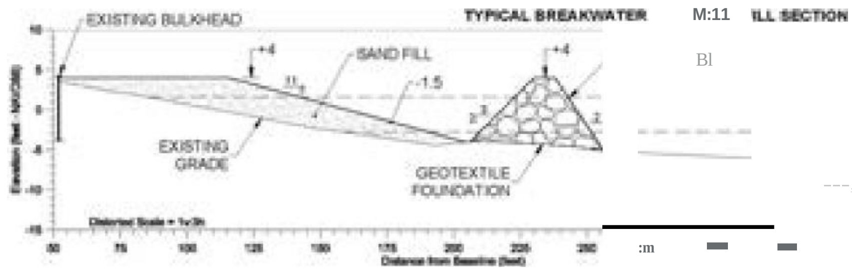
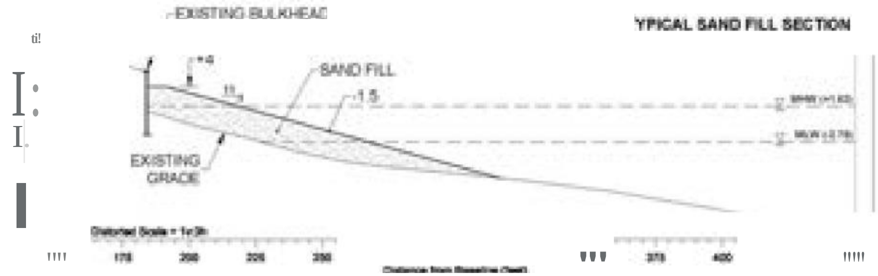
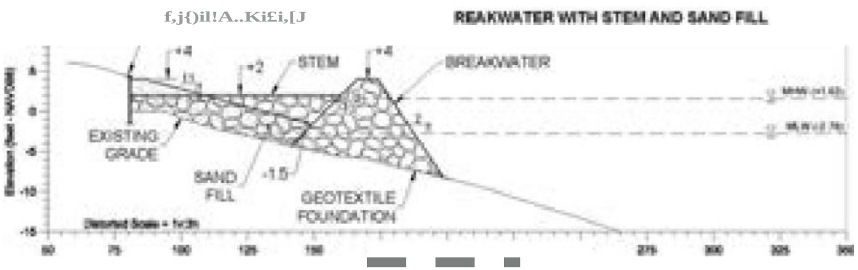
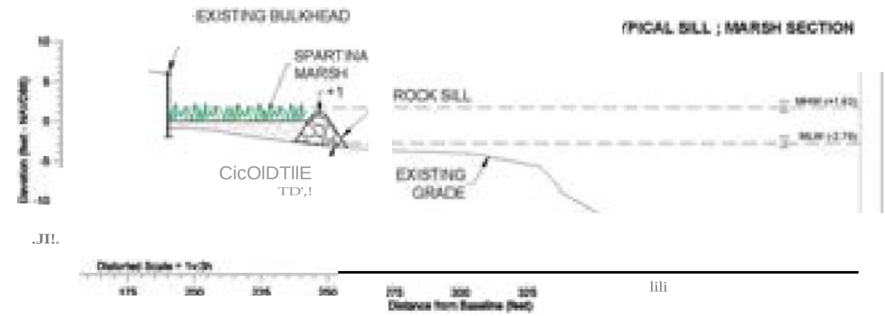
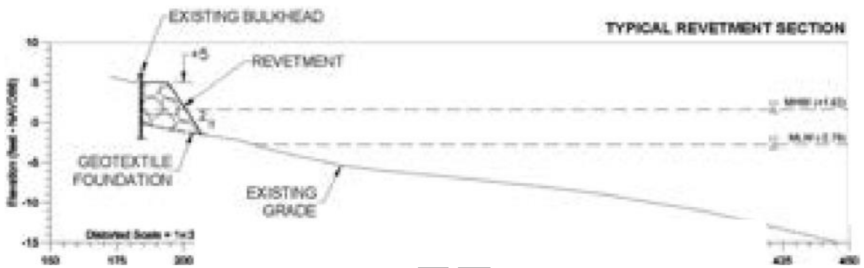










NOTES:
1. DESIGN SHORELINE = +1.3? FT NAVD88.
2. BEACH SLOPE IS ASSUMED TO BE 1V:?H WITH UPPER BEACH OF

REVISIONS				
LTR	DESCRIPTION	BY	DATE	APPR'VD

olsen

PRELIMINARY CONCEPT

SOUTHPORT
SHOREFRONT IMPROVEMENT PLAN

TYPICAL SECTIONS

SHW

8 of 8

Southport N.C. Established 1792

Typical Section Views

olsen associates, inc.

I

Next Steps

- Preferred approach confirmation
- Schematic level design update
- Regulatory agency pre-application briefing
- Permit application and agency coordination
- Final design and plans and specification development
- Bid advertisement
- Contractor selection
- Construction
- Post-construction reporting and monitoring

Considerations

- Water Depths Seaward of Project
- Available Funding
- Riparian Ownership
- Cultural Resources
- Future SLR

Current Activities

- Updated detailed topographic and hydrographic survey
- Cultural resource survey and investigation

ATTACHMENT D

Report Entitled:

An Archaeological Reconnaissance and Remote-Sensing Survey
Along the Cape Fear River Waterfront at Southport
Brunswick County, North Carolina

Volume 1: Technical Assessment

Submitted to:

Olsen Associates, Inc.
2618 Herschel Street
Jacksonville, Florida 32204

Submitted by:

Gordon P. Watts, Jr., PhD, RPA
Principal Investigator

Tidewater Atlantic Research, Inc.
P. O. Box 2494
Washington, North Carolina 27889

Submittal Date:

4 June 2023

Abstract

Olsen Associates, Inc. (Olsen) of Jacksonville, Florida is the project engineer representing the City of Southport, North Carolina in its efforts to stabilize the Cape Fear River waterfront. In order to determine the proposed project's effects on potentially significant submerged cultural resources, OA contracted with Tidewater Atlantic Research, Inc. of Washington, North Carolina to conduct a visual and remote-sensing survey of the stabilization sites. Field research for the project was conducted on 21 and 22 March, 30 March, and 21 April 2023. Remote sensing in the western areas was carried out on 11 May and 20 May 2023. The initial fieldwork was carried out following an onsite meeting with Stephen Atkinson (Underwater Archaeology Branch [UAB]) at Fort Fisher. That preliminary investigation focused on low-tide examinations of the exposed shoreline on 21 and 22 March. In the eastern portion of the project site the waterfront is characterized by existing rock sill and Spartina (marsh grass). In that area any impact will be marginal and inshore of the rock sill, the Spartina is stable. Based on the visual examination there will be no impact to archaeological resources in that area. In the area immediately west of the existing rock sill, additional rock sills will be constructed. Inshore of those rock sills the beach will be rebuilt and Spartina planted. At low tide that area of river bottom was exposed and visual investigation confirmed nothing of archaeological significance was visible. Low-tide imagery recorded by Moffatt and Nichol confirmed that observation and the conclusion that there will be no adverse impact to archaeological resources. Due to dock structures in that area, systematic sonar and magnetometer remote sensing would be both impractical and potentially hazardous. South and west of that area the proposed stabilization plans include construction of seven "Y" shaped breakwaters and two detached breakwaters all to be constructed of stone. Inshore of those structures, sand will be deposited. Low-tide visual examination and magnetic and acoustic remote sensing confirmed that neither breakwater construction nor beach nourishment will have an adverse impact on cultural resources. Remains of a lower hull structure identified as the *Roland* and documented by UAB personnel will benefit from sand placement site stabilization. Aside from that site, no submerged cultural resources were identified in the project areas that will be impacted.

Table of Contents

List of Figures

Introduction

Olsen Associates, Inc. of Jacksonville, Florida (Olsen) is the project engineer representing the City of Southport, North Carolina in its efforts to stabilize the Cape Fear River waterfront. In order to determine the proposed project's effects on potentially significant submerged cultural resources, Olsen contracted with Tidewater Atlantic Research, Inc. (TAR) of Washington, North Carolina to conduct a visual and remote-sensing survey of the stabilization site. The visual and remote sensing investigation carried out by TAR archaeologists was designed to provide accurate and reliable identification, documentation and assessment of submerged cultural resources in the study area.

The resource identification and assessment methodology was developed by TAR to comply with criteria identified in the National Historic Preservation Act of 1966 (Public Law 89-665), National Environmental Policy Act of 1969 (Public Law 11-190), Executive Order 11593, Advisory Council on Historic Preservation Procedures for the protection of historic and cultural properties (36 CFR Part 800), and updated guidelines described in 36 CFR 64 and 36 CFR 66. Results of the investigation were designed to furnish the City of Southport and Olsen with the archaeological data required to comply with submerged cultural resource legislation and regulations.

Field research for the project was conducted on 21 and 22 March, 30 March and 21 April 2023. Remote sensing in the western areas was carried out on 11 May and 20 May 2023. The initial fieldwork was carried out following an onsite meeting with North Carolina Underwater Archaeology Branch (UAB) personnel [Stephen Atkinson] at Fort Fisher. Preliminary investigation focused on low-tide examinations of the exposed shoreline on 21 and 22 March. In the eastern portion of the project site the waterfront is characterized by existing rock sill and Spartina (marsh grass). In that area any impact will be marginal and inshore of the rock sill the Spartina is stable. Based on the visual examination there will be no impact to archaeological resources.

In the area immediately west of the existing rock sill, additional rock sills will be constructed. Inshore of that rock sill the beach will be rebuilt and Spartina marsh grass planted. At low tide the river bottom between the docks and piers was exposed and visual investigation confirmed nothing of archaeological significance was observed. Low-tide imagery recorded by Moffatt and Nichol (M&N) confirmed that observation and the conclusion that there will be no adverse impact to archaeological resources. Due to dock structures in that area systematic sonar and magnetometer remote sensing would be both impractical and potentially hazardous.

South and west of those areas the proposed stabilization plans include construction of seven "Y" shaped breakwaters and two detached breakwaters all proposed to be constructed of stone. Inshore of those structures sand will be deposited. Low-tide visual examination and magnetic and acoustic remote sensing confirm that neither breakwater construction nor beach nourishment will have an adverse impact on potentially significant cultural resources. Remains of a lower hull structure identified as the *Roland* (documented by UAB personnel) will not be impacted by sill construction and the documented vessel remains will benefit from sand placement site stabilization. Aside from that site no submerged cultural resources were identified in the project areas that will be impacted.

Project Personnel

Project survey personnel included Principal Investigator Gordon P. Watts, Jr. and Remote-Sensing Operators Harry Pecorelli and Wayne Strickland. Senior Historian Robin Arnold carried out the historical and literature research. Dr. Watts analyzed the remote-sensing data. Dr. Watts and Ms. Arnold prepared this report.

Project Location

The Southport survey site is located off the city's waterfront on the west side of the Cape Fear River. The proposed shoreline stabilization will extend from a point northwest of the entrance to the intracoastal waterway channel to a second point west-southwest of the entrance to Bonnets Creek (Figure 1).

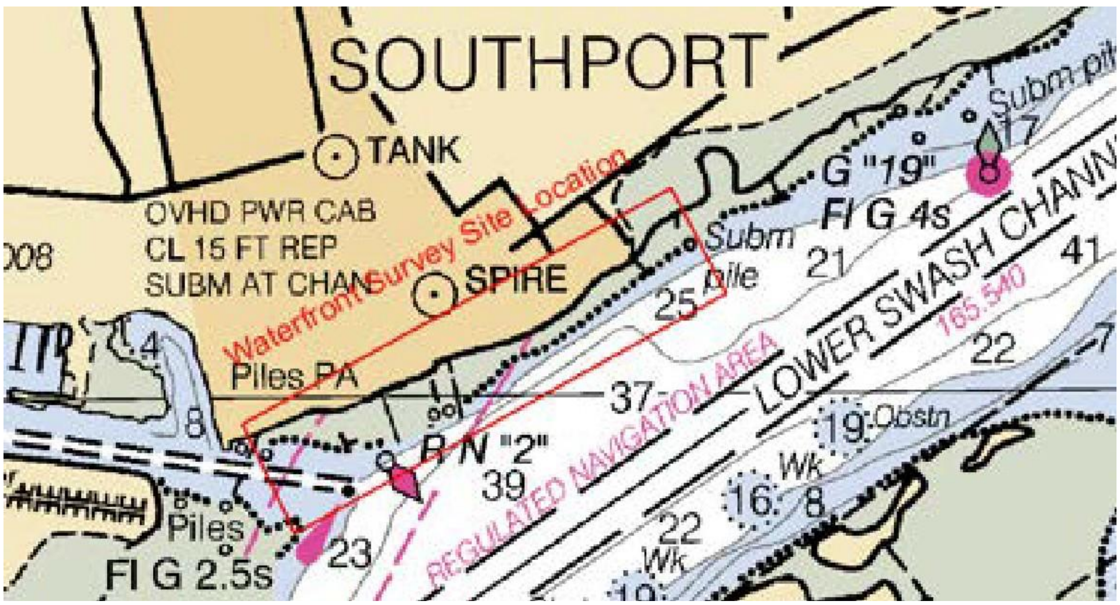


Figure 1. Detail of project location chart Cape Fear River No. 11537-1 1970.

The area investigated extends for roughly 3000 feet along the Southport waterfront. The northeast section of that waterfront is characterized by an existing rock sill. That feature extends from a point northeast of a rock groin west of the mouth of Bonnets Creek to a second point approximately 685 feet southwest. That section of the riverfront is characterized by Spartina marsh protected by rock sill (Figure 2). Southwest of that northeastern section of the project area the waterfront is not currently protected. The proposed project plan includes constructing 11 rock sills. Those sills will be constructed along the low-tide line and parallel to the beach and extend approximately 850 feet to the southwest. Inshore of those rock sill features, Spartina will be planted.

Figure 2. Northeast and center sections of Southport waterfront stabilization plan (courtesy of Olsen).

The third section of the project area extends farther west to a point north-northeast of the entrance to the Intracoastal Waterway. In that area, shoreline stabilization will include construction of nine breakwater sill structures. Seven of those breakwater sills are shaped like an inverted "Y" with stems pointing to the shoreline. Near the west section, the remaining two breakwater sills will have no stems and will be constructed parallel to the shoreline near the low-tide line. Between the proposed breakwaters and the shoreline, sand will be deposited to cover debris and to form a beach (Figure 3).

Figure 3. Western section of waterfront stabilization plan (courtesy of Olsen).

Description of Field Investigations

Field investigations related to the Southport waterfront survey project commenced with a visit to the UAB located at Fort Fisher. Principal Investigator Gordon Watts met with Assistant State Archaeologist Stephen Atkinson on 21 March 2023 to discuss the project and fieldwork carried out in the project area and immediate vicinity by UAB personnel. Mr. Atkinson provided information on the investigation and documentation of shoreline vessel remains identified as the *Roland* (Figure 4). He provided sonar data from a remote-sensing survey UAB collected during its remote-sensing survey along the Southport waterfront.

Figure 4. *Roland* aground and abandoned off the Southport waterfront.

Following the 21 March UAB consultation, the remainder of 21 March and 22 March 2023 were devoted to making low-tide observations along the Southport waterfront. Rock sill along the eastern section shoreline characterized that segment of the project area. Inshore of the rock sill and bulkhead on private property, Spartina contributed to a stable waterfront (Figure 5). No evidence of cultural features or material was identified and no additional investigation is recommended in this area of the project as proposed.

Figure 5. Eastern section of the shoreline illustrating bulkheads, Spartina and rock sill.

In the central area of the proposed project, the shoreline is unprotected but relatively stable under normal circumstances (Figures 6 and 7). Outside private property bulkheads, only patches of Spartina contribute to stability. Proposed construction of rock sills parallel to the shoreline throughout that area will no doubt contribute significantly to enhanced stability. Shoreline stability will be further enhanced by beach nourishment and Spartina planting inside the proposed rock sills. Out to, and including, the area of proposed sill construction no evidence of cultural features or material was identified. Consequently, no additional investigation is recommended in this area of the project as proposed.

Figure 6. Central area shoreline looking northeast.

Figure 7. Central area shoreline looking southwest.

In the western area of the proposed project, the eroded shoreline is partially protected by sill (Figures 8 and 9). Virtually no Spartina exists in this section of the shoreline to contribute to stability. Much of the shoreline is littered with debris from stabilization efforts and previous structures (Figure 10). Proposed construction of nine rock sill breakwater features and beach nourishment will no doubt contribute significantly to enhanced stability and public beach access. Out to the area of sill construction, only one potentially significant cultural resource feature has been identified. That feature was identified by UAB personnel as the lower hull remains of the abandoned vessel *Roland* (Figure 11).

Figure 8. Western area shoreline looking east from city pier.

Figure 9. Western area shoreline looking west from pilot facility bulkhead.

Figure 10. Southport waterfront and structures prior to 1954 Hurricane Hazel event (courtesy of Wayne Strickland).

Figure 11. Photomosaic of hull remains identified as the *Roland* (courtesy of UAB).

To reliably identify submerged cultural resources in the western section of the project area below the low-tide line, TAR archaeologists also conducted a remote-sensing survey. All survey activities were conducted from the 25-foot vessel *Scuba South III* (Figure 12).

Figure 12. 25-foot Sea Hawk *Scuba South III* (courtesy of Wayne Strickland).

In order to fulfill the requirements for survey activities in North Carolina, magnetic and acoustic remote-sensing equipment were employed. This combination of remote sensing represents the state of the art in submerged cultural resource location technology and offers the most reliable and cost-effective method to locate and identify potentially significant targets. Data collection was controlled using a differential global positioning system (DGPS). DGPS produces the highly accurate coordinates necessary to support a sophisticated navigation program and assures reliable target location.

An EG&G GEOMETRICS G-858 cesium magnetometer, capable of plus or minus 0.001 gamma resolution, was employed to collect magnetic data in the survey area. To produce the most comprehensive magnetic record, data was collected at 10 samples per second. Due to shallow water within the project area, the magnetometer sensor was bow mounted. Magnetic data were recorded as a data file associated with the computer navigation system. Data from the survey were contour plotted using QUICKSURF computer software to facilitate anomaly location and definition of target signature characteristics. All magnetic data were correlated with the acoustic remote sensing records.

A HUMMINGBIRD 1199 digital sidescan sonar was used due to very shallow water in much of the survey area. CHESAPEAKE TECHNOLOGY SONARWIZ.MAP data processing software was employed to review and analyze acoustic data from the survey area. Due to shallow water within the project area, the sidescan sonar transducer was hull mounted. Acoustic data were collected using a range scale of 30 meters to provide a combination of 300% coverage and high-target signature definition. Acoustic data were recorded as a digital file and tied to the magnetic and positioning data by the computer navigation system.

A TRIMBLE AgGPS was used to control navigation and data collection in the survey area. That system has an accuracy of plus or minus three feet, and can be used to generate highly accurate coordinates for the computer navigation system. The DGPS was employed in conjunction with an onboard 2.4 GHz laptop loaded with HYPACK navigation and data collection software. All magnetic and acoustic records were tied to positioning events generated by HYPACK. Positioning data generated by the navigation system were tied to magnetometer records by regular annotations to facilitate target location and anomaly analysis. All data is related to the North Carolina State Plane Coordinate System, NAD 83, U.S. Survey Foot.

Data Analysis

To ensure reliable magnetic anomaly and acoustic target identification and assessment, preliminary analysis of the magnetic and acoustic data was carried out as it was generated. For final analysis QUICKSURF contouring software, magnetic data generated during the survey were contour plotted at 10-gamma intervals for analysis and accurate location of magnetic anomalies. The magnetic data was examined for anomalies that were isolated and analyzed in accordance with intensity, duration, areal extent and signature characteristics. Sonar records were analyzed to identify targets on the basis of configuration, areal extent, target intensity and contrast with background, elevation and shadow image, and were also reviewed for possible association with identified magnetic anomalies.

Data generated by the remote-sensing equipment were developed to support an assessment of each magnetic and acoustic signature. Analysis of each target signature included consideration of magnetic and sonar signature characteristics previously demonstrated to be reliable indicators of historically significant submerged cultural resources. Assessment of each target includes avoidance options and possible adjustments to avoid potential cultural resources.

Where avoidance is not possible the assessment includes recommendations for additional investigation to determine the exact nature of the cultural material generating the signature and its potential National Register of Historic Places significance. Historical evidence was developed into a background context which identified possible correlations with magnetic targets (Volume 2). A magnetic contour map of the western survey areas was produced to aid in the analysis of magnetic and acoustic targets.

Description of Findings

Visual surveys of the eastern and center Southport waterfront project areas identified no evidence of potentially significant cultural resources. In the northeastern project area extent, shoreline sill and Spartina have created a stable shoreline environment (Figure 13). There are no potentially significant cultural resources in this area that are currently threatened.

Figure 13. Eastern Southport shoreline environment aerial image (courtesy of McKim & Creed [M&C]).

In the central area immediately to the west, the shoreline is currently stabilized by bulkheads on private property (Figure 14). There, shoreline erosion has progressed and high tides currently reach private property bulkheads. In that area, low-tide visual surveys confirmed that construction of proposed sills and inshore planting of Spartina will not impact any potentially significant cultural resources.

Figure 14. Central Southport shoreline environment aerial image (courtesy of M&C).

In the western area east of the Southport pier, the majority of shoreline adjacent to Bay Street is currently stabilized by rock sill (Figure 15). There, shoreline erosion has progressed and high tides currently reach the foot of the rock sill. In that area, low-tide visual surveys and remote sensing confirmed that construction of proposed sills and inshore creation of a sand beach will not impact any potentially significant cultural resources.

Figure 15. East section of the western area shoreline aerial image (courtesy of M&C).

In this area of the Southport waterfront, the TAR magnetic remote sensing survey identified 10 anomalies. Plotting those anomalies and the associated magnetic contours confirmed that only one small anomaly, SP-L2-A1-NM-36.3g-66f, corresponded with one of the proposed sill breakwater structures (Figure 16). That anomaly does not have signature characteristics that suggest an association with a potentially significant submerged cultural resource.

Sidescan sonar data in this section of the Southport waterfront confirmed that material generating the detected magnetic anomalies was not exposed. In addition, sonar coverage confirmed that no bottom surface evidence of potentially significant magnetic or non-magnetic submerged cultural material was exposed (Figure 17).

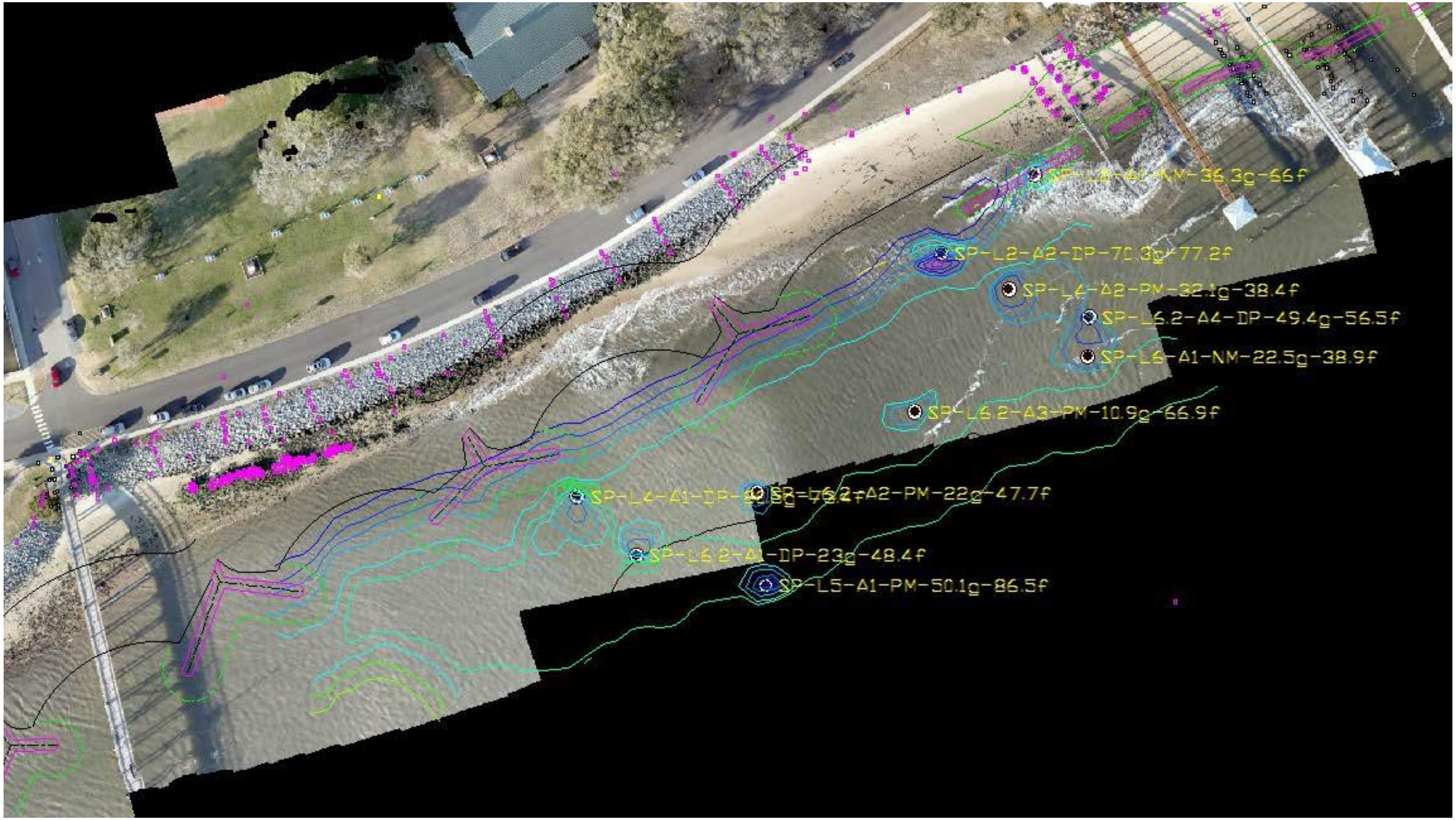


Figure 16. East section of the western area shoreline superimposed with TAR anomalies, contours and proposed breakwater features (courtesy of M&C).

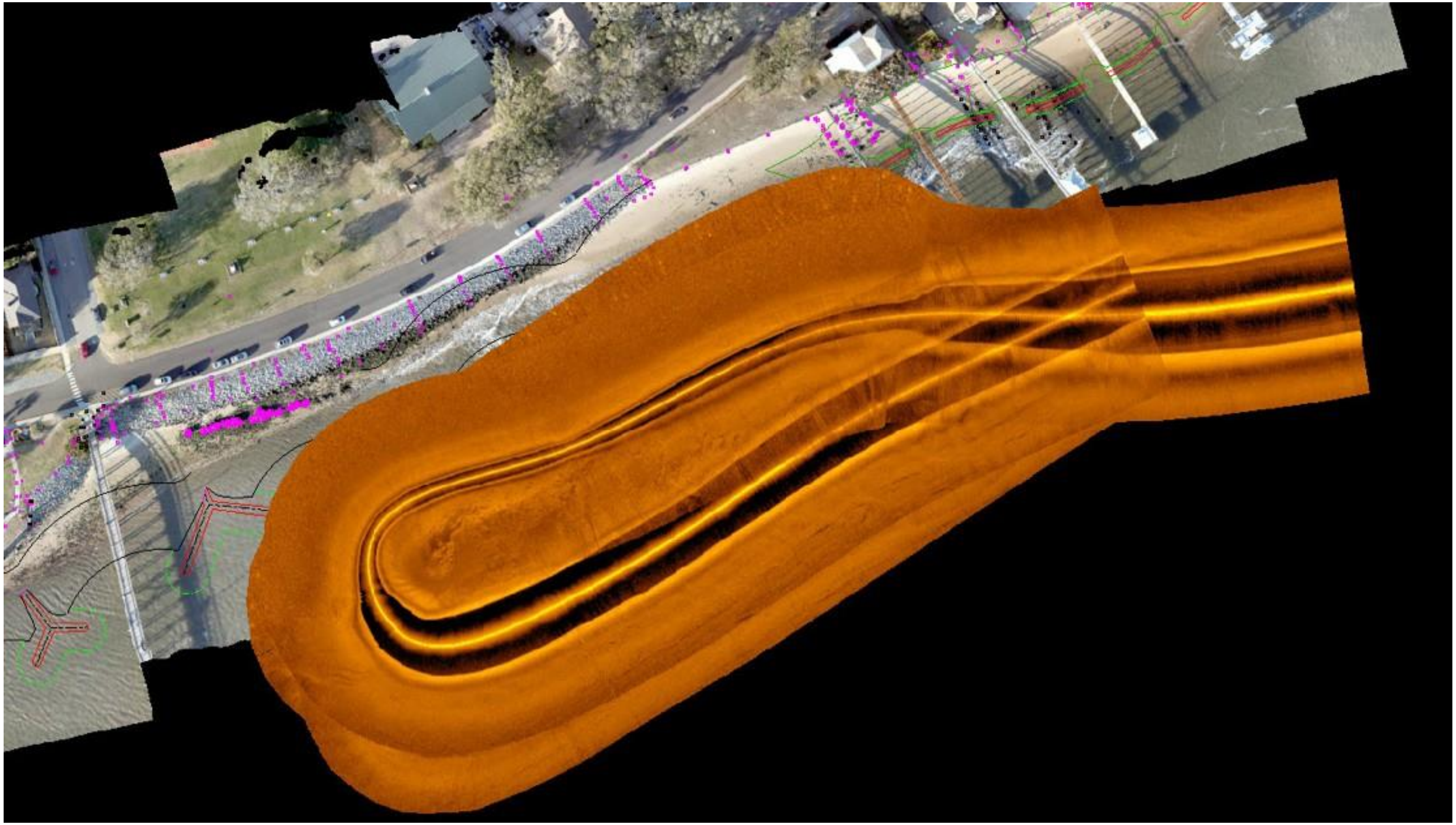


Figure 17. East section of the western area shoreline superimposed with TAR sonar coverage (courtesy of M&C).

In the western area west of the Southport pier, the eastern portion of that shoreline adjacent to Bay Street is currently stabilized by rock sill and bulkhead structures (Figure 18). There, shoreline erosion has progressed and high tides currently reach the foot of the rock sill. In that area low-tide visual surveys and remote sensing confirmed that the construction of proposed sills and inshore creation of a sand beach will not impact any potentially significant cultural resources.

Figure 18. West section of the western area shoreline aerial image (courtesy of M&C).

In this area of the Southport waterfront, the TAR magnetic remote-sensing survey identified 21 anomalies (Figure 19). Plotting those anomalies and the associated magnetic contours confirmed that none of the anomalies correspond geographically with the proposed breakwater structures.

Sidescan sonar data in this section of the Southport waterfront confirmed that material generating the magnetic anomalies was not exposed. In addition, sonar coverage confirmed that no bottom-surface evidence of potentially significant magnetic or non-magnetic submerged cultural material was exposed (Figure 20).

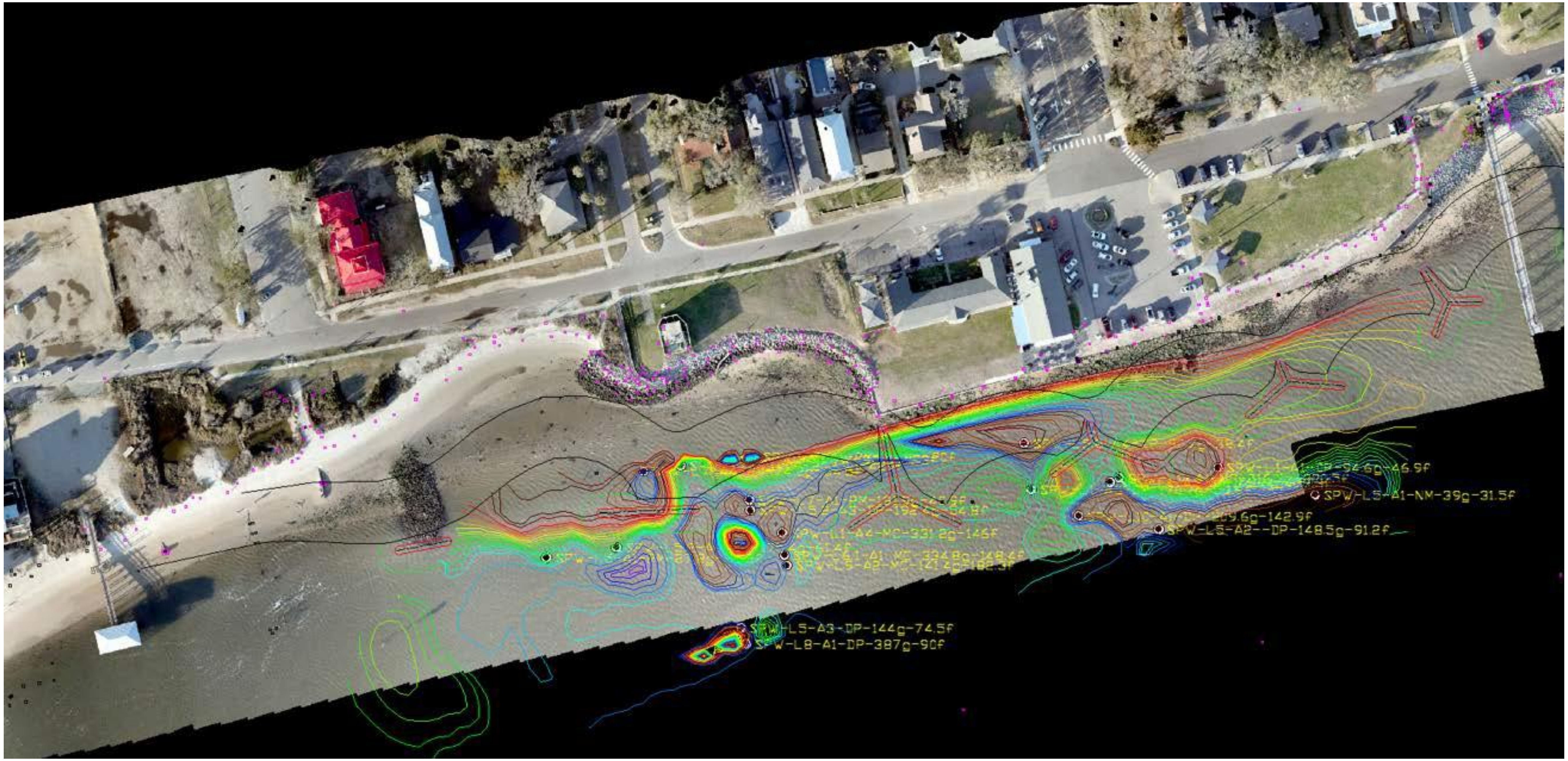


Figure 19. West section of the western area shoreline superimposed with TAR magnetic anomalies, contours and proposed breakwater features (courtesy of M&C).

Figure 20. West section of the western area superimposed with TAR sonar coverage (courtesy of M&C).

Conclusions and Recommendations

A survey of archival and archaeological literature and background research confirmed evidence of sustained historic maritime activity associated with the Southport waterfront. That activity began in the eighteenth century and continued through the twentieth century. The aerial photograph of Southport before the Hurricane Hazel event (Figure 10) clearly illustrated that development. It also documents the extent to which the proposed waterfront stabilization sill features lie within the historical terrestrial environment. That image also documents the extent of commercial maritime features extending beyond the shoreline that are responsible for much of the ferrous debris offshore of the proposed stabilization features.

The single exception appears to be the remains of a twentieth-century vessel identified by UAB as the *Roland*. Those lower hull remains were documented using photography (Figure 11) and by measured drawings recorded by UAB personnel Chris Southerly, Stephen Atkinson, and Madeline Spencer in July 2022 (Figure 21).

The surviving remains of the vessel lie immediately west of the Southport pilot station bulkhead and will be close to (and north of the inshore end of) the proposed western "Y" breakwater stem. While the breakwater and sand fill will provide protection for the surviving lower hull remains, the site should be carefully avoided during breakwater construction and beach sand placement. In the event that is not possible, additional investigation and documentation of the surviving hull remains is recommended to preserve design and construction data.

Figure 21. UAB personnel documenting exposed lower hull remains immediately west of the Southport pilot facility bulkhead (courtesy of UAB).

Aside from those previously investigated vessel remains, the TAR visual and remote sensing investigation of the proposed Southport shoreline stabilization area confirmed that no additional historically significant cultural material might be impacted. In the eastern portion of the project site the waterfront is characterized by existing rock sill and Spartina. In that area any existing sill feature adaptation impact will be marginal. Inshore of the rock sill the Spartina is stable. Based on the visual examination there will be no impact to potentially significant archaeological resources in this section of the proposed project.

In the area immediately west of the existing rock sill, construction of 11 additional rock sills are proposed between existing pier and dock structures. Inshore of the proposed rock sills the beach will be rebuilt with fill and Spartina will be planted. At low tide, the river bottom between the docks and piers was exposed. A visual investigation of the proposed location of new sills confirmed nothing of archaeological significance was exposed. That on site observation was additionally reinforced by low-tide drone imagery recorded by M&N. Based on low-tide observations and aerial images there will be no adverse construction, fill or Spartina planting impact to potentially significant archaeological resources in this section of the proposed project.

South and west of those areas, the proposed stabilization plans include construction of seven "Y" shaped breakwaters and two detached breakwaters to be constructed of stone. Inshore of those structures sand will be deposited. With the exception of the lower-hull structure documented by UAB, several low-tide visual examinations in this area identified no additional potentially significant cultural resources. Magnetic and acoustic remote sensing in the sections of this area on either side of the Southport pier were carried out to cover the bottom surface not exposed during low tides. Sonar imagery identified no potentially significant acoustic targets.

Magnetometer data identified 10 anomalies in the project area east of the pier. One small anomaly, SP-L2-A1-NM-36.3g-66f, was identified at the location of the western breakwater structure in the previous section. None of the remaining anomalies correspond with the locations of proposed breakwaters (Figure 22). None of the anomalies have associated sonar targets indicating that material generating those signatures is buried. In this section low-tide visual examinations and sonar remote sensing identified no submerged cultural resources that will be impacted by project related construction.

Magnetometer data identified 21 anomalies in the western project area west of the pier. None of those anomalies correspond with the locations of proposed breakwater structures (Figure 23).

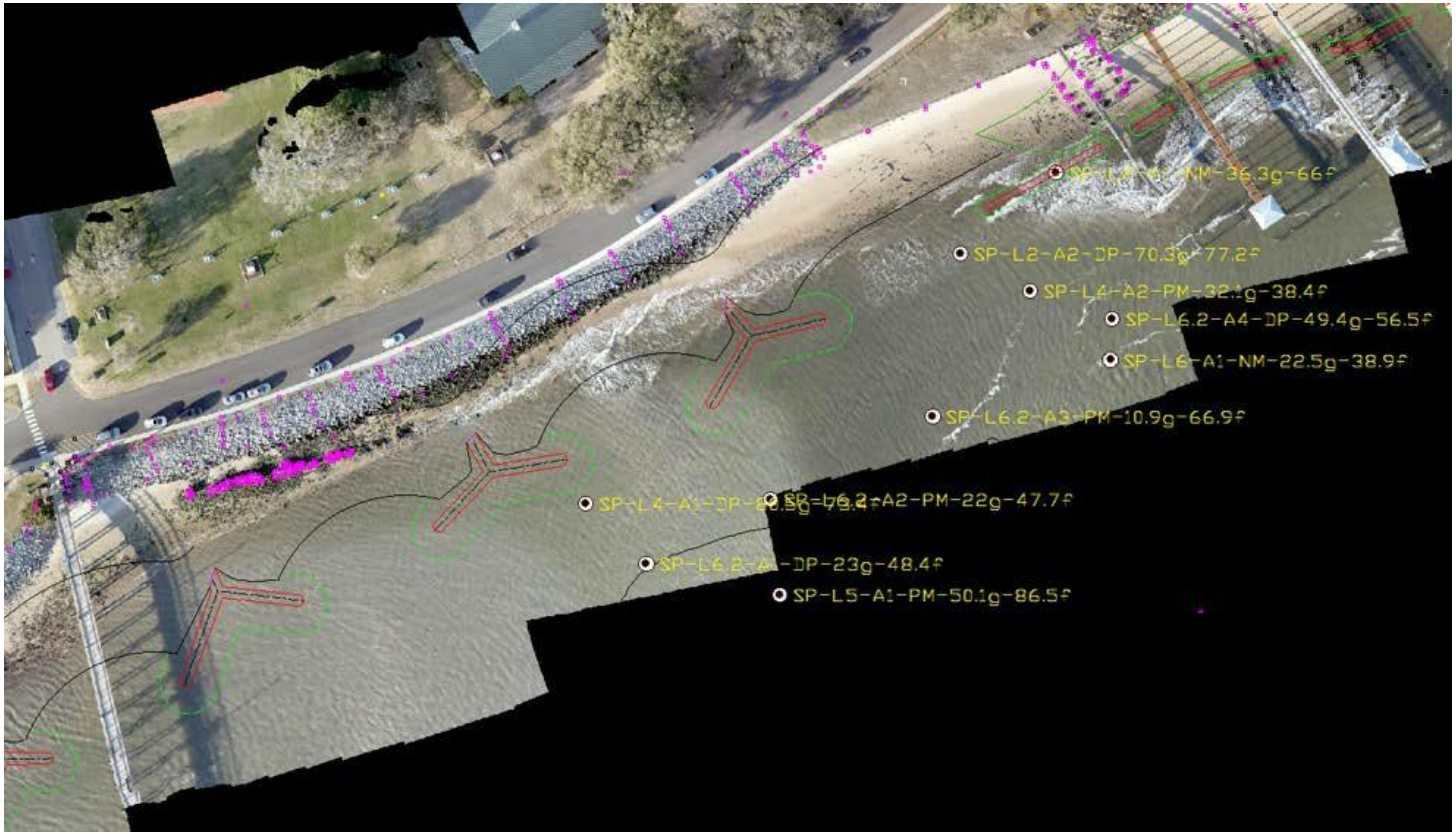


Figure 22. East section of the western area superimposed with TAR anomalies and proposed breakwater structures (courtesy of M&C).

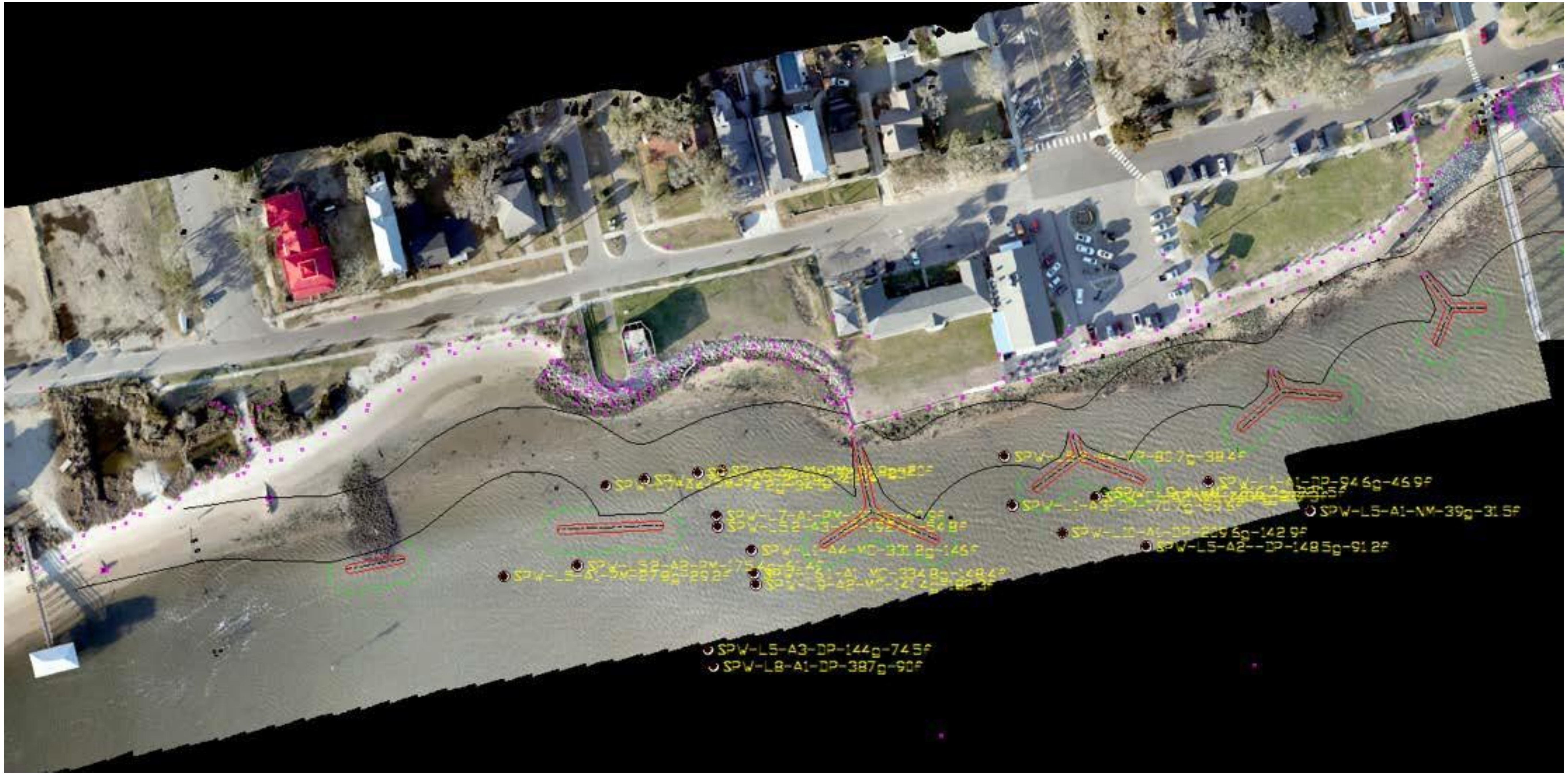


Figure 23. West section of the western area superimposed with TAR anomalies and proposed breakwater structures (courtesy of M&C).

None of the magnetic anomalies have associated sonar targets indicating that material generating those signatures is buried. In this section low tide visual examinations confirmed only the lower hull remains west of the Southport pilot station bulkhead represent a potentially significant cultural resource. If avoided, those remains will not be impacted by breakwater construction. Stabilization feature construction and beach fill can actually contribute significantly to their preservation. Aside from that site no submerged cultural resources were identified in the project areas that will be impacted.

Unexpected Discovery Protocol

In the event that any Southport waterfront project activities expose prehistoric or historic cultural material not identified during the remote-sensing survey, the construction company under contract should be required to *immediatel*y notify the designated point of contact for the City of Southport, North Carolina State Historic Preservation Office (Raleigh), the UAB (Fort Fisher), and Olsen. Notification should address the location, where possible, the nature of material exposed by project activities, and options for *immediate* archaeological inspection and assessment of the site(s).

Appendix A

APPENDIX A: MAGNETIC ANOMALY TABLE

X Coordinate	Y Coordinate	Area	Line #	Anomaly #	Signature	Intensity	Duration	Analysis	Assessment
2298723.89	62540.14	Southport East	L2	A1	Negative Monopolar	36.3g	66f	Small Ferrous Object	Not Significant
2298659.87	62485.94	Southport East	L2	A2	Dipolar	70.3g	77.2f	Small Ferrous Object	No Potential Impact
2298409.25	62318.62	Southport East	L4	A1	Dipolar	80.5g	73.4f	Small Ferrous Object	No Potential Impact
2298706.4	62461.11	Southport East	L4	A2	Positive Monopolar	32.1g	38.4f	Small Ferrous Object	No Potential Impact
2298539.23	62257.46	Southport East	L5	A1	Positive Monopolar	50.1g	86.5f	Small Ferrous Object	No Potential Impact
2298760.44	62414.87	Southport East	L6	A1	Negative Monopolar	22.5g	38.9f	Small Ferrous Object	No Potential Impact
2298449.99	62278.39	Southport East	L6.2	A1	Dipolar	23g	48.4f	Small Ferrous Object	No Potential Impact
2298533.12	62321.23	Southport East	L6.2	A2	Positive Monopolar	22g	47.7f	Small Ferrous Object	No Potential Impact
2298641.57	62377.05	Southport East	L6.2	A3	Positive Monopolar	10.9g	66.9f	Small Ferrous Object	No Potential Impact
2298761.54	62442.11	Southport East	L6.2	A4	Dipolar	49.4g	56.5f	Small Ferrous Object	No Potential Impact
2297793	61985.12	Southport West	L1	A1	Dipolar	94.6g	46.9f	Small Ferrous Object	No Potential Impact
2297687.62	61971.03	Southport West	L1	A2	Negative Monopolar	143.4g	35f	Moderate Ferrous Object	No Potential Impact
2297610.08	61963.66	Southport West	L1	A3	Dipolar	170.7g	59.6f	Moderate Ferrous Object	No Potential Impact
2297366.09	61921.42	Southport West	L1	A4	Multicomponent	331.2g	146f	Moderate Ferrous Object(s)	No Potential Impact
2297888.28	61958.47	Southport West	L5	A1	Negative Monopolar	39g	31.5f	Small Ferrous Object	No Potential Impact
2297734.84	61925.12	Southport West	L5	A2	Dipolar	148.5g	91.2f	Moderate Ferrous Object	No Potential Impact
2297325.69	61828.7	Southport West	L5	A3	Dipolar	144g	74.5f	Moderate Ferrous Object	No Potential Impact
2297135.21	61897.17	Southport West	L5	A1	Positive Monopolar	27.8g	29.2f	Small Ferrous Object	No Potential Impact
2297203.88	61907.21	Southport West	L5.2	A2	Positive Monopolar	175.4g	61.4f	Moderate Ferrous Object	No Potential Impact
2297334.93	61943.47	Southport West	L5.2	A3	Dipolar	192.4g	54.8f	Moderate Ferrous Object	No Potential Impact
2297603.09	62009.02	Southport West	L5.2	A4	Dipolar	80.7g	38.4f	Small Ferrous Object	No Potential Impact
2297368.31	61899.5	Southport West	L6.1	A1	Multicomponent	334.8g	148.4f	Moderate Ferrous Object(s)	No Potential Impact
2297333.73	61953.62	Southport West	L7	A1	Positive Monopolar	191.9g	40.9f	Moderate Ferrous Object	No Potential Impact
2297330.71	61813.05	Southport West	L8	A1	Dipolar	387g	90f	Small Ferrous Object	No Potential Impact
2297696.21	61975.45	Southport West	L9	A1	Multicomponent	216.3g	220.5f	Moderate Ferrous Object(s)	No Potential Impact
2297370.68	61889.62	Southport West	L9	A2	Multicomponent	141.4g	182.3f	Moderate Ferrous Object(s)	No Potential Impact
2297656.46	61937.86	Southport West	L10	A1	Dipolar	209.6g	142.9f	Moderate Ferrous Object	No Potential Impact
2297338.76	61995.93	Southport West	L7	A1	Positive Monopolar	77.8g	20f	Small Ferrous Object	No Potential Impact
2297316.2	61993.64	Southport West	L7	A2	Positive Monopolar	92.3g	23f	Small Ferrous Object	No Potential Impact
2297266.63	61987.26	Southport West	L7	A3	Dipolar	203.8g	42.1f	Moderate Ferrous Object	No Potential Impact
2297230.24	61981.69	Southport West	L7	A4	Positive Monopolar	74.2g	34.5f	Small Ferrous Object	No Potential Impact

ATTACHMENT E

NOTES:

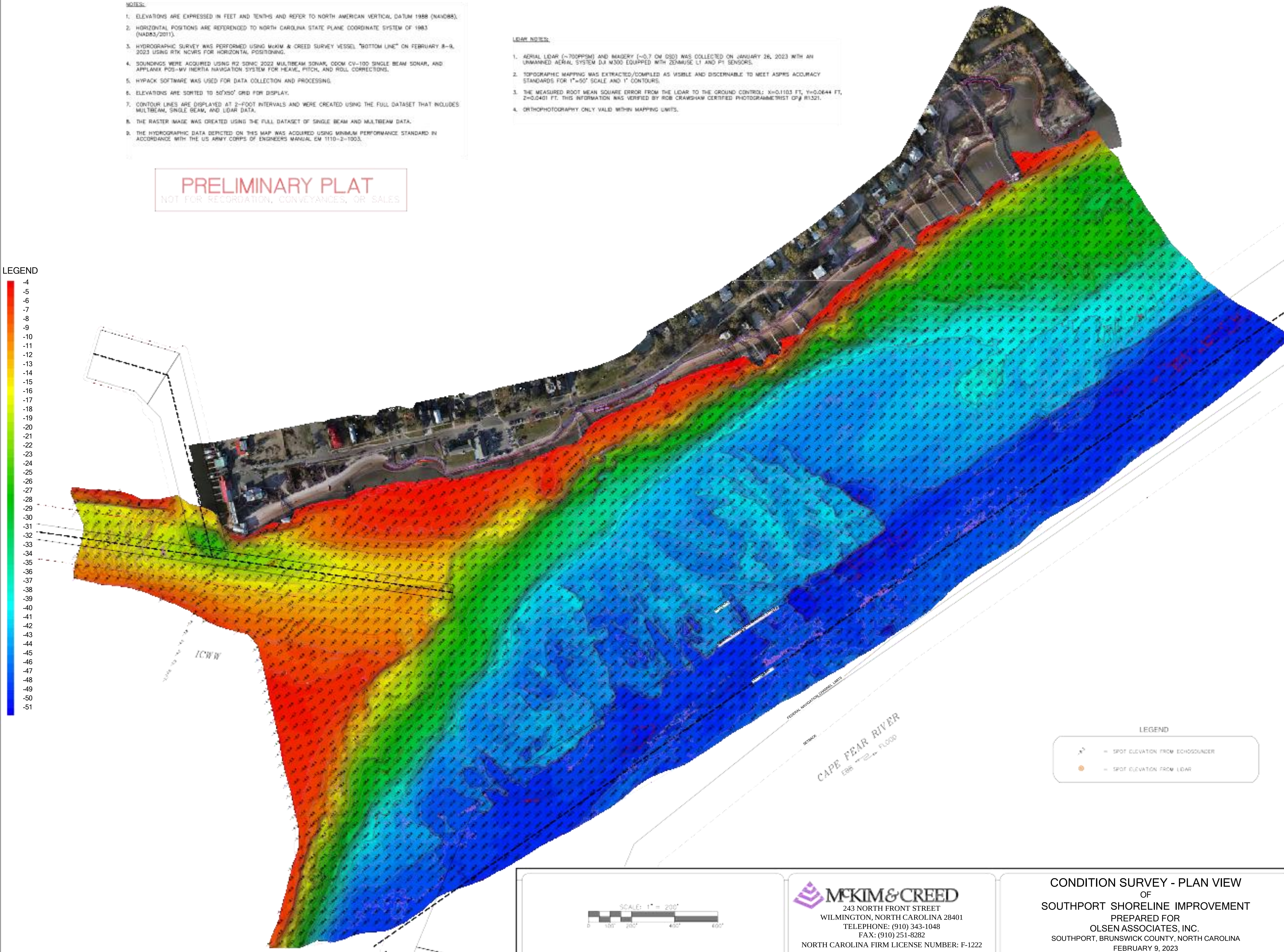
1. ELEVATIONS ARE EXPRESSED IN FEET AND TENTHS AND REFER TO NORTH AMERICAN VERTICAL DATUM 1988 (NAVD88).
2. HORIZONTAL POSITIONS ARE REFERENCED TO NORTH CAROLINA STATE PLANE COORDINATE SYSTEM OF 1983 (NAD83/2011).
3. HYDROGRAPHIC SURVEY WAS PERFORMED USING McKIM & CREED SURVEY VESSEL "BOTTOM LINE" ON FEBRUARY 8–9, 2023 USING RTK NCVRS FOR HORIZONTAL POSITIONING.
4. SOUNDINGS WERE ACQUIRED USING R2 SONIC 2022 MULTIBEAM SONAR, ODOM CV-100 SINGLE BEAM SONAR, AND APPLANIX POS-MV INERTIA NAVIGATION SYSTEM FOR HEAVE, PITCH, AND ROLL CORRECTIONS.
5. HYPACK SOFTWARE WAS USED FOR DATA COLLECTION AND PROCESSING.
6. ELEVATIONS ARE SORTED TO 50'X50' GRID FOR DISPLAY.
7. CONTOUR LINES ARE DISPLAYED AT 2-FOOT INTERVALS AND WERE CREATED USING THE FULL DATASET THAT INCLUDES MULTIBEAM, SINGLE BEAM, AND LIDAR DATA.
8. THE RASTER IMAGE WAS CREATED USING THE FULL DATASET OF SINGLE BEAM AND MULTIBEAM DATA.
9. THE HYDROGRAPHIC DATA DEPICTED ON THIS MAP WAS ACQUIRED USING MINIMUM PERFORMANCE STANDARD IN ACCORDANCE WITH THE US ARMY CORPS OF ENGINEERS MANUAL EM 1110-2-1003.

LIDAR NOTES:

1. AERIAL LIDAR (~700PPSM) AND IMAGERY (~0.7 CM GSD) WAS COLLECTED ON JANUARY 26, 2023 WITH AN UNMANNED AERIAL SYSTEM DJI M300 EQUIPPED WITH ZENMUSE L1 AND P1 SENSORS.
2. TOPOGRAPHIC MAPPING WAS EXTRACTED/COMPILED AS VISIBLE AND DISCERNABLE TO MEET ASPRS ACCURACY STANDARDS FOR 1"=50' SCALE AND 1' CONTOURS.
3. THE MEASURED ROOT MEAN SQUARE ERROR FROM THE LIDAR TO THE GROUND CONTROL: X=0.1103 FT, Y=0.0644 FT, Z=0.0401 FT. THIS INFORMATION WAS VERIFIED BY ROB CRAWSHAW CERTIFIED PHOTOGRAMMETRIST CP# R1321.
4. ORTHOPHOTOGRAPHY ONLY VALID WITHIN MAPPING LIMITS.

PRELIMINARY PLAT
NOT FOR RECORDATION, CONVEYANCES, OR SALES

VICINITY MAP – NOT TO SCALE



LEGEND

= SPOT ELEVATION FROM ECHOSOUNDER

= SPOT ELEVATION FROM LIDAR

SCALE: 1" = 200'

0 100' 200' 400' 600'

McKIM&CREED
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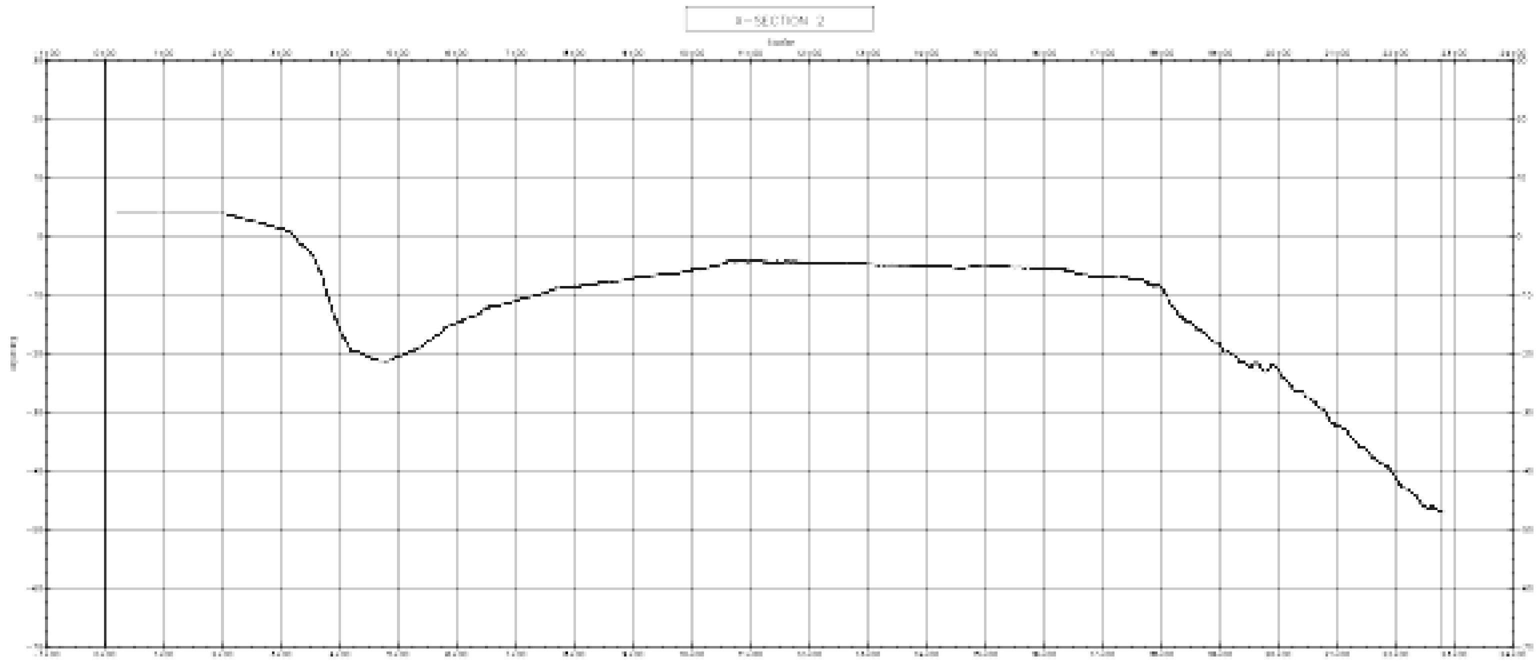
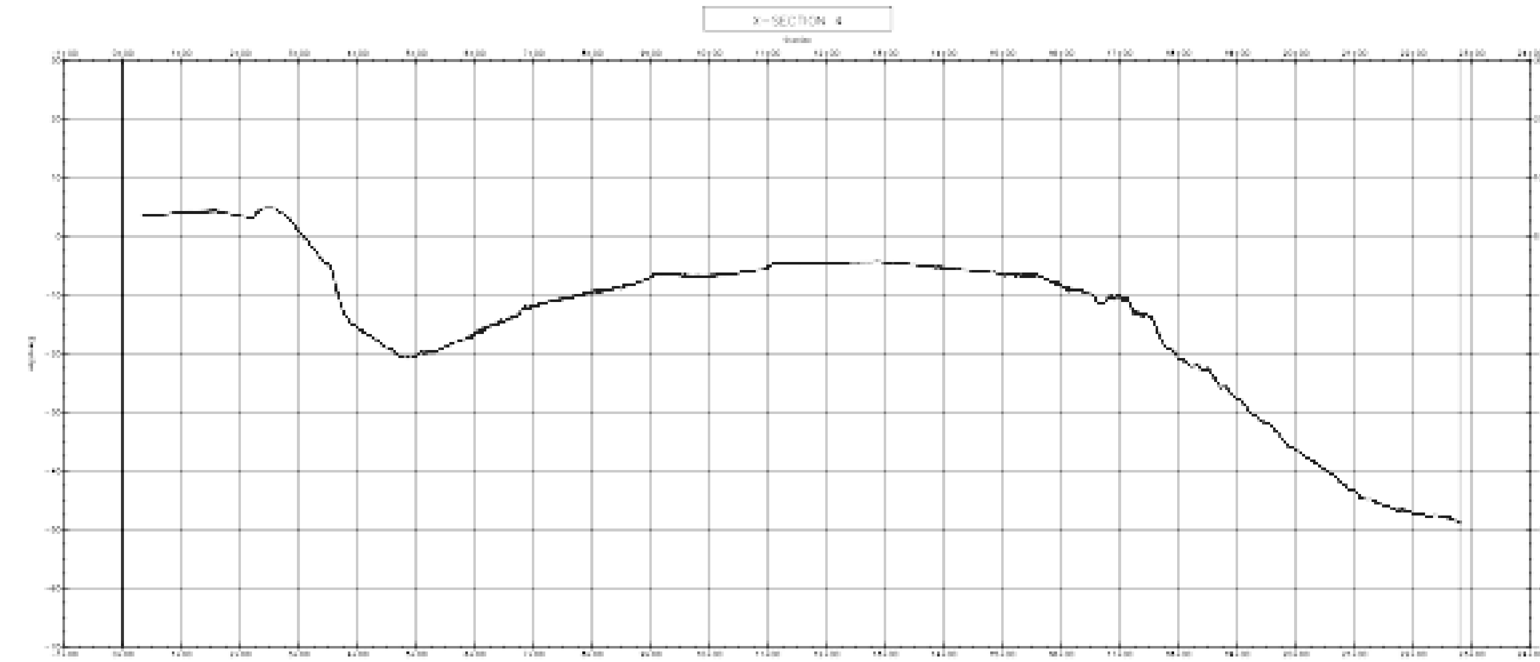
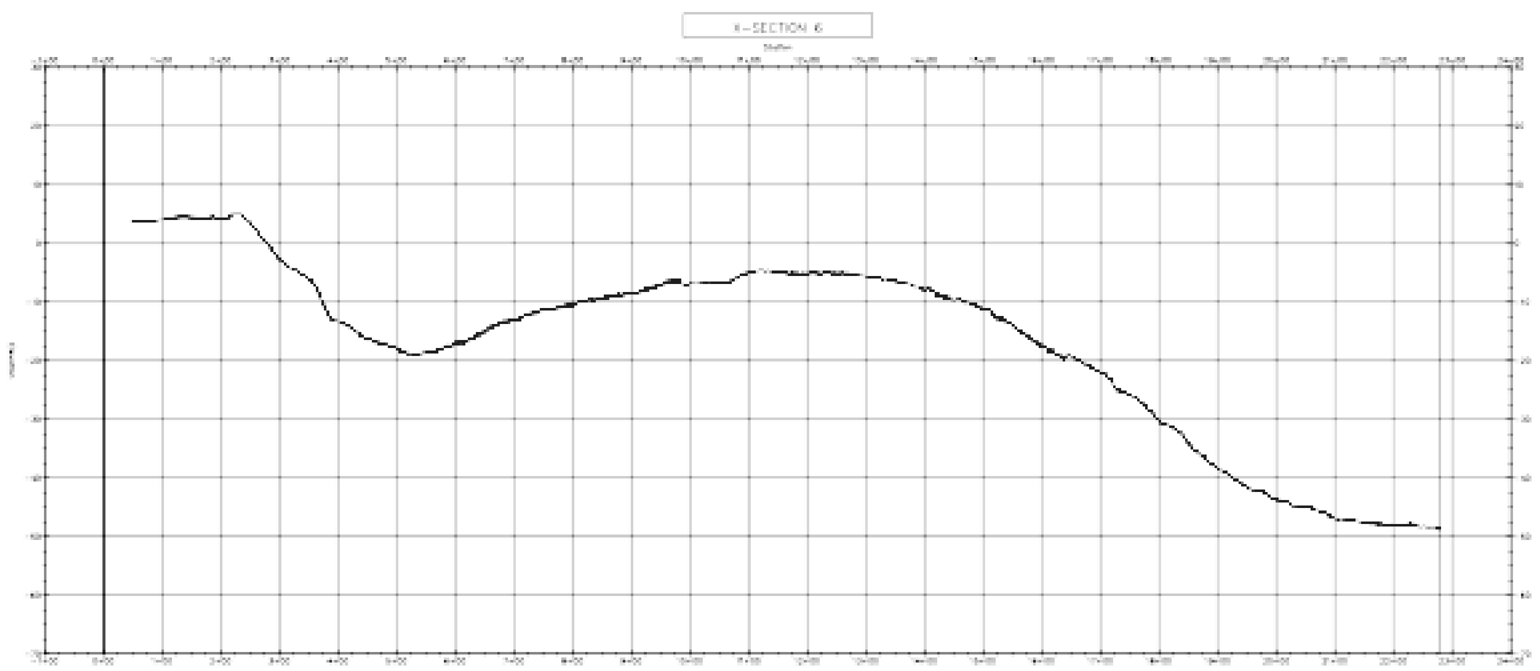
CONDITION SURVEY - PLAN VIEW
OF
SOUTHPORT SHORELINE IMPROVEMENT
PREPARED FOR
OLSEN ASSOCIATES, INC.
SOUTHPORT, BRUNSWICK COUNTY, NORTH CAROLINA
FEBRUARY 9, 2023

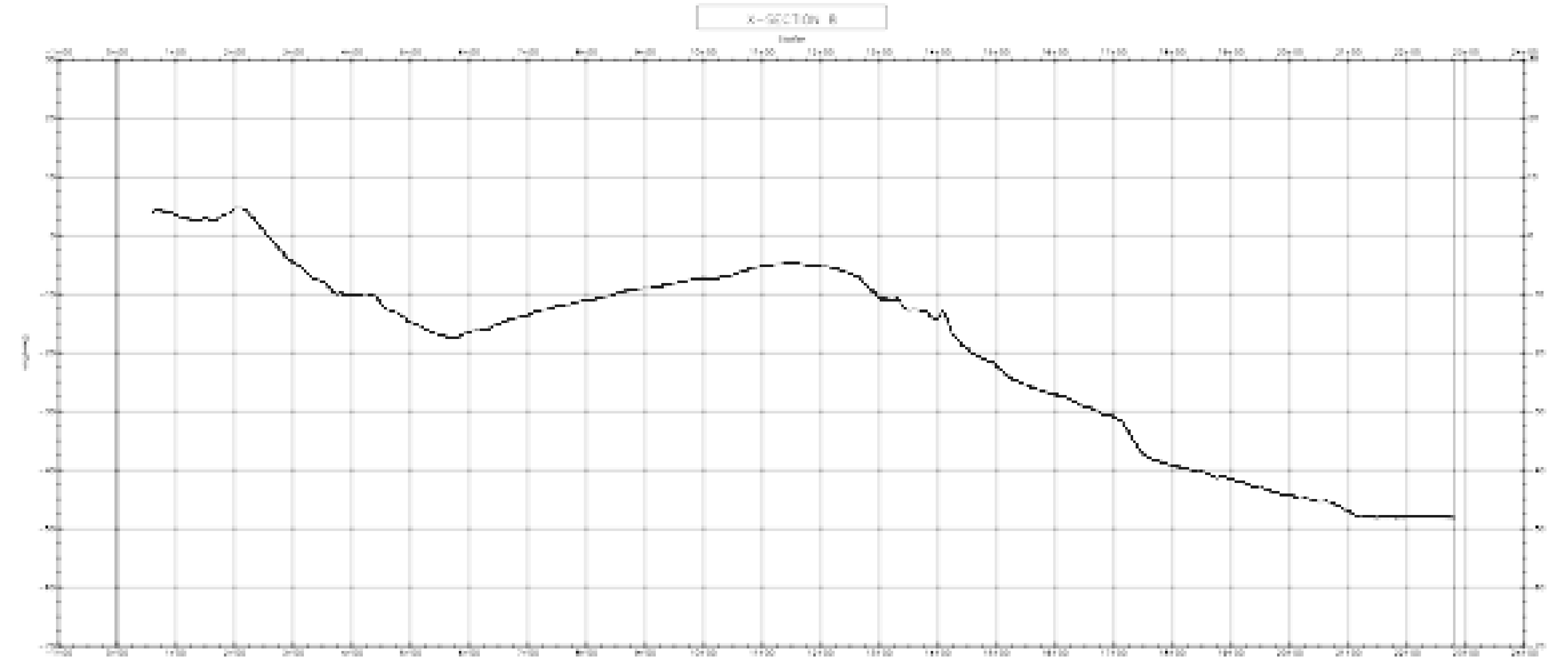
JOB NUMBER:	03028-0005
SCALE:	1" = 200'
CAD NUMBER:	VH-030280005.DWG
PLS:	DLJ
PARTY CHIEF:	JTL
CAD TECH:	CRB
FIELD BOOK/PAGE:	W2087 56-66
DRAWING NUMBER	2023-026

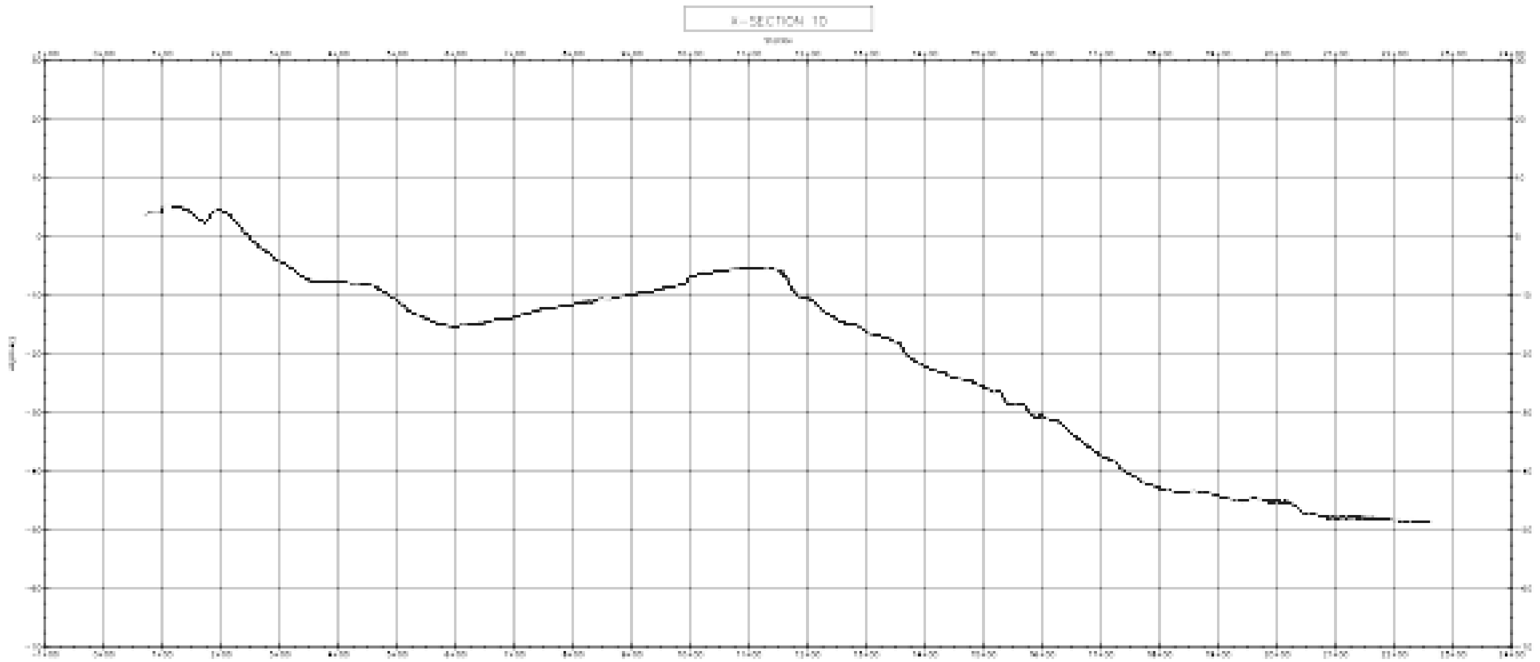
SHEET 1 OF 9

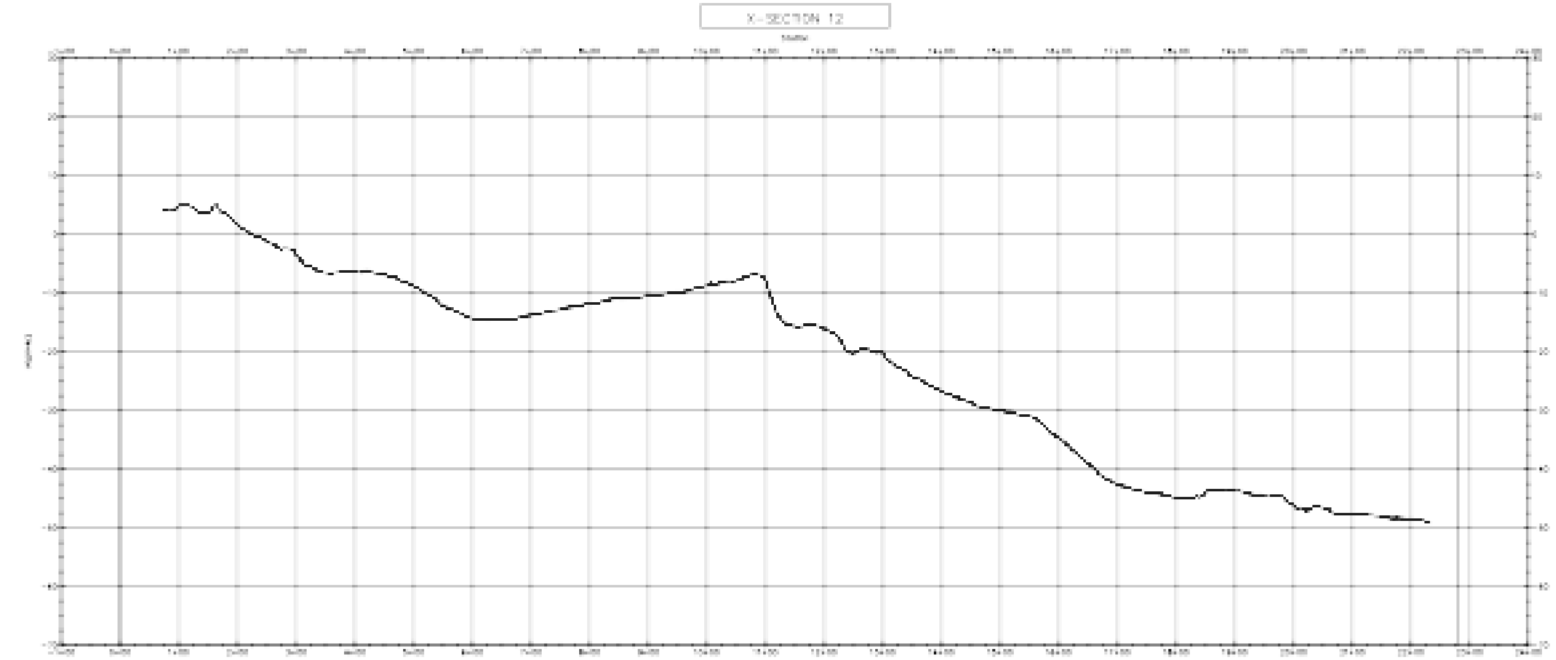


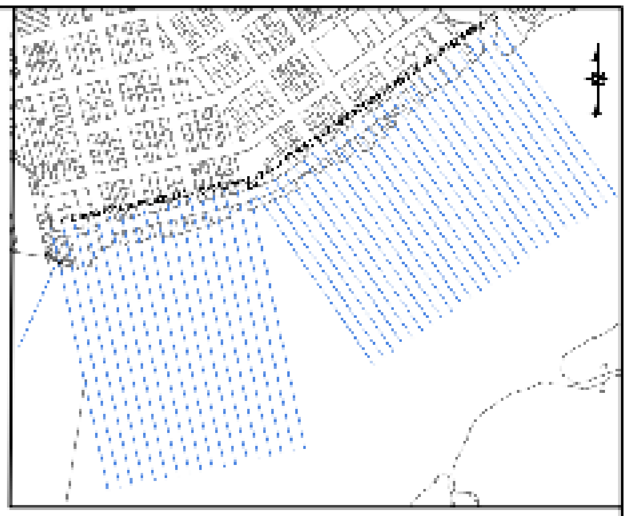












SCALE: 1" = 1000'

0 500' 1000' 2000' 3000'

CROSS SECTIONS NOTES:

- THE SURVEY CONTOURS ARE REPRESENTED BY THE BLUE LINE.
- FULL DATASET WAS USED TO CREATE THE CROSS-SECTIONS.
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PRELIMINARY PLAT

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VERTICAL 1" = 20'
HORIZONTAL 1" = 200'

0 10 20 40 60
0 100 200 400 600

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FIELD BOOK/PAGE.	W2087 56-66
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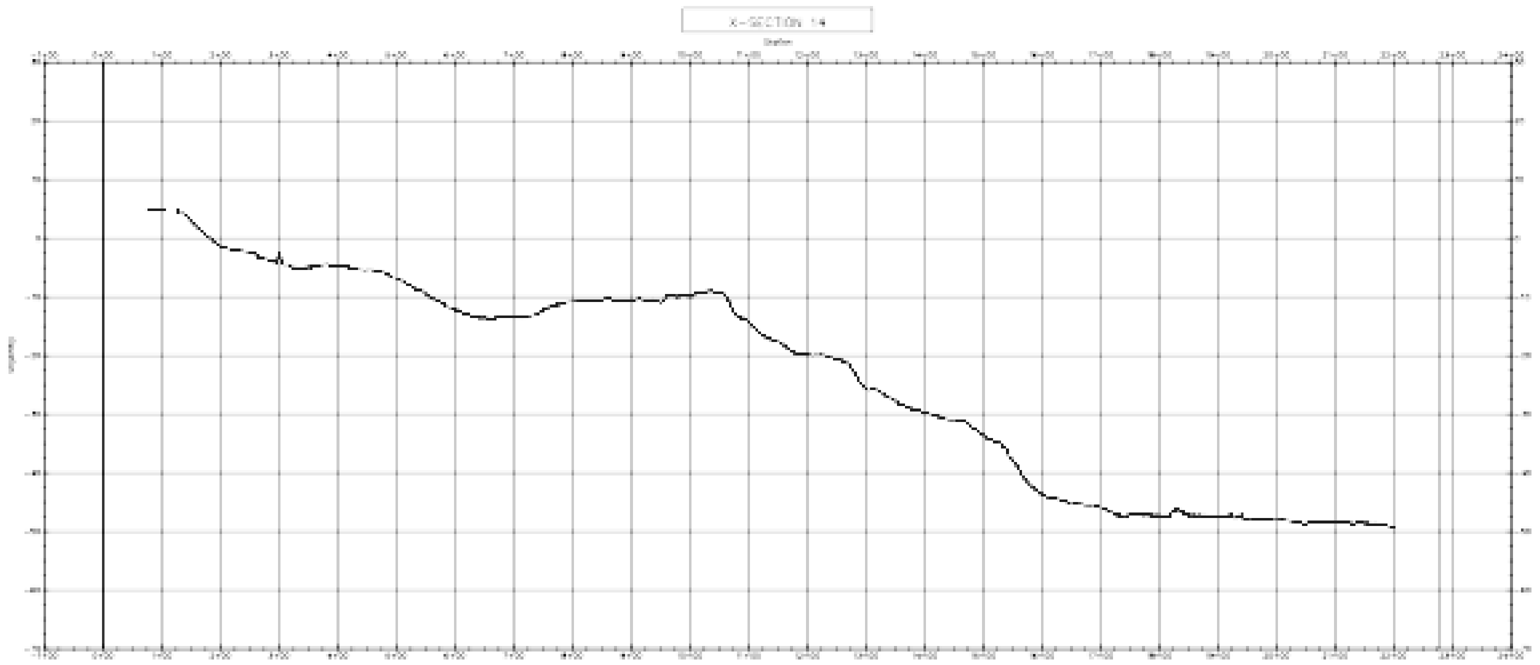
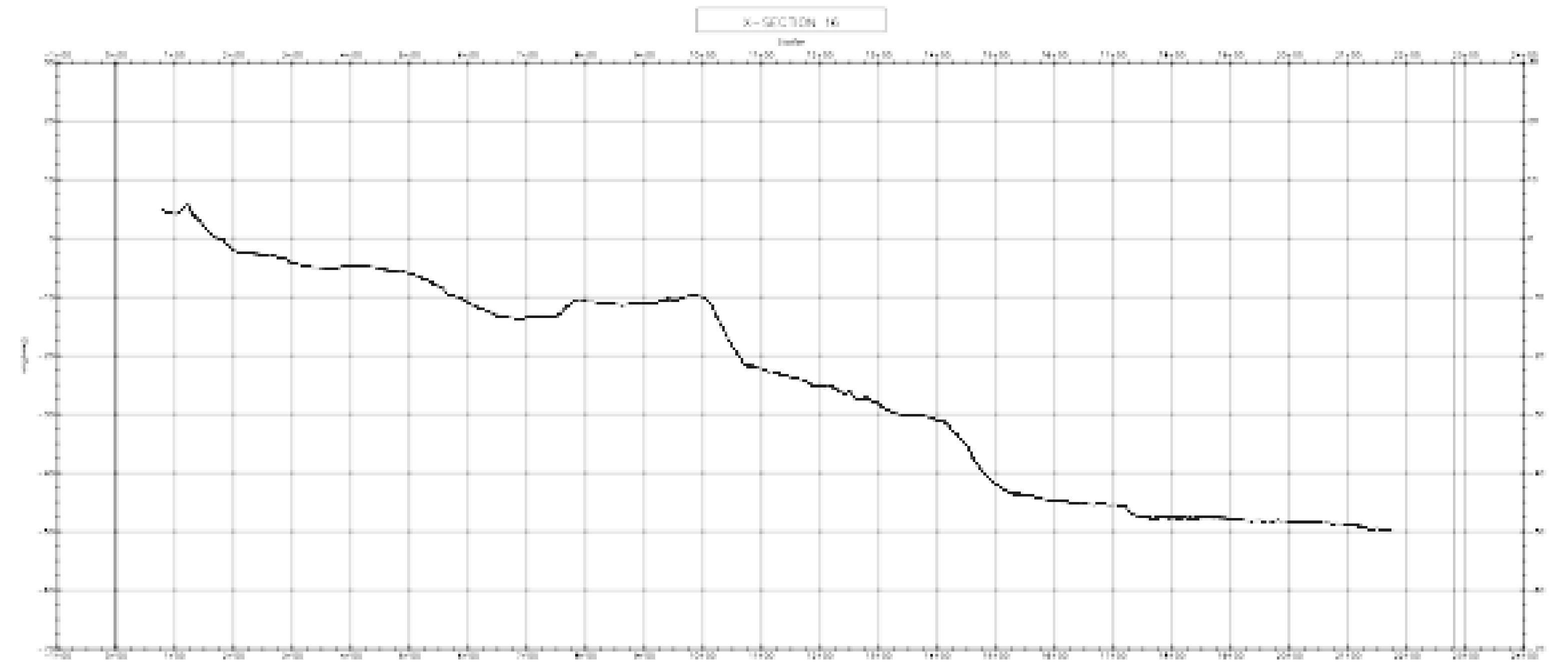
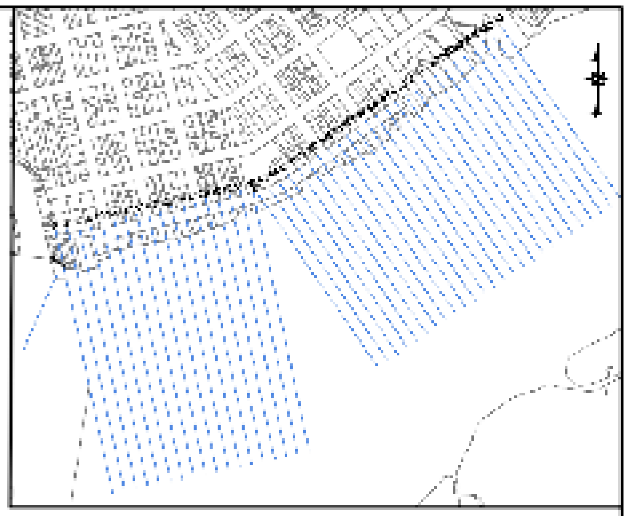
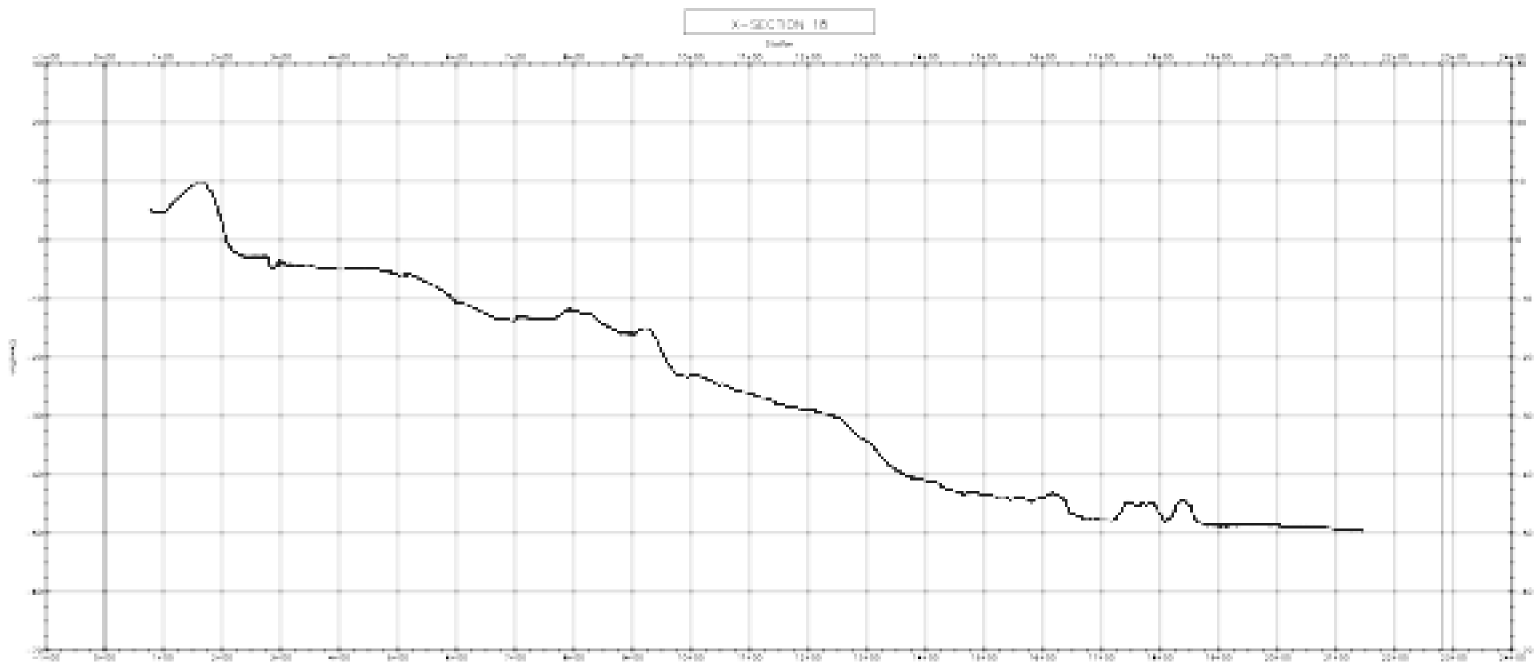
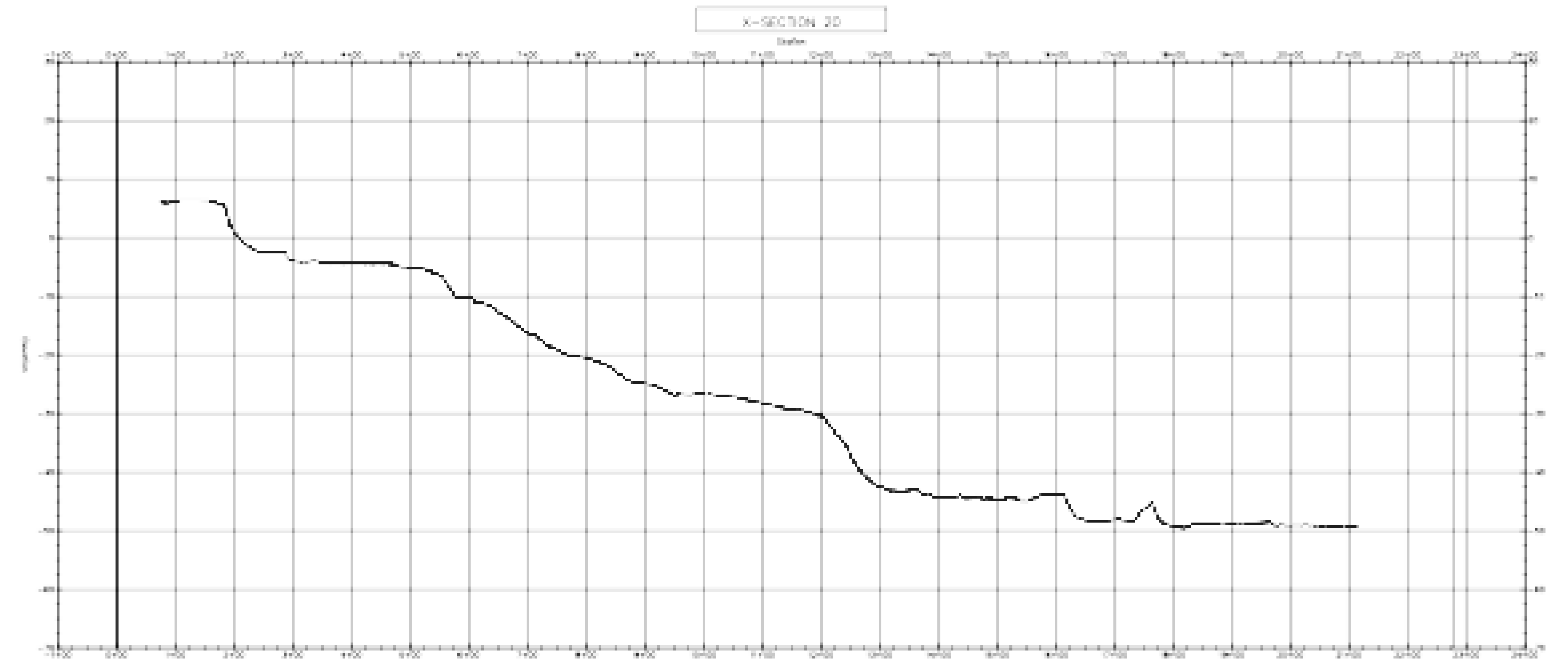
SHEET 2 OF 9











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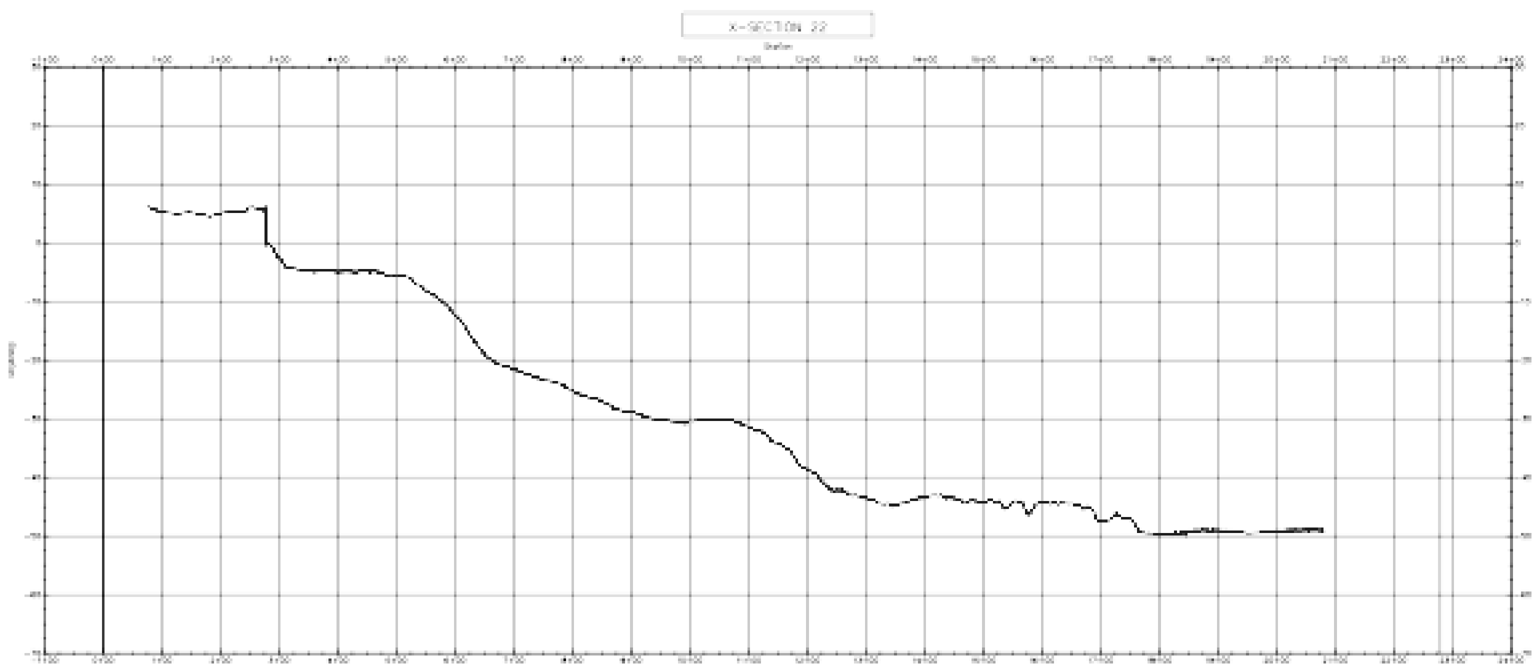

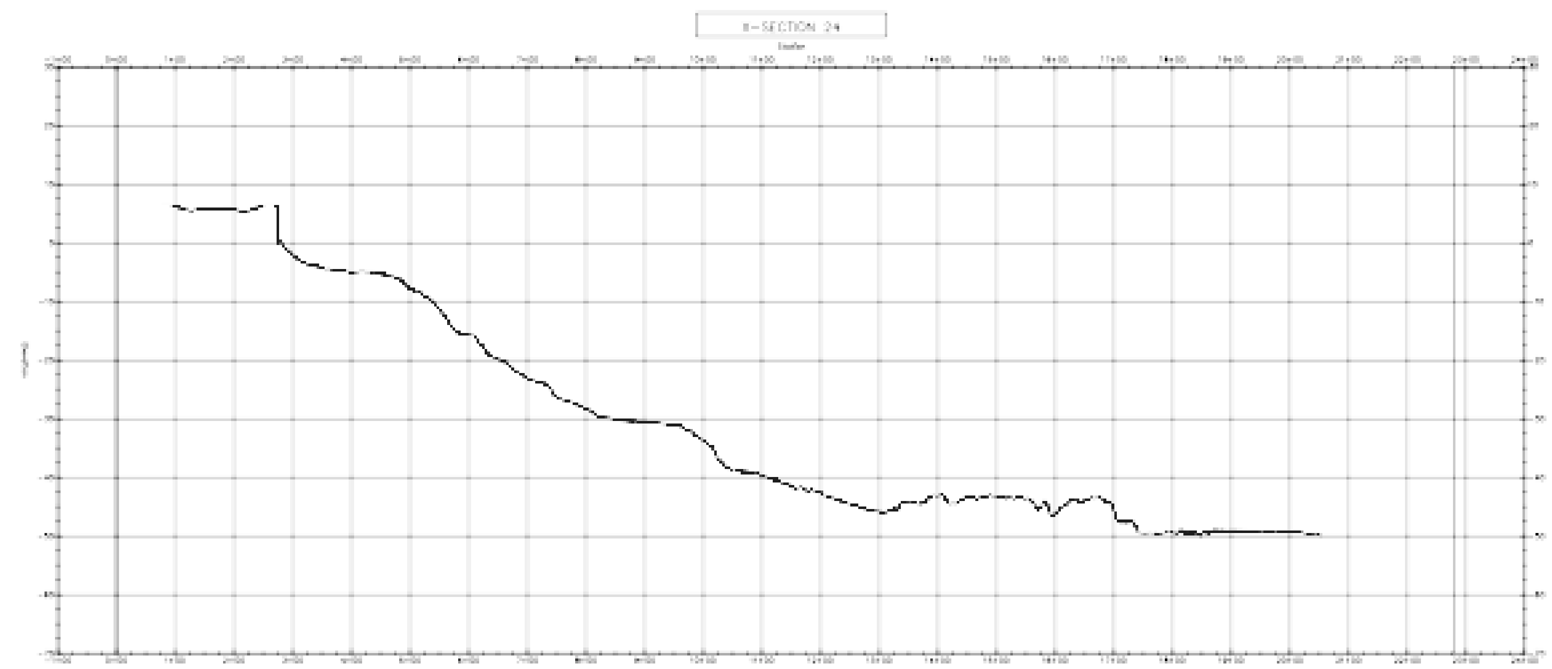

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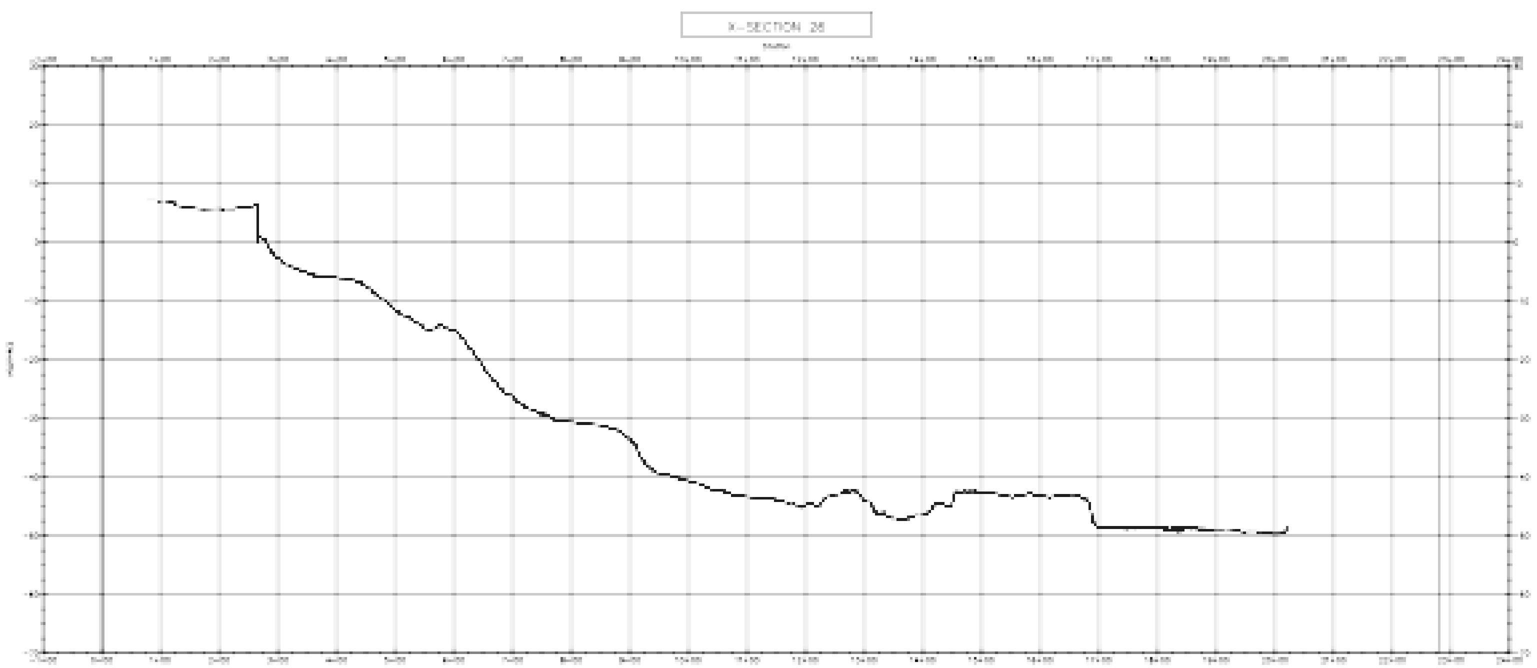
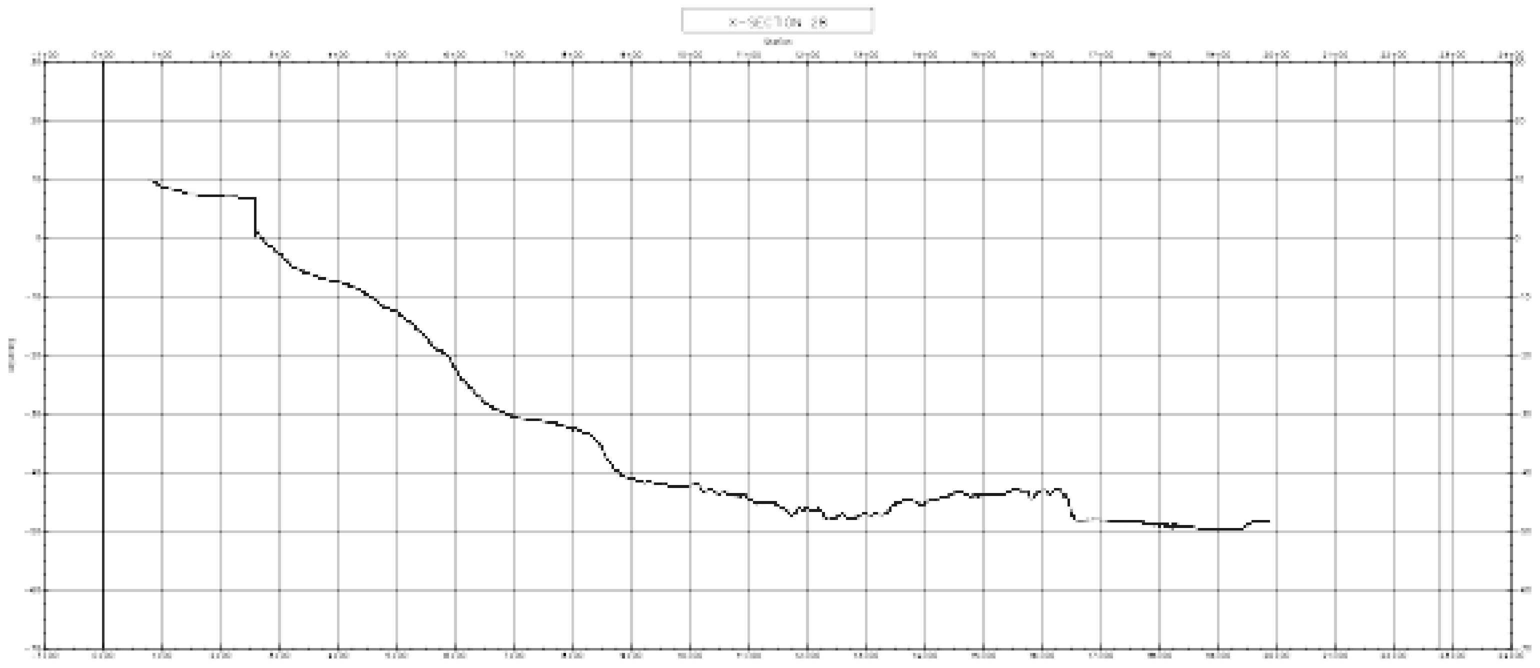
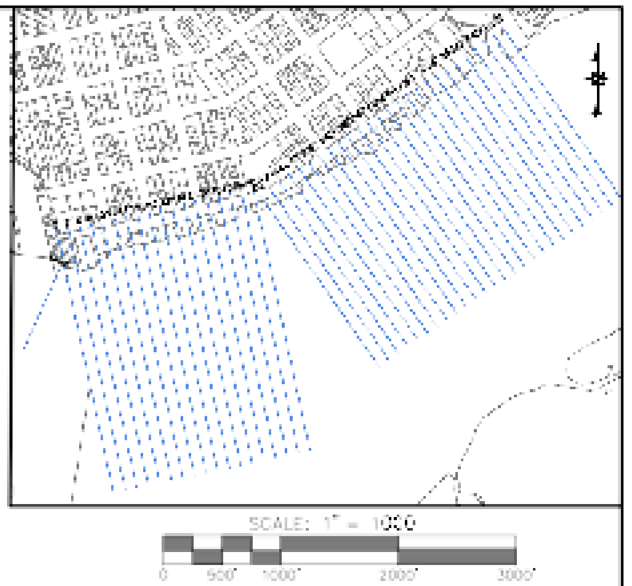
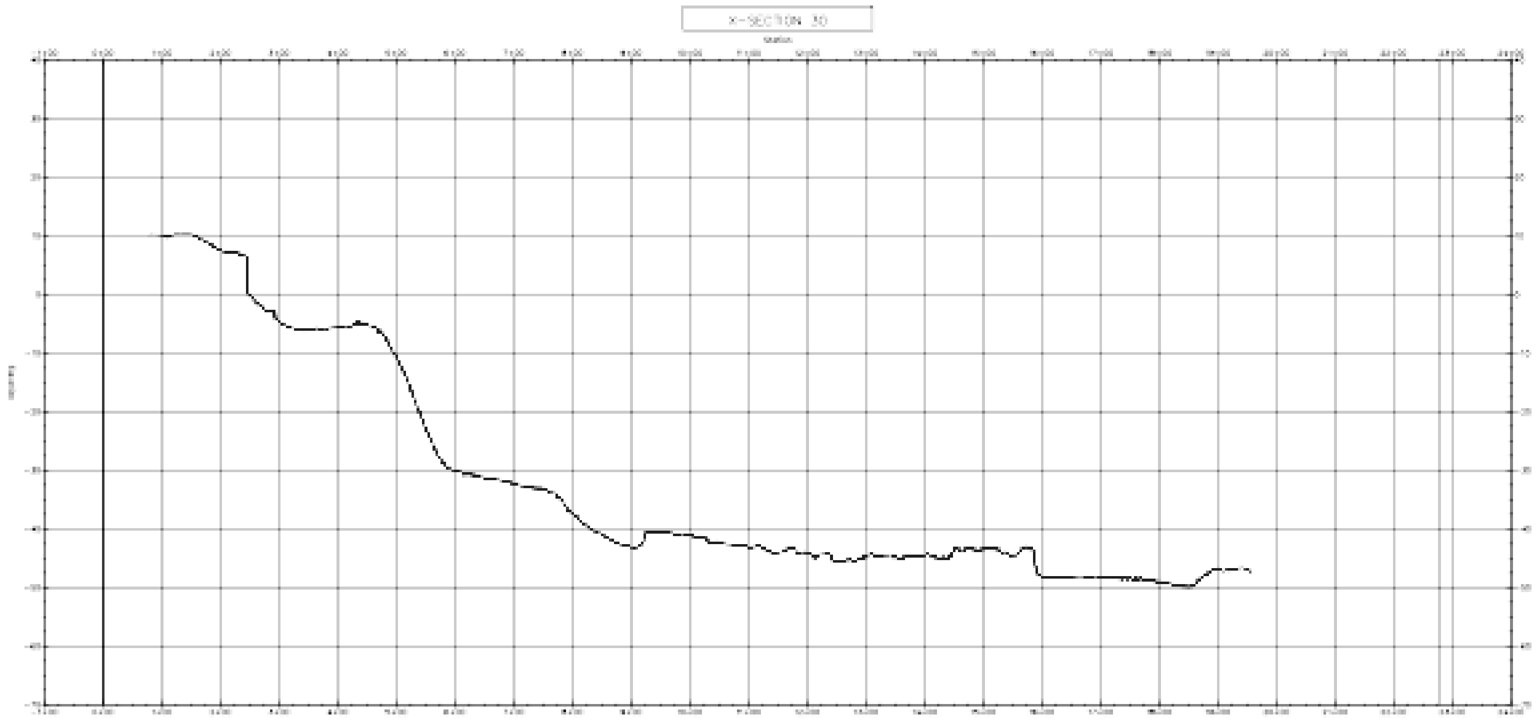
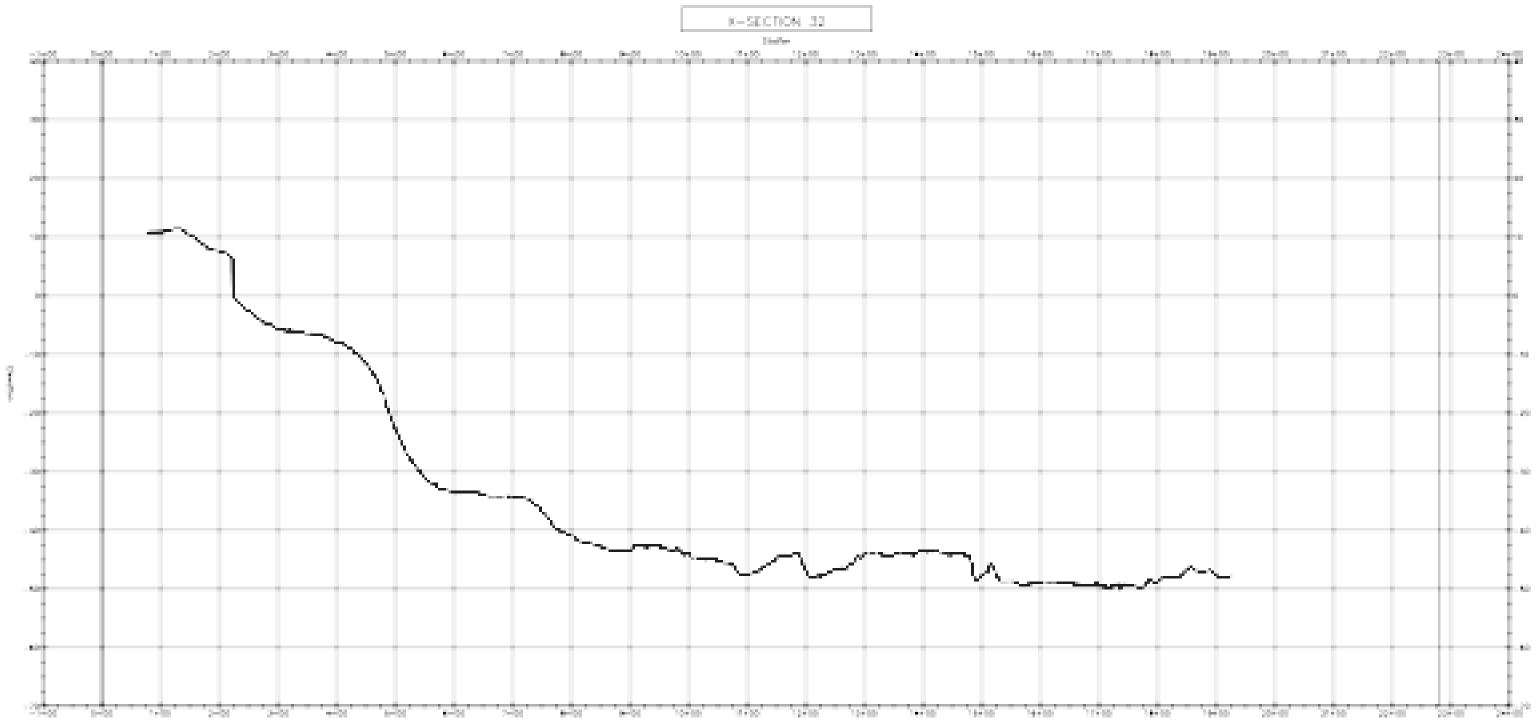
SHEET 3 OF 9











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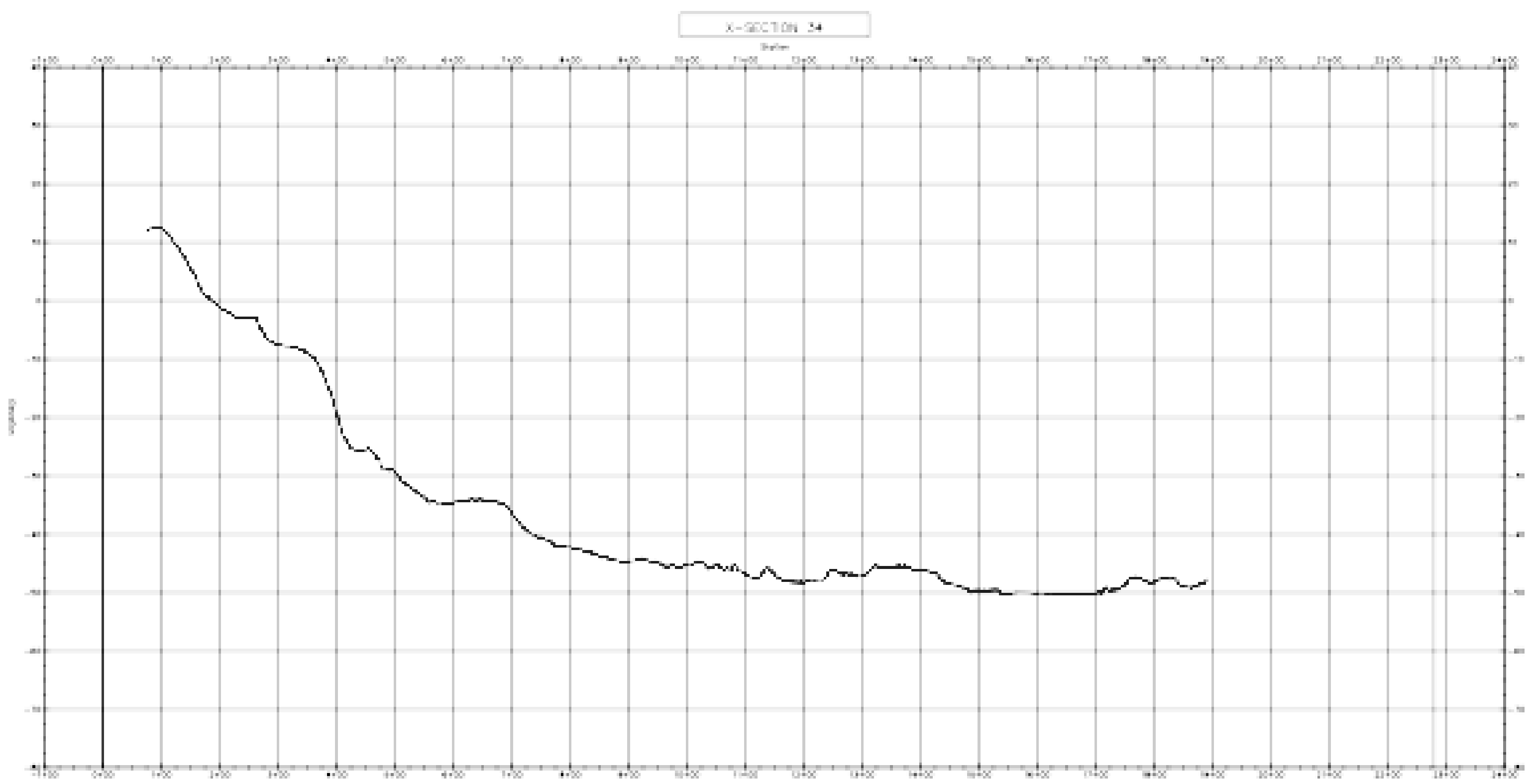

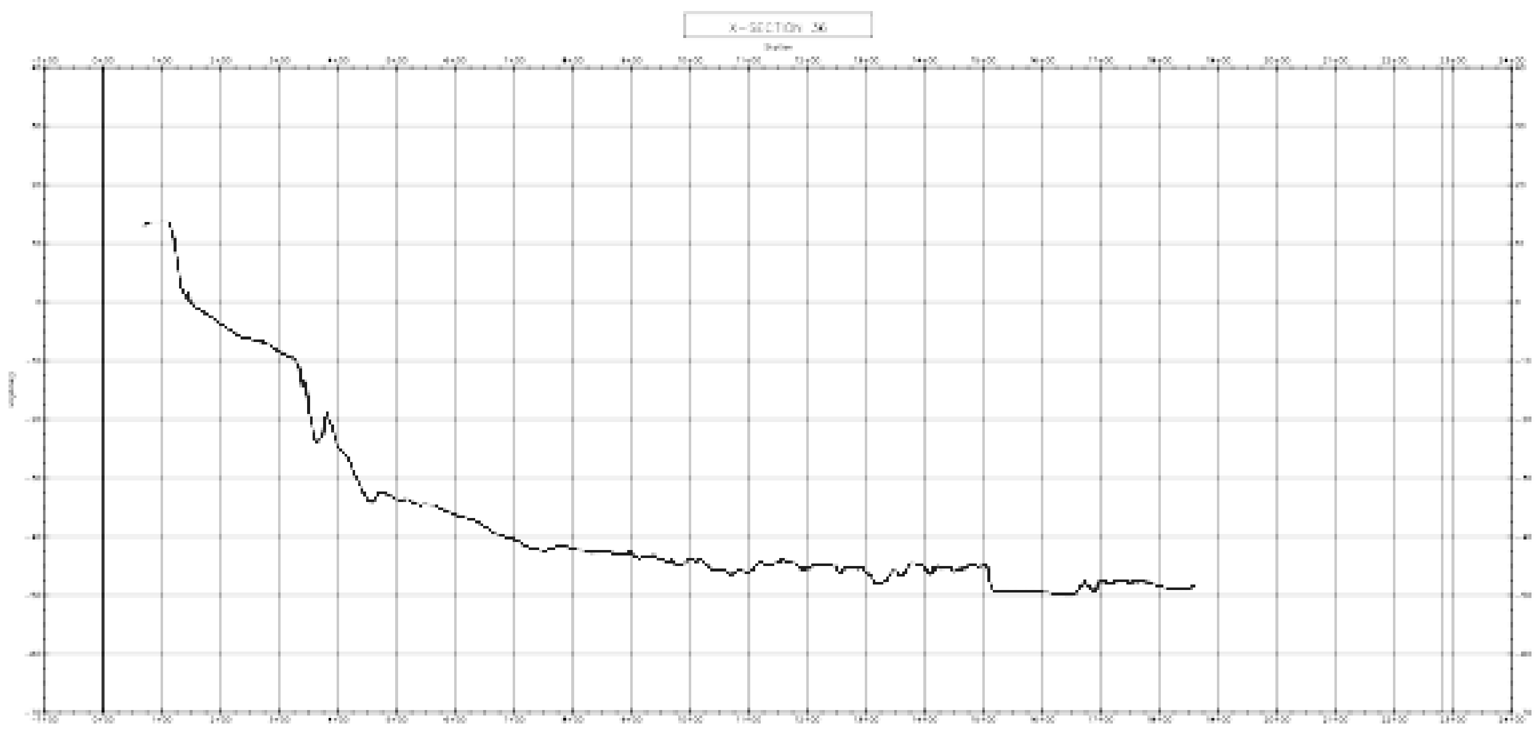

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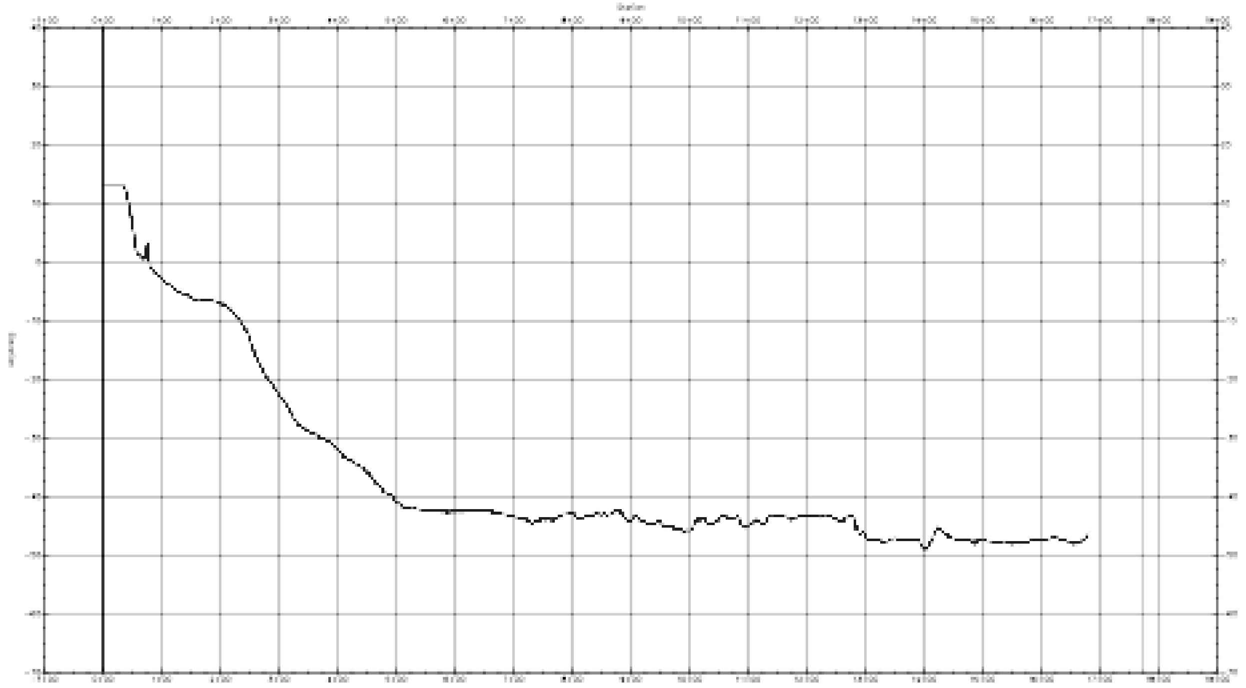

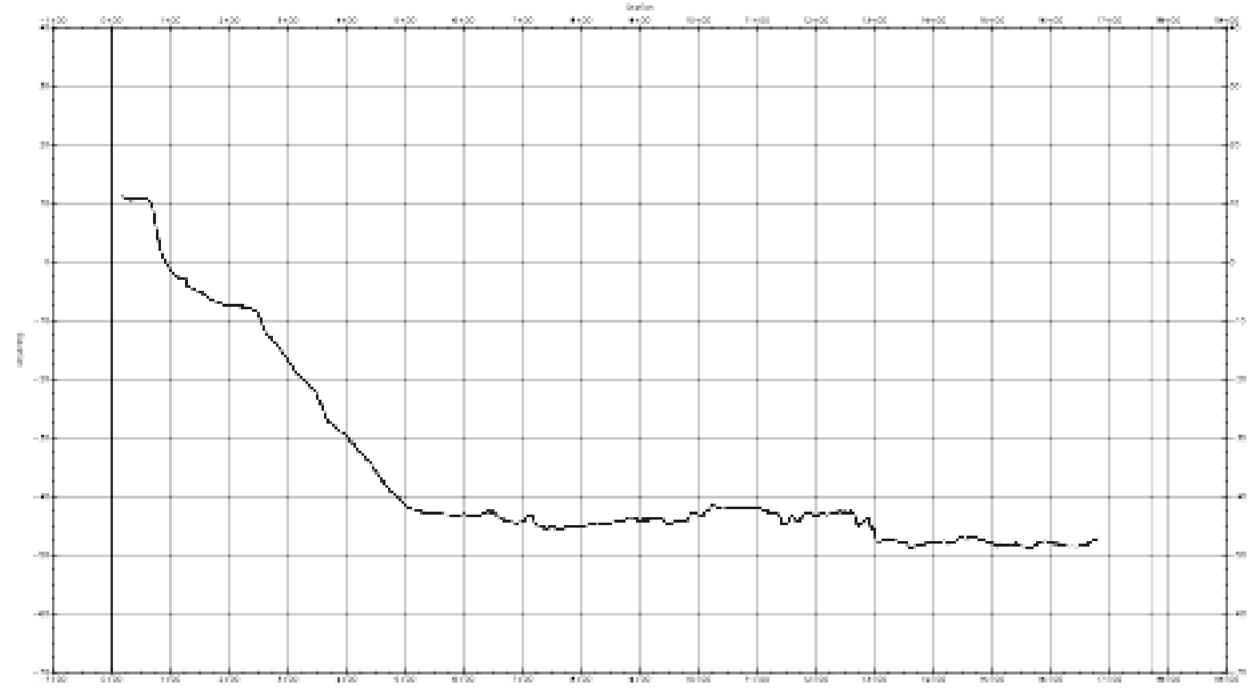

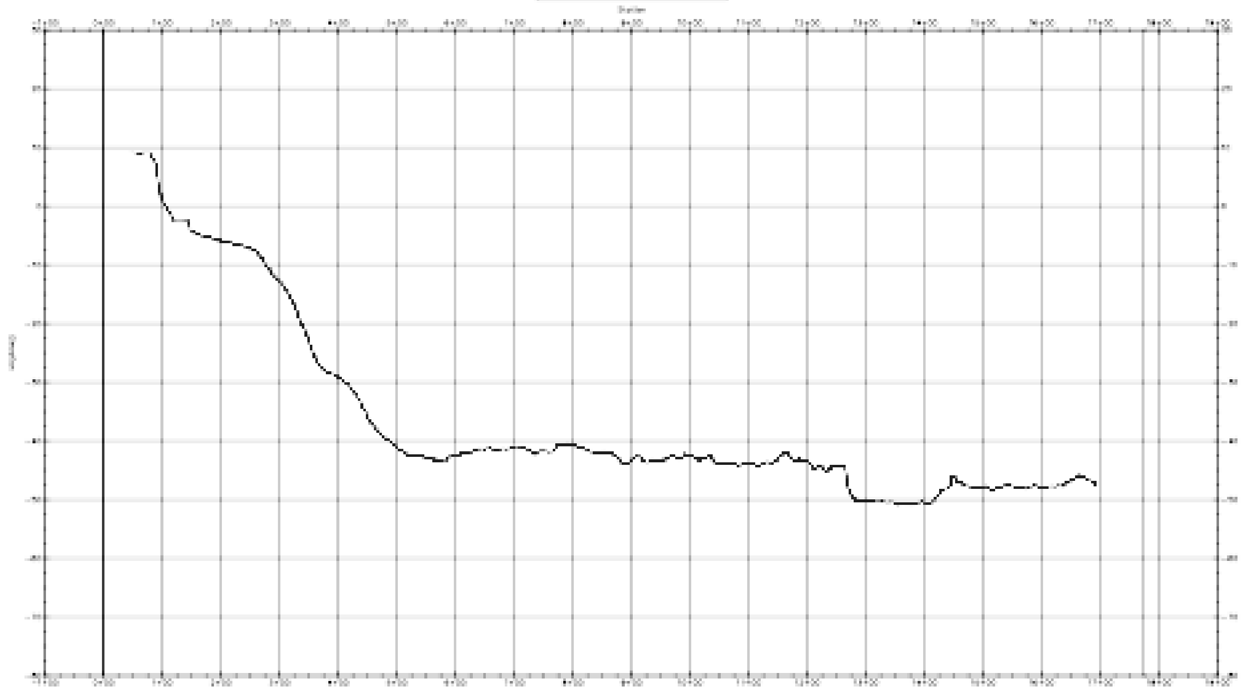

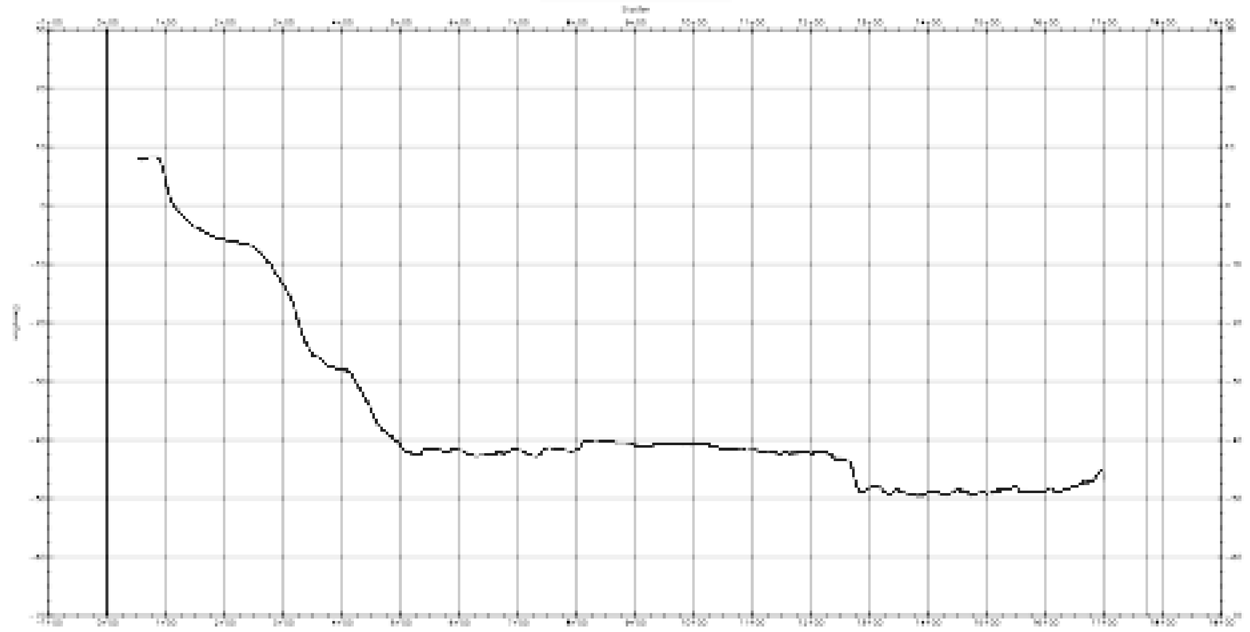

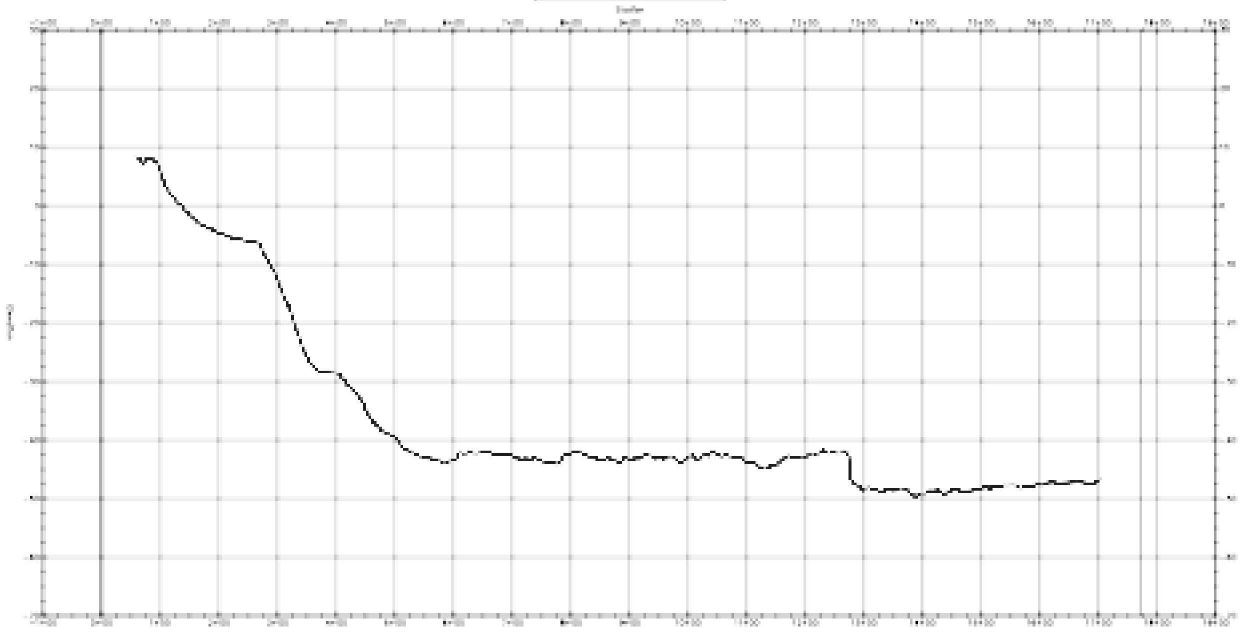

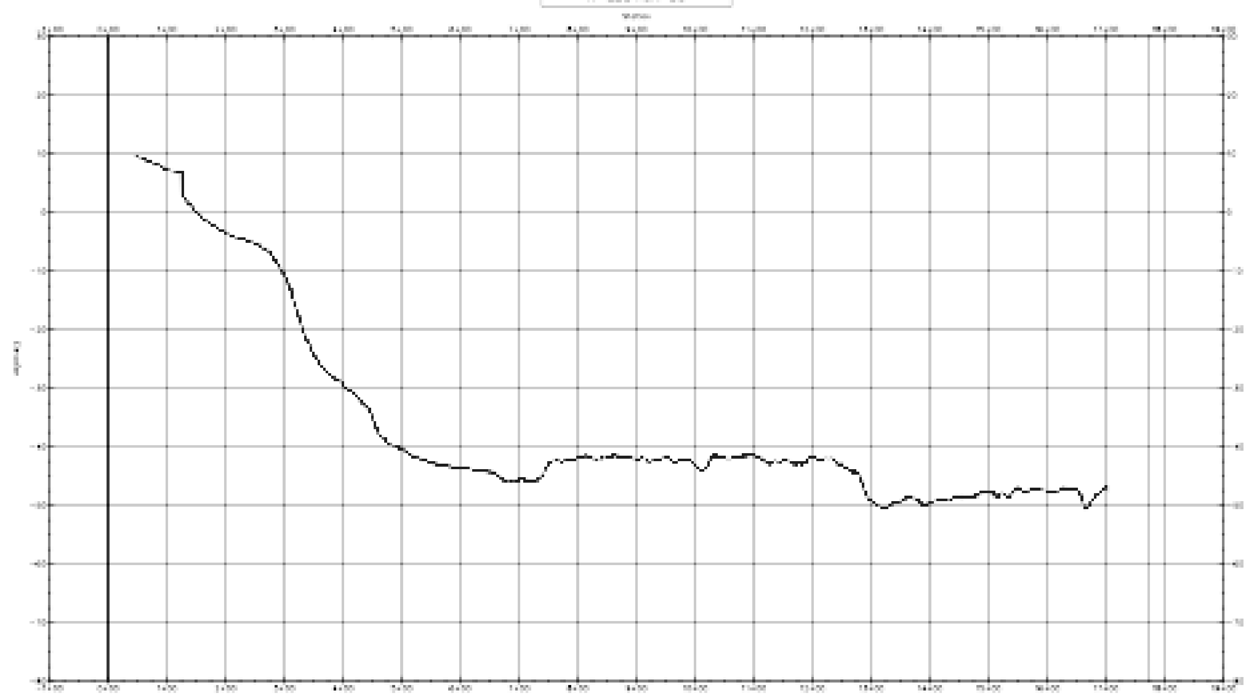

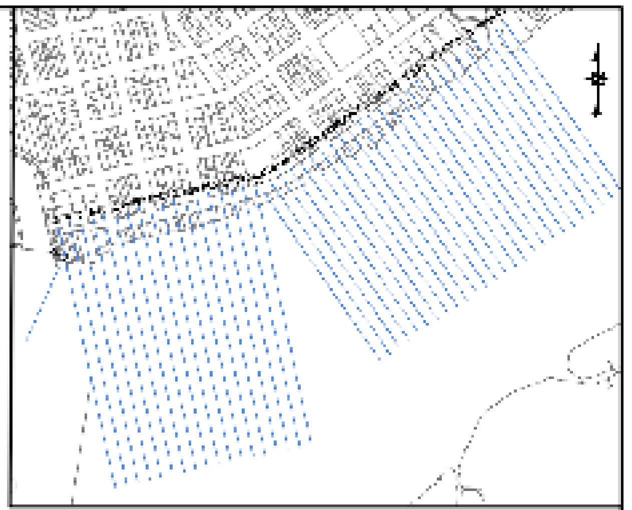

SCALE: 1" = 1000'

0 500' 1000' 2000' 3000'

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CONDITION SURVEY - CROSS SECTIONS
OF
SOUTHPORT SHORELINE IMPROVEMENT
PREPARED FOR
OLSEN ASSOCIATES, INC.
SOUTHPORT, BRUNSWICK COUNTY, NORTH CAROLINA
FEBRUARY 9, 2023

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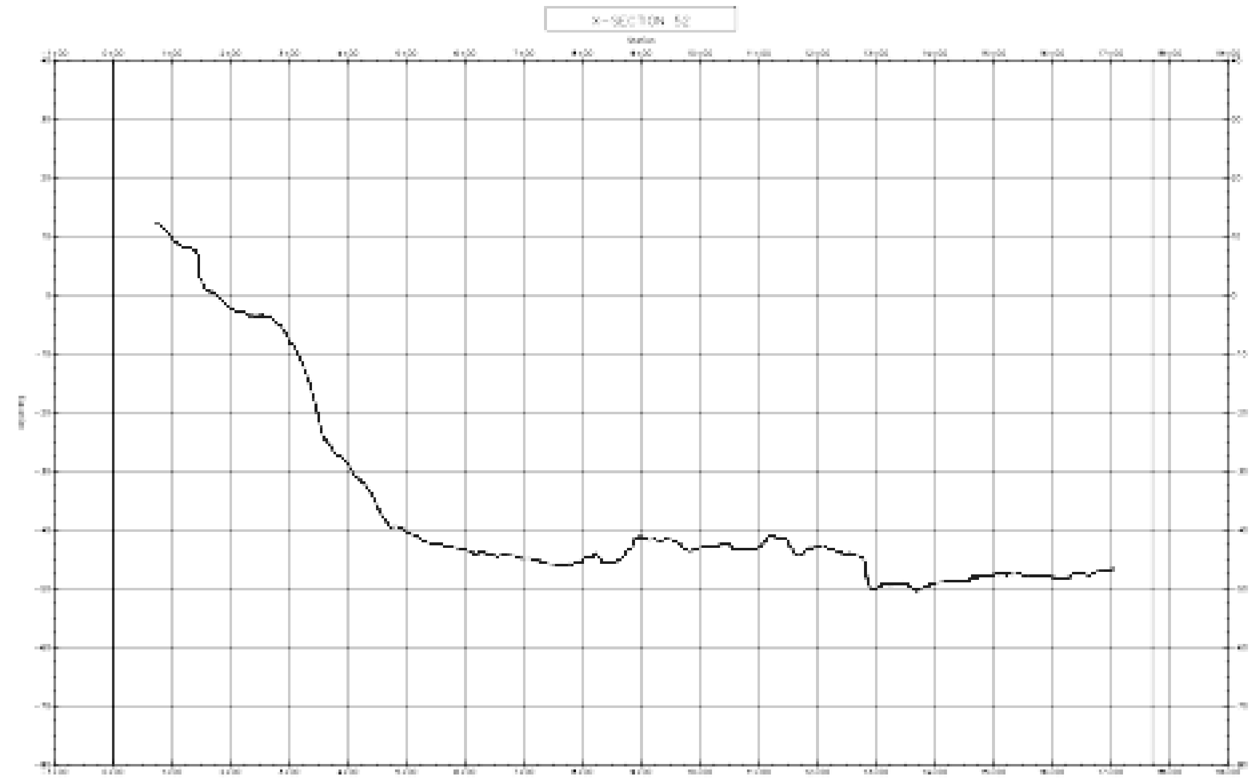

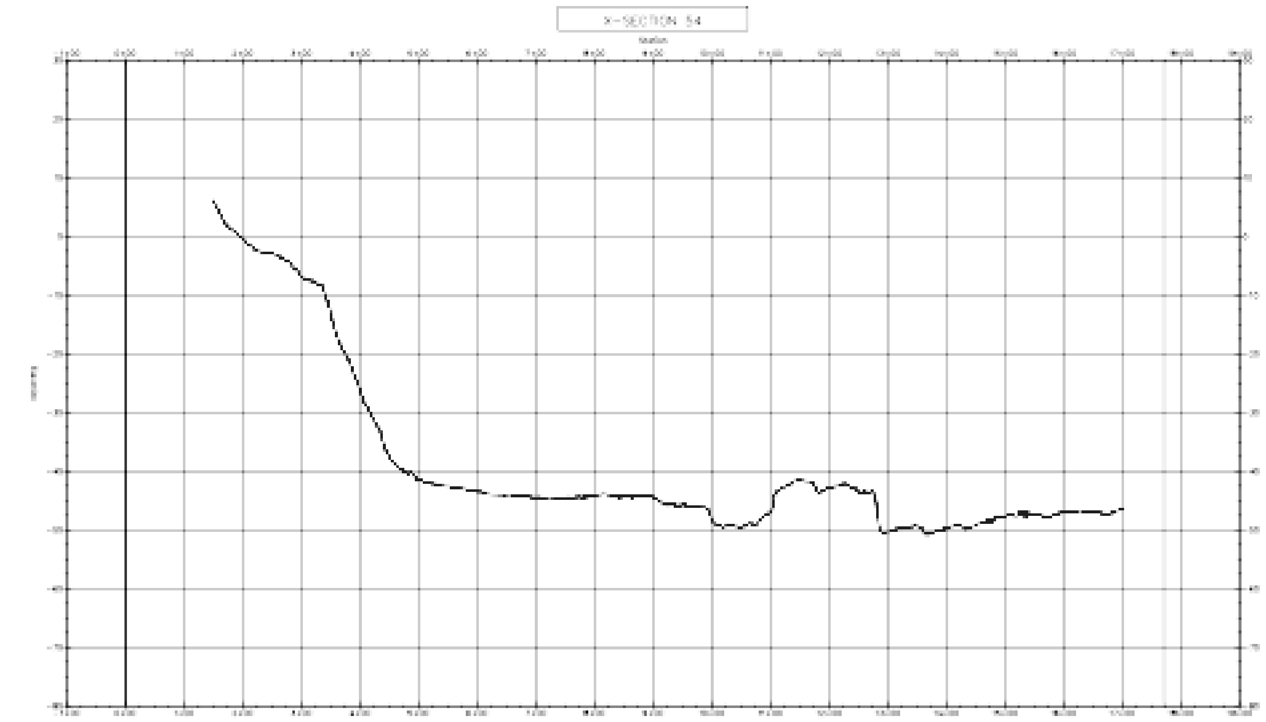

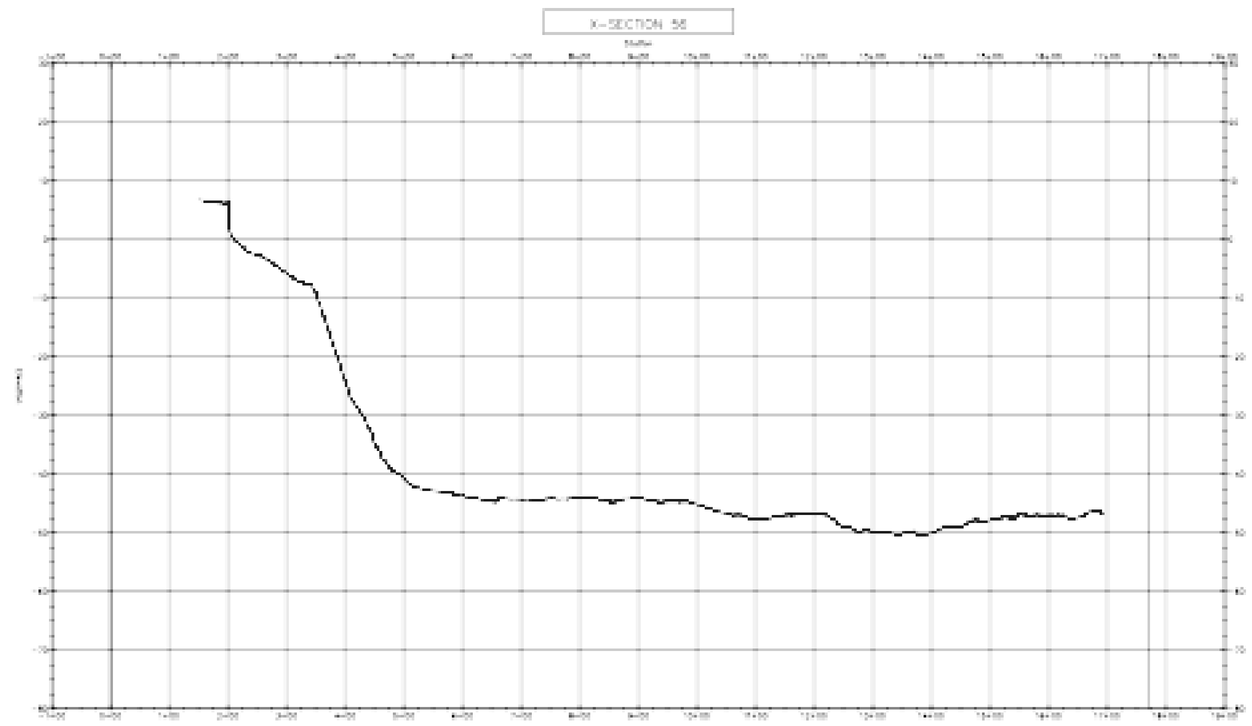

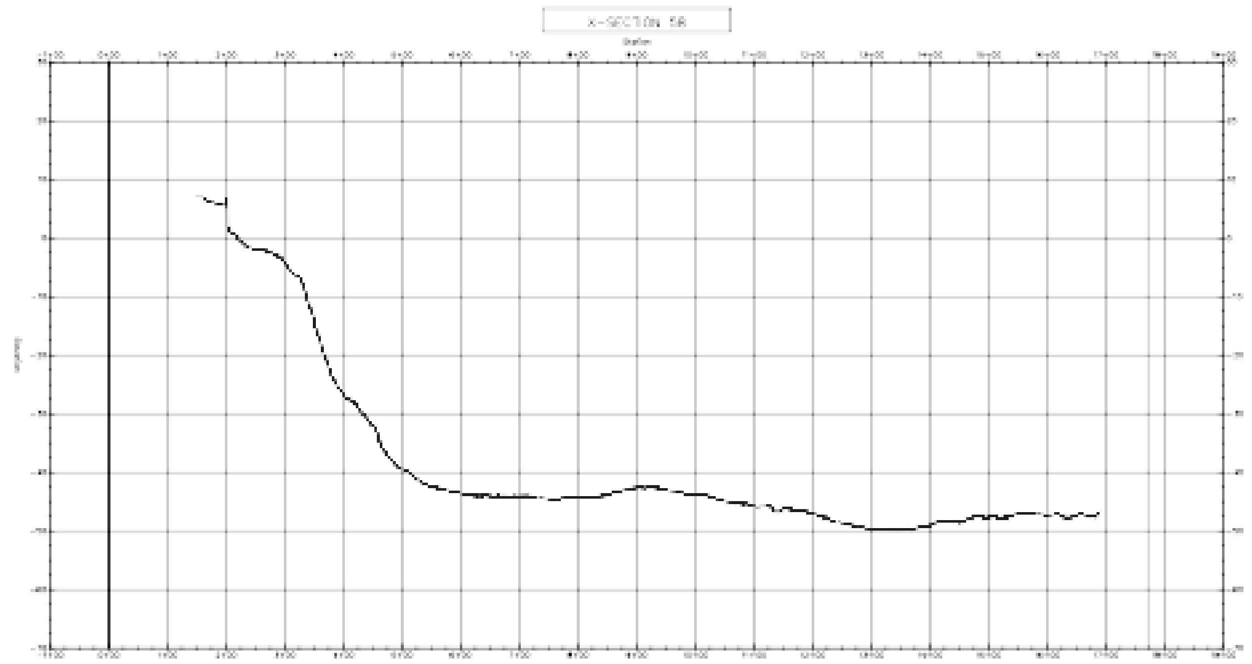

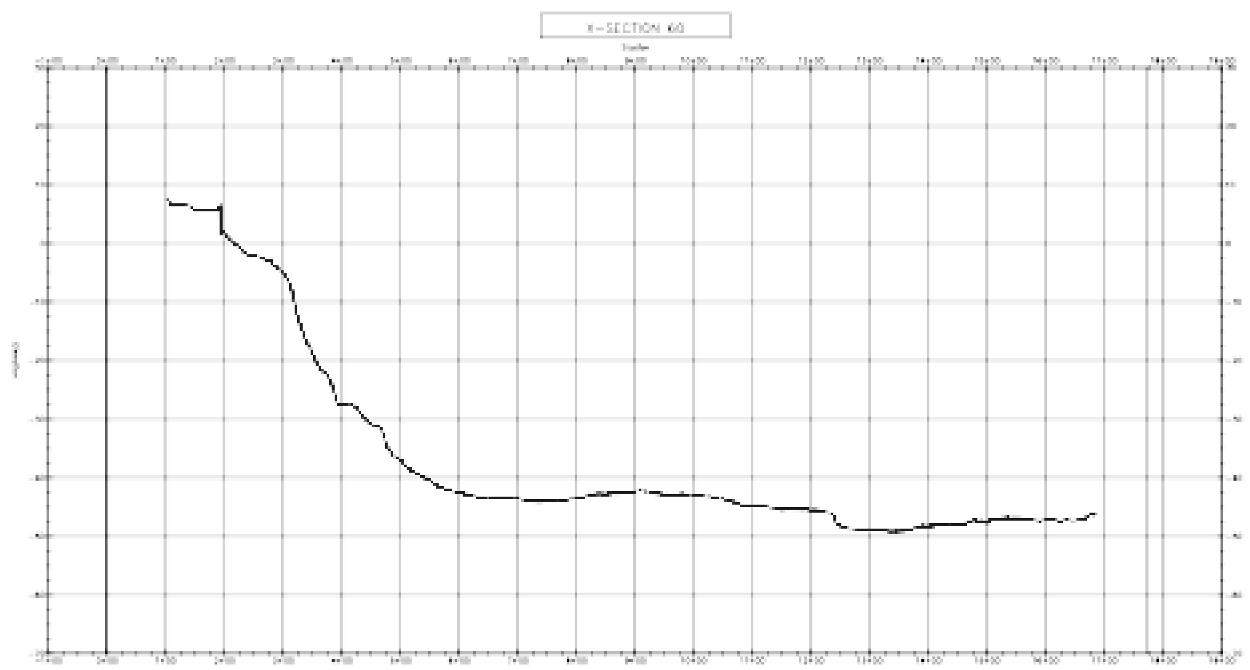

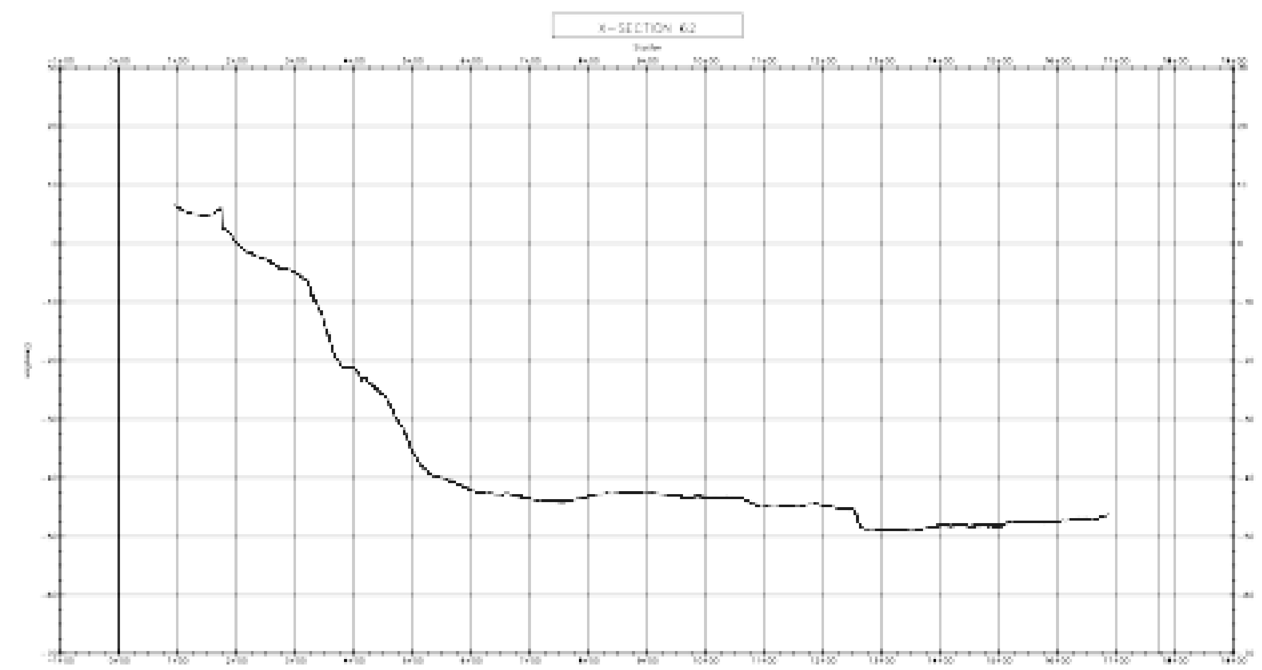

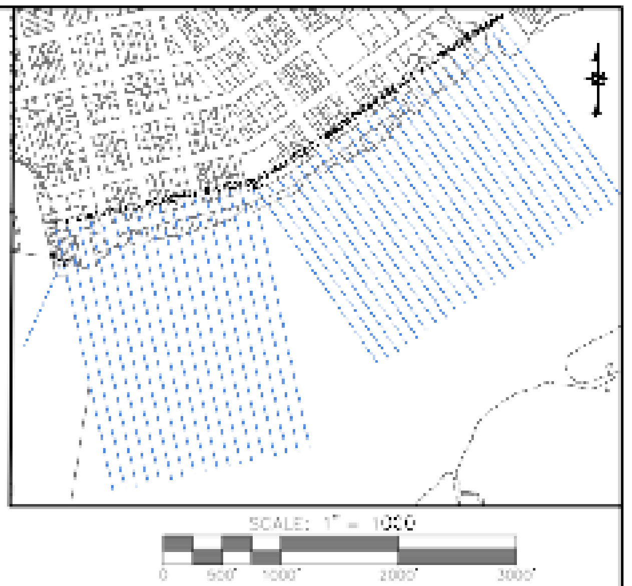

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0 10 20 40 60
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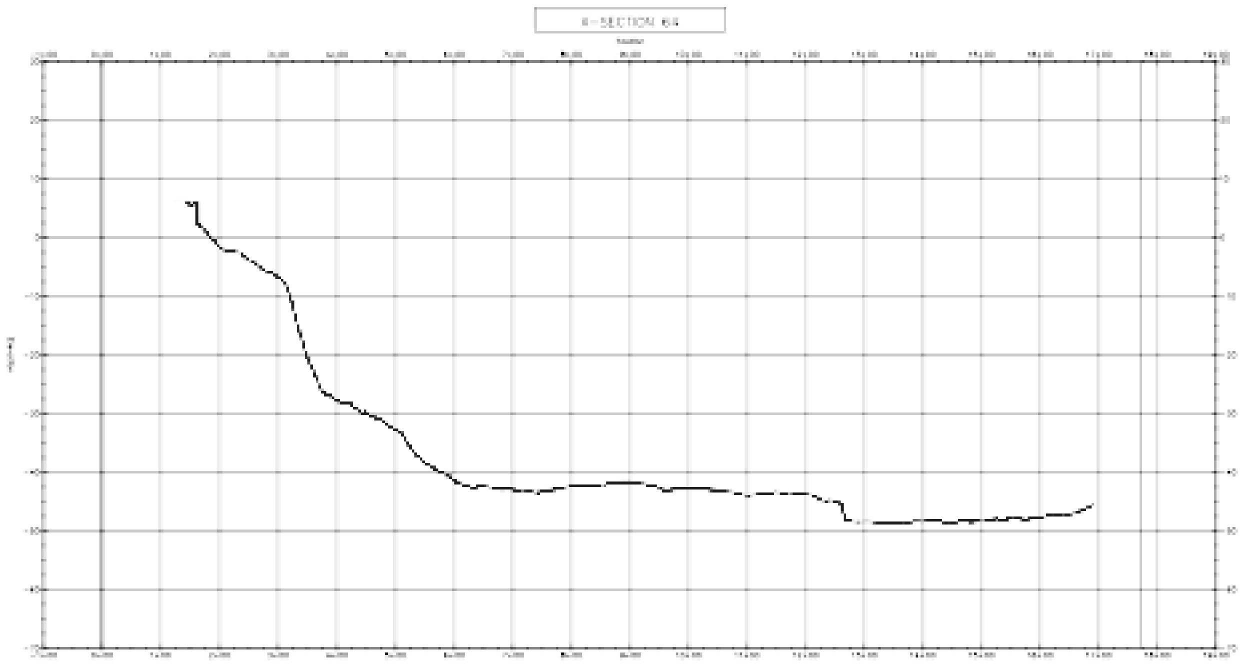
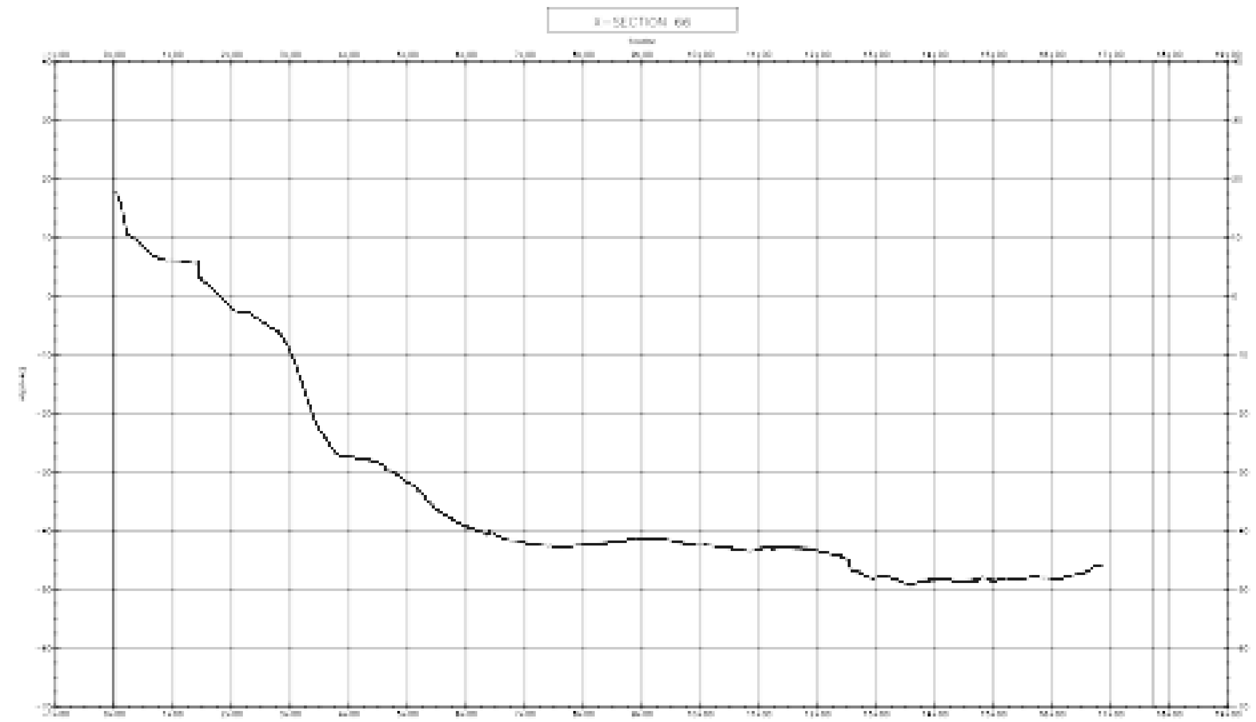
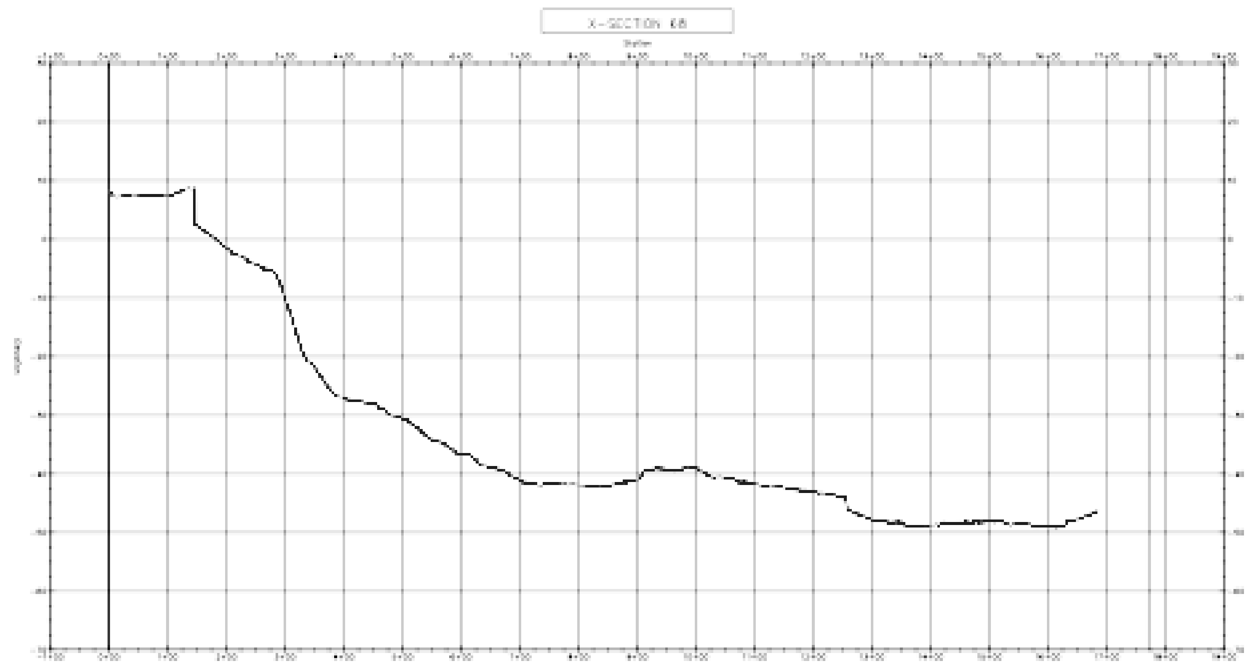
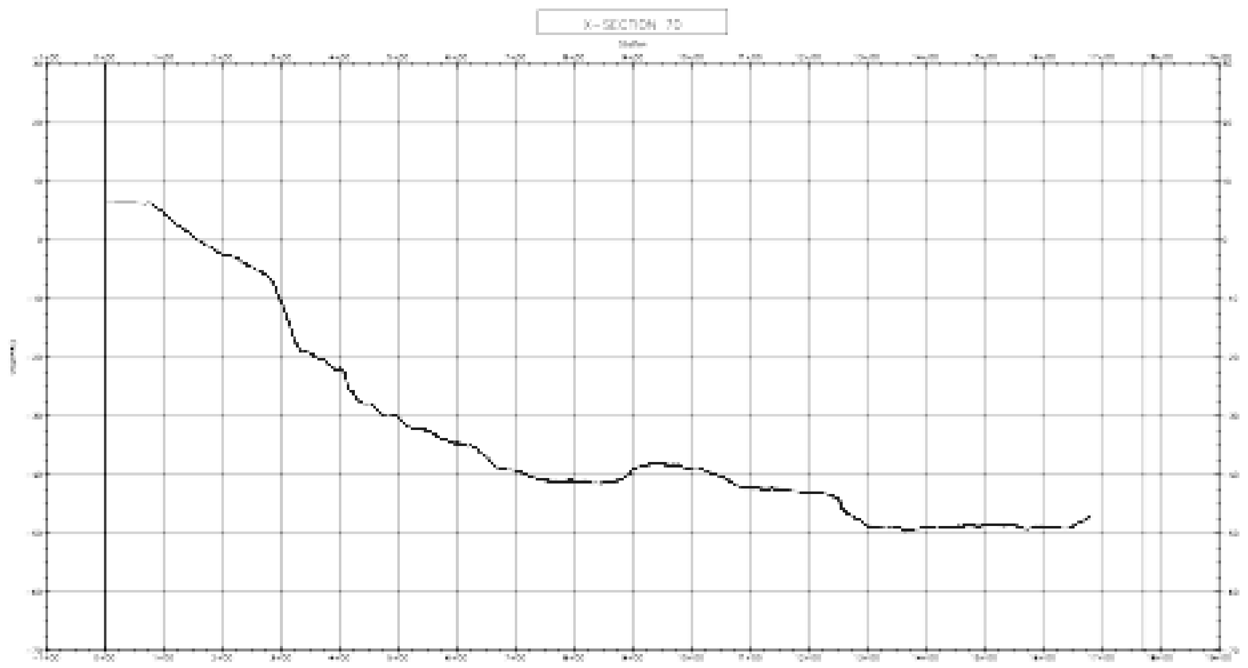
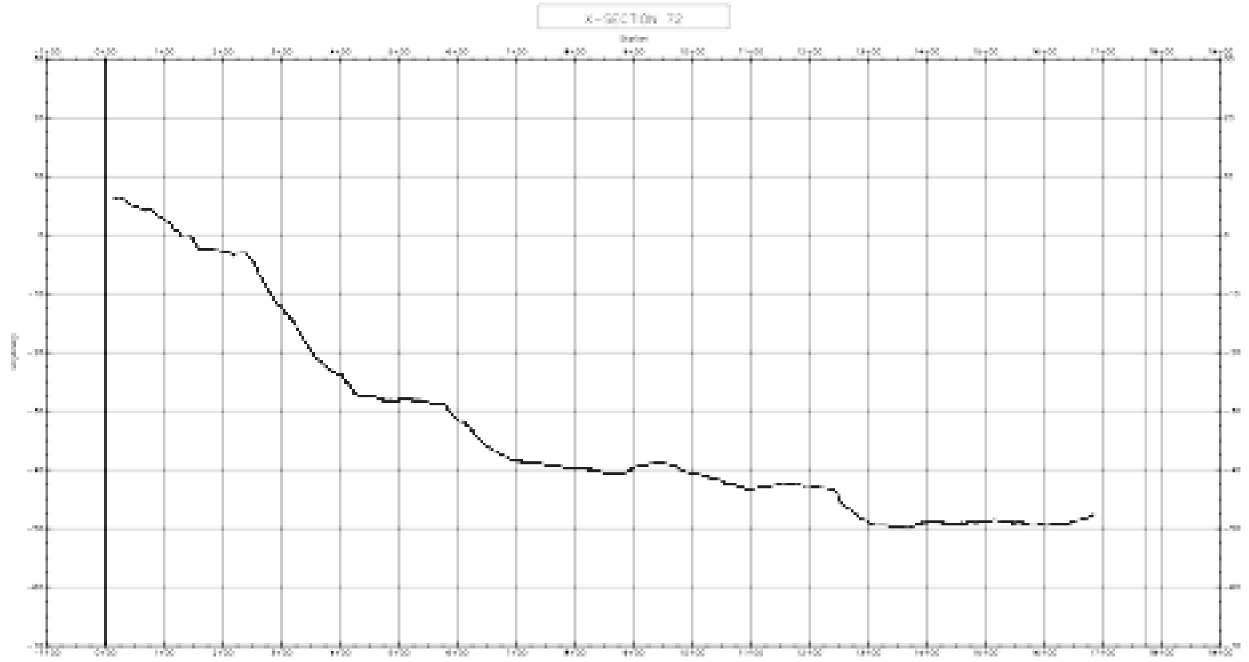
SHEET 6 OF 9

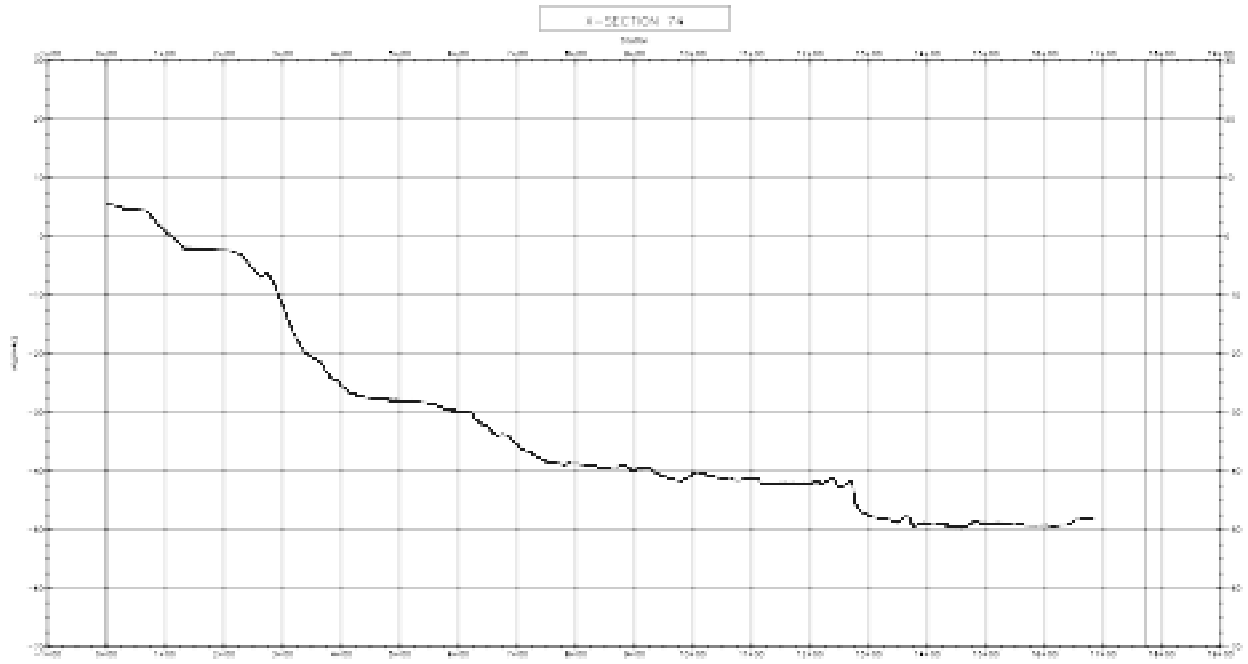


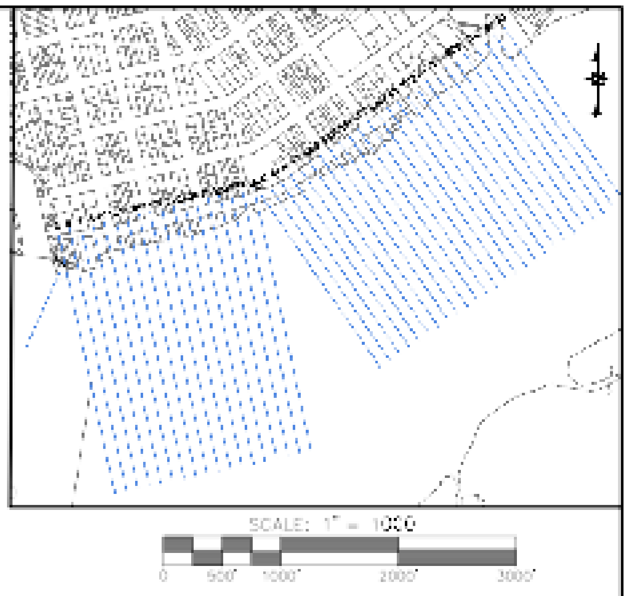












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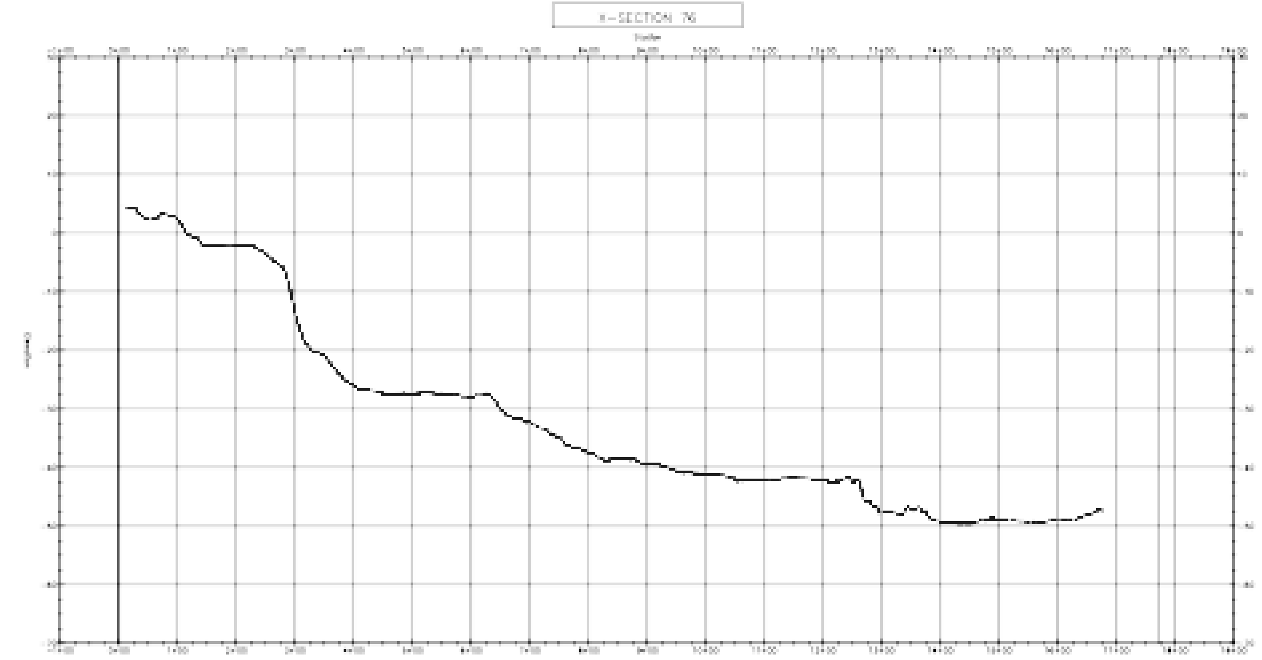
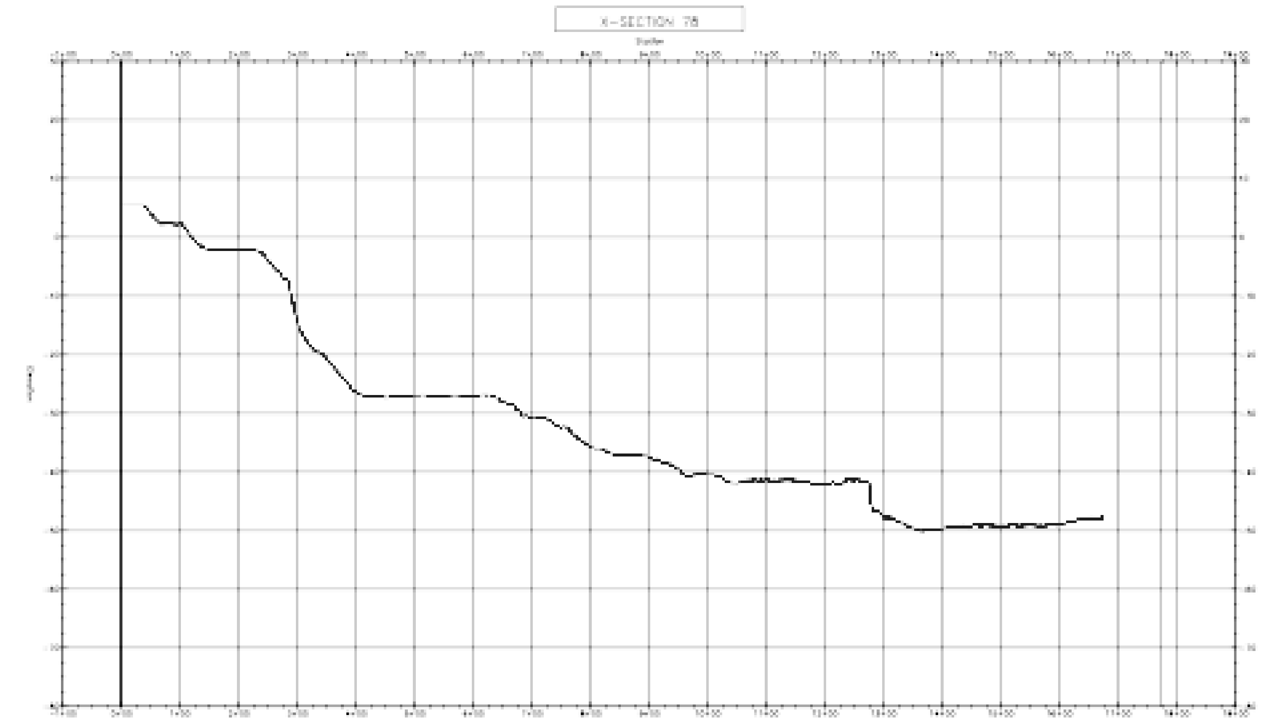
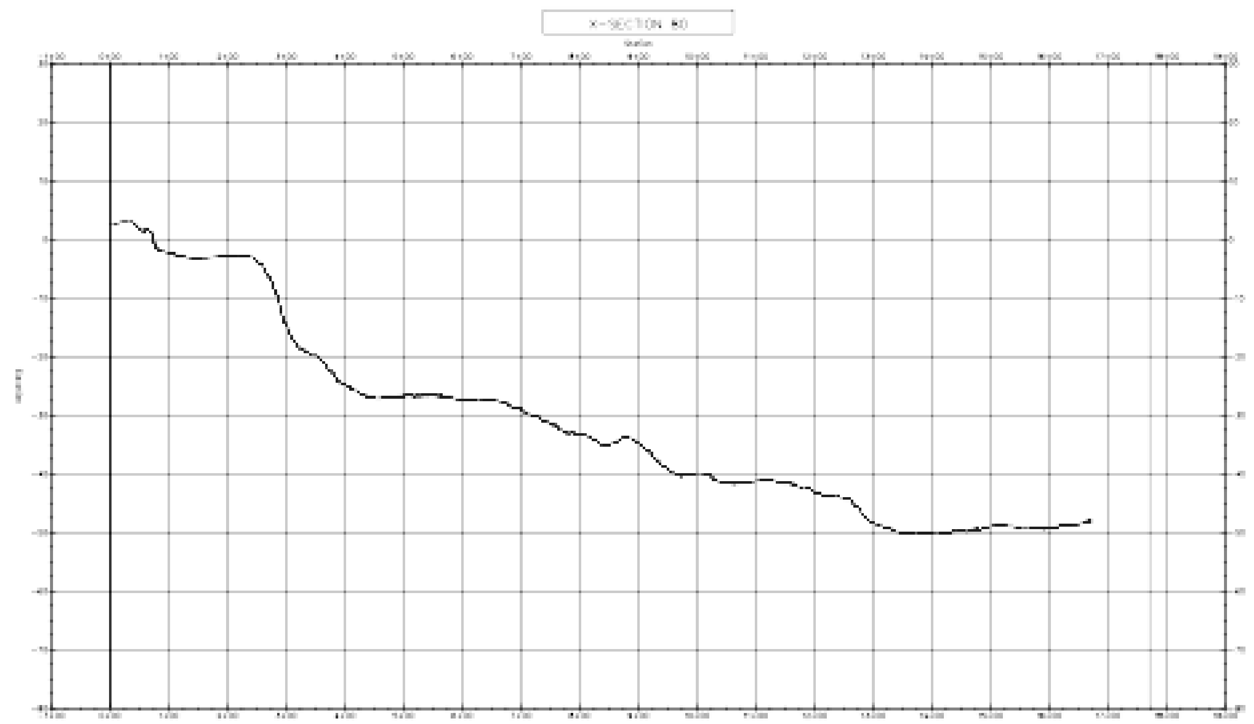
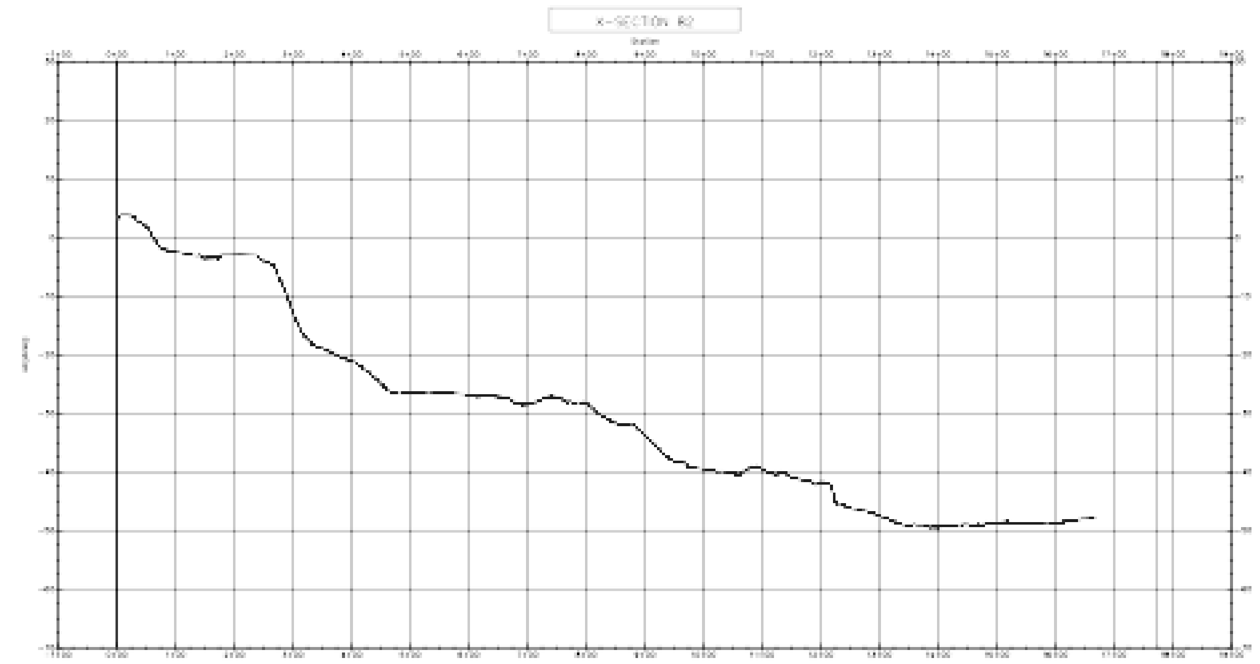
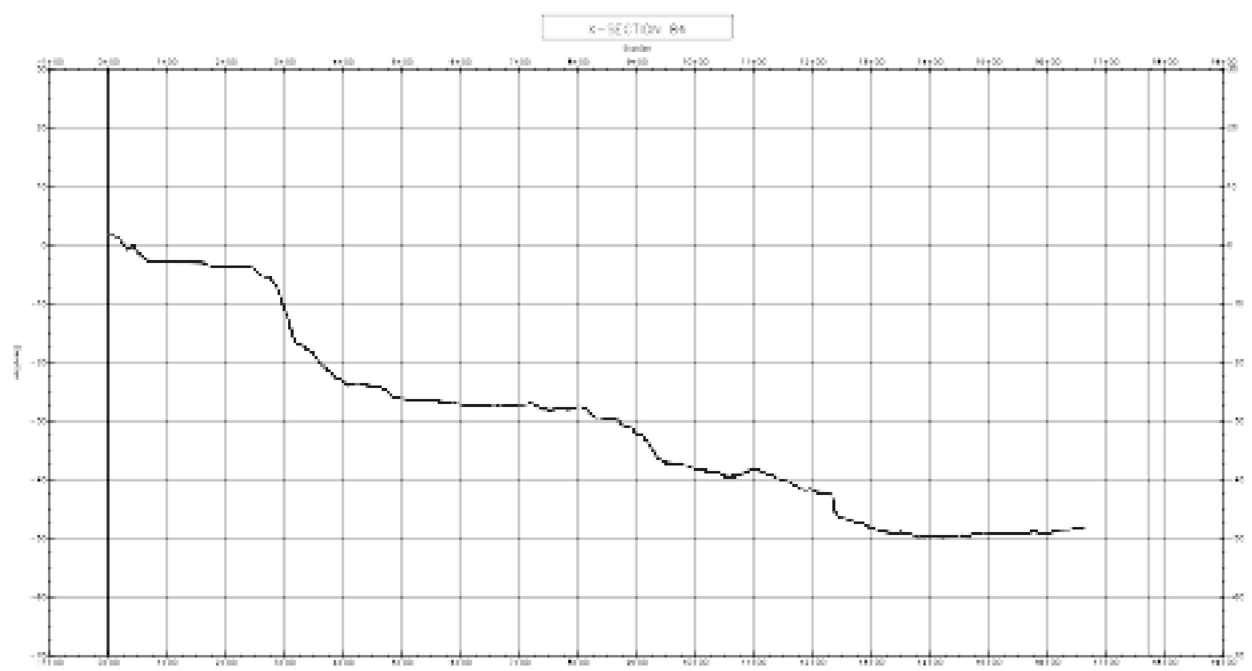
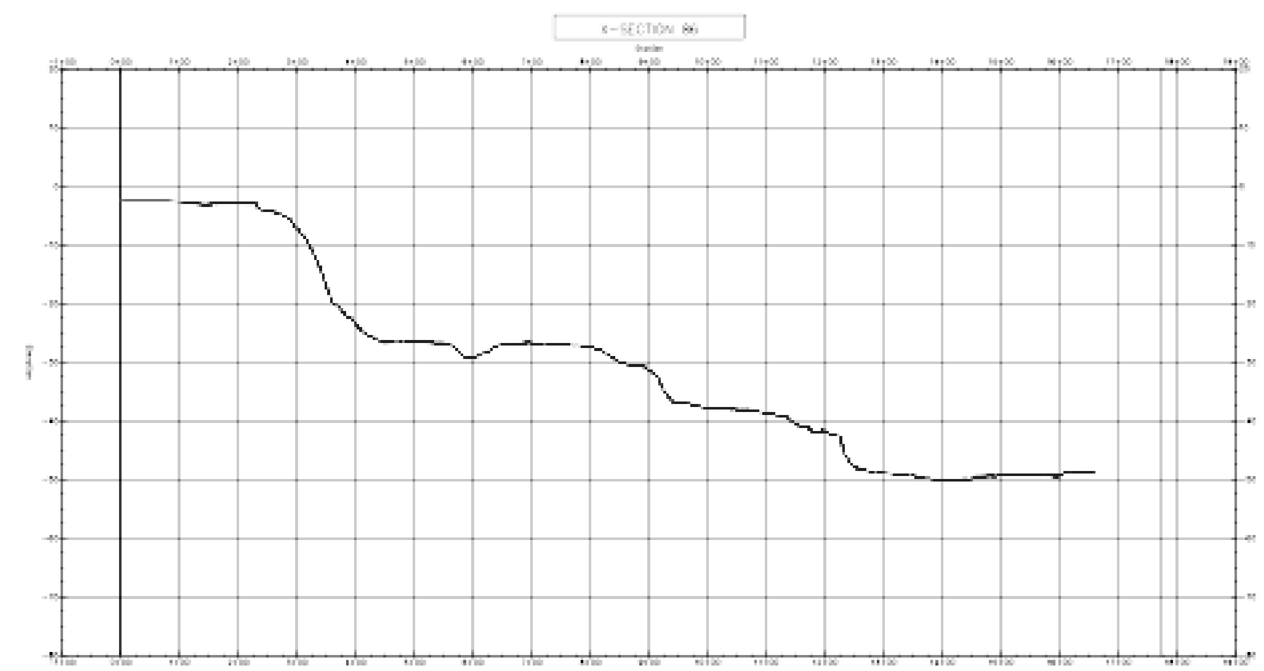


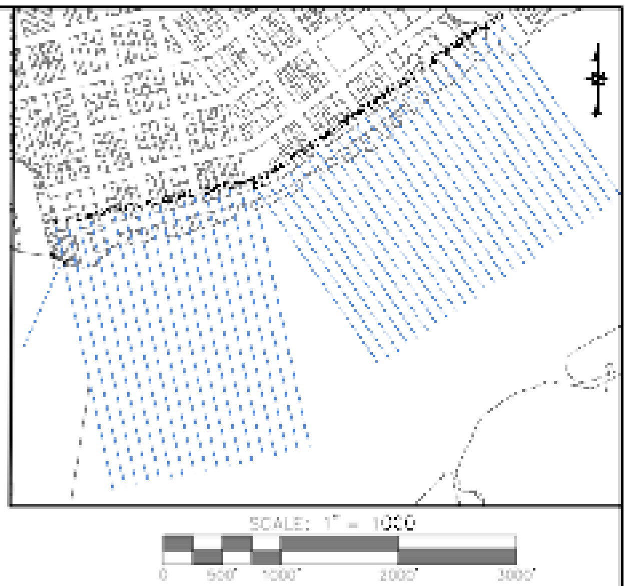












CROSS SECTIONS NOTES:

- THE SURVEY CONTOURS ARE REPRESENTED BY THE BLUE LINE.
- FULL DATASET WAS USED TO CREATE THE CROSS-SECTIONS.
- ELEVATIONS ARE IN FEET BASED ON NAVD88.
- STATION 0+00 ON THE X-AXIS IS THE BEGINNING OF THE LINE AS SEEN ON THE MAP ABOVE AND THE PROFILE RUNS FROM NORTH TO SOUTH.

PRELIMINARY PLAT
NOT FOR RECORDATION, CONVEYANCES, OR SALES

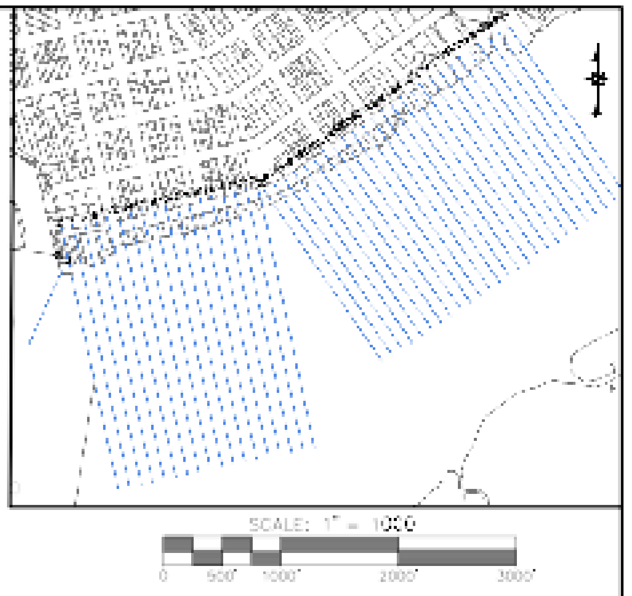
CROSS SECTION SCALE
VERTICAL 1" = 20'
HORIZONTAL 1" = 200'
0 10 20 40 60
0 100 200 400 600

McKIM&CREED
243 NORTH FRONT STREET
WILMINGTON, NORTH CAROLINA 28401
TELEPHONE: (910) 343-1048
FAX: (910) 251-8282
NORTH CAROLINA FIRM LICENSE NUMBER: F-1222

CONDITION SURVEY - CROSS SECTIONS
OF
SOUTHPORT SHORELINE IMPROVEMENT
PREPARED FOR
OLSEN ASSOCIATES, INC.
SOUTHPORT, BRUNSWICK COUNTY, NORTH CAROLINA
FEBRUARY 9, 2023

JOB NUMBER:	03026-0005
SCALE:	1" = 200'
CAD NUMBER	WI-030260005.DWG
PLS:	DLJ
PARTY CHIEF:	JTL
CAD TECH:	CRB
FIELD BOOK/PAGE:	W2087 56-66
DRAWING NUMBER	2023-026

SHEET 8 OF 9



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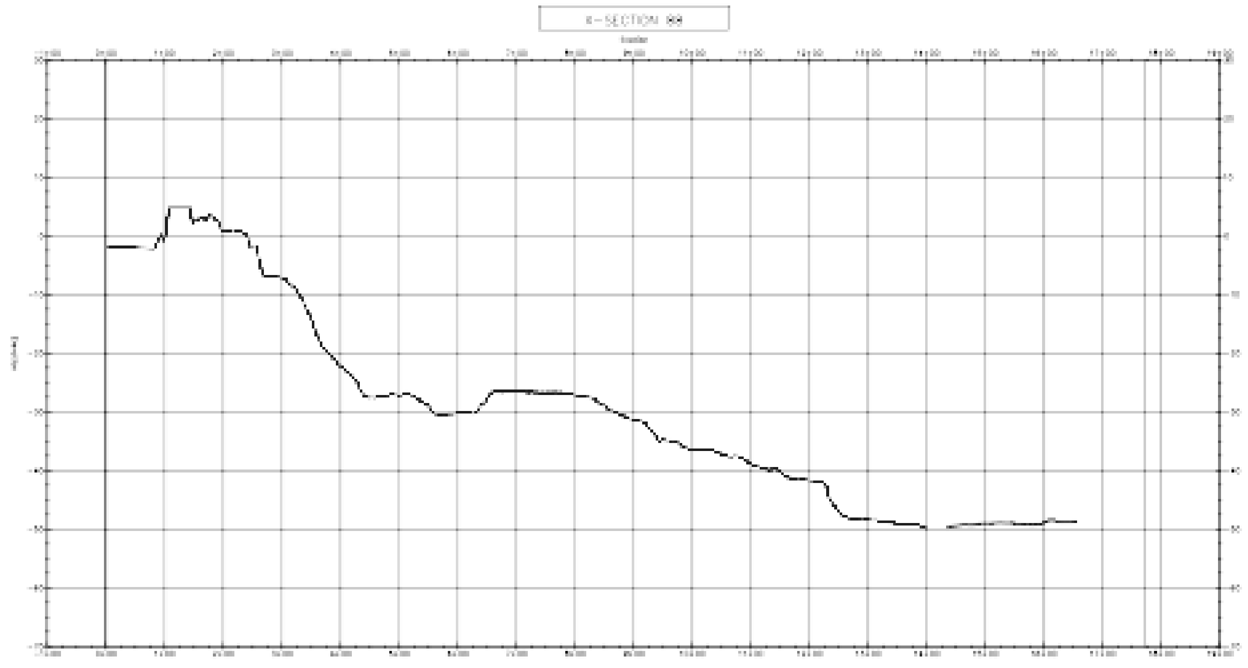

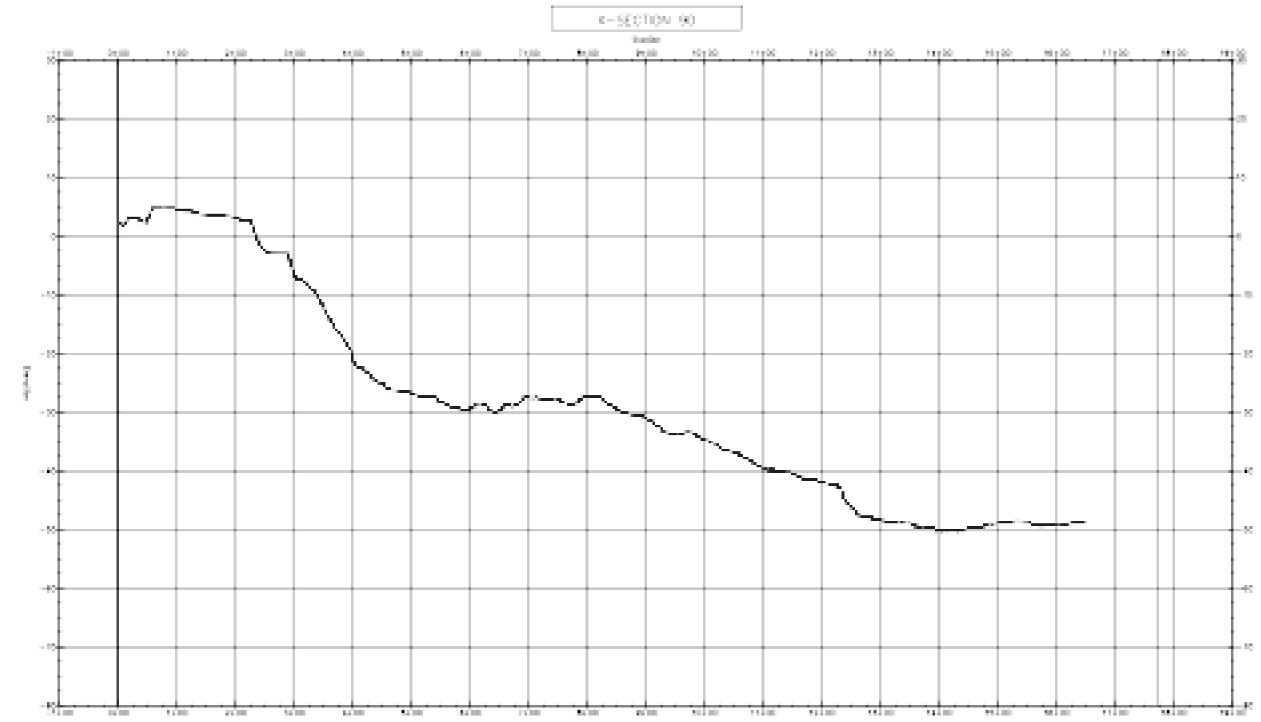

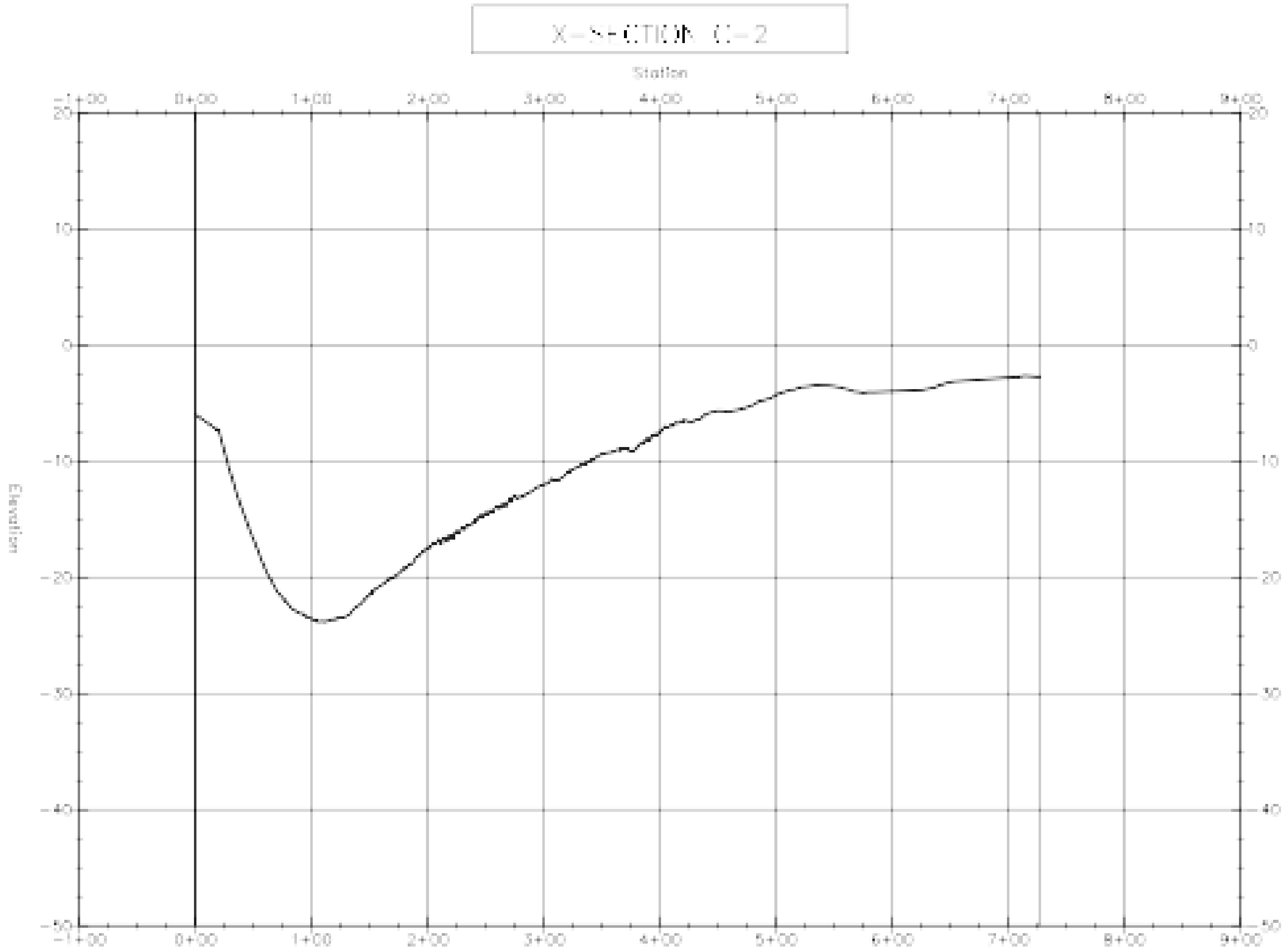

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FEBRUARY 9, 2023

JOB NUMBER:	03025-0005
SCALE:	1" = 200'
CAD NUMBER	WI-03025005.DWG
PLS.	DLJ
PARTY CHIEF.	JTL
CAD TECH:	CRB
FIELD BOOK/PAGE.	W2087 56-66
DRAWING NUMBER:	2023-026