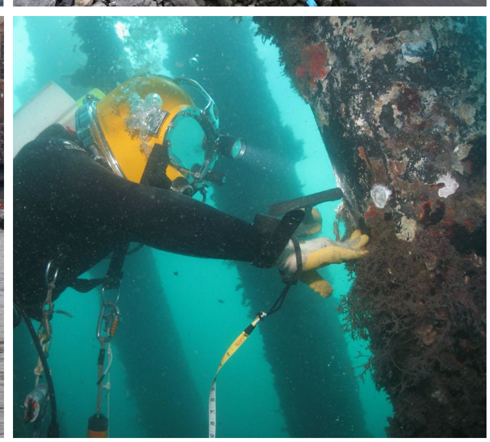
Waterfront Facilities Maintenance Management System

Inspection Guidelines Manual





Prepared by ch2m. May 2016

NYCEDC
New York City Economic Development Corporation

NEW YORK CITY ECONOMIC DEVELOPMENT CORPORATION
WATERFRONT FACILITIES MAINTENANCE MANAGEMENT SYSTEM

INSPECTION GUIDELINES MANUAL

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1. INTRODUCTION

1.1 BACKGROUND, PURPOSE, AND OBJECTIVES

This NYC Waterfront Inspection Guideline Manual (Manual) has been prepared to provide a single comprehensive set of guidelines for the City for the inspection, assessment and monitoring of waterfront structures, shorelines, and wetlands. These guidelines can be used by all City agencies and their consultants that work on the City's waterfront, but has been specifically prepared for the New York City Economic Development Corporation's (EDC) "Waterfront Facilities Maintenance Management System" (WFMMS). The WFMMS consists of inspection criteria, reporting methods, and software to develop, track, and maintain capital budgets for all waterfront assets.

The comments and examples provided in this manual are the result of many years of experience involving inspections of hundreds of waterfront facilities. In addition, the descriptions, ratings, and assessments are based on standards currently used or under development by the American Society of Civil Engineers (ASCE), the United States Navy (US Navy), Port Authority of New York and New Jersey, US Army Corps of Engineer (USACE), and the New York City Department of Parks and Recreation (DPR).

1.2 SCOPE AND LIMITATIONS

The WFMMS uses the following types of inspections to track the condition of the City's waterfront facilities:

- Baseline Inspection
- Routine Level Inspection
- Rapid Level Inspection
- Design Level Inspection
- Construction Inspection
- Post-Construction Inspection
- Post-Event Inspection
- Engineering Investigation

This manual presents the definition and purpose for each type of inspection. In addition, the manual provides guidelines for when each type of inspection should be performed, along with an overview of the scope of work for each inspection.

1.3 ELEMENTS OF THE WFMMS

The WFMMS consists of two major elements as follows:

Inspection Guidelines. The inspection guidelines set the standards for all consultants performing inspections of city assets to follow when conducting inspections of waterfront facilities which encompasses traditional hard structures as well as soft structures such as shorelines and wetlands. The guidelines describe the overall management system for inspecting, rating, and reporting the condition of waterfront facilities and presenting the data in a form compatible with the management database. Following these guidelines will result in a consistent set of fit for purpose inspection reports that use standard terminology for conditions and recommendations, standard analytical methods, and standard cost estimating procedures where applicable.

Application. The WFMMS application is a web-based SQL database system that utilizes GIS to track inspection results and to provide information needed to determine the required remedial actions, develop long term capital budgets, and analyze inspection and capital budget data. This application will be accessible to consultants performing the inspections and will serve as a depository of information for all waterfront assets.

1.4 ORGANIZATION OF MANUAL

This Manual is organized to present all required information in a logical sequence and contains specific requirements for hard structures, shorelines, and wetlands. The Manual has been divided into the following sections:

- Section 2 describes the general inspection program standards, including the WFMMS application requirements, quality control checks, personnel qualifications, preparation for field surveys, and the types of inspections that can be performed
- Section 3 outlines the inspection requirements for hard structures, including the scope of inspections, inspection types, defect definitions for different types of materials, condition assessment ratings, and recommendations
- Section 4 outlines the inspection requirements for shorelines, including the scope of inspections, components of a shoreline inspection, inspection types, condition assessment ratings, and recommendations
- Section 5 outlines the inspection requirements for wetlands, including the scope of inspections, components of a wetland inspection, inspection types, condition assessment ratings, and recommendations

- Section 6 describes the documentation and reporting requirements for each of the inspection types
- Section 7 outlines the general requirements for the implementation of an inspection program
- In Appendix A, checklists for inspection of various types of waterfront structures commonly found in the City are given. Appendix B provides a glossary. In Appendix C, examples of text, figure, and photograph page layouts are given, and writing styles are discussed. Appendix D provides guidance on the corrosion rates for steel components. Appendix E provides sample calculations and Appendix F further describes the functions of wetlands. Appendix G lists the references used in the development of this Manual.

2. GENERAL INSPECTION PROGRAM STANDARDS

2.1 OVERVIEW AND FLOW OF ACTIVITIES

The following events, shown in the flowchart on Figure 2-1, illustrate a typical scenario to show how this manual and the application will work together:

- The application will be accessed to determine the inspection schedule of the facilities. If a facility is to be inspected, a request for proposal for the inspection will typically be sent out to consultants. In the request, the type of inspection to be performed, the scope of work, the use of the facility to be inspected, and access to the previous inspection report, if available, will be provided.
- Provided the prior inspection supplies sufficient information, the consultant(s) will prepare a proposal. If sufficient information is not available or a prior inspection has not been done, a site visit may be necessary to allow the consultant(s) to clarify the scope of work and estimate time and costs for the inspection. Upon approval of the proposal, the selected consultant will begin preparing for the inspection.
- The consultant will perform the inspection adhering to guidelines set forth in this manual. During the inspection, if conditions are found that warrant loading restrictions or pose a hazard, the property owner/manager would be notified and access to the affected areas of the facility would be restricted and/or other remedial action undertaken.
- After the inspection, the consultant will prepare the appropriate deliverable in accordance with the guidelines in Section 6 of this manual. The consultant will upload the report electronically and also input the findings and recommendations into the WFMMS application using the provided user login information.

The submitted report and findings entered into the application will then be used to determine remedial actions to be taken, develop long-term capital budgets, and analyze inspection and capital budget data.

The WFMMS application can be accessed at: www.nycedc.com/wfmms

A screenshot of the WFMMS application is shown on Figure 2-2. The consultant will be provided with the necessary login information to access previous reports and findings for the facility.

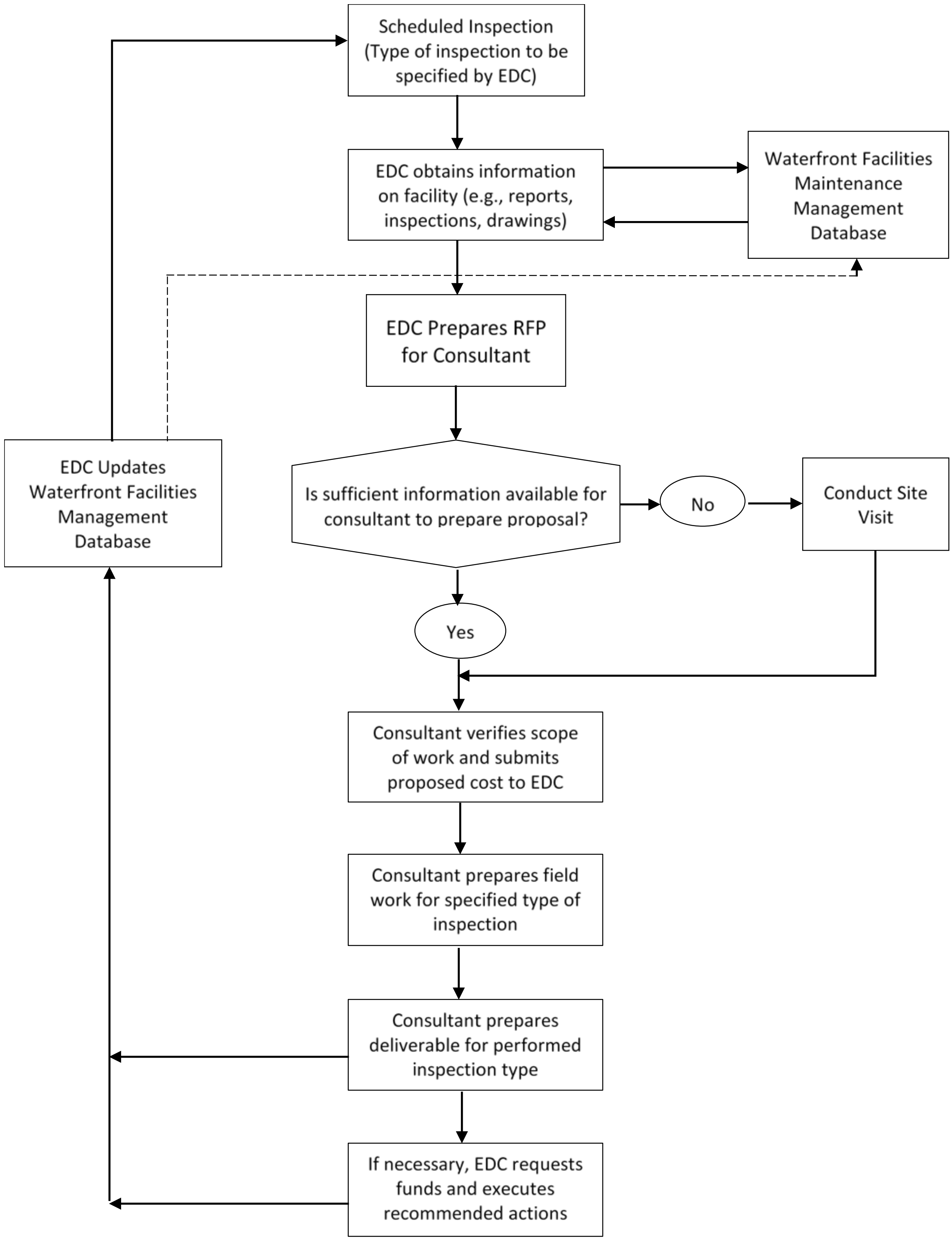


FIGURE 2-1. FLOW OF INSPECTION

FIGURE 2-2. SCREENSHOT OF WFMMS APPLICATION

2.2 WFMMS DATABASE REQUIREMENTS

2.2.1 Structure Addressing and Boundaries

There are four levels of identification used in the WFMSS – site, facility, system, and component. They have been established to facilitate the input of information into the WFMMS. Two examples of a facility breakdown are presented on Figures 2-3 and 2-4.

Some facilities entered into the WFMMS have not been previously inspected using the guidelines contained in this Manual. As a result, the facility has not been separated into its various levels. Therefore, the consultant shall divide the facility according to the definitions provided in this manual, and submit the proposed breakdown in the proposal prior to or during the inspection depending on the complexity of the facility. The definitions of the various levels are presented in the following subsections.

(A) SITE

The site is the highest level in the WFMMS. The site may group a number of facilities together in a definable unit based on use and distinct property boundaries. If a site consists of only one facility, the site and the facility are identical.

(B) FACILITY

A facility may be a pier, wharf, marina, shoreline, wetland, or any of a number of major items which, taken together, comprise a site. Typically the facility will be defined based on ownership or responsibility. Upon completion of the inspection, the facility shall be assigned an overall condition assessment rating as defined in Sections 3.3, 4.3, or 5.3.

(C) SYSTEM

Each facility within a site is divided into systems. A list of the system types included in the WFMMS is provided in Table 2-1. The boundaries of a system are determined primarily by structural considerations or logical inspection units. Each structural configuration change or change in construction material at the facility requires a separate system designation. Upon completion of the inspection, each system shall be assigned an overall condition assessment rating as defined in Sections 3.3, 4.3, or 5.3. For instance, if the facility is a stretch of beach, the system types that comprise it may include a sandy shoreline, groyne, and high-level deck platform (boardwalk). Each of these system types will then be further divided into components. Typically, each system will be given a name or identified differently from the system types included in the WFMMS. For instance, the system may be referred to as "Pier 4", but the system type associated with the pier would be "high-level platform."

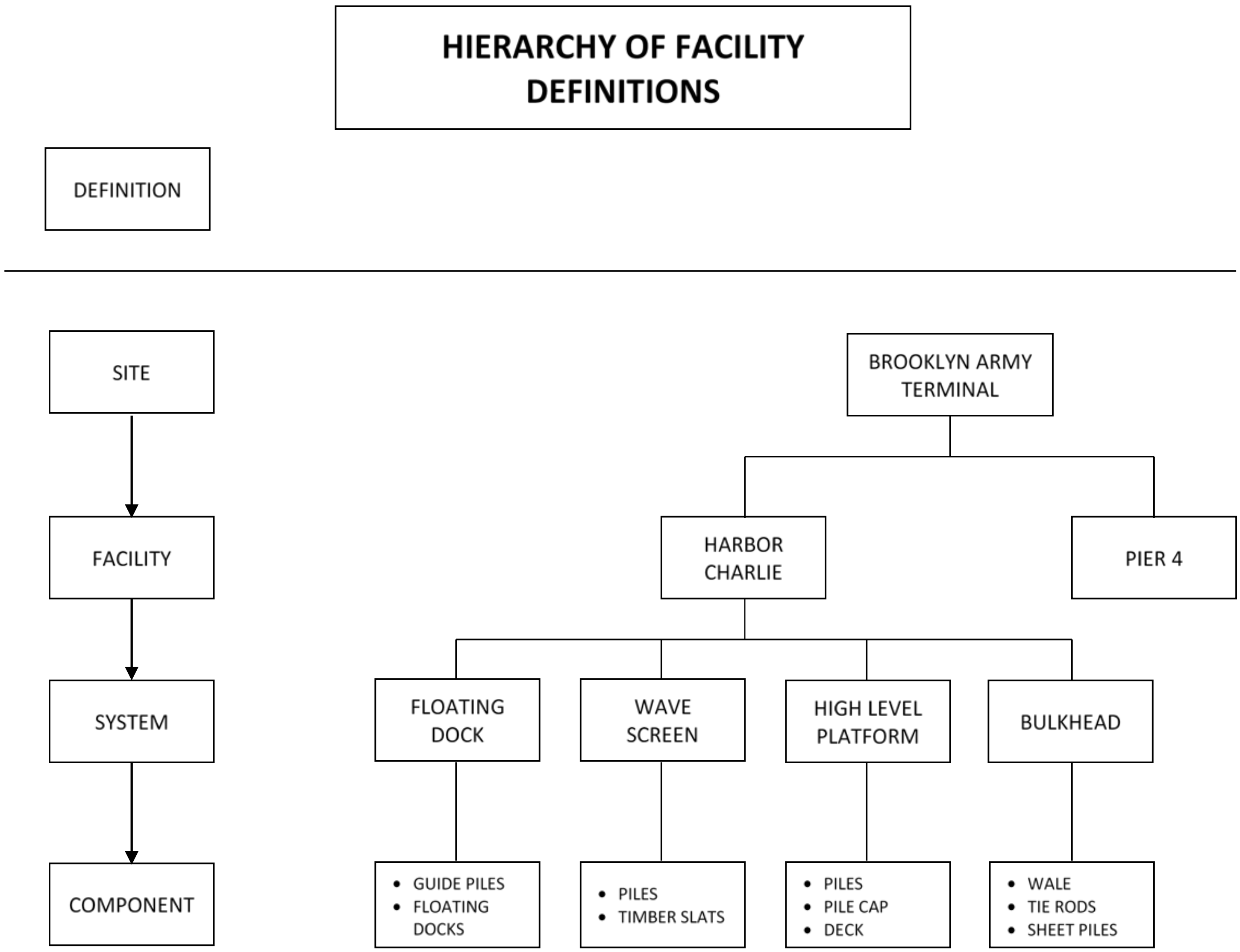


FIGURE 2-3. EXAMPLE FACILITY BREAKDOWN (SIMPLE)

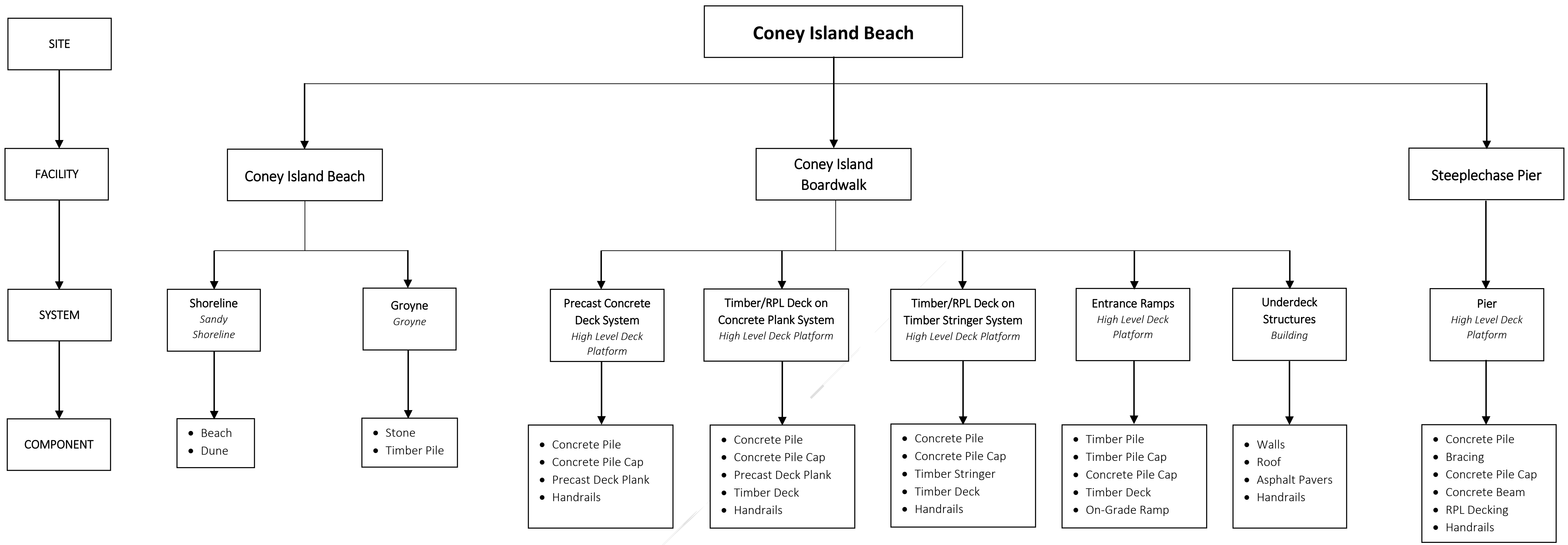


FIGURE 2-4. EXAMPLE FACILITY BREAKDOWN (COMPLEX)

(D) COMPONENT

For hard structures, a component is defined as an individual structural member, the collection of which makes up the system. Components may include piles, pile caps, decks, floats, barges, gangways, etc. Upon completion of the inspection, each component shall be assigned an overall condition assessment rating as defined in Section 3.3. In addition to assigning an overall condition assessment rating, during the inspection each individual component shall also be rated individually using the appropriate damage grade, as defined in Section 3.1.3 for material elements.

For shorelines, typical components may include beaches or dunes. Upon completion of the inspection, each component shall be assigned an overall condition assessment rating as defined in Section 4.3.

For wetlands, typical components may include one of the following: the wetland shoreline, tidal creeks and pools, marsh vegetation and habitat. Upon completion of the inspection, each component inspected shall be assigned an overall condition assessment rating as defined in Section 5.3.

2.2.2 System Types and Materials

The City's waterfront is generally comprised of hard structures, shorelines, wetlands, or a combination of these. In the WFMMS, each waterfront facility is assigned one or more applicable system types contained in Table 2-1.

TABLE 2-1
LIST OF SYSTEM TYPES IN THE WFMMS DATABASE

Hard Structures		Shorelines	Wetlands
Bulkhead	Pile Field	Sandy Shoreline	Spartina Dominated
Building	Boat Ramp	Unclassified Shoreline	Phragmites Dominated
Steel Sheet Pile Cell	Revetment	Marine Forest	Scrub/Shrub/Wooded
Cribbing	Wave Screen		Manmade Wetland
Dolphin	Bridge Pier		
Floating Docks	Ferry Landing		
Floating Barge	Combined Sewer Outfall		
Fender Rack	Outfall		
Gravity Retaining Wall	Vent Structure		
Groyne			
High-Level Deck Platform			
Low-Level Deck Platform			
Pile Supported Barge			

The majority of hard structures that comprise the City's waterfront facilities are either bulkhead or pile-supported piers/wharves. Structures such as bulkheads are typically constructed with either timber, stone/granite blocks, concrete, or steel/composite sheet piles. The piers and wharves can be further grouped into low-level relieving platforms or high-level platforms, both of which are supported by either timber, steel, or concrete piles. The platform structures are typically constructed of concrete or timber.

Shorelines are typically categorized as either sandy, unclassified, or marine forests.

Wetlands along the City's waterfront are either dominated by *Spartina* species, *Phragmites* (giant reed), or characterized by shrubs, scrub or wooded swamps dominated by trees. Manmade category could include stormwater treatment wetlands or mitigation wetlands.

2.3 QUALITY CONTROL

It is important to ensure that quality and consistency are incorporated into all correspondence and deliverables prepared by the consultant performing the inspections. It is the responsibility of the Team Leader (Project Engineer) to ensure that the proper guidelines for drawings, reports, submission requirements, and other technical items are established and followed. Qualifications for the Team Leader are described in Section 2.4.1(B). The following list identifies some of the quality control checks that shall be applied to all inspection reports:

- Table of contents is correct
- Site, Location, and Facility plans are clear and correct
- Facility hierarchy breakdown has been provided and condition assessment ratings have been assigned to every facility, system, and component
- Recommended repairs are appropriate
- All repairs are indicated on the appropriate drawing correctly with the correct symbols and color designation (cross reference between write-up and drawings)
- The number of repairs and the type of repairs are stated consistently throughout the report.
- All photograph captions, figures, and drawings are correct (cross reference with write-up)
- All photographs, tables, and figures referred to in the text are properly referenced
- All calculations have been checked and signed by a qualified reviewer

- Prior to submittal, the report shall be checked in detail by the Project Manager and, subsequent to the incorporation of comments, by a principal of the company.

2.4 PREPARING FOR THE INSPECTION

The first step for the preparation of an inspection is to assemble a qualified team. Once a qualified team is assembled, the preparation for the inspection includes three principal activities: Information Gathering, Planning, and Equipment Gathering. The minimum qualifications for the inspection team and the highlights of these inspection preparation activities are described below.

2.4.1 Personnel and Qualifications

The inspection of waterfront facilities, including underwater inspection and the inspection of shorelines and wetlands, is very specialized, and should only be carried out by personnel with the experience and expertise required to successfully complete the work.

For hard structures, beyond experience in inspecting marine structures, the consulting firm performing the inspection should have proven experience in the design and rehabilitation of marine structures similar to those being inspected. Additional experience in cost estimating and supervising the construction and repair of marine structures is also required. The consulting team performing the underwater inspections must have commercial diving capabilities and must include personnel who can analyze the structure and prepare the inspection reports. This capability leads to a more efficient and accurate inspection project in that the engineers performing the inspection have a first-hand knowledge of the inspected structures and there is no loss of understanding of critical information due to inefficient communication. Diving will be performed in accordance with the requirements of the federal commercial diving standards of the Occupational Safety and Health Administration (OSHA) (29 CFR Part 1910) and shall at minimum include a three-person dive team utilizing a three-part umbilical with continuous hard-wire communications and other commercial dive gear. Use of scuba diving equipment which does not permit hard-wire communication between the diver and topside for the inspection shall not be permitted. At a minimum, the dive team shall include a diver, tender, and team leader. Each member of the dive team shall be capable of diving in the case of an emergency and have the ability to inspect and assess conditions.

For shorelines, the consulting firm performing the inspection should have proven experience in the monitoring of shorelines, the design of shoreline protection structures, and possess a good understanding of coastal processes. Additional experience in cost estimating and supervising the construction and repair of beaches is also required. The consulting team performing the shoreline inspection must have coastal engineering capabilities with personnel who can analyze and interpret the collected data and prepare the inspection reports.

For wetlands, the consulting firm performing the inspection should have proven experience with the assessment of tidal wetlands functions including an understanding of the various stressors that impact different wetland types, native and invasive flora of the Mid-Atlantic region wetlands, and their soil properties. Additional experience in cost estimating and supervising the restoration of wetlands is also required.

In general, the consultant performing the inspection should not be actively involved in directly performing waterfront construction work in the New York area. It is important that an unbiased firm, which will not benefit from overstating damage or finding additional quantities of repair work, carries out the inspection.

The consulting team performing inspections should, at minimum, include members with the project roles in Table 2-2. The project roles are defined below. Additional specialized roles may be required depending on the inspection's objectives, requirements, and data collection techniques.

TABLE 2-2
PROJECT ROLES REQUIRED FOR INSPECTIONS

Team Member	Facility Type		
	Hard Structures	Shorelines	Wetlands
Project Manager	X	X	X
Team Leader	X	X	X
Diving Inspector / Engineer-Diver	X		
Inspector	X	X	X
Coastal Engineer		X	
Wetland Scientist			X
Surveyor*	X	X	X

* The surveyor shall be part of the consulting team as required by the type of inspection.

(A) PROJECT MANAGER

The inspection team should be staffed by qualified professionals in the marine engineering field, under the direct supervision of the Project Manager. The Project Manager shall be a registered/licensed Professional Engineer in the State of New York, specializing in civil, structural, environmental, or coastal engineering with at least ten years of experience in a responsible capacity in the inspection, design, and construction of waterfront facilities.

If inspections include wetlands, the Project Manager shall also have a functional understanding of coastal wetland ecology and wetland regulations.

(B) TEAM LEADER (PROJECT ENGINEER)

The Team Leader shall be a registered/licensed Professional Engineer, specializing in civil, structural, environmental, or coastal engineering, with at least three years of experience in a responsible capacity in the inspection or design of the system being inspected.

If the inspection work includes underwater inspection, the Team Leader should also be a certified diver with commercial training, and should perform a minimum of 25% of the diving inspection work.

If the inspection work includes wetlands, the Team Leader should have a minimum of 3 years of experience with wetland monitoring, wetland delineations or in the assessment of wetland functions. The Team Leader should be a wetland ecologist or have a degree in a related field of expertise.

The Team Leader shall be at the site for the duration of the field inspection, and shall personally direct the inspection team to assure that each component is properly inspected and its condition is properly documented. When unusual structural problems or details are encountered, the Team Leader shall personally observe and evaluate the situation, and where applicable, seek assistance from subject matter experts.

(C) DIVING INSPECTORS, INCLUDING ENGINEER-DIVERS

Divers shall be certified, preferably with commercial training, and shall have experience diving in low visibility, high currents, and areas with limited space. At a minimum, the divers should hold a certification from a recognized training organization such as the Association of Diving Contractors International (ADCI) or International Marine Contractors Association (IMCA), and should have a minimum of two years of in-water diving experience being employed under conditions similar to the inspection site. The divers should have documented experience and/or training to make determinations of the condition of materials, retrieve samples, perform non-destructive testing, and take underwater photographs and measurements.

(D) INSPECTORS

Engineers or technicians with at least 12 months of experience and a working knowledge of timber, steel, and concrete waterfront construction. If the inspection includes wetlands, a working knowledge of marsh vegetation, specifically of salt marsh plants found in the North Atlantic region, wetland hydrology and soils is also required.

(E) COASTAL ENGINEER

Coastal engineers shall have a degree in coastal or ocean engineering, or related field, with at least 12 months of experience and a working knowledge of coastal processes and beach monitoring/profiling. The coastal engineer may not be at the site for the duration of the field inspection, however, should be part of the consulting team to assure that the inspection team is properly documenting conditions and support the Team Leader in the development of the inspection report.

(F) WETLAND SCIENTIST

Wetland scientists shall have a degree in ecology or related field, with at least 12 months of experience with wetland monitoring, or wetland delineations as well as a working knowledge of coastal wetlands functions. The wetland scientist may not be at the site for the duration of the field inspection, however, should be part of the consulting team to assure that the inspection team is properly documenting conditions and to support the Team Leader in the development of the inspection report.

(G) SURVEYOR

The lead surveyor shall be a registered/licensed land surveyor in the State of New York with at least 3 years of experience and a working knowledge of the surveying equipment and technique being employed as part of the inspection. For hydrographic surveys, the lead surveyor shall be an American Congress on Surveying and Mapping (ACSM) Certified Hydrographer.

2.4.2 Information Gathering

In preparing for an inspection, consultants should gather and familiarize themselves with drawings, previous inspection reports or repair data, and inspection forms, worksheets, and sketches of the structure to be inspected. Prior to the start of the inspection, the property owner or manager will provide the consultant with a list of all known records of the structure to be inspected. This information will be obtained from the WFMMS application and may include previous inspection reports as well as design or as-built drawings for repairs or new construction. These documents are useful regardless of the type of inspection, and are described below.

(A) DRAWINGS OF THE STRUCTURE TO BE INSPECTED

The most useful drawings are the plans and the typical cross sections indicating the basic element types and their arrangement. The original "As-Built" drawings should be used when available. It is important to verify that the drawings contain up-to-date information, as many waterfront structures have undergone significant modifications, which may not be reflected on any drawings.

(B) PREVIOUS INSPECTION REPORTS OR REPAIR DATA

In order to identify trends in the deterioration of structures and to identify if rehabilitation has been carried out, it is necessary to refer to previous inspection findings. For shorelines, previous inspection reports containing shoreline profiles will help determine whether the shoreline is undergoing accretion or erosion and serve as a basis for comparison. Similarly for wetlands, previous inspection reports will help identify trends in the health of the wetland and serve as a basis for comparison.

(C) PUBLICALLY AVAILABLE DATA

Publically available data such as digital terrain models, bathymetry, and satellite imagery provides both useful current and historic data that may be used to identify trends in shoreline movement. GIS data compiled by local, state, and federal agencies contains extensive data on wetland habitats, inventories, vegetation, etc. which may help in the planning of wetland inspections. The consultant selected for the inspection shall perform an online search of publically available data to support the inspection effort and report development.

2.4.3 Planning

For the successful execution of all inspections, the inspector must carefully review the available drawings, reports, and publically available data. Conditions such as space constraints, tides, operating vessels, navigational constraints, season, and site accessibility place a number of constraints on the execution of the inspection. For wetlands, the inspector also should review available aerial photographs or satellite imagery.

Tide tables should be reviewed during the planning stage to determine the optimal time for an inspection. In most cases, inspections should be planned around low tides, i.e., ideally with the low tide level in the middle of the inspection day.

Inspections should be scheduled to avoid conflicts with operations at a berth. A berthed vessel may substantially reduce the amount of available light, and may hinder access. In addition, working near a berthed ship may be dangerous especially when divers are in the water.

When planning re-inspections of shorelines and wetlands, they should be performed, to the extent possible, at the same month or, at least, during the same season as the previous inspection. This will help make the comparison of inspection results more useful and minimize differences that may result from seasonal effects.

For all inspections, a site-specific Safety Plan shall be prepared by the consultant and submitted for approval prior to the start of any field work. In addition, the consultant shall coordinate with and obtain all the necessary approvals and/or permits from the relevant agencies to gain access to the facility being inspected.

2.4.4 Equipment Gathering

Underwater inspections, topographic and bathymetric surveys, aerial photography, and environmental and hydrodynamic condition monitoring require a substantial amount of specialized equipment. For the purpose of this manual we have not focused on defining all of the potential tools available to the consultant. The ASCE Manual on Waterfront Facilities Inspection and Assessment provides a general overview of some of the available tools and shall be referenced by the consultant as appropriate. Most inspections can be performed using conventional tools and equipment. These are described below.

(A) EQUIPMENT SELECTION

Inspections require a variety of tools to clean and measure structural elements. Several of the most widely used materials, tools, and instruments for inspections are listed below:

- Geological (inspection) hammer
- Hand light
- Wire brush
- Folding ruler
- Measuring tape
- Lead line
- Survey rod
- Pile caliper
- Spray paint
- Crack width gage/scale
- Ultrasonic thickness (UT) meter
- Awl/Ice pick

For wetland inspections the following additional equipment are required:

- GPS (with sub-meter accuracy)
- Plant field guide
- Refractometer (Salinity meter)
- 1-m^2 quadrant
- Waders
- Sharpshooter shovel

(B) CONDITION DOCUMENTATION

All documentation, photographic equipment, and office supplies should be kept in a watertight box. The contents of the box should generally include:

- Drawings, sketches, standard inspection forms, reference drawings, and a notebook (for preparing supplemental sketches and recording additional information, if necessary)
- Clipboard
- Calculator
- Tide tables
- Pencils and erasers
- Digital camera (with a minimum resolution of 12 megapixels, GPS tracking, and ability to record video)
- Notebook computers or tablets should be used to the fullest extent possible for the direct entry of field data.

(C) PHOTOGRAPHIC EQUIPMENT

The most convenient camera for above water work is one that is small, automatic, shock/weatherproof, and equipped with a wide-angle lens. Underwater photographs should be taken with an underwater digital camera. A clearwater box should be used for taking underwater photographs through turbid water.

Above water photography is required for all inspection types, and underwater photography should be used whenever possible. Digital cameras should be used to obtain electronic format photographs which should be tracked with GPS coordinates and high-definition video, where appropriate. Video documentation should be obtained to better illustrate anomalous conditions described in the inspection report.

2.4.5 Field Survey

A suitable scheme shall be devised for designating individual piles and other structural members. The consultant shall use the pile numbering/designation systems on existing "as-built" drawings, where available, or on previous reports. Usually a combination of numbers and letters is used. The inspection can be conducted bent-by-bent, or element type-by-element type, although a bent-by-bent inspection is generally more efficient. Where discrete elements or bents are not available to guide the inspection, such as along stretches of bulkhead, revetment, or shoreline, the facility should be stationed at a minimum of 100 ft intervals starting from one end of the facility to the other. Discrete markers should be used for stationing to help facilitate the inspection. For wetlands, the location of stations is determined in accordance with the July 2013 Natural Areas Conservancy Salt Marsh Assessment Protocol (NACSMA) protocol and is described in Section 5.

For hard structures, using Section 3 as an assessment guide, the locations and types of defects should be recorded using the appropriate assessment terms, and a damage grade should be assigned to each above and underwater element.

For shorelines and wetlands, Sections 4 and 5, respectively, provide guidelines on how to perform the condition assessments.

2.5 TYPES OF INSPECTIONS

The WFMMS defines eight types of inspections. These inspections have been developed to address specific purposes and common project objectives. The eight types of inspections used in the WFMMS are:

- Baseline Inspection
- Routine Level Inspection
- Rapid Level Inspection
- Design Level Inspection
- Construction Inspection
- Post-Construction Inspection
- Post-Event Inspection
- Engineering Investigation

A typical flow and context of inspection activities associated with each inspection type is shown on Figure 2-5. Figure 2-5 represents a typical flow of inspection activities and may be tailored to suit specific project objectives as needed. Combining inspection types may be necessary or advantageous in some cases to avoid duplication of effort and to minimize mobilization costs.

Table 2-3 summarizes the general purpose of each inspection type in the program. The following sections further define the scope of each inspection type based on the type of waterfront facility being inspected.

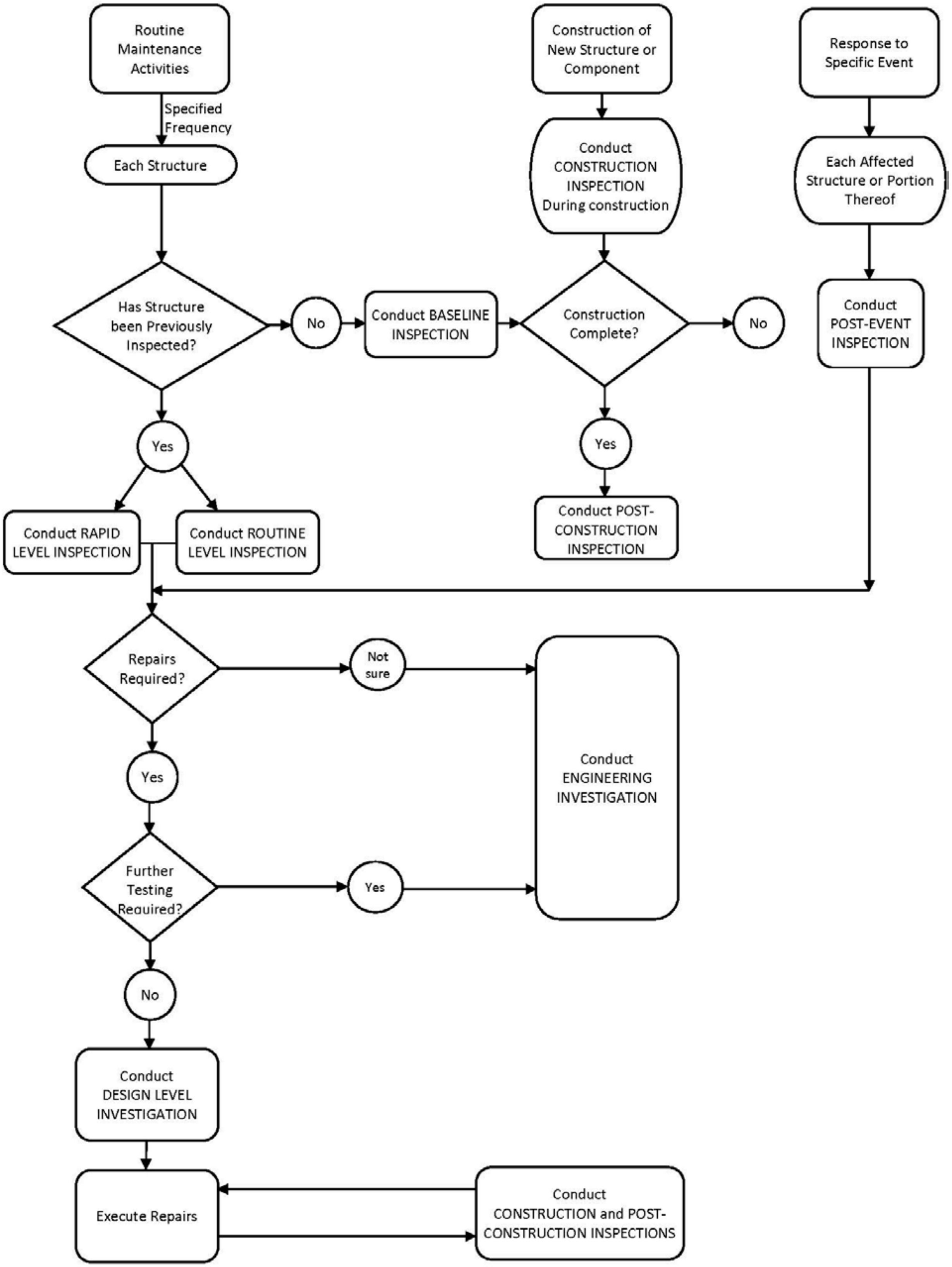


FIGURE 2-5. FLOW OF INSPECTION TYPES

TABLE 2-3
SUMMARY OF INSPECTION TYPES

Inspection Type	Purpose of Inspection
Baseline Inspection	To assess the general overall condition of the facility, develop an asset inventory for the facility, verify that the facility was built according to available design drawings, assign condition assessment ratings, estimate service life, and assign recommended actions with associated order-of-magnitude cost estimates wherever applicable. Baseline Inspections are undertaken for facilities that have never been inspected or require an asset inventory.
Routine Level Inspection	To assess the general overall condition of the facility, update the asset inventory for the facility, assign condition assessment ratings, estimate service life, and assign recommended actions with associated order-of-magnitude cost estimates wherever applicable. Routine Level Inspections are undertaken on a cyclical basis as part of a regular maintenance program for the facility.
Rapid Level Inspection	To make a quick general assessment of the condition of the facility, assign condition assessment ratings, and assign recommended actions with associated order-of-magnitude cost estimates wherever applicable. An asset inventory and estimate of remaining service life are not required for a Rapid Level Inspection. Rapid Level Inspections may be undertaken as part of a regular maintenance program for the facility or to address emergency or immediate issues not attributed to a specific event.
Design Level Inspection	To collect relevant information and data required for the preparation of design drawings and specifications. Design Level Inspections should be conducted with as little interval as practicable between the inspection and the start of construction.
Construction Inspection	To ensure that the ongoing construction quality is acceptable and in accordance with the design plans and specifications.
Post-Construction Inspection	To ensure that the completed construction quality is acceptable and in accordance with the design plans and specifications. In addition to ensuring proper construction quality, the purpose of the post-construction inspection is to develop an asset inventory (if one doesn't already exist) to serve as a baseline for future maintenance activities and to update the recommendations of the most recent Routine Inspection.
Post-Event Inspection	To be performed after a significant and potentially damaging event such as an earthquake, storm, vessel impact, flooding, fire, etc. The purpose of the inspection is to rapidly assess the condition of the system and to determine whether additional attention is required as a result of the event.
Engineering Investigation	To perform detailed testing, analysis, or investigation of a system in order to understand the nature and/or extent of the deterioration, and/or evaluate its capacity to perform its intended function.

3. HARD STRUCTURES INSPECTION REQUIREMENTS

3.1 GENERAL

3.1.1 Scope of Hard Structure Inspections

This section of the manual applies to the inspection of hard structures along the waterfront. This includes structures such as piers, wharves, bulkheads, revetments, floating docks, groynes, wave screens, etc. which are included in the WFMMS's list of systems. For a full list of hard structure system types included in the WFMMS see Table 2-1.

3.1.2 Standard Component Inspection Levels

The following are the definitions of standard levels of examination effort that apply to individual inspected components. The procedures prescribed for most inspection types are commonly a combination of at least two of these levels. The terms Level I, Level II, and Level III are based on the American Society of Civil Engineers (ASCE) Waterfront Facilities Inspection and Assessment Manual and are referred to frequently in the Scope of Work. They are summarized in Table 3-1, and are defined as follows. Further guidance on the level of inspection effort, including recommended sampling size and methodology, for above and underwater inspections of steel, concrete, and masonry components is provided in Table 3-2.

(A) LEVEL I - GENERAL EXAMINATION

Level I examination is essentially a "swim-by" overview, which does not involve cleaning of any structural components, and can therefore be conducted much more rapidly than the other levels of examination. The Level I examination should confirm as-built structural plans and detect obvious major damage or deterioration due to overstress (ship impact, ice), severe corrosion, or extensive biological growth and attack.

The underwater inspector shall rely primarily on visual and/or tactile observations (depending on water clarity) to make condition assessments. These observations are normally made over the total exterior surface area of the underwater structure (bulkhead, seawall, platform, etc.). The inspector should also confirm the continuity of the full length of all members and system components and detect undermining or exposure of normally buried elements.

(B) LEVEL II - DETAILED EXAMINATION

Level II examination is directed toward detecting and identifying damaged/deteriorated areas that may be hidden by biofouling organisms or surface deterioration. At this level, a limited amount of measurements may be made. This data should be sufficient to assess the relative condition of the facility and permit estimates of its load capacity.

Level II examinations will often require cleaning of structural components. Since cleaning is time consuming, it is generally restricted to areas that are critical (such as connections, attachment points, or welds) or which may be representative of the entire structure. The amount and thoroughness of cleaning to be performed is governed by what is necessary to discern the general condition of the overall facility. Methods of cleaning may include hand scrapers or mechanical systems such as high-pressure water blasters. For piles, a 1 ft. high band around the perimeter of the pile should be cleaned at designated locations, generally near the low waterline, near the mudline, and midway between the low waterline and the mudline. On large solid faced components such as retaining structures, 1 ft by 1 ft areas should be cleaned at three levels.

All defects found on the component are quantified and measured in detail. This includes following cracks up or down a pile, or measuring the full extent of spalling on a concrete component.

Simple instruments such as calipers, measuring scales, and ice picks are commonly used to take simple dimensional measurements. However, a small percentage of more accurate detailed measurements may also be taken using more sophisticated instruments. These will validate large numbers of simple measurements, and in some hard-to-measure areas will actually be easier and faster to obtain. Where the visual scrutiny, cleaning, and/or simple measurements reveal extensive deterioration, a small sampling of detailed measurements will enable gross estimates to be made regarding the structure's integrity.

(C) LEVEL III - HIGHLY DETAILED EXAMINATION

Level III examination will often require the use of non-destructive testing (NDT) techniques, but may also require the use of partially destructive techniques such as sample coring through concrete and timber structures, physical material sampling and off-site testing, or in-situ surface hardness testing. The purpose of this type of evaluation is to detect hidden or interior damage, loss in cross-sectional area, and to evaluate material properties. A Level III examination will usually require prior cleaning. The use of NDT techniques are generally limited to key structural areas, areas that may be suspect, or structural elements which may be representative of the underwater structure.

TABLE 3-1
SUMMARY OF INSPECTION LEVELS

Level	Purpose	Detectable Defects				
		Pile Wrap	Steel	Concrete	Wood	Composite
I	General visual /tactile inspection to confirm as-built conditions and detect severe damage.	Missing wrap Large tears in wrap	Extensive corrosion Corrosion holes Severe mechanical damage Broken piles	Major spalling and cracking Severe reinforcement corrosion Broken piles	Major loss of cross-section Broken piles, caps, decking, stringers, and bracings Severe abrasion or marine borer attack	Permanent deformation Major cracking or mechanical damage Broken piles
II	Detect surface defects normally obscured by marine growth	Poor fit of wrap to pile Tears and cuts	Moderate mechanical damage Major corrosion pitting Coating loss	Surface cracking and spalling Corrosion staining Exposed reinforcing steel and/or prestressing strands	External pile damage due to marine borers Splintered, split, or cracked piles Loss of bolts and fasteners Early signs of marine borer and insect infestation	Cracking Delamination Material degradation
III	Detect hidden damage or collect more detailed information	Corrosion of steel pile beneath wrap External and/or pile damage due to marine borers beneath wrap Dissolved oxygen level in entrained water Loss of bolts and fasteners	Thickness of material Electrical potentials for cathodic protection Thickness of coating	Location of reinforcing steel Beginning of corrosion of reinforcing steel Internal voids / delamination Change in material strength	Internal damage due to marine borers (internal voids) Decrease in material strength	N/A

Note: The term "defect" is defined as any anomaly in the shape or internal structure of an element and/or material(s) which adversely affects its functional capacity or service life.

TABLE 3-2
LEVELS OF INSPECTION EFFORT

Element	Level I		Level II		Level III	
	Sample Size[a]	Method	Sample Size[a]	Method	Sample Size[a]	Method
Topside and Above Water Inspections						
Steel Elements [b, c]						
Piles (≤24in. dia.)	100%	Visual/Tactile	As necessary	Visual: Removal of corrosion to observe parent metal and pitting size	As necessary	Remaining thickness measurement
Large or Solid-Faced Elements/Piles (>24 in. dia:)[d]	100%	Visual/Tactile	As necessary	Visual: Removal of corrosion to observe parent metal and pitting size	As necessary	Remaining thickness measurement
Concrete Elements[c]						
Piles (≤24in. dia.)	100%	Visual/Tactile	As necessary	Visual/Auditory: Sounding	As necessary	Electrical potential measurements, corrosion mapping, coring
Large or Solid-Faced Elements/Piles (>24 in. dia:)[d]	100%	Visual/Tactile	As necessary	Visual/Auditory: Sounding	As necessary	Electrical potential measurements, corrosion mapping, coring
Timber Elements[c]						
Piles	100%	Visual/Tactile	As necessary	Visual/Auditory: Sounding and Probing	As necessary	Drilling, coring
Large or Solid-Faced Elements [d]	100%	Visual/Tactile	As necessary	Visual/Auditory: Sounding and Probing	As necessary	Drilling, coring
Masonry						
Pilasters (≤24 in. per side)	100%	Visual/Tactile	As necessary	Visual/ Probing: Sampling of joint material	As necessary	Coring
Large or Solid-faced Elements (>24 in. per side)[d]	100%	Visual/Tactile	As necessary	Visual/ Probing: Sampling of joint material	As necessary	Coring
Underwater Inspections						
Steel Elements[b,c]						
Piles (≤24 in. dia.)	100%	Visual/Tactile	10%	Visual: Removal of marine growth in three elevation bands	5%	Remaining thickness measurement, electrical potential measurements, corrosion profiling as necessary
Large or Solid-faced Elements/ Piles (>24 in: dia:)[d]	100%	Visual/Tactile	Every 100 lin ft (LF)/ Quarter Points	Visual: Removal of marine growth in 1 sq ft area at three elevations	Every 200 LF/5%	Remaining thickness measurement, electrical potential measurements, corrosion profiling as necessary

Element	Level I		Level II		Level III	
	Sample Size[a]	**Method**	**Sample Size[a]**	**Method**	**Sample Size[a]**	**Method**
Concrete Elements[c]						
Piles (≤24in. dia.)	100%	Visual/Tactile	10%	Visual: Removal of marine growth in three elevation bands	0%	N/A
Large or Solid-Faced Elements/ Piles (>24 in. dia:)[d]	100%	Visual/Tactile	Every 100 LF/Quarter Points	Visual: Removal of marine growth in 1 sq ft areas at three elevations	0%	N/A
Timber Elements[c]						
Piles	100%	Visual/Tactile	10%	Visual: Removal of marine growth on three bands Measurement: Remaining diameter	5%	Internal marine borer infestation evaluation
Large or Solid-Faced Elements[d]	100%	Visual/Tactile	Every 50 LF	Visual: Removal of marine growth in 1 sq ft area at three elevations	Every 100 LF	Internal marine borer infestation evaluation
Masonry						
Pilasters (≤24 in. per side)	100%	Visual/Tactile	10%	Visual: Removal of marine growth in three elevation bands	0%	N/A
Large or Solid-faced Elements (>24 in. per side)[d]	100%	Visual/Tactile	Every 100 LF/Quarter Points	Visual: Removal of marine growth in 1 sq ft area at three elevations	0%	N/A

[a]The minimum inspection sample size for small structures shall include at least two components of each underwater component type.

[b]Coated elements: Inspect the element with the coating intact.

[c]Jacketed or encased elements: Visually inspect the jackets and encasements for deterioration. Inspect the base element to the extent possible.

[d]Large, solid-faced elements may include bulkheads, retaining walls, dam fascia, tunnel/pipeline walls, piers, gates, tank walls, caissons, piles greater than 24 in. in diameter, etc.

3.1.3 Material Elements Assessment Terms and Damage Grades

The results of the facility inspection must be documented clearly, concisely, and efficiently using commonly understood terminology. The use of standardized terminology and data recording forms can simplify and expedite the recording process in the field and facilitate the reporting of observed conditions in the field. However, the use of common terminology must be clearly defined, both in the field with the inspection team and in the text of the report. To the extent possible and wherever applicable, the terminology contained in Appendix C of this manual shall be used in the report.

The most useful information for an engineering analysis is strictly quantitative. For example, timber pile load calculations should be based on true remaining cross-sectional area. However, this type of data can be time consuming to obtain in the field. It would be cost prohibitive, for example to physically measure the remaining cross sectional area of each pile supporting a timber pier. Thus, during the Routine Inspection, a damage grade should be assigned to each structural element inspected. These ratings should be based on remaining structural capacity and must be clearly defined for the team conducting the inspection. During Level II and Level III efforts of inspection, a damage grade shall be assigned and measurements of critical dimensions and defects should be made for each structural element. Comparing the damage grades with the measured data will provide a verification of the definitions for ratings.

Examples of assessment terms and damage grades to be used during inspections of different material types are provided in the following subsections. These terms are provided as a guide, and additional terms may be used as appropriate for the structure inspected. The sample figures provided in this section of the Manual show cross-sections of piles, however, these are meant to be representative only and the described damage grades are applicable for various components of each presented material type.

(A) STEEL MEMBERS

The damage grades for steel components are described in Table 3-3 with samples presented on Figure 3-1. The following is a list of the most common structural deficiencies affecting steel members:

a. Corrosion
   - Minor (or Light) - A light surface corrosion with no apparent loss of section.
   - Moderate - Corrosion that is loose and flaking with some pitting. The scaling or exfoliation can be removed with some effort by use of a scraper or chipping hammer. The element exhibits measurable but not significant loss of section.

- Severe - Heavy, stratified corrosion or corrosion scales with extensive pitting. Removal requires exerted effort and may require mechanical means. Significant loss of section.

b. Impacted Corrosion - Corrosion collected between two interfacing surfaces, usually two steel plates. Impacted corrosion can be minor, moderate, or severe as described above. Impacted corrosion can severely deform the steel members due to the expansive nature of the corrosion product.

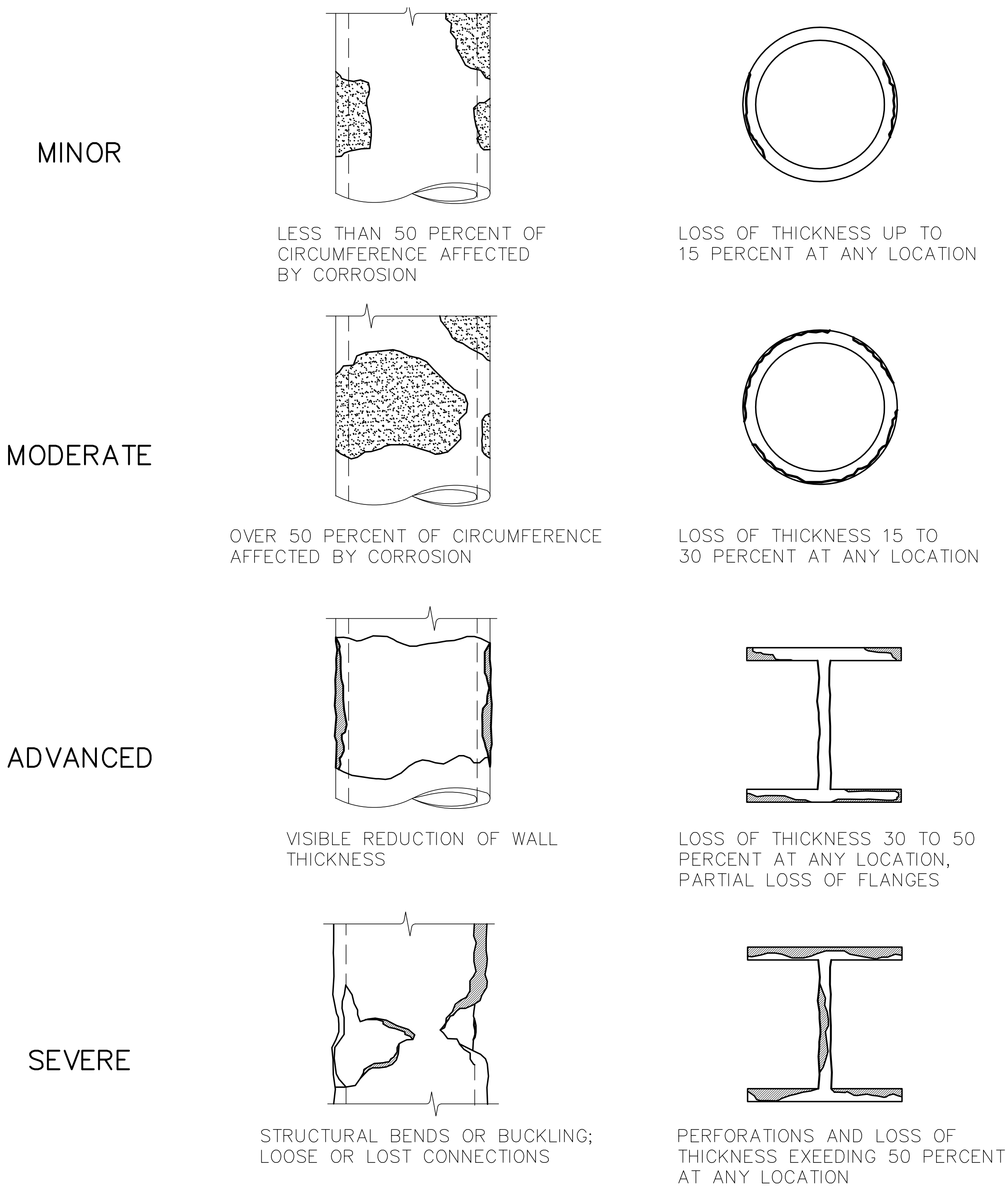
c. Pitting - Formation of cavities due to corrosion. Minor, moderate, and severe pitting categories are used based upon depth and density of cavities.

TABLE 3-3
DAMAGE GRADES FOR STEEL COMPONENTS

Damage Grade	Existing Damage[1]	Defects Indicating Higher Damage Grade(s)
Not Inspected	• Not inspected, inaccessible or passed by	
No Damage	• Protective coating intact • No apparent loss of material	
Minor	• Less than 50 percent of perimeter or circumference affected by corrosion at any elevation or cross section • Loss of thickness up to 15 percent of nominal at any location	Minor damage not appropriate if: • Changes in straight line configuration or local buckling • Corrosion loss exceeding fabrication tolerances (at any location)
Moderate	• Over 50 percent of perimeter or circumference affected by corrosion at any elevation or cross section • Loss of thickness 15 to 30 percent of nominal at any location	Moderate damage not appropriate if: • Changes in straight line configuration or local buckling • Loss of thickness exceeding 30 percent of nominal at any location
Advanced	• Partial loss of flange edges or visible reduction of wall thickness on pipe piles • Loss of nominal thickness 30 to 50 percent at any location	Advanced damage not appropriate if: • Changes in straight line configuration or local buckling • Perforations or loss of wall thickness exceeding 50 percent of nominal
Severe	• Structural bends or buckling, breakage and displacement at supports, loose or lost connections • Loss of wall thickness exceeding 50 percent of nominal at any location	

(1) Any defect listed below is sufficient to identify relevant damage grade.

Steel components are typically coated or galvanized for corrosion protection. The extent of remaining coating on the steel member, if any, shall also be described when assigning a damage grade.



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DAMAGE GRADES FOR STEEL COMPONENTS

FIGURE 3–1

(B) CONCRETE MEMBERS

The damage grades for regular and prestressed concrete components are described in Tables 3-4 and 3-5, respectively. In addition, Figures 3-2 and 3-3 present examples of marine concrete deterioration. The following is a list of the most common structural defects affecting concrete members:

a. Cracking - A separation into two or more parts as identified by the space between fracture surfaces in the concrete.
   - Hairline - Crack width less than 1/32 in.
   - Fine - Crack width between 1/32 in. and 1/16 in.
   - Medium - Crack width between 1/16 in. and 1/8 in.
   - Wide - Crack width greater than 1/8 in.

   The above definitions for cracks can be modified, depending upon the type of structural element. Cracking should also be classified by type. Three primary types of cracking include overstressing, corrosion, and general cracking. An overstressing crack results from external loads which cause high internal stresses that exceed the strength of the concrete member. Corrosion cracks are the result of the expansion of chemical products generated by the corrosion of the steel reinforcement. General cracks typically include shrinkage, thermal and chemical reaction cracks caused by the expansion of concrete, which occurs during chemical reaction between concrete constituents or these constituents and the environment. Common chemical reactions include alkali-silica (ASR), alkali-carbonate (ASC), and sulfate reactions. These reactions are further described in Appendix B of this manual. The cause and structural consequences of the various types of cracking are important and should be discussed in the inspection report.

b. Efflorescence - A white deposit caused by crystallization of soluble salts brought to the surface by moisture leaching through the concrete
c. Delamination - A layered separation of the concrete. When a delaminated area of concrete is struck (sounded) with a hammer, a hollow sound will be emitted.
d. Leaching - The dissolution and washing away of the calcium hydroxide in concrete. Moisture enters the concrete through cracks open to the surface.
e. Spall - A roughly circular, oval, or elongated depression in the surface of a concrete element caused by separation of a portion of the surface concrete.
   - Small (Pop-out) - Less than 6 in. in diameter and 1 in. deep.
   - Medium - Between 6 in. and 12 in. in diameter and up to 2 in. deep.

- Large - Over 12 in. in diameter and any depth.

f. Scaling (or Erosion) - the gradual loss of surface mortar and aggregates.
    - Light Scaling - Loss of surface mortar up to 1/4 in. deep.
    - Medium Scaling - Loss of surface mortar between 1/4 in. and 1/2 in. deep, including loss between large aggregate.
    - Heavy Scaling - Loss of mortar greater than 1/2 in. deep significantly exposing large aggregate.

g. Hollow Area - An area of concrete that emits a hollow sound when struck with a hammer, indicating the existence of a fracture plane beneath the surface.

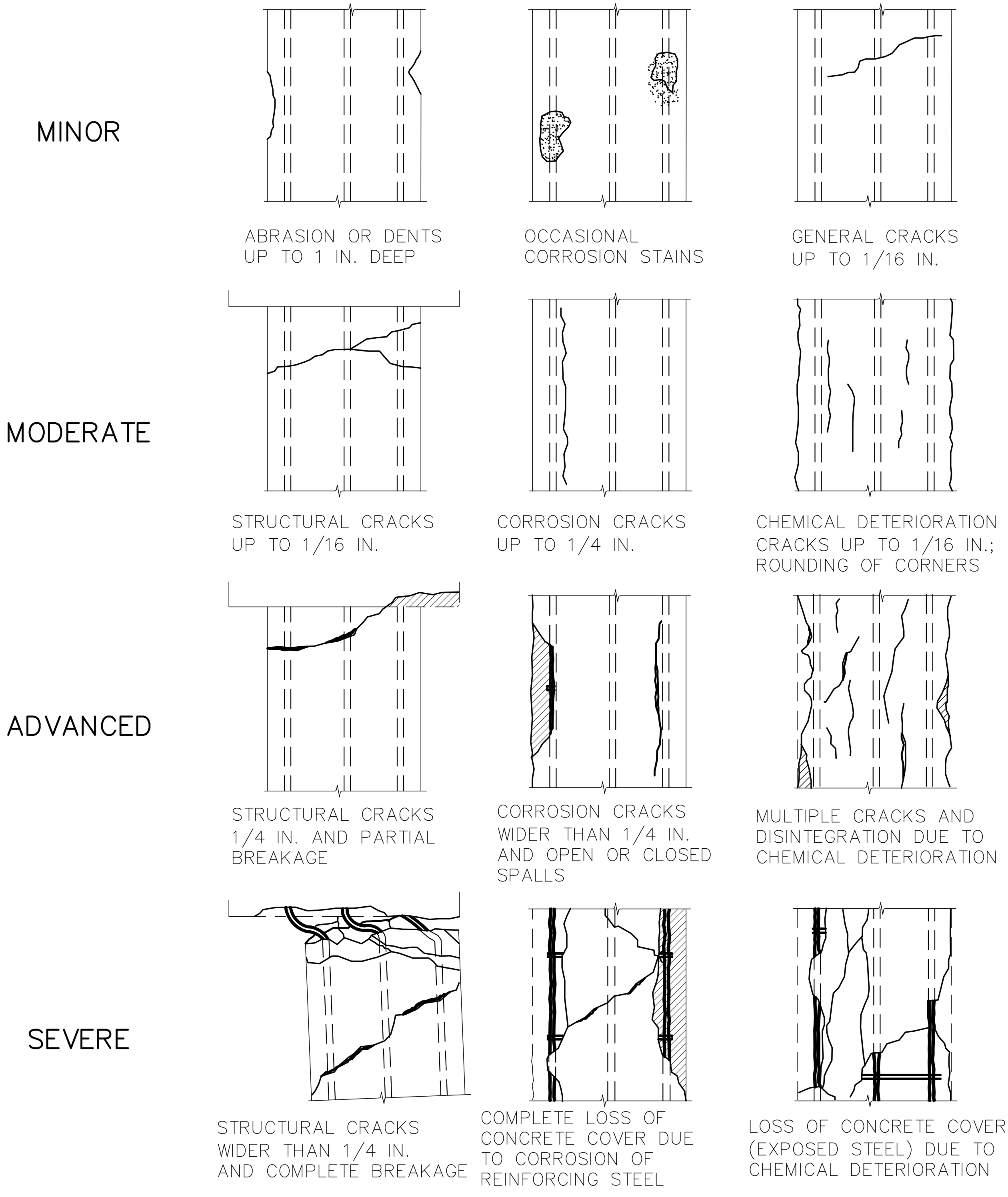
h. Honeycomb - Typically small pocket voids formed by the entrapment of air during the placement of the concrete.

TABLE 3-4
DAMAGE GRADES FOR CONCRETE COMPONENTS

Damage Grade	Existing Damage[(1)]	Defects Indicating Higher Damage Grade(s)
Not Inspected	• Not inspected, inaccessible or passed by	
No Damage	• Good original surface, hard material, sound	
Minor	• Mechanical abrasion or impact dents up to 1 in. • General cracks up to 1/16 in. in width • Occasional corrosion stains or small pop-out corrosion spalls	Minor damage not appropriate if: • Structural damage • Corrosion cracks • Chemical deterioration[(2)]
Moderate	• Structural cracks up to 1/16 in. in width • Corrosion cracks up to 1/4 in. in width • Chemical deterioration[(2)]: Random cracks up to 1/16 in.; "Soft" concrete and rounding of corners up to 1 in. deep	Moderate damage not appropriate if: • Structural breakage and/or spalls • Exposed reinforcement • Loss of cross section due to chemical deterioration beyond "rounding of corner edges"
Advanced	• Structural cracks 1/16 in. to 1/4 in. in width and partial breakages (structural spalls) • Corrosion cracks wider than 1/4 in. and open spalls (excluding pop-outs) • Multiple cracking and disintegration of surface layer due to chemical deterioration	Advanced damage not appropriate if: • Loss of cross section exceeding 30 percent due to any cause
Severe	• Structural cracks wider than 1/4 in. or complete breakage. Loss of bearing and displacement at connections • Complete loss of concrete cover due to corrosion of reinforcing steel with over 30 percent of diameter loss for any main reinforcing bar • Loss of concrete cover (exposed steel) due to chemical deterioration • Loss of over 30 percent of cross section due to any causes described above	

(1) Any defect listed below is sufficient to identify relevant damage grade.

(2) Chemical Deterioration: Sulfate attack, alkali-silica reaction or ettringite distress.



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DAMAGE GRADES FOR CONCRETE COMPONENTS

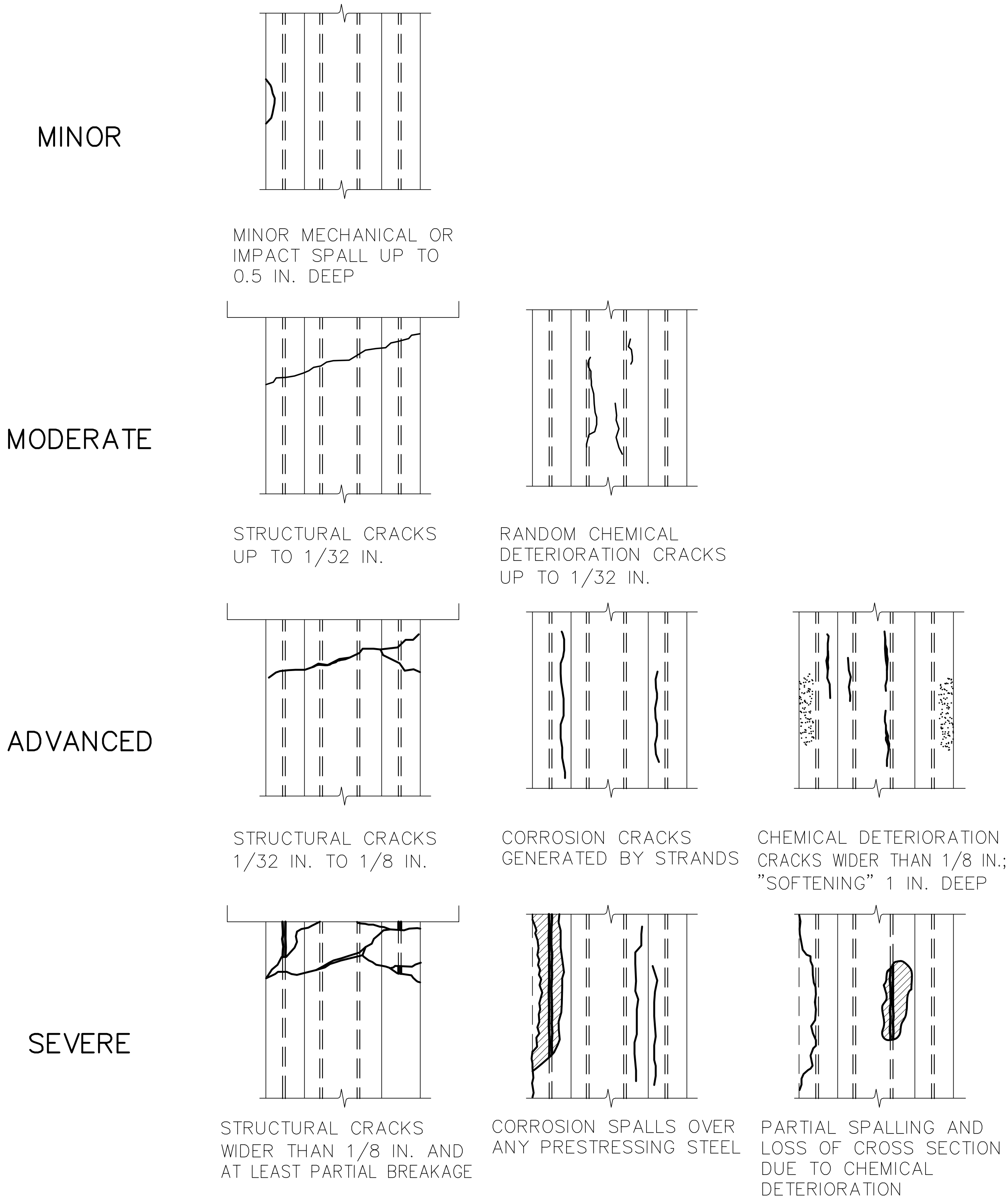
FIGURE 3–2

TABLE 3-5
DAMAGE GRADES FOR PRESTRESSED CONCRETE COMPONENTS

Damage Grade	Existing Damage(1)	Defects Indicating Higher Damage Grade(s)
Not Inspected	• Not inspected, inaccessible or passed by	
No Damage	• Good original surface, hard material, sound	
Minor	• Minor mechanical or impact spalls up to 0.5 in. deep	Minor damage not appropriate if: • Structural damage • Corrosion damage • Chemical deterioration(2) • Cracks of any type or size
Moderate	• Structural cracks up to 1/32 in. in width • Chemical deterioration: random cracks up to 1/32 in. in width	Moderate damage not appropriate if: • Structural breakage and/ or spalls • Corrosion cracks • Loss of cross section in any form • "Softening" of concrete
Advanced	• Structural cracks 1/32 in. to 1/8 in. in width • Any corrosion cracks generated by strands or cables • Chemical deterioration: cracks wider than 1/16 in. "Softening" or concrete up to 1 in. deep	Advanced deterioration not appropriate if: • Exposed prestressing steel
Severe	• Structural cracks wider than 1/8 in. and at least partial breakage or loss of bearing • Corrosion spalls over any prestressing steel • Partial spalling and loss of cross section due to chemical deterioration	

(1) Any defect listed below is sufficient to identify relevant damage grade.

(2) Chemical Deterioration: Sulfate attack, alkali-silica reaction or ettringite distress.



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DAMAGE GRADES FOR
PRESTRESSED CONCRETE COMPONENTS

FIGURE 3–3

(C) TIMBER MEMBERS

The damage grades for timber components are described in Table 3-6 with samples presented on Figure 3-4. The following is a list of the most common structural deficiencies affecting timber elements:

a. Marine Borer Attack
   - Limnoria - Commonly referred to as wood gribbles, these crustaceans are tiny wood eaters that attack the timber from the outside, continually reducing the diameter of a timber pile. Severe attack will result in an hourglass shape to the pile.
   - Teredo - Commonly referred to as shipworms, these mollusks burrow minute holes into the timber and attack from within. Severe attack will result in a hollowing of the pile, leaving just the outer shell, and may go undetected. Teredo leave a white calcified trail that may be exposed by exterior timber deterioration.

b. Fungal Rot - A breakdown of the cellular structure of the timber by fungi, evident by discoloration and softening of the wood. Advanced fungal attack will cause destruction of the wood cells and will cause the timber to easily break apart when struck with a hammer. Fungi require air to survive, thus fungal rot only occurs above water.

c. Checking - Vertical cracking of the timber surface due to drying and shrinking. Minor checking is generally acceptable in standard timber design. However, excessive checking may be problematic. Checking may create an opening for marine borers to access the untreated interior of a pile.

d. Overloading - Overstressing of the timber element by continuous or impact loads in excess of their ultimate capacity. Typically evident by severe vertical cracks in the timber that cross the grain, breakage of the timber, or bulging of the timber with splitting of the wood fibers.

e. Peeling - Delamination of the outer surface of the timber with minor separation of the outer wood fibers. Depending on the severity, peeling may allow marine borers access to the interior of the timber.

f. Abrasion - Reduction of the timber surface due to continual rubbing by debris, ice, or suspended particulates in the water. When combined with Limnoria attack, abrasion may rapidly reduce the cross-sectional area of piles.

g. Connecting Hardware Corrosion - Pins and bolts connecting timber members are subject to corrosion and may provide the weak link in a structure if they fail.

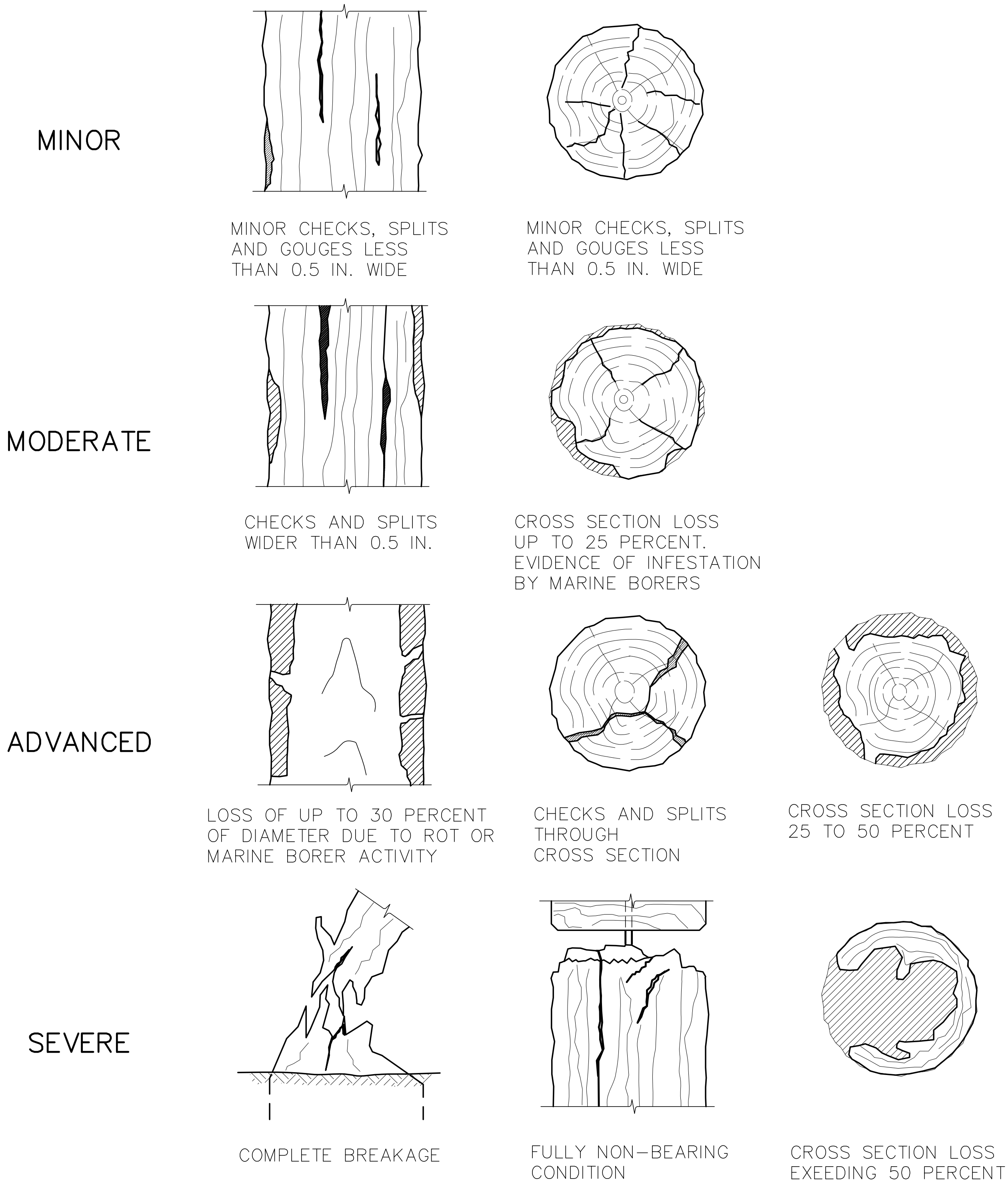
h. Broken - Member mechanically damaged so that it is no longer able to effectively transmit load.

i. Split - Longitudinal cracking that completely penetrates a member. Additionally, holes left in the timber due to missing hardware provide openings for marine borers to access the untreated interior of the timber.

TABLE 3-6
DAMAGE GRADES FOR TIMBER COMPONENTS

Damage Grade	Existing Damage(1)	Defects Indicating Higher Damage Grade(s)
Not Inspected	• Not inspected, inaccessible or passed by	
No Defects	• Sound surface material	
Minor	• Checks, splits and gouges less than 0.5 in. wide	Minor damage not appropriate if: • Loss of cross section • Marine borer infestation • Displacements, loss of bearing or connections
Moderate	• Checks and splits wider than 0.5 in. • Remaining diameter loss up to 15 percent • Cross section area loss up to 25 percent. Corroded hardware. • Evidence of infestation by marine borers	Moderate damage not appropriate if: • Displacements, loss of bearing or connections
Advanced	• Checks and splits through full depth of cross section • Remaining diameter loss 15 to 30 percent • Cross section area loss 25 to 50 percent. Heavily corroded hardware. • Displacement and misalignments at connections	Advanced damage not appropriate if: • Partial or complete breakage
Severe	• Remaining diameter reduced by more than 30 percent • Cross section area loss more than 50 percent • Loss of connections and/ or fully non-bearing condition • Partial or complete breakage	

(1) Any defect listed below is sufficient to identify relevant damage grade.



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DAMAGE GRADES FOR TIMBER COMPONENTS

FIGURE 3-4

(D) COMPOSITE MEMBERS

Composite components refer to fiber-reinforced polymer (FRP) composites which use a polymer-based resin as the matrix and a variety of fibers such as glass, carbon, or aramid as the reinforcement.

The damage grades for composite components are described in Table 3-7 with samples presented on Figure 3-5. The following is a list of the most common structural deficiencies affecting composite elements:

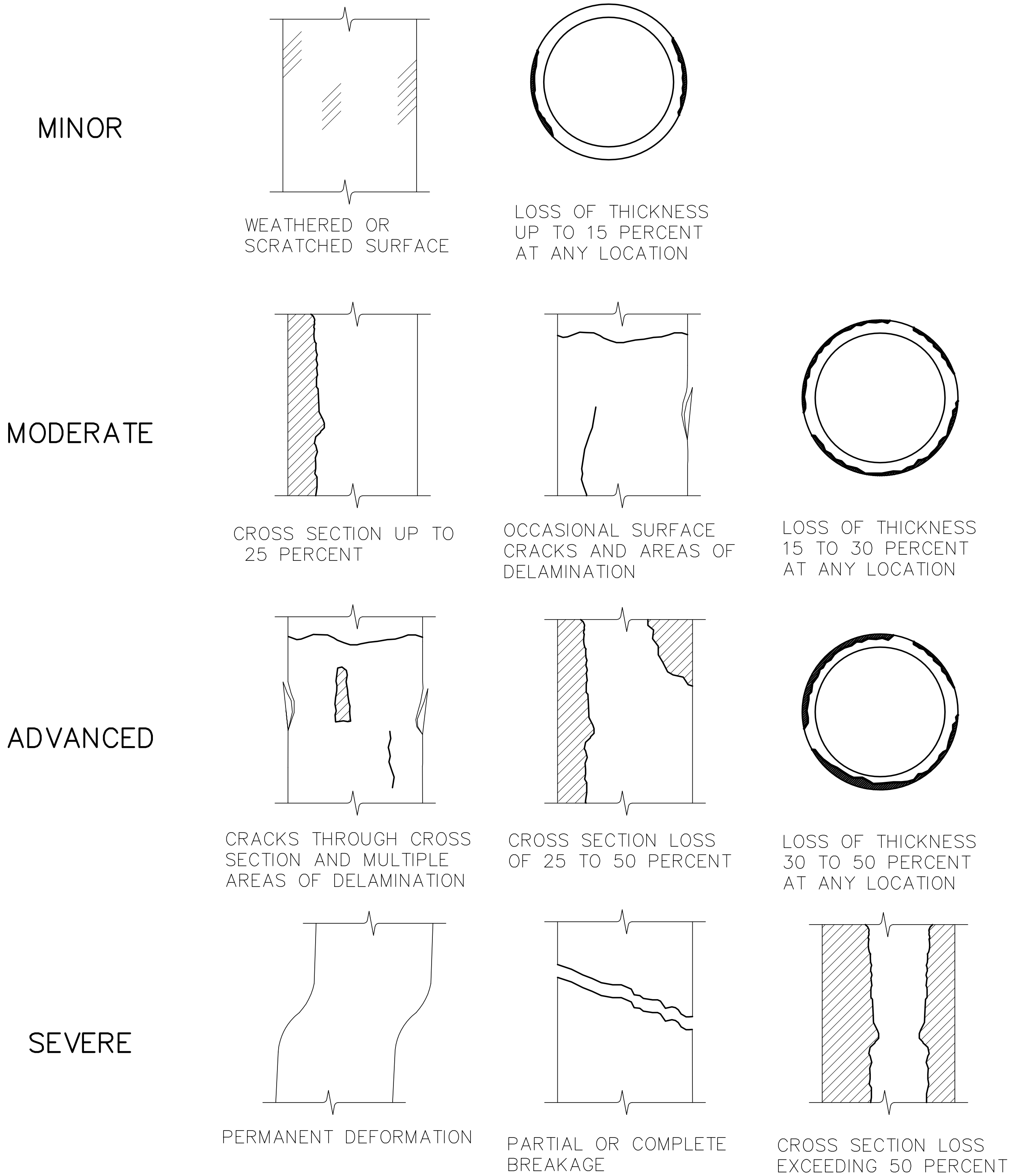
a. Cracking - A separation into two or more parts as identified by the space between fracture surfaces in the composite element. Cracks may extend through the thickness of the element or only be at the surface.
    - Crazing - Hairline cracks at or under the surface of the laminate
    - Hairline - Crack width less than 1/32 in.
    - Fine - Crack width between 1/32 in. and 1/16 in.
    - Medium - Crack width between 1/16 in. and 1/8 in.
    - Wide - Crack width greater than 1/8 in.
b. Air bubble (void) - Air entrapment within and between the plies of reinforcement, usually spherical in shape
c. Chip - A small piece of broken off edge or surface
d. Foreign inclusion - Metallic or nonmetallic particles embedded in the laminate which are foreign to its composition
e. Blister - Rounded elevation of the surface of the laminate
f. Burned - Thermal decomposition of the composite element typically characterized by discoloration, distortion, or destruction of the surface laminate.
g. Delamination - Separation of the layers of material at the edge of a laminate. Areas with delamination are characterized by separation of the plies or layers in the laminate as in blistering, or by disbanding of the secondary overlay. They are common around the edges of secondary overlays. Delamination may be visible on the surface or may be internal.
h. Pit - Small crater in the surface of the laminate
i. Fracture - Rupture of the laminate surface without complete penetration
j. Scratch - Shallow mark or groove in the composite surface
k. Abrasion - Reduction of the composite section area due to continual rubbing by debris, ice, or suspended particulates in the water. Abrasion may rapidly reduce the cross-sectional area of piles.

l. Broken - Member mechanically damaged so that it is no longer able to effectively transmit load.

TABLE 3-7
DAMAGE GRADES FOR COMPOSITE COMPONENTS

Damage Grade	Existing Damage[(1)]	Defects Indicating Higher Damage Grade(s)
Not Inspected	• Not inspected, inaccessible or passed by	
No Defects	• Sound surface material • No weathering or scratches	
Minor	• Weathered or scratched surface • Loss of thickness up to 15 percent of nominal at any location	Minor damage not appropriate if: • Deformation of element • Displacements, loss of bearing or connections • Fractures, delamination, burns • Loss of cross section
Moderate	• Loss of thickness 15 to 30 percent of nominal at any location • Cross section area loss up to 25 percent. Corroded hardware • Occasional delamination and surface cracks	Moderate damage not appropriate if: • Deformation of element • Displacements, loss of bearing or connections • Fractures and multiple areas of delamination
Advanced	• Cracks through full depth of cross section • Cross section area loss 25 to 50 percent • Loss of thickness 30 to 50 percent of nominal at any location • Fractures and multiple areas of delamination • Displacement and misalignments at connections	Advanced damage not appropriate if: • Partial or complete breakage • Permanent deformation
Severe	• Permanent deformation • Cross section area loss more than 50 percent • Loss of thickness more than 50 percent at any location • Loss of connections and/ or fully non-bearing condition • Partial or complete breakage	

(1) Any defect listed below is sufficient to identify relevant damage grade.



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DAMAGE GRADES FOR
COMPOSITE COMPONENTS

FIGURE 3–5

3.2 TYPES OF INSPECTIONS

This section describes the various types of inspections that are used in the WFMMS. Given the variety of waterfront structures and the multitude of conditions under which these structures are expected to perform, it is not the intent of this manual to provide a detailed methodology for the inspection of every type of waterfront structure. General descriptions of common problems found on components associated with specific types of waterfront structures are provided in Appendix A, and is meant to serve as a reference for inspectors. Depending on the primary objective(s) of the inspection, the inspection scope, methodology and focus will need to be tailored accordingly.

3.2.1 Baseline Inspection

(A) PURPOSE

The Baseline Inspection serves as the basis of the WFMMS. The primary purpose of the Baseline Inspection is to assess the general overall condition of the structure, develop an asset inventory for the facility, verify that the structure was built in accordance with the design drawings, assign condition assessment ratings, estimate remaining service life, and determine recommended actions and associated cost. The recommended action cost estimates will be used to substantiate requests for funding in order to maintain and rehabilitate the waterfront facilities. Baseline Inspections are performed for structures which have never been inspected or for structures which may have been previously inspected but where an asset inventory was not developed. An asset inventory containing a listing of all components and their relevant quantities must be developed for all facilities and systems included in the WFMMS.

(B) SCOPE OF WORK

The Baseline Inspection includes a 100 percent visual/tactile inspection of each above water and underwater component. The inspection is geared towards verifying that the structure was built according to the design drawings, identifying the structural components that comprise the facility, and obtaining the number and percentage of components with damage or deterioration, and the location of isolated major damage, such as breakage and overstressing. Any deviations from the design drawings should be recorded and documented in the report. The inspection data are used as the basis for satisfying the following primary goals of the Baseline Inspection:

- Develop an asset inventory for the facility that catalogues all applicable structural components for input into the WFMMS
- Confirmation of overall dimensions, pile plan, and other physical features
- Confirmation of spot elevations to an accuracy of 3 cm (if not indicated on available drawings)

- An overall condition assessment rating for the facility, each individual system, and each component
- A quantification of the load carrying capacity of the structure, including any reduction in the original load rating due to observed deterioration
- An estimation of remaining service life
- Recommended actions, including the need for any Engineering Investigation or Design-Level Inspections, and associated order-of-magnitude cost estimates
- An order-of-magnitude cost for the in-kind replacement of the facility
- The scope of the Engineering Investigation or Design Level Inspection, if required
- The recommended type and time interval to the next inspection

For the above water portion of the inspection, all elements above mean low water (MLW) are part of the scope of the inspection. This includes a general visual survey of the condition of the upland area including deck topsides, expansion joints, curbs, and marine hardware (fenders, bollards, etc.), as well as checking for sinkholes and/or differential settlements.

Due to limited visibility and the presence of marine growth, the underwater portion of the Baseline Inspection generally includes Level I (swim-by) inspection effort for 100 percent of the underwater elements (piles and retaining structure), as well as a Level II effort for 10 percent of the underwater elements. In addition, a small percentage of the elements (approximately 5 percent) should receive Level III effort of inspection to detect any hidden damage. Refer to Table 3-2 for guidance on specific levels of inspection effort required for different structural components and materials.

If significant damage or deterioration is observed, a quantitative engineering evaluation of the effect of the damage on the structural capacity should be conducted. The evaluation is typically limited to an evaluation of capacity and does not consider the actual or anticipated loading (structural demand), since such information is typically not readily available to the inspectors at the time of the inspection. Should conditions warrant, an Engineering Investigation should be recommended to evaluate the actual/anticipated loading against the reduced capacity determined as a result of the inspection. The results of such structural capacity evaluations should be used in assigning a condition assessment rating.

The deliverable for the Baseline Inspection is the Baseline Inspection report, as defined in Chapter 6 of this manual.

3.2.2 Routine Level Inspection

(A) PURPOSE

The Routine Level Inspection is similar to the Baseline Inspection in most aspects and serves as the basis of the WFMMS. The primary difference between the Routine Level and Baseline Inspections is that for Routine Level Inspections a comparison with previous inspection results is performed. Although an asset inventory would have already been performed previously for a structure undergoing a Routine Level Inspection, the asset inventory should be reviewed and updated as necessary for the purposes of updating the WFMMS.

Routine Level Inspections are typically performed on a regularly-scheduled basis, and represent a proactive, rather than a reactive, approach to maintenance. By conducting Routine Level Inspections on a regular basis, deteriorated elements can be detected and remediated before deterioration progresses to a level that could threaten structural integrity. In addition, significant damage, or breakage caused by impact from vessels, floating debris, or other sources which may not have triggered a Post-Event Inspection, can be detected during Routine Level Inspections.

(B) SCOPE OF WORK

The Routine Level Inspection includes a 100 percent visual/tactile inspection of each above water and underwater component, as well as a Level II and III effort as contained in Table 3-2. It is geared towards obtaining the number and percentage of elements with damage or deterioration, and the location of isolated major damage, such as breakage and overstressing. The inspection data are used as the basis for satisfying the following primary goals of the Routine Level Inspection:

- Confirmation of spot elevations to an accuracy of 3 cm (if not indicated on available drawings)
- An overall condition assessment rating for the facility, each individual system, and each component
- Comparison with previous inspection findings and results
- A quantification of the load carrying capacity of the structure, including any reduction in the original load rating due to observed deterioration
- An estimation of remaining service life
- Recommended actions, including the need for any Engineering Investigation or Design-Level Inspections, and associated order-of-magnitude cost estimates
- The scope of the Engineering Investigation or Design Level Inspection, if required
- The recommended type and time interval to the next inspection

The deliverable for the Routine Level Inspection is the Routine Level Inspection report, as defined in Chapter 6 of this manual.

3.2.3 Rapid Level Inspection

(A) PURPOSE

Rapid Level Inspections are short duration investigations for emergency or immediate issues that need to be addressed that are not attributable to a specific event, or to provide a quick general condition assessment of the structure as part of a regular maintenance program. They may also be conducted to provide preliminary information regarding a facility for which no previous reports or records are available and where a Baseline Inspection may not be possible. The primary purpose of a Rapid Level Inspection is to confirm the integrity of the structure, determine general facility and structure dimensions (as necessary), and to determine if further attention to the structure is necessary.

(B) SCOPE OF WORK

Rapid Level Inspections are intended to be rapid, visual/tactile inspections.

The Rapid Level Inspection is typically conducted above the waterline and limited to a Level I inspection effort for 100 percent of the components in the area to be inspected. However, if above water conditions or other knowledge should indicate that underwater damage may have occurred, then the scope of the Rapid Level Inspection should be expanded to include an underwater inspection as well. The scope of work for a Rapid Level Inspection is typically detailed in the request for proposal (RFP) document provided to the consultant or will be clarified during the proposal development stage. The inspection data are used as the basis for satisfying the following primary goals of the Rapid Level Inspection:

- An overall condition assessment rating for the facility, each individual system, and each component
- Comparison with previous inspection findings and results, if available
- Recommended actions, including the need for any Engineering Investigation or Design-Level Inspections, and associated order-of-magnitude cost estimates
- The scope of the Engineering Investigation or Design Level Inspection, if required
- The recommended type and time interval to the next inspection

The deliverable for the Rapid Level Inspection is the Rapid Level Inspection report, as defined in Chapter 6 of this manual.

3.2.4 Design Level Inspection

(A) PURPOSE

The purpose of the Design Level Inspection is to record defects to be repaired, including all relevant defect attributes, such that rehabilitation construction bid documents may be generated. A repair method should be assigned to each defect during the inspection so that the necessary relevant information can be collected. Design Level Inspections should be conducted only when rehabilitation is to be performed and should be conducted with as little interval as practicable between the time of the Design Level Inspection and the execution of repairs. Long intervals can result in increased deterioration and an increase in the scope of the rehabilitation. Typically, Design-Level Inspections will result from a recommendation made following Baseline, Routine, or Rapid Level Inspections and/or after an Engineering Investigation has been completed and the scope of repairs has been defined. However, when the need for rehabilitation is obvious and the priority is clear, a Design Level Inspection may be conducted without being preceded by a Baseline, Routine, or Rapid Level Inspection. Where appropriate the Design Level Inspection may be combined with an Engineering Investigation.

(B) SCOPE OF WORK

Prior to commencing a Design Level Inspection, the criteria for determining what is to be repaired should be established. In addition, the method(s) of repair should be determined for all typical conditions on the structure. The Design Level Inspection is then performed to document the nature, location, and size of defects to be repaired, assign a repair method based on the pre-established criteria, and to identify potential obstructions or site constraints that may affect the proposed repair(s). This inspection typically requires that, at minimum, a Level II inspection effort be performed on all elements to be repaired, in that the elements are cleaned and the extent of damage measured. Additional testing and surveying may be required depending on the component, nature of the deterioration, and proposed repair method.

The method of investigation used in conducting a Design Level Inspection may have significant implications on the amount of time it takes to conduct the inspection. The key to determining the proper method of investigation is understanding the types of repairs to be executed for the repair project and the data required to support the design of the repair. Sufficient data must be collected to prepare reasonably accurate repair quantities for the development of a construction cost estimate and for the contractors to base their bid on.

The deliverable for the Design Level Inspection is the Design Report, as defined in Chapter 6 of this manual.

3.2.5 Construction Inspection

(A) PURPOSE

The purpose of the Construction Inspection is to ensure that the ongoing construction quality is acceptable and in accordance with the design plans and specifications.

(B) SCOPE OF WORK

The scope of a Construction Inspection typically includes both above and underwater inspections and may also include the use of specialized testing equipment to ensure compliance with the design plans and specifications. The inspection will generally be at a Level I or II effort depending on the work involved.

The deliverable for the Construction Inspection is a Daily Construction Report as defined in Chapter 6 of this Manual, and where applicable, a punch list of issues to be resolved by the contractor.

3.2.6 Post-Construction Inspection

(A) PURPOSE

The purpose of the Post-Construction Inspection is to ensure that the construction has been completed in accordance with the design plans and specifications, an asset inventory of the facility has been developed, the status of previous recommendations is updated, and all punch list items have been resolved.

(B) SCOPE OF WORK

The scope of the Post-Construction Inspection is similar to the Construction Inspection, except for additional reporting requirements. Additional reporting requirements for the Post-Construction Inspection include the preparation of a report that updates the previously assigned condition assessment ratings (when an existing structure is repaired), a collation of all Daily Construction Reports, and developing or updating the facility asset inventory as applicable.

The deliverable for the Post-Construction Inspection is a Post-Construction Inspection Report as defined in Chapter 6 of this manual.

3.2.7 Post-Event Inspection

(A) PURPOSE

Post-Event Inspections are short duration investigations that are conducted following a significant, potentially damage-causing event such as a storm, vessel impact, earthquake, fire, flood, or similar event. The primary purpose of a Post-Event Inspection is to rapidly confirm the integrity of the structure and to determine if further attention to the structure is necessary as a result of the event.

(B) SCOPE OF WORK

Post-Event Inspections are intended to be rapid, visual/tactile inspections. They are conducted in order to determine if an event resulted in any significant damage requiring repairs. The focus of the inspection should be on damage caused by the event. Such damage may include breakage, overstressing cracks, settlement, etc. Long term or pre-existing deterioration, such as corrosion-related damage, should be ignored during Post-Event Inspections, unless the deterioration immediately threatens the integrity of the structure.

Post-Event Inspections are typically conducted above the waterline and limited to a Level I inspection effort for 100 percent of the elements in the area to be inspected. However, if above water conditions or other knowledge should indicate that underwater damage may have occurred, then the scope of the Post-Event Inspection should be expanded to include an underwater inspection as well. For example, a vessel impact often results in damage above the waterline as well as below; therefore an underwater inspection may be triggered only where above water damage is also visible.

The deliverable for the Post-Event Inspection is a Post-Event Inspection Report as defined in Chapter 6 of this manual.

3.2.8 Engineering Investigation

(A) PURPOSE

Engineering Investigations are performed for the purpose of collecting more detailed information than normally obtained during Baseline, Routine Level, or Rapid Level Inspections. These inspections are highly detailed and typically include engineering analysis and/or material testing. Engineering Investigations are typically conducted at a Level II or Level III inspection effort and may require further laboratory testing of samples collected in the field. Such information may be necessary to understand the nature and/or extent of deterioration prior to determining the need for and type of repairs. In addition, when the load capacity of the structure is unknown but is required to verify its adequacy for a specific use, an Engineering Investigation of the subject area should be conducted. Information gathered should be in sufficient detail to perform a structural analysis and to verify adequacy for the intended use. Engineering Investigations may also be performed in order to determine the remaining useful life of the structure.

Engineering Investigations are typically performed on an exceptional basis as a result of a recommendation from the Baseline, Routine Level, Rapid Level, or Post-Event Inspection. However, an Engineering Investigation may also be performed concurrently with other types of inspections where appropriate.

(B) SCOPE OF WORK

The scope of an Engineering Investigation may vary widely depending on the objectives of the inspection and/or the nature of the structure and the deterioration, and may include but is not limited to:

- Chloride content testing of concrete in order to estimate the time to initiation of severe steel reinforcement corrosion.
- Dissolved Oxygen (DO) testing to determine the effectiveness of timber pile wrapping against marine borer infestation.
- Electric potential measurements to determine the effectiveness of cathodic protection systems for steel elements.
- Timber coring to determine the level of marine borer infestation and damage.
- Concrete coring for physical testing and/or petrographic analysis.
- Creosote retention testing.
- Coupon sampling (removing a section of steel) for laboratory testing.
- Detailed inspection of a limited area of a structure in order to determine specific load capacity.
- Periodic inspection of specific structural elements to determine rate of deterioration.
- Test pits to determine the structural integrity of buried elements such as tie rods or wales.

Engineering Investigation deliverables typically include laboratory/testing reports, and/or reports presenting the results of the detailed inspection and subsequent engineering analysis.

3.3 CONDITION ASSESSMENT RATINGS

Each facility, system, and component group in the WFMMS shall be given a condition assessment rating following the inspection. The ratings are important in establishing the priority of follow-on actions to be taken. This is particularly true when many systems are included in an inspection program and follow-on activities must be ranked or prioritized due to limited resources. The six terms that should be used to describe the conditions of hard structures are described below.

- "Good" – No problems or only minor problems noted. Structural elements may show some very minor deterioration, but no overstressing observed.

- "Satisfactory" – Minor to moderate defects and deterioration observed, but no overstressing observed.
- "Fair" – All primary structural elements are sound; but minor to moderate defects and deterioration observed. Localized areas of moderate to advanced deterioration may be present but do not significantly reduce the load bearing capacity of the structure.
- "Poor" – Advanced deterioration or overstressing observed on widespread portions of the structure, but does not significantly reduce the load carrying capacity of the structure.
- "Serious" – Advanced deterioration, overstressing, or breakage may have significantly affected the load bearing capacity of primary structural elements. Local failures are possible and loading restrictions may be necessary.
- "Critical" – Very advanced deterioration, overstressing, or breakage has resulted in localized failure(s) of primary structural elements. More widespread failures are possible or likely to occur and load restrictions should be implemented as necessary.

The condition assessment rating should be assigned upon completion of the Baseline, Routine Level, Rapid Level, Post-Event, and Post-Construction Inspection and remain associated with the structure until the structure is re-evaluated following repairs or upon completion of the next scheduled inspection.

It is important to understand that ratings are used to describe the existing in-place structure relative to its condition when newly built. The fact that the structure was designed for loads which are lower than the current standards for design should have no influence upon the ratings. In addition, current loads on a structure that are substantially lower than the original design loads should also have no influence on the ratings.

It is equally important to understand that the correct assignment of ratings requires both experience and an understanding of the structural concept of the structure to be rated. Judgement must be applied considering:

- Scope of damage (total number of defects)
- Severity of damage (type and size of defects)
- Distribution of damage (local vs. general)
- Types of components affected (their structural "sensitivity")

Assignment of ratings should reflect an overall characterization of the facility, system, or component group being rated. For example, if the component group 'piles' exhibit deterioration characterized by the rating of "serious", but the rest of the structure is characterized as only "fair", then the entire structure may be rated as "serious." However, if a less critical element group such as deck is characterized as "serious," and the rest of the structure is characterized as "fair", then the entire structure may be rated as "fair" or possibly "poor", depending upon the circumstances. It is evident from this example that the qualifications of individuals assigning ratings are important in ensuring that the ratings are assigned consistently and uniformly in accordance with the guidelines provided herein.

3.4 RECOMMENDED ACTIONS

Recommended actions are typically assigned upon completion of each inspection type. The recommended actions are categorized into the following four general types of actions, which are described below:

- Emergency/Immediate action
- General repair recommendation
- Additional investigation and engineering analysis
- No action

3.4.1 Emergency/Immediate Actions

Emergency/Immediate actions require prompt response to prevent unsafe conditions at the structure. These actions may consist of barricading the structure to block access, posting load restrictions, mobilizing a repair crew to quickly restore safe conditions, or performing a structural analysis to prove that the condition may be tolerated by the structure through redundancies. The consultant must notify the property owner or manager of immediate actions as soon as they are discovered. The notification must be made by phone or email and shall be immediately followed by a letter from the consultant which describes the structure condition and recommended actions.

3.4.2 General Repair Recommendations

General repair recommendations are required following the Baseline, Routine Level, and Rapid Level Inspections in order to determine the order-of-magnitude cost estimates for future actions including rehabilitation, design, and inspection work.

These recommendations are grouped into two different levels of importance as presented below.

(A) PRIORITY

Priority level actions are recommendations for which no immediate measures are required, but for which further investigations, design, and implementation of interim or long-term rehabilitation should be undertaken. The priority action takes precedence over all other scheduled work and should be implemented within a timeframe directed by the consultant performing the Inspection.

Typically these actions are required to maintain the structure in a safe operating condition, and/or prevent deterioration from continuing to a point where future repairs will be significantly more costly. Priority level actions should be completed within 1 to 3 years depending on the severity of the condition.

(B) ROUTINE

Routine level actions should be undertaken as part of a scheduled maintenance program, other scheduled project, or routine facility maintenance depending upon the action required. The routine recommended actions shall be in accordance with good engineering and industry practice to maintain the structure and reduce future capital expenses.

Postponing routine recommended actions will not compromise the structural integrity of the facility or significantly increase the cost to rehabilitate the structure. During the next Routine Level Inspection, the routine level recommended actions should be reevaluated to determine if their status has changed. The consultant should anticipate that recommended routine actions that consist of rehabilitation will likely be implemented one year after the completion of the next Routine Level Inspection.

3.4.3 Additional Investigation and Engineering Analysis

Additional Investigation should be recommended when more information is needed to better determine the overall structural condition, the cause or significance of non-typical deterioration, or an appropriate repair method.

An Engineering Analysis should be recommended when damage or defects are encountered which require a structural investigation or evaluation to determine if rehabilitation or load restrictions are required. While the scope of Baseline and Routine Level Inspections already include the structural evaluation of individual components, the Engineering Analysis should consider all actual/anticipated loads that are or will be imposed on the structure.

3.4.4 No Action

Recommended when no further action is necessary at the facility until the next scheduled Routine or Rapid Level Inspection.

3.4.5 Frequency of Inspections

As part of the recommended actions, the consultant should recommend the type of inspection to be performed and when the inspection should be performed. Guidance on the frequency of inspections is provided in Section 7 of this manual.

4. SHORELINE INSPECTION REQUIREMENTS

4.1 GENERAL

4.1.1 Scope of Shoreline Inspections

This section of the manual applies to the inspection of shorelines along the waterfront. This includes sandy beaches, natural or debris strewn shorelines, and marine forests as contained in the WFMMS's list of systems. For a full list of systems in the WFMMS that are associated with shorelines see Table 2-1.

The scope of shoreline inspections will vary depending on the objectives and requirements of the adopted shoreline management scheme, but will generally include the littoral zone as shown on Figure 4-1. The littoral zone includes the dune, swash zone (berm and beach face), and surf zone (inner and outer). Shoreline inspections may comprise of different components that utilize various types of equipment, surveys, and data collection techniques. The components that comprise a shoreline inspection are described in the following section.

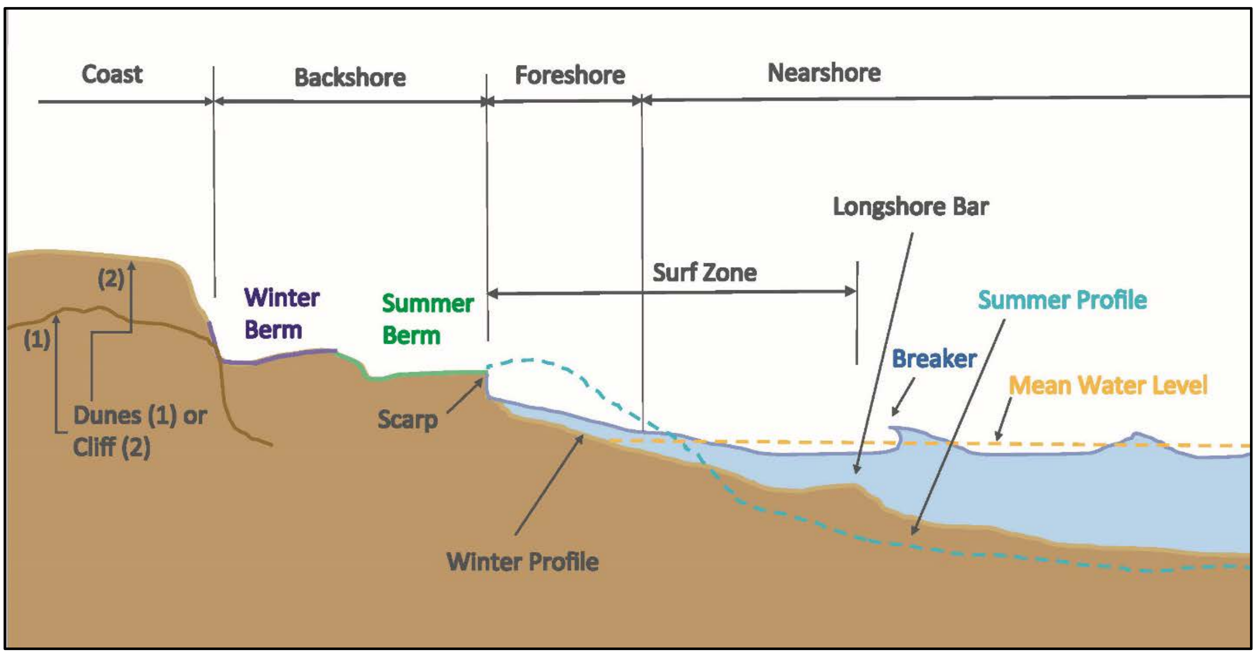


FIGURE 4-1. TYPICAL SECTION OF SHORELINE

4.1.2 Components of a Shoreline Inspection

Components of a shoreline inspection are listed below and described in the following subsections:

- Shoreline profiling

- Topographic survey
- Bathymetric survey
- Digital aerial photography
- Hydrodynamic conditions
- Environmental monitoring
- Geotechnical investigation
- Sediment sampling

For the WFMMS, shoreline profiling and surveying will be the most commonly employed inspection components.

(A) SHORELINE PROFILING

(1) Purpose

The purpose of shoreline profiling is to:

- Establish setback lines for the development of coastal zone management initiatives
- Determine shoreline condition, profile, and position (i.e. wet/dry sand interface) with respect to a reference base line
- Determine shoreline composition (e.g. change in grading; areas of deposition/erosion of fine/coarse sediment)
- Observe changes and damage to shoreline features (e.g. berms/ cliffing)
- Compare the level of the shoreline against markers/visual indicators used to assess if trigger levels for intervention have been reached

(2) Description

Shoreline profiling involves the visual inspection of shorelines, control structures and dunes against pre-defined visual inspection criteria, recording each inspection including assessed condition grade in a standardized inspection form and supported with fixed aspect digital photographs at a minimum of each transect using a GPS enabled camera with photos taken from the same position and of the same view, etc.

Transect intervals should be set based on the monitoring need for the shoreline and the number of transects taken should be frequent enough to distinguish alongshore variation of beach profiles. This will depend on the nature of the shoreline that is being inspected and will be indicated in the scope of work provided to the consultant. Each transect should cover the full profile from behind the shoreline berm/dune down to at least mean low water level. A minimum of 3 readings along the shore parallel contours shall be obtained for each transect. The selected spacing will depend on the nature of the shoreline, however, shall be such that a meaningful shoreline profile can be developed.

Shoreline position is taken from a reference base line such as a vertical datum or existing permanent structure on the upper beach typically at 100 ft intervals. The shoreline position is taken as the interface between dry and wet sand, which is typically the mean higher high water (MHHW) shoreline. A sample is shown on Figure C-13 in Appendix C. A comprehensive and systematic methodology for collection, analysis and reporting of shoreline position is provided in the National Park Service's Protocol, NPS (2012).

(B) TOPOGRAPHIC SURVEY

(1) Purpose

The purpose of a topographic survey is to determine changes in shoreline levels, volumes, and morphology. Topographic surveys can be used to evaluate long-term trends in plan shape, areas of accretion/erosion, volume changes and 3D change of spits and complex dune systems. Data from topographic surveys may also be used as input for coastal modelling studies.

(2) Description

Topographic surveys should be undertaken by a licensed surveyor using a land-based RTK-GPS topographic survey system or LiDAR. The RTK-GPS and LiDAR surveys should be supplemented with shoreline profiling.

Upon completion, in addition to the CAD survey file, the survey should be accompanied by a detailed survey report that includes survey metadata and details of every survey control point used. The survey report will be incorporated into the inspection report deliverable. In addition, the survey should be supported with fixed aspect photographic records using a GPS enabled camera with photos taken from the same position and of the same view, etc.

(C) BATHYMETRIC SURVEY

(1) Purpose

The purpose of a bathymetric survey is to determine changes in nearshore seabed levels, volumes, morphology (e.g. sand banks and channels) and superficial seabed sediment composition. Data from bathymetric surveys may also be used as input for coastal modelling studies.

(2) Description

Bathymetric surveys should be performed using a multi-beam system extending from the shoreline below mean low water to the -25 ft depth contour (relative to NAVD88), unless otherwise specified. Upon completion, in addition to providing the CAD survey file, the survey should be accompanied by a summary report that details the survey methodology. The report will be incorporated into the inspection report deliverable.

Accuracy varies significantly depending on conditions, but vertical accuracy of +/-6 in., horizontal accuracy of +/-3 ft are considered satisfactory.

(D) DIGITAL AERIAL PHOTOGRAPHY

(1) Purpose

Digital aerial photography is used to evaluate long-term trends in plan shape, recession rates and spatial change of spits and complex dune systems which may not be readily observable from land or water-based inspections. Where required, special features such as false color infrared images may be used to detect features such as algal blooms in the nearshore, which may affect water quality and marine habitat.

(2) Description

Digital aerial photography should be done using the appropriate equipment with qualified professional staff. Fully georectified digital images in both visible and infrared spectrums are captured typically from a light aircraft or unmanned aerial vehicle. These are prepared in full 3D control using a combination of surveyed ground control points, base mapping and terrain models.

Aerial photography is typically flown to a 4 in. resolution, which is equivalent to 1:5000 scale film. The interpretations of aerial photographs must include corrections for distortion effects related to camera tilt, variable scales, relief displacement, and radial lens distortion. Once processed, the georectified images should achieve a Root Mean Square Error (RMSE), which describes the difference between true position of a feature (defined by survey data) and the feature's position in the georeferenced image, of better than +/-4 in.

Photos should be taken when tide levels are lowest and future flights should endeavor to occur at about the same time of year each time.

(E) HYDRODYNAMIC CONDITIONS

(1) Purpose

Hydrodynamic conditions along the shoreline may be required to understand the forcing conditions that cause different shoreline responses and longer term trends such as sea level rise or changes in wave climate. Nearshore hydrodynamic conditions also enable calibration/validation of coastal models that may be used for design, flood risk mapping and flood forecasting/warning.

(2) Description

The collection of hydrodynamic parameters may include local wave conditions typically at the -25 ft depth contour (relative to NAVD88), local wind speed/direction, water levels via tide gauges or similar measuring devices, or currents in the nearshore area using acoustic Doppler current profilers (ADCPs) or other current meters such as an acoustic Doppler velocimeter (ADV). Hydrodynamic conditions data should be collected continuously over a long period (>10 years) to allow assessment of trends and robust extreme value analysis. The deployment of these specialized instruments should be undertaken by qualified technicians and/or engineers.

Long-term hydrodynamic data is generally available for most landmark sites throughout the City. In cases where data is not available or suitable, then a minimum of 2 months of data should be recorded, as some data is better than no data to calibrate and validate coastal numerical models. The longer the available record the better for modelling purposes.

Publically available data should be researched and utilized to the extent possible prior to undertaking a hydrodynamic condition data acquisition program.

(F) ENVIRONMENTAL MONITORING

(1) Purpose

Environmental monitoring is done to assess natural habitat evolution (e.g. gain/loss of different habitat types) and to inform new shoreline management initiatives including scheme design and during/post-scheme monitoring to discharge environmental consent requirements.

(2) Description

Field surveys of habitat, ecology and water quality (water sampling) to provide baseline assessment against which repeat surveys can be compared to for the purpose of monitoring changes over time either as part of general trend monitoring or in relation to specific management activities. Parameters monitored will depend on setting and may be related to changes to legally designated habitats, the physical and human environment and environmental quality.

Environmental monitoring should be supported with fixed aspect photographic records using a GPS enabled camera with photos taken from the same position and of the same view, etc.

The frequency of this type of inspection depends on its purpose. May be related to specific scheme or may be annual if focused on trends over time. Will also depend on features to be surveyed and when it is best to do so, accounting for things such as seasonality of habitat and breeding seasons for species, etc.

(G) GEOTECHNICAL INVESTIGATION

(1) Purpose

A geotechnical investigation may be performed as part of a shoreline inspection to assess the seabed composition, determine shoreline permeability, and to obtain soil profiles for the determination of cross-sectional area and volume changes. The data obtained from a geotechnical investigation may also be used for the design of foundations for shoreline protection structures.

(2) Description

The scope of the geotechnical investigation depends on the objective of the investigation, but may include test pits, borings, cone penetration test (CPT), or a geophysical survey. If assessing shoreline permeability, the investigation may include installation of piezometers to measure water level variation within the shoreline over time.

(H) SEDIMENT SAMPLING

(1) Purpose

Sediment sampling is typically done to determine shoreline material characteristics such as particle size, chemical composition, etc. This data may be used to assess seasonal and long-term changes to the shoreline material, determine suitability of the material for other uses, or to inform coastal sediment transport modelling studies.

(2) Description

Sediment sampling involves the collection of shoreline and nearshore seabed sediments using grab samples to enable physical and chemical analysis of sediment. Grab samples should be taken along at the same intervals as the shoreline profiling at the upper shoreline, MHW, and MLW marks. For grab samples, about 1 lb of sample should be taken for analysis. As part of the shoreline profiling effort, the surface sediment type (e.g. mud, sand, gravel) alongside each survey point should be noted.

In nearshore areas, more targeted sampling is typically applied and should be determined by analysis of bathymetric survey data.

4.2 TYPES OF INSPECTIONS

4.2.1 Baseline Inspection

(A) PURPOSE

The Baseline Inspection serves as the basis of the WFMMS. The primary purpose of the Baseline Inspection is to assess the general overall condition of the shoreline in order to establish a comprehensive initial baseline survey across pre-defined shoreline profile locations at a particular point in time. Baseline Inspections are performed for shorelines which have never been inspected or where shoreline profile survey data is not available.

(B) SCOPE OF WORK

The scope of a Baseline Inspection includes the following shoreline inspection components:

- Shoreline profiling

- Topographic survey
- Bathymetric survey

Shoreline profiling should be performed at intervals specified in the scope of work document.

Additional surveys and investigations may be undertaken during the Baseline Inspection as required to support the overall program requirements and intent. The inspection components listed above are the minimum required to satisfy the requirements for a shoreline Baseline Inspection under the WFMMS.

The inspection data are used as the basis for satisfying the following primary goals of the Baseline Inspection:

- Confirmation of overall dimensions, shoreline characteristics, and other physical features
- An overall condition assessment rating for the shoreline and its components
- Recommended actions, including the need for any Engineering Investigation or Design-Level Inspections, and associated order-of-magnitude cost estimates
- The scope of the Engineering Investigation or Design Level Inspection, if required
- The recommended type and time interval to the next inspection

The deliverable for the Baseline Inspection is the Baseline Inspection report, as defined in Chapter 6 of this manual.

4.2.2 Routine Level Inspection

(A) PURPOSE

The Routine Inspection is similar to the Baseline Inspection in most aspects and serves as the basis of the WFMMS. The primary difference between the Routine Level and Baseline Inspections is that for Routine Level Inspections the shoreline profile will be compared with previous inspection results in order to determine general trends such as seasonal changes and movements in the shoreline.

Routine Level Inspections are typically performed on a regularly-scheduled basis, and represent a proactive, rather than a reactive, approach to maintenance. By conducting Routine Level Inspections on a regular basis, shoreline movements, damage, and trends can be detected so that remediation/mitigation measures can be planned and implemented in a timely manner. The data collected from Routine Level Inspections can be used to help define appropriate trigger levels for when intervention may be required. For instance, trigger levels may be a low volume of sediment along a frontage or a low beach crest height or width in relation to increased risk of wave overtopping which could then lead to flooding.

Unlike rehabilitation of hard structures, the rehabilitation of shorelines typically needs to be done on a system-wide basis and covers a much larger area with far-ranging environmental impacts on surrounding areas. As such, rehabilitation of shorelines requires extensive planning and studies over a long term period prior to any construction taking place.

(B) SCOPE OF WORK

The scope of a Routine Level Inspection includes the following shoreline inspection components:

- Shoreline profiling
- Topographic survey

Shoreline profiling should be performed at intervals specified in the scope of work document.

Additional surveys and investigations may be undertaken during the Routine Level Inspection as required to support the overall program requirements and intent. Unless vessel navigation is a specific concern or the nearshore water depths are required to support a design (ie. dredging, etc.), bathymetric surveys are typically not required as part of the Routine Level Inspection. The inspection components listed above are the minimum required to satisfy the requirements for a shoreline Routine Level Inspection under the WFMMS.

The primary objective of the Routine Level Inspection is to evaluate changes in shoreline levels, cross-sectional area, and volume over time above the MLW level. The inspection data are used as the basis for satisfying the following primary goals of the Routine Level Inspection:

- An overall condition assessment rating for the shoreline and its components
- Comparison with previous inspection findings and results
- Recommended actions, including the need for any Engineering Investigation or Design-Level Inspections, and associated order-of-magnitude cost estimates
- The scope of the Engineering Investigation or Design Level Inspection, if required
- The recommended type and time interval to the next inspection

The deliverable for the Routine Level Inspection is the Routine Level Inspection report, as defined in Chapter 6 of this manual.

4.2.3 Rapid Level Inspection

(A) PURPOSE

Rapid Level Inspections are short duration investigations for emergency or immediate issues that need to be addressed which are not attributable to a specific event, or to provide a quick general condition assessment of the shoreline as part of a regular maintenance program. They may also be conducted to provide preliminary information regarding a shoreline for which no previous reports or records are available and where a Baseline Inspection may not be possible. The primary purpose of a Rapid Level Inspection is to confirm the integrity of the shoreline, determine general shoreline characteristics, and to determine if further attention to the shoreline is necessary.

(B) SCOPE OF WORK

The scope of a Rapid Level Inspection includes the following shoreline inspection components:

- Shoreline profiling

Shoreline profiling should be performed at intervals specified in the scope of work document.

The Rapid Level Inspection is performed to determine the general shoreline condition, shoreline composition (e.g. change in grading; areas of deposition/erosion of fine/coarse sediment), changes in shoreline features (e.g. berms/dune), damage to shoreline structures, and to determine whether trigger levels for intervention have been reached.

The inspection data are used as the basis for satisfying the following primary goals of the Rapid Level Inspection:

- An overall condition assessment rating for the shoreline and its components
- Comparison with previous inspection findings and results, if available
- Recommended actions, including the need for any Engineering Investigation or Design-Level Inspections, and associated order-of-magnitude cost estimates
- The scope of the Engineering Investigation or Design Level Inspection, if required
- The recommended type and time interval to the next inspection

The deliverable for the Rapid Level Inspection is the Rapid Level Inspection report, as defined in Chapter 6 of this manual.

4.2.4 Design Level Inspection

(A) PURPOSE

The purpose of the Design Level Inspection is to establish a comprehensive baseline survey across pre-defined shoreline profile locations in support of the design of repairs to the shoreline system.

(B) SCOPE OF WORK

The scope of a Design Level Inspection includes, at minimum, the following shoreline inspection components:

- Shoreline profiling
- Topographic survey

Shoreline profiling should be performed at intervals specified in the scope of work document.

Additional surveys and investigations may be undertaken during the Design Level Inspection as required to support the overall design requirements and intent. The inspection components listed above are the minimum required to establish a baseline condition of the shoreline prior to the implementation of any rehabilitation work.

The deliverable for the Design Level Inspection is the Design Report, as defined in Chapter 6 of this manual.

4.2.5 Construction Inspection

(A) PURPOSE

The purpose of the Construction Inspection is to ensure that the ongoing construction quality is acceptable and in accordance with the design plans and specifications.

(B) SCOPE OF WORK

The scope of a Construction Inspection typically includes the following shoreline inspection components:

- Shoreline profiling
- Topographic survey

Shoreline profiling should be performed at intervals required to verify the ongoing construction or as specified in the scope of work document.

Additional surveys and investigations may be undertaken during the Construction Inspection as required to support the overall design requirements and intent. In some cases, the inspection components listed above may not be required to verify the construction and should be substituted as appropriate.

The deliverable for the Construction Inspection is a Daily Construction Report as defined in Chapter 6 of this Manual, and where applicable, a punch list of issues to be resolved by the contractor.

4.2.6 Post-Construction Inspection

(A) PURPOSE

The purpose of the Post-Construction Inspection is to ensure that the construction has been completed in accordance with the design plans and specifications, a baseline survey is established, the status of previous recommendations is updated, and all punch list items have been resolved.

(B) SCOPE OF WORK

The scope of the Post-Construction Inspection is similar to the Construction Inspection except for additional reporting requirements. Additional reporting requirements for the Post-Construction Inspection include the preparation of a report that updates the previously assigned condition assessment ratings (when an existing shoreline has been rehabilitated), a collation of all Daily Construction Reports, and a comprehensive baseline survey across pre-defined shoreline profile locations has been established for the newly constructed or rehabilitated shoreline system.

The scope of a Post-Construction Inspection includes, at minimum, the following shoreline inspection components:

- Shoreline profiling
- Topographic survey

Shoreline profiling should be performed at intervals required to verify the completed construction or as specified in the scope of work document.

Additional surveys and investigations may be undertaken as part of the Post-Construction Inspection as required to support the overall design requirements and intent. In some cases, the inspection components listed above may not be required to verify the construction and should be substituted as appropriate.

The deliverable for the Post-Construction Inspection is a Post-Construction Inspection Report as defined in Chapter 6 of this manual.

4.2.7 Post-Event Inspection

(A) PURPOSE

Post-Event Inspections are short duration investigations that are conducted following a significant, potentially damage-causing event such as a storm, tsunami, earthquake, flood, or similar event where either a pre-defined wave/water level threshold is reached. The primary purpose of a Post-Event Inspection is to rapidly confirm the condition of the shoreline and to determine if further attention to the shoreline is necessary as a result of the event. Performing Post-Event Inspections will also improve the understanding of short term shoreline response to more extreme conditions by taking a snapshot of the shoreline immediately after the event. The short term response to extreme events may not be captured by future Routine Level Inspections which could take place several years after the event.

(B) SCOPE OF WORK

The scope of a Post-Event Inspection includes, at minimum, the following shoreline inspection components:

- Shoreline profiling
- Topographic survey

Shoreline profiling should be performed at intervals required to assess the shoreline response to the event or as specified in the scope of work document.

Additional surveys and investigations may be undertaken as part of the Post-Event Inspection as required to support the overall inspection requirements and intent. For instance, the inspection and subsequent reporting for shorelines damaged by a storm may need to be tailored to meet federal funding requirements. In some cases, the inspection components listed above may not be required to verify the shoreline response and should be substituted as appropriate.

The deliverable for the Post-Event Inspection is a Post-Event Inspection Report as defined in Chapter 6 of this manual.

4.2.8 Engineering Investigation

(A) PURPOSE

Engineering Investigations are performed for the purpose of collecting more detailed information than normally obtained during Baseline, Routine Level, or Rapid Level Inspections. Investigations may include engineering analysis, coastal area modeling, and/or sampling.

Engineering Investigations are typically performed on an exceptional basis as a result of a recommendation from the Baseline, Routine Level, Rapid Level, or Post-Event Inspection. However, an Engineering Investigation may also be performed concurrently with other types of inspections where appropriate.

(B) SCOPE OF WORK

The scope of an Engineering Investigation may vary widely depending on the objectives of the inspection and/or the nature of the shoreline, and may include but is not limited to:

- Investigation to establish site-specific hydrodynamic conditions (waves, currents, tides, etc.)
- Digital aerial photography
- Coastal modeling to establish extreme conditions
- Numerical modeling for water quality study
- Sediment transport study
- Water and/or sediment sampling
- Dune vegetation mapping
- Water turbidity measurements
- Geotechnical investigations
- Physical modeling

Engineering Investigation deliverables typically include laboratory/testing reports, and/or reports presenting the results of the detailed inspection and subsequent engineering analysis/modeling.

4.3 CONDITION ASSESSMENT RATINGS

Each facility, system, and component group in the WFMMS shall be given a condition assessment rating following the inspection. The ratings are important in establishing the priority of follow-on actions to be taken. This is particularly true when many systems are included in an inspection program and follow-on activities must be ranked or prioritized due to limited resources. Unlike hard structures, shorelines are assessed on a five point scale. The five terms that should be used to describe the conditions of shorelines are described in Table 4-1 in general terms and how they specifically relate to beaches and dunes.

TABLE 4-1
CONDITION RATINGS FOR SHORELINES

Condition Rating	Description		
	General	Beaches	Dunes
Good	Cosmetic defects that will have no effect on performance.	Flat or shallow beach slope, wide beach, established vegetation. Key features include backshore and crest with no evidence of erosion. Stable beach profile with minimal changes between inspection periods. Established vegetation possibly with young plant growth. Minor foreign objects may be present but causing no scour or instability.	Wide stable dune system. Extensive dense dune vegetation. Key features include dense established dune vegetation with young plant growth. No vegetation damage or loss. High upper beach fronting dunes. Strand line appears seaward due to accreting upper beach. Minimal or localized erosion of seaward dune slope. Minor foreign objects may be present but causing no scour or instability. Access restricted to prevent animal damage and human interference.
Satisfactory	Minor defects that will not reduce the overall performance of the asset	Wide shallow shingle beach. Key features include shallow and wide slope with minor or localized erosion. Beach profile fluctuates seasonally with profile recovery under beach building conditions. Backshore remains wide and high with strand line on mid to lower beach. Minor or localized erosion of backshore or crest. Established vegetation possibly with young plant growth. Minor localized scour due to presence of minor foreign objects but with no effect on stability.	Wide dune system. Dune stable with good coverage of established vegetation. Accumulation of sand against fence. Key features include good vegetation cover with no vegetation damage or loss. Strand line high on upper beach fronting dunes. Minimal or localized erosion of seaward dune slope. Access restricted to prevent animal damage and human interference. Minor localized scour due to presence of minor foreign objects with no effect on stability.
Fair	Defects that could reduce performance of the asset is present	Beach may be narrow or steep in localized areas. Key features include minor or localized erosion of slope or toe resulting in reduction of slope width. Minor erosion of backshore or crest indicated by cliffing. Strand line high on backshore indicates reduced backshore or crest width. Localized areas of vegetation. Minor foreign objects present with possible localized effects on stability associated with minor scour.	Stable dune with localized areas of non-vegetated dune. Key features include stable dune system with erosion of seaward dune slope indicated by cliffing. No collapse of dune front face. Localized areas of vegetation damage or loss with minimal effect on dune systems' ability to retain sediment. Minor foreign objects present with possible localized effects on stability associated with minor scour.
Poor	Defects that would significantly reduce performance of the asset is present. Further investigation is needed.	Narrow, steep, unstable beach. Beach is subject to high degree of movement. Key features include sustained and prolonged erosion of beach slope, toe, backshore or crest. Strand line appears high on backshore indicating frequent inundation. If seawall is present toe will be exposed. Moderate damage to vegetation. Moderate scouring around minor foreign objects present. No significant beach crest. Spring tides will allow direct wave attack to the base of the cliff.	Lower lying unstable dune system. Significant areas of non-vegetated dune is present with severe cliffing of front face. Key features include loss of vegetation with significant effect on dune systems' ability to retain sediment. Severe erosion of seaward dune slope with possible partial or localized collapse of dune front face. Low beach fronting dunes. Severe scour around minor foreign objects present. Badly trampled access points, devoid of vegetation. Vegetation or other objects falling over edge of dune crest.

Condition Rating	Description		
	General	Beaches	Dunes
Serious / Critical	Severe defects resulting in complete performance failure of the asset.	Steep, narrow beach. Extensive erosion of foreshore with reduced beach profile. Key features include sustained and prolonged erosion of beach slope and toe with significantly lowered beach profile. Strand line occurs high on backshore. Evidence of significant overtopping exhibited by sediment on the landward side of the crest, runnels from overtopping water and damage to backshore plants from over washing. Complete loss of vegetation. Severe foreign objects present resulting in significant scour. Beach volume depleted resulting in loss of the beach crest and direct wave attack to land at the rear.	Complete loss or lowering of dune system. Key features include marrow and flat dune system. Severe and extensive damage or loss of vegetation. Low beach fronting dunes. Severe erosion of seaward dune slope. Collapse of dune front face with evidence of significant overtopping exhibited by runnels from overtopping water and damage to vegetation on back slope from over washing. Severe foreign objects present, resulting in significant scour.

The condition assessment rating should be assigned upon completion of the Baseline, Routine Level, Rapid Level, Post-Event, and Post-Construction Inspection and remain associated with the shoreline until the shoreline is re-evaluated following rehabilitation or upon completion of the next scheduled inspection.

4.4 RECOMMENDED ACTIONS

Recommended actions are typically assigned upon completion of each inspection type. The recommended actions are categorized into the following four general types of actions, which are described below:

- Emergency/Immediate action
- General repair recommendation
- Additional investigation and engineering analysis
- No action

4.4.1 Emergency/Immediate Actions

Emergency/Immediate actions require prompt response to prevent unsafe conditions at the shoreline. These actions may consist of barricading access to the shoreline to block access, mobilizing a repair crew to quickly restore safe conditions, or creating a buffer zone to maintain pedestrian safety. The consultant must notify the property owner or manager of immediate actions as soon as they are discovered. The notification must be made by phone or email and shall be immediately followed by a letter from the consultant which describes the condition and recommended actions.

4.4.2 General Repair Recommendations

General repair recommendations are required following the Baseline, Routine Level, and Rapid Level Inspections in order to determine the order-of-magnitude cost estimates for future actions including rehabilitation, design, and inspection work.

These recommendations are grouped into two different levels of importance as presented below.

(A) PRIORITY

Priority level actions are recommendations for which no immediate measures are required, but for which further investigations, design, and implementation of interim or long-term rehabilitation should be undertaken. The priority action takes precedence over all other scheduled work and should be implemented within a time frame directed by the consultant performing the inspection.

(B) ROUTINE

Routine level actions should be undertaken as part of a scheduled maintenance program, other scheduled project, or routine facility maintenance depending upon the action required. The routine recommended actions shall be in accordance with good engineering and industry practice to maintain the shoreline and reduce future capital expenses.

Postponing routine recommended actions will not compromise the integrity of the shoreline or significantly increase the cost of future remedial action. During the next Routine Level Inspection, the routine level recommended actions should be reevaluated to determine if their status has changed. The consultant should anticipate that recommended routine actions that consist of rehabilitation will likely be implemented one year after the completion of the next Routine Level Inspection.

4.4.3 Additional Investigation and Engineering Analysis

Additional Investigation should be recommended when more information is needed to better determine the overall condition of the shoreline, understand the cause and impacts of the observed shoreline movement, or to collect data for more in-depth analysis, modeling, and management of the shoreline.

The NPS 2012 protocol discusses methodologies to analyze the shoreline position and beach profile data. NPS also recommends the Digital Shoreline Analysis System (DSAS) for transforming the surveyed shoreline into a data matrix for engineering analysis.

An Engineering Analysis should be recommended when numerical or physical modeling or other detailed coastal studies are required to determine the short and long term impacts of the recommended action(s) or no action, understand the cause and impacts of the observed shoreline movement, and for the development of a shoreline management plan.

4.4.4 No Action

Recommended when no further action is necessary until the next scheduled Routine or Rapid Level Inspection.

4.4.5 Frequency of Inspections

As part of the recommended actions, the consultant should recommend the type of inspection to be performed and when the inspection should be performed. Guidance on the frequency of inspections is provided in Section 7 of this manual.

5. WETLAND INSPECTION REQUIREMENTS

5.1 GENERAL

5.1.1 Scope of Wetlands Inspection

This section of the manual applies to the inspection of wetlands adjacent to the waterfront shoreline and, that generally extend from the shoreline to the upland. This includes Spartina dominated, Phragmites dominated, scrub/shrub/wooded, and manmade wetlands as contained in the WFMMS's list of systems. For a full list of systems in the WFMMS that are associated with wetlands see Table 2-1. Example components that comprise each of these systems includes wetland (or marsh) shoreline, tidal creeks and pools, marsh vegetation and habitat, and buffer.

The scope of wetland inspections will vary depending on the objectives and requirements of the adopted wetland management scheme, but will generally be focused on the low marsh zone from mean tide level (MTL) up to the mean high water (MHW), but may also include the middle mash area up to mean higher high water (MHHW) and the upland buffer depending on inspection type, as shown on Figure 5-1. According to the New York City Department of Parks and Recreation (NYCDPR), New York City salt marshes exhibit very little zonation. There is high marsh and low marsh; however, the low marsh is often a very scant sliver along tidal creeks. The components or metrics that comprise a wetland inspection are described in the following section.

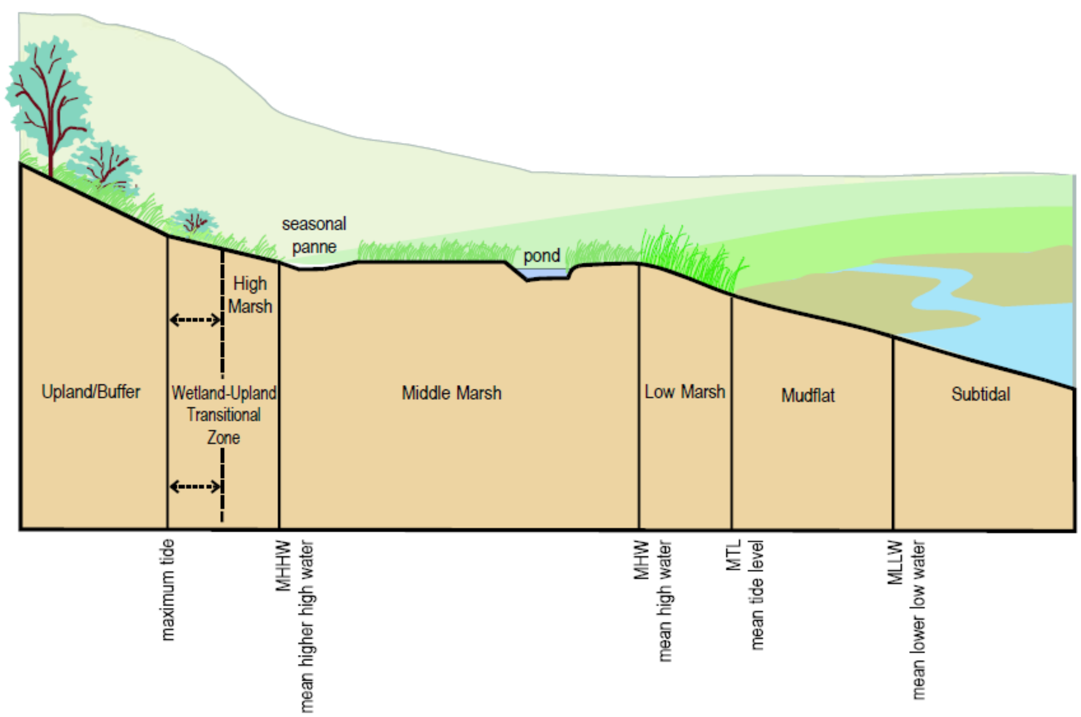


FIGURE 5-1. TYPICAL PROFILE OF TIDAL WETLAND

The NYCDPR Natural Resources Group (NRG) received an EPA Wetlands Program Development Grant to study NYC salt marsh systems and evaluate their current condition and vulnerability to sea level rise and the effects of urbanization. The NYCDPR project developed from this grant includes evaluating existing marsh complexes utilizing a rapid assessment protocol and conducting long-term sediment accretion and marsh surface elevation monitoring. To the exception of long-term sediment accretion and marsh surface elevation monitoring, data collected for the NRG wetlands project are relevant to the WFMMS wetlands inspections, therefore efforts have been made to use the same data collection protocols and methodologies used by NRG. Data collected through the implementation of the WFMMS should therefore be compatible with and complement data collected by NRG while avoiding duplication of efforts.

Where applicable, the selected inspection methods are the same as those described in Natural Areas Conservancy Salt Marsh Assessment (NACSMA) July 2013 protocol (NAC-NYCDPR 2013) and in the Site-Specific Intensive Monitoring (SSIM) model developed for the NYCDPR long-term marsh monitoring plan whose methods are described in NYCDPR 2014a, as well as subject to the associated quality assurance project plan (QAPP) (NYCDPR 2014b). The objectives of the NACSMA is to determine the relative condition of each salt marsh sampled within New York City, and to be able to statistically compare among them. Those objectives are similar to those of the WFMMS, and NACSMA attributes measured and statistical approach will also allow for comparison of wetland conditions over time. The NYCDPR QAPP was developed to cover basic SSIM methodologies for tidal wetlands in the coastal region of New York City by adapting methodology described in the Mid-Atlantic Coastal Wetland Assessment (MACWA) through training and communication with the Partnership for the Delaware Estuary. Users of this manual are therefore encouraged to consult these NYCDPR documents before applying wetland inspections methods described herein.

NACSMA metrics used in the WFMMS include vegetation composition and structure and soil characteristics (shear vane strength). SSIM metrics include vegetation community attributes, soil (shear vane strength), erosion at tidal creeks, and pool expansion.

5.1.2 Functions and Ecological Services of Wetlands

The terms functions and ecological services (or values) when discussing wetlands have different meanings. Functions are the physical, chemical, and biological processes occurring in and making up an ecosystem. Processes include the movement of water through the wetland into streams or the ocean; the decay of organic matter; the release of nitrogen, sulfur, and carbon into the atmosphere; the removal of nutrients, sediment and organic matter from water moving into the wetland; and the growth and development of all the organisms that require wetlands for life.

Ecological services are "an estimate, usually subjective, of worth, merit, quality, or importance" (Richardson 1994). Wetland ecological or economic services derive from outputs that can be consumed directly, such as food, recreation, or timber; indirect uses which arise from the functions occurring within the ecosystem, such as water quality, and flood control; possible future direct outputs or indirect uses such as biodiversity or conserved habitats; and from the knowledge that such habitats or species exist (known as existence value) (Serageldin 1993). Following are wetland functions that are relevant to coastal marshes:

- Hydrologic flux and storage
- Biogeochemical cycling and storage
- Biological productivity
- Decomposition
- Community structure and wildlife support

Detailed descriptions of each of these functions are provided in Appendix F.

5.1.3 Types of Wetlands

(A) SPARTINA DOMINATED WETLANDS

The Spartina dominated wetland type represents the coastal wetland environment that are dominated by Spartina plant species, such as *Spartina alterniflora* and *Spartina patens*. *S. alternifloraisa* grass often divided in a tall and a short form. The tall form grows 1-2 m (3-6 ft) while the short form can be as short as 10 cm (3 in.), with a continuous gradation between both forms. It has smooth green stems and leaves. Usually light green to green in coloring.

S. alterniflora (salt marsh cordgrass) dominates the low marsh zone of tidal marshes on the East Coast of the U.S. *S. patens* is found higher in the intertidal zone (Teal, 1962; Bertness, 1991).

Ecological and economic services of Spartina dominated marshes include water quality, flood control, erosion control, community structure and wildlife support, recreation, aesthetics, and commercial benefits.

(B) PHRAGMITES DOMINATED WETLANDS

The Phragmites dominated wetland type represents coastal wetland environment that are dominated by *Phragmites australis*, the invasive common reed. It is a large perennial wetland grass easy to distinguish because of its 2-6 m height and fluffy seed-head. Usually light green to green in coloring with brown reeds at the base of plant and brown tops.

According to Yuhas et al. (2005), *australis* is usually found on high marshes, but it has been moving into low marshes and replacing *S. alterniflora* (Fell et al. 1998; Angradi et al., 2001; Windham & Lathrop, 1999).

P. australis changes the marsh physically, hydrologically, and chemically (Angradi et al., 2001; Windham & Lathrop, 1999), and this can affect the utilization of the marsh by fish, birds, and other animals. *P. australis* has been replacing native vegetation on the Atlantic coast since the early 1900s (Weinstein & Balletto, 1999; Fell at al., 1998; Angradi et al., 2001; Windham & Lathrop, 1999). Marsh managers have responded by trying to decrease the dominance of *P. australis* on salt marshes. Numerous restoration projects have been undertaken in which *P. australis* was removed and *S. alterniflora* replanted. However, there have been few direct comparisons of the relative level of function of marshes before and after restoration (Yuhas et al. 2005).

Ecological and economic services of Phragmites dominated marshes include water quality, flood control, erosion control, but, because of it is an invasive plant to New York, would rank lower in terms of community structure and wildlife support, recreation, aesthetics, and commercial benefits.

(C) SCRUB/SHRUB/WOODED WETLANDS

Scrub, shrub or wooded wetlands represent coastal wetland environment dominated by woody vegetation and is characterized by natural or semi-natural vegetation like trees or shrubs. This category of wetlands is part of the WFMMS database. However, it is rarely observed around New York City, so will not be described in more detail.

(D) MANMADE WETLANDS

Tidal wetlands constructed to provide mitigation for impacts to (or loss of) existing wetlands are the most dominant manmade wetlands in New York City area. Wetlands constructed for stormwater storage or treatment also belong to the manmade wetlands type, but only a few of these are found along the New York City shoreline.). Mitigation wetlands are constructed to comply with a US Army Corps of Engineers permit pursuant to section 404 of the Clean Water Act and/or a NYDEC permit pursuant to the Tidal Wetland Act of 1973.

Ecological and economic services of these manmade wetlands will depend on their design objectives. For example, stormwater wetlands should provide water quality, flood control and erosion control. Mitigation wetlands values will depend on the success criteria set through the permitting process.

5.1.4 Components of a Wetland Inspection

The components (or metrics) of a wetland inspection that are included in the WFMMS are listed below and described in the following subsections:

- Tidal wetland shoreline position [NPS Methodology]
- Tidal wetland shoreline condition assessment
- Tidal wetland shoreline profiling
- Marsh vegetation and habitat assessment
- Pool expansion and historical waterward erosion
- Digital aerial photography
- Topographic surveys

For the WFMMS, wetland shoreline condition assessment, vegetation and habitat assessment, and the field stressors assessment (which include tidal creek and wetland pool condition) will be the most commonly employed inspection components.

(A) WETLAND SHORELINE POSITION

(1) Purpose

The purpose of assessing wetland shoreline position is to monitor the rate and magnitude of changes in wetland shoreline position over time. The wetland shoreline position is affected by sea level rise, sediment supply, wave energy, and boat wake.

(2) Description

The National Park Service (NPS) has created the Northeast Coastal and Barrier Network (NCBN), as part of the congressionally-mandated Natural Resource Challenge, to ensure the systematic collection and use of scientific data in managing the nation's parks (NPS NCBN 2003). Within this structure, the NCBN has developed a series of scientific protocols to address a variety of natural resource issues appropriate to coastal locations, including the use of state-of-the-art GPS equipment to determine shoreline position. Although this methodology has not been used to specially address wetland shoreline, it will provide a readily visible overall assessment of temporal changes in wetland shoreline position over time.

Methods: Surveys are conducted using a sub-meter GPS receivers, and is capable of post-processed differential correction, or can accommodate real-time differential-correction of the survey points, such as the Trimble GeoXT or GeoExplorer® 6000 Series GeoXH Handheld. Position. Data is then post-processed and later manually corrected for obvious systematic errors. This included corrections of loops, obvious errant nodes, and clusters of nodes caused by surveyor pauses. The NCBN shoreline protocol (Psutty et al. 2010) includes a number of standard operation procedures (SOP) that detail appropriate GPS shoreline position methodology.

The NCBN shoreline position methodology was defined for beaches and sand dunes and must be adjusted to conform to the tidal wetland typical profile represented on Figure 5.1. For wetlands shoreline position, the survey follows the top of the area between the edge of the vegetated low marsh (approximately at MTL) and MLW.

(B) TIDAL WETLAND SHORELINE CONDITION ASSESSMENT

(1) Purpose

The purpose of tidal wetland shoreline condition assessment is to:

- Determine wetland shoreline condition
- Observe changes and damage to wetland shoreline features
- Compare the level of the wetland shoreline against markers/visual indicators used to assess if trigger levels for intervention have been reached

Observations should be made where the water body adjacent to the shoreline must be a tidally influenced creek or open bay with a minimum width of 30 m. This criterion will ensure that the water body has sufficient surface area and fetch to be exposed to wave and erosion energies.

(2) Description

The tidal wetland shoreline condition assessment involves visual inspection of the shoreline for presence of structures, recording each inspection including assessed condition grade in a standardized inspection form and supported with fixed aspect digital photographic records at a minimum of each transect using a GPS enabled camera with photos taken from the same position and of the same view, etc. for each survey as well as measurements of creek bank erosion.

Shoreline condition is assessed with two metrics: shoreline alterations and bank erosion in tidal creeks. Both of these metrics are assessed at the plot locations adjacent to wetland shoreline (see Sample Survey Plan for Wetlands in Appendix C).

Shoreline alterations include presence of built structures or non-natural materials along the shoreline at transect points, such as bulkheads, old wharfs, rip rap, but not natural materials such as shell, debris and living shorelines.

Erosion of tidal creek banks is determined following the procedure detailed in the SSIM and would be used when more refined study of the wetland erosion is required.

Following the SSIM methodology, the largest one to two tidal creeks within each marsh complex or facility that have eroded since 1974 (determined by comparison of georeferenced 1974 aerial images to 2012 post-Sandy aerial images for marsh loss) are chosen. Along the closest bank or edge of the selected tidal creek(s), random numbers as number of paces along edge are used to locate transects. Each transect includes three erosion pins installed from creek edge into marsh, perpendicular to the marsh shoreline. Creek bank shoreline is defined as the border between unvegetated and vegetated (live, emergent vegetation stems that at peak growing season June-August are not shorter than 30 cm, and that are at least 50 cm from the nearest other vegetation proceeding from shoreline waterward).

From the first pin (most waterward), approximate perpendicular angle is estimated to the creek edge direction, and the next two pins are placed at 3 m (~10 ft) and 6m (~20 ft) proceeding towards the interior marsh.

In this manner, 5 transects of three pins at each permanent study site would be installed per shoreline/creek bank site, and photographs of adjacent creek bank would be taken at installation/baseline.

Rates of net change would be averaged for a permanent study site (n=5), and compared among sites for each time interval. Net change will be change in distance of creek bank edge to each pin (baseline-distance at subsequent time intervals). Erosion pins will be measured annually in June (when baseline will be installed).

(C) TIDAL WETLAND SHORELINE PROFILING

(1) Purpose

The purpose of tidal wetland shoreline profiling is to:

- Determine wetland shoreline profile with respect to a reference base line
- Determine wetland shoreline surface elevation (e.g. change in grading; areas of deposition/erosion of fine/coarse sediment)
- Observe changes and damage to shoreline features (e.g. vegetated marsh, mudflats)
- Compare the level of the shoreline against markers/visual indicators used to assess if trigger levels for intervention have been reached

(2) Description

Transect intervals should be set based on the monitoring need for the wetland shoreline and the number of transects taken should be frequent enough to distinguish alongshore variation of marsh profiles. This will depend on the nature of the shoreline that is being inspected and will be indicated in the scope of work provided to the consultant. Each transect should cover the full profile from upland-high marsh transition zone down to MLLW. A minimum of three readings along the shore parallel contours shall be obtained for each transect. The selected spacing will depend on the nature of the shoreline, however, shall be such that a meaningful shoreline profile can be developed.

Shoreline position is taken from a reference base line such as a vertical datum or existing permanent structure on the upland area. A sample is shown on Figure C-16 in Appendix C.

(D) MARSH VEGETATION AND HABITAT CONDITION ASSESSMENT

(1) Purpose

The purpose of the marsh vegetation and habitat assessment is to broadly characterize the vegetation cover and structure and to identify invasive species present and assess extent of invasive species occurrence. Vegetation is major attribute of wildlife habitat which provides valuable social and economic benefits to society through activities such as bird watching or nature observation.

(2) Description

Several metrics are used to assess vegetation condition including: dominant species, presence of invasive species, presence of rare or endangered plants, and special wetland communities. Each inspection including assessed condition grade is recorded in a standardized inspection form and supported with digital photographic records.

For consistency with the NYCDPR long-term monitoring, marsh vegetation assessment will follow methods similar to those described in the SSIM.

Methods: Vegetation is characterized in twenty 1 m^2, randomly placed quadrats at each study site. Quadrats are randomly selected among plots illustrated on Figure C-12 in Appendix C. Quadrat locations are selected from pre-established plots as shown in Appendix C of this manual as Figure C-12. Each quadrat will be assessed using visual percent cover estimates for each of the dominant species observed. In addition, stem heights and densities per species are measured in each quadrant.

From these measures, species richness is calculated (# species/plot) and individual and total percent cover is estimated. Additionally, average stem height and density are calculated and compared among sites. To determine change in vegetation communities in each study site over time, nonparametric statistical analyses are used given that the data are not normally distributed.

The vane shear test is an in-situ geotechnical testing methods used to estimate the undrained shear strength of fully saturated clays without disturbance. The test is described in the SSIM and will be used as an indicator of change in belowground biomass for the WFMMS and help identify vulnerability to erosion.

(E) POOL EXPANSION AND HISTORICAL WATERWARD EROSION

(1) Purpose

The purpose of the pool expansion and historical waterward erosion is to evaluate and score the severity of loss of wetland surface area.

(2) Description

Pool expansion and historical waterward erosion would follow a detailed procedure described in the SSIM and would be used when more refined study of the wetland erosion is required. NYCDPR analyzed waterward shoreline loss of marsh area was analyzed in GIS by comparing historical shorelines mapped by the New York State Department of Environmental Conservation (NYSDEC) in 1974 with a recent map of the shoreline edge created using 2012 aerial photography (see Digital Aerial Photography below). An average annual rate of shoreline marsh area loss (or gain) was calculated based on the change in shoreline observed between 1974 and 2012. NYCDPR compared six sites across the city and categorized the amount of shoreline loss from low to high rates of loss using 1-5 scale. Similar trend analysis would be conducted for each marsh complex to identify actively expanding pools before proceeding with the field measurements described below.

Following the methodology described in the SSIM, two or three pools would be selected for measurement of change over time at each marsh complex or facility. Pools will be GPS'd and a GIS shapefile will be created indicating locations of pools. Pools should be measured in spring for maximum length, maximum width, and depth at a fixed point, and an erosion pin should be placed at each pool at a clear pool perimeter.

As with the SSIM, parameters are chosen to best reflect change in surface area over time. Maximum length and width reflect any change that occurs (expansion or contraction) over time, though not at a given point. Depth of pool is too difficult to assess and therefore depth data is collected as a crude metric to detect large changes or fluctuations; more as a qualitative metric rather than quantitative.

(F) DIGITAL AERIAL PHOTOGRAPHY

(1) Purpose

Digital aerial photography is used to evaluate long term trends in wetland shape and recession rates or large changes due to a catastrophic event such as Hurricane Sandy. Historical shorelines mapped by the NYSDEC in 1974 or 2012 post-Sandy aerial photographs can be used as a baseline for comparing wetland changes. Where required, special features such as false color infrared images may be used to detect features such as changes in vegetation communities, algal blooms in wetland ponds, which are indicative of water quality issues and habitat value.

(2) Description

Fully georectified digital images in both visible and infrared spectrums are captured typically from a light aircraft, though unmanned aerial vehicles may also be used. These are prepared in full 3D control using a combination of surveyed ground control points, base mapping and terrain models.

For photos to be used to assess wetland features, it is preferable to undertake flights when tide levels are lowest each time and future flights should endeavor to occur at about the same time of year each time.

According to the NYCDPR SSIM QAPP, georeferenced 1974 aerial images to 2012 post-Sandy aerial images can be used to provide baseline data.

(G) TOPOGRAPHIC SURVEY

(1) Purpose

To determine design-level, construction, post-construction and post event topography.

The purpose of a topographic survey is to determine changes in wetland shoreline levels and morphology. The survey should determine the elevation of the low marsh, where *Spartina alterniflora* dominates, middle-high marsh where *Spartina patens*, and *Distichlis spicata* dominates, including the MHW and MHHW benchmark as well as breaks in slope. Accurate topography must be determined to insure adequate wetland community development following wetland construction or restoration activity.

Topographic surveys should also include survey of Surface Elevation Table (SET) that monitor changes in marsh surface elevation, where NYCDPR has installed them.

(2) Description

Topographic surveys should be undertaken by a licensed surveyor using a land-based RTK-GPS topographic survey system or LiDAR, from which profiles are then extracted. The RTK-GPS and LiDAR surveys should be supplemented with tidal wetland shoreline profiling. The NPS has developed a protocol to conduct GPS-based coastal topography surveys that includes a series of SOPs describing the details of the process (Psuty et al. 2012). Accuracy varies significantly depending on conditions, but vertical accuracy of +/-6 in., horizontal accuracy of +/-3 ft are considered satisfactory.

Upon completion, in addition to the CAD survey file, the survey should be accompanied by a detailed survey report that includes survey metadata and details of every survey control point used. The survey report will be incorporated into the inspection report deliverable. In addition, the survey should be supported with fixed aspect photographic records using a GPS enabled camera with photos taken from the same position and of the same view, etc.

The survey transects used should also include the erosion pin transects described under Tidal Wetland Shoreline Condition Assessment [(5.1.4 (B)] as well as vegetation assessment quadrats described under Marsh Vegetation and Habitat Conditions Assessment [5.1.4 (D)] so elevation data can be correlated with the collection of vegetation type data (species present and percent cover) at each RTK point.

5.2 TYPES OF INSPECTIONS

5.2.1 Baseline Inspection

(A) PURPOSE

The Baseline Inspection serves as the basis of the WFMMS. The primary purpose of the Baseline Inspection is to assess the general overall condition of the wetland in order to establish a comprehensive initial baseline survey of wetland attributes in pre-defined locations at a particular point in time (i.e. a snapshot). Baseline Inspections are performed for wetlands which have never been inspected or wetland survey data is not available or incomplete.

(B) SCOPE OF WORK

The scope of a Baseline Inspection includes the following wetland inspection components:

- wetland shoreline position
- tidal wetland shoreline condition assessment
- vegetation condition assessment
- pool expansion and historical waterward erosion
- topographic survey

Tidal wetland shoreline condition assessment should be performed at site-specific intervals corresponding to plot locations determined by the survey grid as shown on the NACSMA sampling protocol (see Figure C-12 in Appendix C). Baseline topographic survey may also may be conducted using remote sensing tool such as LiDAR, where appropriate vertical accuracy is available.

Additional surveys and investigations may be undertaken during the Baseline Inspection as required to support the overall program requirements and intent. The inspection components listed above are the minimum required to satisfy the requirements for a wetland Baseline Inspection under the WFMMS.

The inspection data are used as the basis for satisfying the following primary goals of the Baseline Inspection:

- Confirmation of overall dimensions, wetland characteristics, and other physical features
- An overall condition assessment rating for the wetland and its components
- Recommended actions, including the need for any Engineering Investigation or Design-Level Inspections, and associated order-of-magnitude cost estimates
- The scope of the Engineering Investigation or Design Level Inspection, if required
- The recommended type and time interval to the next inspection

The deliverable for the Baseline Inspection is the Baseline Inspection report, as defined in Chapter 7 of this manual.

5.2.2 Routine Level Inspection

(A) PURPOSE

The Routine Inspection is similar to the Baseline Inspection in most aspects and serves as the basis of the WFMMS. The primary difference between the Routine Level and Baseline Inspections is that for Routine Level Inspections the wetland condition will be compared with previous inspection results in order to determine general trends and overall health of the wetland.

Routine Level Inspections are typically performed on a regularly-scheduled basis, and represent a proactive, rather than a reactive, approach to maintenance. By conducting Routine Level Inspections on a regular basis, changes to wetland conditions over time can be detected so that remediation/mitigation measures can be planned and implemented in a timely manner. The data collected from Routine Level Inspections can be used to help define appropriate trigger levels for when intervention may be required. For instance, trigger levels may be observation of loss of just a few square meters of marsh area or extensive or rapidly developing invasive species cover. These triggers may be followed by the implementation of an invasive plant control program.

Unlike repairs to hard structures, the rehabilitation or restoration of wetlands typically needs to be done on a system-wide basis and covers a much larger area. As such, restoration of wetlands requires extensive planning and studies over a long term period prior to any construction taking place.

(B) SCOPE OF WORK

The scope of a Routine Level Inspection includes the following wetland inspection components:

- wetland shoreline position
- tidal wetland shoreline condition assessment
- vegetation condition assessment
- pool expansion and historical waterward erosion
- digital aerial photography
- topographic survey

Tidal wetland shoreline condition assessment should be performed at site-specific intervals corresponding to plot locations determined by the NACSMA sampling protocol (see example Figure C-12 in Appendix C).

Additional surveys and investigations may be undertaken during the Routine Level Inspection as required to support the overall program requirements and intent. The inspection components listed above are the minimum required to satisfy the requirements for a wetland Routine Level Inspection under the WFMMS.

The primary objective of the Routine Level Inspection is to evaluate changes in the wetland profile, health and to assess whether trigger levels have been reached. The inspection data are used as the basis for satisfying the following primary goals of the Routine Level Inspection:

- An overall condition assessment rating for the wetland and its components
- Comparison with previous inspection findings and results
- Recommended actions, including the need for any Engineering Investigation or Design-Level Inspections, and associated order-of-magnitude cost estimates
- The scope of the Engineering Investigation or Design Level Inspection, if required
- The recommended type and time interval to the next inspection

The deliverable for the Routine Level Inspection is the Routine Level Inspection report, as defined in Chapter 6 of this manual.

5.2.3 Rapid Level Inspection

(A) PURPOSE

Rapid Level Inspections are short duration investigations for emergency or immediate issues that need to be addressed that are not attributable to a specific event, or to provide a quick general condition assessment of the wetland as part of a regular maintenance program. They may also be conducted to provide preliminary information regarding a wetland for which no previous reports or records are available and where a Baseline Inspection may not be possible. The primary purpose of a Rapid Level Inspection is to confirm the general health of the wetland, determine general wetland characteristics, and to determine if further attention to the wetland is necessary.

(B) SCOPE OF WORK

The scope of a Rapid Level Inspection includes the following shoreline inspection components:

- tidal wetland shoreline condition assessment
- vegetation condition assessment

Tidal wetland shoreline profiling should be performed at site-specific intervals focused on potential problem areas identified through the use of geographic information systems or aerial photography. Vegetation condition assessment should identify dominant species cover.

The Rapid Level Inspection is performed to determine the general wetland condition, wetland composition, presence of invasive vegetation, and to determine whether trigger levels for intervention have been reached.

The inspection data are used as the basis for satisfying the following primary goals of the Rapid Level Inspection:

- An overall condition assessment rating for the wetland and its components
- Comparison with previous inspection findings and results, if available
- Recommended actions, including the need for any Engineering Investigation or Design-Level Inspections, and associated order-of-magnitude cost estimates
- The scope of the Engineering Investigation or Design Level Inspection, if required
- The recommended type and time interval to the next inspection

The deliverable for the Rapid Level Inspection is the Rapid Level Inspection report, as defined in Chapter 6 of this manual.

5.2.4 Design Level Inspection

(A) PURPOSE

The purpose of the Design Level Inspection is to establish a comprehensive baseline survey across pre-defined wetland shoreline profile locations in support of the design of a wetland restoration project.

(B) SCOPE OF WORK

The scope of a Design Level Inspection includes, at minimum, the following wetland inspection components:

- tidal wetland shoreline condition assessment
- vegetation condition assessment
- topographic survey

Tidal wetland shoreline condition assessment should be performed at site-specific intervals corresponding to plot locations determined by the NACSMA sampling protocol (see example Figure C-12 in Appendix C).

Additional surveys and investigations may be undertaken during the Design Level Inspection as required to support the overall design requirements and intent. The inspection components listed above are the minimum required to establish a baseline condition of the wetland prior to the implementation of a wetland restoration or of shoreline protective measures, such as living shorelines.

The deliverable for the Design Level Inspection is the Design Report, as defined in Chapter 6 of this manual.

5.2.5 Construction Inspection

(A) PURPOSE

The purpose of the Construction Inspection is to verify that the newly restored or constructed wetland is in accordance with the construction documents and environmental permit requirements if applicable.

(B) SCOPE OF WORK

The scope of a Construction Inspection typically includes the following wetland inspection components:

- tidal wetland shoreline profiling
- vegetation condition assessment
- topographic survey

Tidal wetland shoreline profiling should be performed at intervals required to verify the ongoing construction in accordance with design criteria and drawings.

Additional surveys and investigations may be undertaken during the Construction Inspection as required to support the overall or specific design requirements and intent. In some cases, the inspection components listed above may not be required to verify the construction and should be substituted as appropriate.

The deliverable for the Construction Inspection is a Daily Construction Report as defined in Chapter 6 of this Manual, and where applicable, a punch list of issues to be resolved by the contractor.

5.2.6 Post-Construction Inspection

(A) PURPOSE

The purpose of the Post-Construction Inspection is to establish a comprehensive baseline survey across pre-defined wetland profile locations after the completion of the newly restored or constructed wetland. Inspections will typically need to be coordinated with mitigation monitoring requirements specified in environmental permits and may include additional components, such as an assessment of the buffer condition.

(B) SCOPE OF WORK

The scope of a Post-Construction Inspection typically includes the following wetland inspection components:

- tidal wetland shoreline profiling

- tidal wetland shoreline condition assessment
- vegetation condition assessment
- pool expansion and historical waterward erosion
- topographic survey

Tidal wetland shoreline profiling should be performed at intervals required to verify the ongoing construction or adherence to design criteria and restoration objectives. Tidal wetland shoreline condition assessment should be performed with the shoreline profiling to identify and evaluate potential early signs of erosion.

Additional surveys and investigations may be undertaken as part of the Post-Construction Inspection as required to support the overall design requirements and intent. In some cases, the inspection components listed above may not be required to verify the construction and should be substituted as appropriate.

The deliverable for the Post-Construction Inspection is a Post-Construction Inspection Report as defined in Chapter 6 of this manual.

5.2.7 Post-Event Inspection

(A) PURPOSE

Post-Event Inspections are short duration investigations that are conducted following a significant, potentially damage-causing event such as a storm, tsunami, earthquake, flood, or similar event where either a pre-defined wave/water level threshold is reached. The primary purpose of a Post-Event Inspection is to rapidly confirm the condition of the wetland and to determine if further attention to the wetland is necessary as a result of the event. Performing Post-Event Inspections will also improve the understanding of short-term wetland response or resiliency to more extreme conditions by taking a snapshot of the shoreline immediately after the event. The short term response to extreme events may not be captured by future Rapid or Routine Level Inspections which could take place several years after the event.

(B) SCOPE OF WORK

The scope of a Post-Event Inspection typically includes the following wetland inspection components:

- tidal wetland shoreline condition assessment
- vegetation condition assessment
- pool expansion and historical waterward erosion
- topographic survey

Tidal wetland shoreline condition assessment should be performed at intervals required to verify the extent of the damage and inform restoration planning as applicable. The vegetation and pool expansion assessment should be limited to a visual inspection with primary focus on the affected area(s) and areas adjacent to natural shoreline.

5.2.8 Engineering Investigation

(A) PURPOSE

Engineering Investigations are performed for the purpose of collecting more detailed information than normally obtained during Baseline, Routine Level, or Rapid Level Inspections. Investigations may include analysis/identification of potential restoration sites, areas appropriate for shoreline protection measures (living shorelines), and/or additional or focused sampling.

Engineering Investigations are typically performed on an exceptional basis as a result of a recommendation from the Baseline, Routine Level, Rapid Level, or Post-Event Inspection. However, an Engineering Investigation may also be performed concurrently with other types of inspections where appropriate.

(B) SCOPE OF WORK

The scope of an Engineering Investigation may vary widely depending on the objectives of the inspection and/or the nature of the wetland, and may include but is not limited to:

- Investigation to establish site-specific hydrological conditions (elevation, tides, etc.)
- Digital aerial photography
- Investigation to estimate accretion/sediment rates
- Coastal modeling to establish extreme conditions
- Numerical modeling for water quality study
- Sediment transport study
- Water and/or sediment sampling
- Geotechnical investigations
- Physical modeling
- Toxic contamination study
- Marsh restoration study
- Shoreline stabilization study

Engineering Investigation deliverables typically include laboratory/testing reports, and/or reports presenting the results of the detailed inspection and subsequent engineering analysis/modeling.

5.3 CONDITION ASSESSMENT RATINGS

Each facility, system, and component group in the WFMMS shall be given a condition assessment rating following the inspection. The ratings are important in establishing the priority of follow-on actions to be taken. This is particularly true when many systems are included in an inspection program and follow-on activities must be ranked or prioritized due to limited resources. The six terms that should be used to describe the conditions of wetlands are described in Table 5-1.

TABLE 5-1
CONDITION RATINGS FOR TIDAL WETLANDS

Condition Rating	Definition
Good	Wetland is not significantly stressed. Native marsh plants dominate the vegetation, shoreline condition shows very low disturbance with no built structures and signs of active erosion resulting in no apparent effect on wetland conditions and functions.
Satisfactory	Wetland is lightly stressed. Native marsh plants dominate the vegetation with sparse patches of non-native plants, shoreline condition shows low disturbance with few built structures but no signs of active erosion resulting in apparent significant effect on wetland conditions and functions.
Fair	Wetland is moderately stressed. Non-native invasive vegetation is prevalent but does not dominate the marsh, shoreline condition shows moderate disturbance with presence of built structures and some signs of visible active erosion resulting in potential significant effect on wetland conditions and functions. Further investigation is recommended.
Poor	Wetland is stressed. Non-native vegetation dominates the marsh, shoreline condition shows disturbance with presence of built structures and visible active erosion which likely result in a significant reduction in wetland conditions and functions. Further investigation is needed.
Serious/Critical	Wetland is highly stressed. Vegetation is lacking in most area. Shoreline erosion active resulting in recession of marsh, marsh pond area is expanding, shoreline condition shows high disturbance which result in a large loss of marsh area and of functions. Further investigation is needed.

5.4 RECOMMENDED ACTIONS

Recommended actions are typically assigned upon completion of each inspection type. The recommended actions are categorized into the following four general types of actions, which are described below:

- Emergency/Immediate action
- General repair recommendation
- Additional investigation and engineering analysis
- No action

5.4.1 Emergency/Immediate Actions

Emergency/Immediate actions generally require prompt response to prevent unsafe conditions at the wetland site. These actions may consist of barricading access to the wetland to block access or creating a buffer zone to maintain pedestrian safety. The consultant must notify the property owner/manager of immediate actions as soon as they are discovered. The notification must be made by phone or email and shall be immediately followed by a letter from the consultant which describes the condition and recommended actions.

5.4.2 General Repair Recommendations

General repair recommendations are required following the Baseline, Routine Level, and Rapid Level Inspections in order to determine the order-of-magnitude cost estimates for future actions including repair, design, and inspection work.

Salt marsh restoration projects focus on re-establishing appropriate hydrologic regimes, soils, and native wetland vegetation communities through fill removal, re-grading, clean soil placement, native plant installation, erosion control and invasive plant management as well as installing bioengineered shoreline stabilization measures such as "living shorelines."

These recommendations are grouped into two different levels of importance as presented below.

(A) PRIORITY

Priority level actions are recommendations for which no immediate measures are required, but for which further investigations, design, and implementation of interim or long-term repairs should be undertaken. The priority action takes precedence over all other scheduled work and should be implemented within a time frame directed by the consultant performing the inspection. Actual priority wetland projects are determined in consultation with NYCDPR.

(B) ROUTINE

Routine level actions should be undertaken as part of a scheduled maintenance program, other scheduled project, or routine facility maintenance depending upon the action required. The routine recommended actions shall be in accordance with good engineering and industry practice to maintain the wetland and reduce future capital expenses. For example, removal of trash or invasive species could be considered routine if needed on a regular basis.

Postponing routine recommended actions will not compromise the health of the wetland or significantly increase the cost of future remedial action. During the next Routine Level Inspection, the routine level recommended actions should be reevaluated to determine if their status has changed.

The consultant should anticipate that recommended routine actions that consist of repair will likely be implemented one year after the completion of the next Routine Level Inspection.

5.4.3 Additional Investigation and Engineering Analysis

Additional Investigation should be recommended when more information is needed to better determine the overall condition of the wetland, understand the cause and impacts of the observed tidal wetland shoreline movement or health degradation, or to collect data for more in-depth analysis, monitoring, and management of the wetland.

An Engineering Analysis should be recommended when numerical or physical modeling or other detailed studies are required to determine the short and long term impacts of the recommended action(s) or no action, understand the cause and impacts of the observed wetland changes, and for the development of a wetland management plan.

5.4.4 No Action

Recommended when no further action is necessary until the next scheduled Routine or Rapid Level Inspection.

5.4.5 Frequency of Inspections

As part of the recommended actions, the consultant should recommend the type of inspection to be performed and when the inspection should be performed. Guidance on the frequency of inspections is provided in Section 7 of this manual.

6. DOCUMENTATION AND REPORTING

6.1 BASELINE AND ROUTINE LEVEL INSPECTION REPORT REQUIREMENTS

The major objectives of the Baseline and Routine Inspection Reports are to develop a detailed inventory of all accessible systems and components within a facility, provide an assessment of the condition of the waterfront facility, and to provide the detailed information needed to substantiate requests for funding in order to maintain and rehabilitate the waterfront facility. The Baseline Inspection Report also serves as the basis for all future inspections.

The outline presented here shall be used for organizing and writing all Baseline and Routine Inspection Reports. In cases where the requirement only applies to a Baseline or Routine Inspection, this will be clearly indicated. This format should be followed as closely as possible but modified as appropriate to address non-standard conditions.

The guidelines pertaining to the detailed subjects to be presented and their arrangement in the sections of the report are discussed immediately following this outline. Rules regarding pagination, arrangements of illustrations, and format are presented in Appendix C of this manual. The report outline is as follows:

Front Information

Report Cover
Title Page
Executive Summary
Table of Contents
List of Figures and Drawings
List of Photographs
List of Tables

Section 1.0 – Introduction

Background/Objectives
Scope of Work

Section 2.0 – Description of Site

Site Location
Description

Section 3.0 – Facility 1

Facility Description
3.1 – System 1 (Example: Hard Structure)
3.1.1 – Description
3.1.2 – Observed Conditions
3.1.2A – Component 1
3.1.2B – Component 2
3.1.2C – Component 3
3.1.3 – Comparison with Previous Inspection Results (for Routine Inspection only)
3.1.4 – Further Analysis
3.1.4A – Structural Condition Assessment

3.1.4B – Berthing Assessment
3.1.4C – Resiliency to Coastal Flooding
3.1.5 – Recommendations
3.2 – System 2 (Example: Shoreline)
3.2.1 – Description
3.2.2 – Observed Conditions
3.2.2A – Shoreline Component 1
3.2.2B – Shoreline Component 2
3.2.2C – Shoreline Component 3
3.2.3 – Comparison with Previous Inspection Results (for Routine Inspection only)
3.2.4 – Further Analysis
3.2.5 – Recommendations
3.3 – System 2 (Example: Wetlands)
3.3.1 – Description
3.3.2 – Observed Conditions
3.3.2A – Wetland Component 1
3.3.2B – Wetland Component 2
3.3.2C – Wetland Component 3
3.3.3 – Comparison with Previous Inspection Results (for Routine Inspection only)
3.3.4 – Further Analysis
3.3.5 – Recommendations

Section 4.0 – Facility 2

For additional facilities, repeat the format as shown for Facility 1.

Section 5.0 – Summary of Recommendation Actions and Estimates

Appendices

A - Key Personnel
B - Calculations
C - Backup Data for Cost Estimates
D - References
E - Field Notes

6.1.1 Front Information

(A) REPORT COVER AND TITLE PAGE

The format for the specific information to appear on the report cover and title page is presented in Appendix C of this manual.

(B) EXECUTIVE SUMMARY

The Executive Summary is a self-contained synopsis of the complete report. Accordingly, it shall be understandable without reference to the text, figures, or tables that are in the main body of the report.

The Executive Summary shall be written with the assumption that the reader is not an engineer and has no prior knowledge of the facilities and its systems or components. The Executive Summary should be a clear and concise summary of the inspection findings and should not be used for introductory statements, inspection objectives, descriptions of the facilities or the inspection, or anything other than a concise summary of structural conditions found, significant actions recommended, and estimated costs of upgrades or repairs. Conclusions and recommended actions must be stated briefly and explicitly. These must be supported by the findings as documented in the text, figures, photographs, tables, and appendices that appear in the report. If any facility is being downrated, it must be so stated in the Executive Summary. When possible, the text should be limited to a single page and tables shall be used to summarize the information. The other information should be provided elsewhere in the report.

The narrative in the Executive Summary shall include the following key information:

- Overall condition rating for each facility
- Condition assessment rating for each system with brief description justifying the assigned rating
- Brief narrative on the adequacy of the system for its present and intended future functions
- Brief narrative on the facility's existing elevations, comparison to the current FEMA base flood elevation(s), and its resiliency (or lack thereof) to the effects of climate change
- Identifiable short or long-term trends for shorelines and wetlands (ie. erosion or widening of beach, etc.)
- Recommended actions, including a brief narrative on the ability for the facility to be repaired, upgraded, or replaced, and its resiliency to the effects of climate change. Where replacement is recommended over repairs or upgrades, clear justification shall be provided.
- Opinion of probable costs for recommended actions
- For Baseline Inspection reports only, provide an order-of-magnitude estimate for the in-kind replacement of the facility
- Dates for when recommended actions should be completed by
- Next recommended type of inspection and timeframe for when it should be undertaken

A table containing the summary of conditions and opinion of probable costs shall be provided at the end of the Executive Summary after the narrative. This table shall include the names of the facilities that were inspected, names of the systems included under each facility, the condition assessment rating for each system, and the opinion of probable costs for the recommended actions for each system. A sample summary table is shown below.

TABLE 6-1
SAMPLE TABLE: SUMMARY OF CONDITIONS AND OPINION OF PROBABLE COSTS

Facility Name and Condition	System Name	Condition Rating	Opinion of Probable Costs for Recommended Actions			
			Immediate	Priority	Routine	Total
Facility A **Fair**	North Pier	Poor	$ 0	$250,000	$750,000	$1,000,000
	South Pier	Serious	$ 0	$500,000	$825,000	$1,325,000
	Bulkhead btwn North and South Piers	Fair	$ 0	$150,000	$500,000	$650,000
Facility B **Fair**	50th Street Pier	Good	$ 0	$ 0	$150,000	$150,000
	North Revetment	Satisfactory	$ 0	$5,000	$200,000	$205,000
	South Bulkhead	Critical	$50,000	$3,000,000	$425,000	$3,475,000
Note: Presented costs include hard and soft costs. For details on the applied markups, see Section X.X.						

A second table summarizing the recommended actions, dates in which the recommended immediate and priority action(s) should be completed by, the next recommended inspection type, and the timing for the next inspection shall also be provided. A sample summary table is shown below.

TABLE 6-2
SAMPLE TABLE: SUMMARY OF RECOMMENDED ACTIONS AND INSPECTIONS

Facility Name	System Name	Recommended Inspection		Implementation Dates for Recommended Actions	
		Type	Date	Immediate	Priority
Facility A	North Pier	Routine	March 2019	N/A	FY 2017
	South Pier			N/A	FY 2017
	Bulkhead btwn North and South Piers			N/A	FY 2017
Facility B	50th Street Pier	Routine	March 2021	N/A	N/A
	North Revetment			N/A	FY 2017
	South Bulkhead	Rapid	June 2016	March 2016	FY 2017

The recommended implementation date for Priority actions shall be the fiscal year in which construction for the recommended action needs to start by. Unless otherwise noted, the fiscal year starts on July 1st and ends on June 30th of the following year. All funding requests, design, permitting, and other front-end activities shall already be accounted for in the provided date. For Immediate actions, the specific month and year for when the action needs to start being implemented by should be provided. More specific dates or timeframes may be indicated as appropriate for engineering investigations.

(C) TABLE OF CONTENTS

The Table of Contents shall list each divisible part of the report (i.e., sections, subsections, and appendices) with its corresponding page number. The Table of Contents for this manual is an example. The order in which the sections are presented in the manual should be duplicated in all Baseline and Routine Inspection reports. There must be a separate chapter for each facility named in the scope of work, and a subsection (i.e., 3.1, 3.2, etc.) for each system. Appendices to be included in the Baseline and Routine Inspection reports are described in Section 6.1.6.

(D) LIST OF FIGURES AND DRAWINGS

The List of Figures shall list each figure title with its corresponding page number. An example List of Figures is provided after the Table of Contents of this manual. All other requirements and suggestions regarding the formatting and arrangement of figures are detailed in Appendix C of this manual.

(E) LIST OF PHOTOGRAPHS

The List of Photographs shall list each photograph description with its corresponding page number. All other requirements regarding photographs are detailed in Appendix C of this manual.

(F) LIST OF TABLES/DATA

The List of Tables shall list the title of each table, with its corresponding page number. An example is provided after the List of Figures of this manual. All other requirements regarding tables are detailed in Appendix C of this manual.

6.1.2 Chapter 1 – Introduction

Chapter 1 shall provide the reader with an introduction to the project. It should include:

- a description of the authorization to perform the work,
- the scope and objectives of the work,
- the make up of the inspection team,
- the period during which the inspection was carried out,
- the level of inspection effort,
- the inspection methods and equipment utilized,
- sources of information, and
- reference to previous inspections, if any.

Also include, if appropriate, any background information that may explain why the inspection was performed and/or what findings may have been anticipated.

6.1.3 Chapter 2 – Description of Site

The purpose of Chapter 2 is to familiarize the reader with the site where the inspections were performed. Specific items to be mentioned include the complete site name, its use, and a description of the location. The text is supplemented with a set of color maps showing the location of the site. Preferably, three maps shall be included. The first shall be a Location Plan showing the site location within the New York City region. The second map shall be a Site Plan showing the site location with respect to nearby major roads and highways. The third map shall be a Facility Plan showing all of the facilities being inspected. This map should include major buildings and roads as landmarks to orient the reader to the facilities being inspected and should outline each facility's boundary. If the site and facility are one in the same then the Site and Facility Plans may be combined into a single Facility Plan. Examples of these maps are provided on Figures 6-1, 6-2, and 6-3.

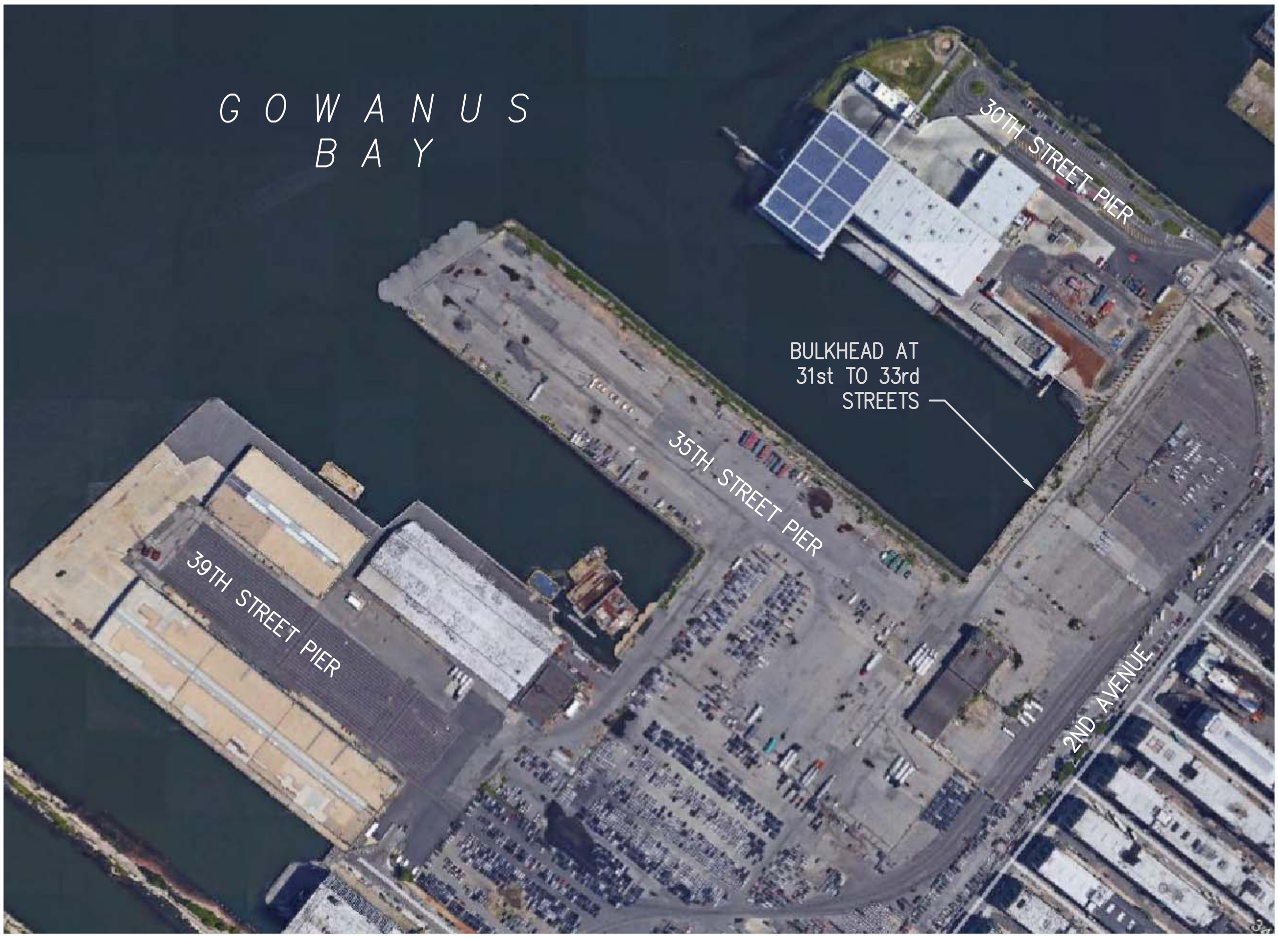
A figure showing the facility hierarchy breakdown shall be provided immediately following the Facility Plan. Samples for a hierarchy of facility were provided on Figures 2-3 and 2-4. The facility and system names on the plans, hierarchy breakdown, and subsequent report sections must be consistent.

LOCATION PLAN
SCALE: 1"=2500'

NEW YORK CITY
ECONOMIC DEVELOPMENT CORPORATION
SOUTH BROOKLYN MARINE TERMINAL, BROOKLYN
LOCATION PLAN

CONSULTANT'S NAME AND LOGO

FIGURE 6–1
SAMPLE LOCATION PLAN



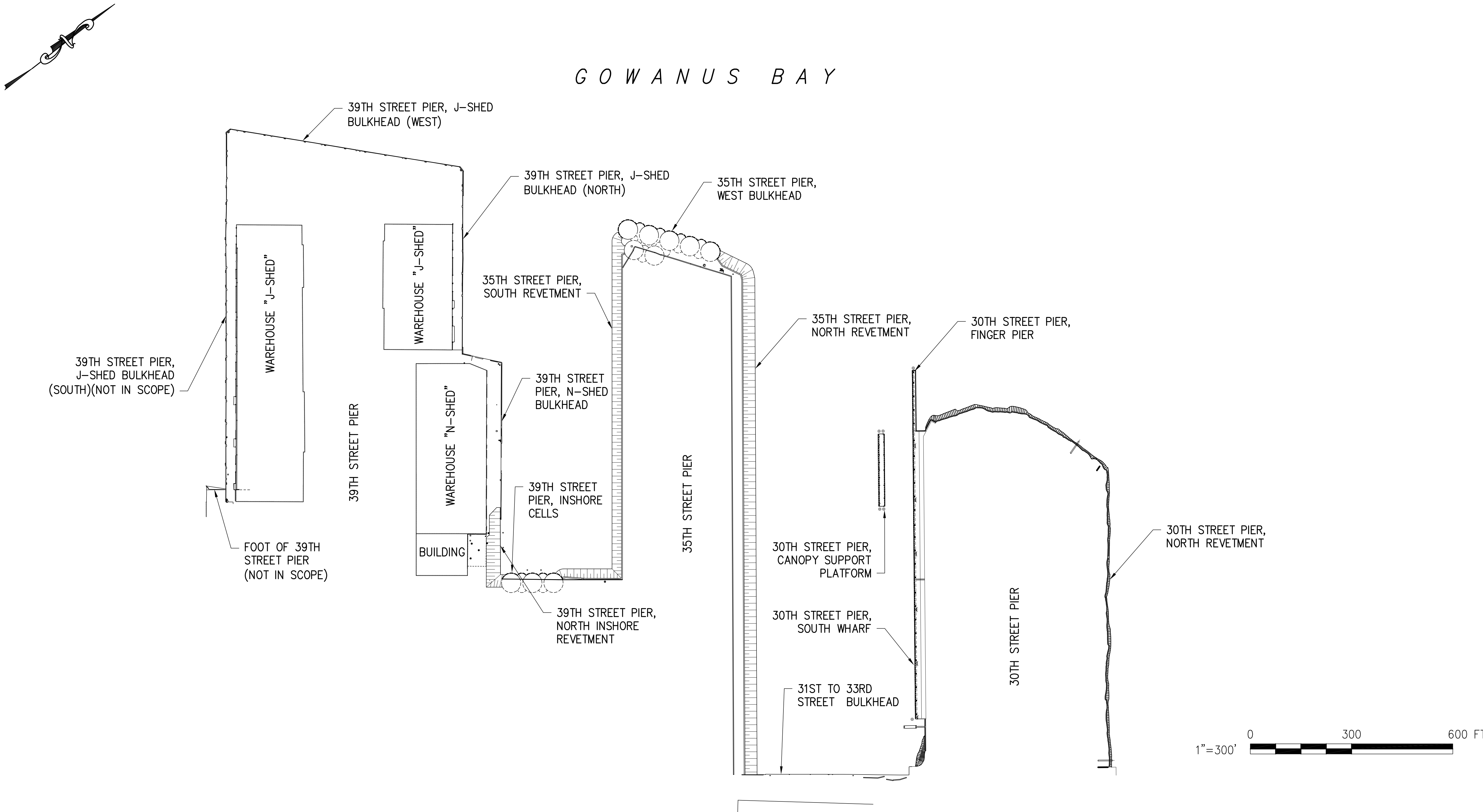
SITE PLAN
SCALE: 1"=500'

0 500 1000 FT.
1"=500'

NEW YORK CITY
ECONOMIC DEVELOPMENT CORPORATION
SOUTH BROOKLYN MARINE TERMINAL, BROOKLYN
SITE PLAN

CONSULTANT'S
NAME AND LOGO

FIGURE 6–2
SAMPLE SITE PLAN



FACILITIES PLAN
SCALE: 1" = 300'

CONSULTANT'S NAME AND LOGO

NEW YORK CITY
ECONOMIC DEVELOPMENT CORPORATION
SOUTH BROOKLYN MARINE TERMINAL, BROOKLYN
FACILITY PLAN

FIGURE 6–3
SAMPLE FACILITY PLAN

6.1.4 Chapter 3 – Inspection of Facility 1

The introductory paragraph for Chapter 3 should present a brief statement to acquaint the reader with such basic information as when the facility was built, the agency responsible for the facility, previous inspections (both above and underwater), major modifications that have been made, and major maintenance that has been performed. One or two photographs depicting the overall topside view of the facility should be included.

The remaining portion of the chapter shall be constructed so that each system inspected at the facility is covered in five separate sequential subsections. The pattern of five subsections shall be repeated for each system. Each system will have a designated name (i.e. Pier 4, Bulkhead Between Station 1+00 and 9+00, etc.) which also serves as the heading for Section 3.1. The five subsections under each system are:

Section 3.1 – System Name

- Section 3.1.1 - Description of System
- Section 3.1.2 - Observed Conditions
- Section 3.1.3 - Comparison with Previous Inspection Results
- Section 3.1.4 – Further Analysis
- Section 3.1.5 - Recommended Actions

(A) DESCRIPTION OF SYSTEM

The system type shall be clearly stated in this subsection. The list of available system types for the WFMMS are contained in Table 2-1.

Present all the information needed to document the geometric shape of the system; the dimensions; the materials of construction; and the shape, arrangement, and dimensions of its components. This information shall be summarized in an asset inventory table which shall include a listing of all components in the system along with relevant their relevant quantities. For components that were not inspected or not accessible, this should be stated. A sample asset inventory table is shown below.

The data contained in the asset inventory table will be used to populate the relevant inventory entry fields in the WFMMS application.

TABLE 6-3
SAMPLE TABLE: SYSTEM ASSET INVENTORY

Component	Description	Unit	Quantity
Steel pipe pile	24 in. diameter x 0.5 in. WT	EA	15
Timber bulkhead	Inaccessible	-	-
Concrete pile cap	Concrete cap	LF	100
Concrete deck	10 in. thick deck	SF	500
Mooring hardware	Bollard	EA	2
Fender System	Extruded rubber fender unit	EA	5

Illustrations depicting plan, section, and elevation views of the system shall be presented to show the present configuration of the components comprising the system. Existing representative profiles shall be shown for shorelines and wetlands at select transects to best convey the overall configuration of the shoreline or wetland being inspected. The following information shall be included on the figures:

- North arrow and key plan on all plan views
- Top of deck, revetment crest, and mudline elevations (at minimum 100 ft intervals) referred to NAVD88
- Tide levels referred to NAVD88 (MLLW, MLW, MHW, MHHW) on all sections and elevations
- Base flood elevation (100-year flood) on all sections and elevations
- Stationing and/or any numbering scheme(s) used during the inspection (if referred to in the inspection findings)
- Areas not within the project scope or which were inaccessible during the inspection

Photographs with explanatory captions shall be used, whenever possible, to augment the description of the system. One or two photographs depicting the overall topside view of the system should be included.

The narrative portion of the "Description of System" shall present summary information on the system's components such as the following:

(1) Hard Structures

- system type (structure type)
- number of pile bents and rows
- number of bearing and batter piles
- length of bulkhead, revetment, etc.
- type and size of decking
- type of fender system and relevant quantities
- type of material for each component
- inaccessible or out of scope components
- interface with other systems
- structure elevation in relation to the base flood elevation (100-year flood)

(2) Shorelines

- length of inspected shoreline
- presence of structures and their overall dimensions along the shoreline (both onshore and offshore)
- general shape, configuration, and composition of the shoreline
- baseline used for the inspection
- inaccessible or out of scope components
- interface with other systems
- beach berm or dune crest elevation in relation to the base flood elevation (100-year flood)

(3) Wetlands

- length of inspected tidal wetland shoreline
- presence of structures and their overall dimensions in the wetland
- general type, hydrology, vegetation cover and composition of the wetland
- most likely wetland functions and ecological services
- inaccessible or out of scope components
- interface with other systems
- wetland shoreline elevation in relation to the base flood elevation (100-year flood)

Where special construction or repair methods have been employed in the past, these shall be explained and supported by drawings or sketches to make clear to the reader exactly how the components are configured.

Since generic terms may be misinterpreted, it is important in the description portion of the report, as elsewhere, to be specific in referring to certain types of components. For example, piles should be qualified as steel sheet piles, concrete vertical piles, timber batter piles, etc. In some cases, it may be necessary to indicate the associated geometric shape. General construction characteristics, such as "concrete-encased H-pile," shall be specified.

(B) OBSERVED CONDITIONS AND RATINGS

The section on Observed Conditions presents, in summary, the status of the system and its components with respect to their soundness and/or degree of deterioration. Each system and component group shall be given a condition assessment rating, as presented in Sections 3.3, 4.3, and 5.3 for hard structures, shorelines, and wetlands, respectively. The condition rating assigned to each system will be used as a measure in determining the adequacy of the system for current and anticipated future functions. Therefore, when assigning a condition assessment rating it is important to note the importance level that has been assigned prior to conducting the inspection.

Descriptions of conditions for all components in the assigned scope of work shall be given. Note deterioration in components due to corrosion, rotting, or spalling, erosion, poor water quality, etc., as appropriate. When noting significant damage, details such as its location, the elevation where the damage is located, extent of affected area, and any quantifiable loss shall be specified. The narrative on the description of conditions should be supplemented with photographs, tables, or figures that clearly identify and locate the observed deficiencies. In tabular information, state the component location, condition, specific defects, and defect location as appropriate. Avoid the use of dittos and arrows where information repeats in a column or row. If a quantity in a column or row is meaningless or not applicable, for a given situation, state this in the table.

The percent of components throughout the system that have experienced comparable degrees of deterioration or damage shall be stated and summarized in tabular form where appropriate. For instance, the number and percent of piles with minor, moderate, advanced, and severe damage grades should be clearly tabulated so that it is clear what percent of the piles supporting the structure is affected and so that an easy comparison can be made to previous inspection results, if the data is available.

Photographs, as well as figures, shall be used to fully convey to the reader the prevailing condition of each component. Photographs and illustrations must be supported by descriptive captions and narrative in the text and should also include general observations. Where a photograph or figure depicts "typical" conditions, this should be clearly stated.

Figures convey information more effectively than photographs, especially when the geometry of the component is too large or complex, or the water is turbid, thereby making the necessary large scale photography ineffective. Legends may be created for the figures to represent such things as the degree of deterioration of individual components, the level of examination used for designated portions of a system, the shape of individual components, and the type of materials. It is critically important to be complete in all illustrations and matrices of data that are presented. Show each pile, regardless of how many times the same shape may be repeated. Where applicable, separate pile and deck plans shall be prepared.

A complete discussion on photographs and the format of drawings to be included in the report is provided in Appendix C of this manual with examples of typical plans and sections.

The Baseline and Routine Inspection reports are used as a basis to justify the expenditure of funds for rehabilitation. Thus, clear and thorough documentation of all significant structural damage is essential in order to justify and obtain funding for rehabilitation.

Additional guidance specific to hard structures, shorelines, and wetlands is provided below.

(1) Hard Structures

Each system component, whether it was inspected or not, shall have its own subsection (Section 3.1.2.A) in the report. The subsection headings shall match exactly the components listed in the hierarchy of facility breakdown. If any components were buried or otherwise inaccessible, and did not get inspected, it should be so stated. If these areas are of suspect integrity, excavation of the components should be recommended.

The discussion on the observed conditions should include general or typical conditions as well as specific items of damage or deterioration for the inspected components. The information should be presented in a logical sequence, usually from bottom to top, e.g., piles, pile caps, deck beams, deck soffit, deck topside, fender system, mooring fittings, etc.

The total number of components in the structure, number of components inspected, and quantity of components with observed conditions should be indicated. A sample table for piles is shown below.

TABLE 6-4
SAMPLE TABLE: SUMMARY OF CONDITION – TIMBER PILES

Component	Total Number Inspected	Damage Grade							
		Minor		Moderate		Advanced		Severe	
		No.	%	No.	%	No.	%	No.	%
Timber pile	400	200	50	100	25	100	25	0	0

Assemble measurements or parameters, such as the remaining thickness of steel components after corrosion attack, remaining pile diameters, etc. and include it in the field notes section of the report appendix. A general description of the obtained measurements or parameters should be provided in the narrative and tabularized where appropriate.

Any scouring action that has taken place, conditions of erosion, or environmental effects that have impacted or may eventually impact the structure or any of its components, shall be noted and explained.

At minimum, the following figures associated with hard structures, as detailed in Appendix C of this manual, shall be included in the report, where applicable:

- Pile Plan – for pile-supported structures (may be combined with Framing Plan)
- Framing Plan – for pile-supported structures (may be combined with Pile Plan)
- Deck Plan – for all types of structures
- Elevations – for bulkheads, cells, and wall-type structures
- Cross-Sections – for all types of structures

(2) Shorelines

The discussion on the observed conditions should be based on the performed shoreline inspection components. Each shoreline component shall have its own subsection (Section 3.2.2.A) in the report with a general description on what was done and the relevant observed conditions. The observed conditions shall include at minimum the following:

- Condition of the shoreline components
- Position of the shoreline
- General description of the beach face slope (gentle, mild, or steep)
- General description of the observed wave energy (low, moderate, high)
- Width of the berm ("dry beach")
- Width of the beach ("wet beach" – distance between the wave run-up and run-down as shown on Figure C-13 is to be measured at each transect)
- Composition/features of the shoreline (sand, rocks, gravel, forested, boulders, etc.)
- General description of the grain size (fine sand, coarse sand, gravel shell, etc.)
- Condition of the dune (vegetated, non-vegetated)
- Presence of man-made structures

Profiling is a key component of shoreline inspections. The shoreline profiles that have been obtained at regular intervals shall be clearly presented on 8-1/2 in. x 11 in. or 11 in. x 17 in. figures, as detailed in Appendix C, and included in the field notes section of the appendix. Results from the shoreline profiling shall be summarized in tabular format and presented using the stationing established for the inspection. The narrative shall include general or typical conditions as well as specific items of notable damage or deterioration along the shoreline. These specific areas shall be located using the appropriate stationing established for the inspection and supported by photographs and/or figures.

A sample table summarizing the shoreline profiles is shown below:

TABLE 6-5
SAMPLE TABLE: SUMMARY OF CONDITIONS – SHORELINE

Survey Date	Station		Description of Shoreline	Photo Reference
	From	To		
11/5/15	0+00	5+00	The beach profile is generally consistent throughout with no visible areas of erosion.	Photo 3-1
	5+00	7+50	Beach width at low tide is less than 10 m	
	7+50	10+00	Beach material is sand/cobbles	Photo 3-2
	10+00	10+50	Sand on the foreshore is soft or hard, color of sand is gray	
11/12/15	10+50	12+50	Beach condition is erosional/stable/depositional	
	12+50	15+50	Beach slope for the underwater portion of beach is steep/ gentle	Photo 3-3
	15+50	17+50	Number of waves and width of the breaking zone is 6+	Photo 3-4

Where the condition of the shoreline is consistent over its length, the shoreline may be divided into longer segments and the condition of each segment shall be presented with applicable photo references.

At minimum, the following figures associated with shorelines, as detailed in Appendix C of this manual, shall be included in the report, where applicable:

- Shoreline Survey Plan
- Shoreline Position Plan
- Beach Profiles

(3) Wetlands

Shoreline condition assessment is a key component of tidal wetland shoreline inspections. The wetland shoreline condition assessments obtained at regular intervals shall be clearly presented on 8-1/2 in. x 11 in. or 11 in. x 17 in. figures, as detailed in Appendix C, and included in the field notes section of the appendix. Results from the wetland shoreline condition assessment shall be summarized in tabular format and presented using the stationing established for the inspection. The narrative shall include general or typical conditions as well as specific items of notable damage or deterioration along the shoreline. These specific areas shall be located using the appropriate stationing established for the inspection and supported by photographs and/or figures.

TABLE 6-6
SAMPLE TABLE: SUMMARY OF CONDITIONS – WETLAND SHORELINE

Survey Date	Station		Description of Wetland	Photo Reference
	From	To		
11/5/15	0+00	5+00	Wetland shoreline and tidal creeks showing significant erosion; sharp slopes and undercut vegetation was observed.	Photo 3-1
	5+00	7+50	Wetland shoreline alterations: in the form of derelict pier potentially exacerbating tidal creek erosion.	Photo 3-2
	7+50	10+00	Wetland shoreline and tidal creeks appears stable, vane sheer test indicative of dense belowground biomass and solid soil.	Photo 3-3
11/12/15	10+00	10+50	Wetland shoreline and tidal creeks showing significant erosion; sharp slopes and undercut vegetation was observed.	Photo 3-4
	10+50	15+00	Wetland shoreline alterations: in the form of derelict pier potentially exacerbating tidal creek erosion.	Photo 3-5
	15+00	17+50	Wetland shoreline and tidal creeks appears stable, vane sheer test indicative of dense belowground biomass and solid soil.	Photo 3-6

At minimum, the following figures associated with wetlands, as detailed in Appendix C of this manual, shall be included in the report, where applicable:

- Wetland Survey Plan – for all wetlands facilities, showing location of assessed areas and other sampling points.
- Wetland Shoreline Profile – for all wetland facilities inspected.
- Wetland Shoreline Position Plan – for all wetland facilities inspected.

(C) COMPARISON WITH PREVIOUS INSPECTION RESULTS (FOR ROUTINE INSPECTIONS ONLY)

Typically, facilities included in the Scope of Work have been previously inspected and therefore have a documented history of inspection and repair. In order to identify both short and long-term trends affecting the facility and/or its system(s), and to determine if previously recommended actions have been carried out, it is important to include a comparison with the previous inspection results. If the previous inspection had no specific recommendations or is vague about the type of deterioration found, it should be so stated in this section. This section of the report should provide a brief summary of the following:

- Date(s) and type of previous inspection(s) dating back to the last Routine Inspection
- Brief description on overall changes to the system, if any, since the last inspection, supplemented by tables and charts as appropriate
- Brief description on any changes to previously assumed or observed deterioration rates
- Summary of previously recommended actions and their current status in a tabular form

- Any other significant changes to the facility or environment that may have affected the system since the last inspection (ie. new construction adjacent to inspected system, etc.)

A typical table summarizing the status of previous recommended actions is shown below.

TABLE 6-7
SAMPLE TABLE: SUMMARY OF PREVIOUS RECOMMENDED ACTIONS FOR SYSTEM 1

Component	Previously Recommended Action (2012)	Current Status (2015)
Steel sheet pile bulkhead	Repair 12 holes in the steel sheet pile bulkhead as a priority action	The bulkhead has not been repaired and the patching of the holes remain a priority action
Asphalt deck	Backfill and re-pave the subsided asphalt deck at Sta. 1+50 as a priority action	The area has not been backfilled and repaved. This item remains a priority action item.
Concrete curb	Repair 25 LF of spalled concrete curb as a routine action	The concrete curb has not been repaired. The curb remains as a routine action item.

Additional guidance specific to hard structures, shorelines, and wetlands is provided below.

(1) Hard Structures

If the previous inspection report included remaining cross-sectional area or thickness measurements of specific members, these parameters should be determined during the current field inspection and compared in this section of the report.

Marine borers are one of the major causes of timber deterioration. This subsection of the report should address trends in the presence of marine borers and indicate whether the level of observed marine borer infestation remains generally the same or has increased since the last inspection.

(2) Shorelines

For shorelines, the comparison of previous inspection results is the most meaningful way to determine short and long term trends that may be affecting the shoreline. Current and all previous beach profiles taken at each transect shall be overlaid onto each other at an appropriate scale so that the reader can clearly see the changes (accretion or erosion), if any, in the beach profile at every transect. When comparing beach profiles, it is preferable if the profiles are from the same month or season of the year in order to minimize effects of seasonal changes that may affect the comparison. A general description of the observed trends shall be provided in tabular form and a summary of the net volume loss or gain along the shoreline since the previous inspection shall be included in the text. Any changes in beach or dune dimensions since the last inspection should be stated. Where longer term data is available, this should also be presented to establish whether the change is a trend or an isolated condition.

A sample table summarizing the changes in the shoreline condition is shown below:

TABLE 6-8
SAMPLE TABLE: SUMMARY OF SHORELINE CHANGES SINCE LAST INSPECTION

Survey Date	Station		Description of Changes Since Last Inspection	Interpretation
	From	To		
11/5/15	0+00	5+00	There has been no change in the shoreline since the last inspection	
	5+00	7+50	Based on Profile XXXX, the shoreline is experiencing erosion between the MLW and MHW marks.	The total change over the long term (i.e. since 2011) it too low to record a rate of erosion greater than 1 ft/year
	7+50	10+00	Based on Profile XXXX, there are two offshore bar which runs parallel to the shoreline. Offshore bar seems flatter compared to the last inspection	Profile seems under calm summer wave conditions beach is recovering from storm/winter conditions
11/12/15	10+00	10+50	There has been no change in the shoreline since the last inspection	
	10+50	15+00	Beach shape is straight for this section of shoreline	
	15+00	17+50	Beach shape is pocket beach for this section of shoreline	

Whenever shoreline position survey data or satellite imagery are available, either through the public domain or as part of the inspection scope, shoreline positions should be compared historic data to identify any significant changes to the shoreline. The survey or satellite imagery shall be presented side by side to allow for easy comparison of the changes. Where appropriate, the changes shall be highlighted to permit the reader to quickly see the difference(s).

The following figures shall be prepared for shorelines:

- Beach Profiles
- Shoreline Position Plan
- Elevation Change Plan – when survey data is available

(3) Wetlands

For wetlands, the comparison of previous inspection results is the most meaningful way to determine short and long term trends that may be affecting the wetland shoreline. Current and all previous shoreline profiles (as determined by topographic survey or LiDAR) at each transect shall be overlaid onto each other at an appropriate scale so that the reader can clearly see the changes (accretion or erosion), if any, in the marsh profile at every transect. A general description of the observed trends shall be provided in tabular form and a summary of the net area loss or gain along the shoreline and tidal creeks and in marsh area since the previous inspection shall be included in the text. Where longer term data is available, such as data collected by NYCDPR, this should also be presented to establish whether the change is a trend or an isolated condition as described below.

In addition, erosion pin changes in distance to tidal creek bank edge (net change per transect) will be averaged by permanent study site and compared with previous inspection measurements.

A sample table summarizing the changes in the shoreline condition is shown below:

TABLE 6-9
SAMPLE TABLE: SUMMARY OF WETLAND CHANGES SINCE LAST INSPECTION

Survey Date	Station		Description of Changes Since Last Inspection	Interpretation
	From	To		
11/5/15	0+00	5+00	There has been no change in the shoreline or tidal creek bank since the last inspection	Erosion and accretion is generally in balance.
	5+00	7+50	Based on shoreline profile and condition assessment, significant erosion is observed at the shoreline and measured at tidal creeks.	The total change over the long term (i.e. since 2011) indicates the average rate of erosion could be greater than 1 ft/year
	7+50	10+00	Shoreline profile shows no change, but measurable erosion is observed at tidal creeks.	Tidal creek bank erosion measurements are indicative of developing loss of wetland shoreline
11/12/15	10+00	10+50	Shoreline profile shows no change, but a significant expansion of pool area is observed	Pool expansion is indicative of waterward erosion and loss of marsh surface
	10+50	15+00	Shoreline profile shows no change but average soil shear vane strength is significant lower than previous measurements.	Weakening soil strength is indicative of increasing susceptibility to erosion
	15+00	17+50	Shoreline profile shows no change, but vegetation cover is lower than previous inspection.	Loss of vegetation is indicative of increasing susceptibility to erosion and loss of wetland function

Waterward shoreline loss of marsh area shall be analyzed in GIS by comparing historical shorelines mapped by NYSDEC in 1974 and more recent maps created by NYCDPR from 2012 aerial photography described in the SSIM or more current satellite imagery if available. The rate of shoreline marsh area loss (or gain) can be calculated based on the change in shoreline observed between current aerial mapped conditions and those of previous maps. Each inspected wetland site can be compared to sites across the city and the amount of shoreline loss can be categorized from 1-5 corresponding to low to high rates of loss.

NYCDPR is planning to implement this approach at six specific long term monitoring sites. Monitoring loss of marsh shoreline at other site will allow for identification of specific shoreline area and prioritization and planning of shoreline restoration.

The following figures shall be prepared for wetlands:

- Wetland Shoreline Profiles
- Elevation Change Plan – when survey data is available
- Wetland Shoreline Position Plan (can also show changes in marsh pond area)

(D) FURTHER ANALYSIS

(1) Hard Structures

This section shall include the following subsections:

- Structural condition assessment
- Berthing assessment
- Resiliency to the effects of climate change

(i) Structural Condition Assessment

Under this subsection, a quantification of the load carrying capacity of the structure shall be made. In some cases, the structure's load carrying capacity will be specified on the available design or as-built drawings, or will have been performed as part of a previous inspection or engineering investigation. If the existing load carrying capacity of the structure is based on a previous load rating, analysis, or other source, this shall be clearly stated and listed under the references in Appendix D of the report. The consultant shall provide an updated load carrying capacity for the structure based on the observed conditions, as appropriate. If the observed deterioration or conditions do not warrant any reduction in the load carrying capacity of the structure, this shall be stated in the report.

In cases where the structure's load carrying capacity is not indicated or readily available, the consultant shall perform the necessary analysis to determine its load carrying capacity. The supporting analyses and calculations shall be presented in Appendix B of the report and reinforced by data and information from other appendices, as appropriate, to substantiate estimates of load carrying capacity. The specific elements, such as bearing piles or batter piles, involved in limiting the capacity of a structure shall be identified and the relative impact of their condition on the overall capacity of the structure shall be assessed.

Determination of load carrying capacity is limited, in most cases, to calculations for individual elements or, at most, to particular sections of a whole structure if the section is in critical condition. Normally, the vertical load carrying capacity is calculated for individual bearing piles. In the case of sheet pile bulkheads, the lateral or longitudinal capacity is to be estimated in very general terms.

Calculation of berthing, mooring, wind, wave, ice, seismic, and current loads are not part of the Baseline or Routine Inspection reports.

The consultant shall provide a capacity versus time graph similar to that shown on Figure 6-4. The graph must show the allowable load for the structure versus service life. Present and future loading conditions should be shown to indicate the capacity for various uses of the structure. For timber and concrete components, the plot should be determined using rates of deterioration calculated from previous inspections or based on available historic data. For steel components, the deterioration rates contained in Appendix D of this Manual should be used, unless historic data is available. Where appropriate, an Engineering Investigation may be recommended for concrete components to obtain additional data so that a rate of deterioration can be estimated. If no previous data exists, the consultant shall provide three separate curves using pessimistic, anticipated, and optimistic deterioration rates. Using this anticipated deterioration curve, the consultant shall determine the remaining useful service life of the structure in years. This value is calculated as the number of years until the capacity of the structure reduces to the combined dead and live loading of the structure. An example of the calculations used to obtain the curve on Figure 6-4 and the structure's service life is provided in Appendix E of this manual.

Tables should be included to summarize the inspection and assessment of the structure. In cases where different parts of a structure have different capacities, a Load Rating Plan that graphically represents load restrictions shall be included to accurately convey the situation. Further explanation, and an example of a Load Rating Plan is included in Appendix C of this manual.

Physical measurements that were made, such as thickness of materials, shall be presented and their meaning and implication explained. Units used to quantify physical measurements of data and parameters derived from computations shall be consistent and, where feasible, interrelationships between quantities shall be spelled out, e.g., "...the vertical piles... retain a capacity of 14.8 tons, which corresponds to a live load capacity of 250 psf for the deck."

Where formulas are used, the definitions and nomenclature shall be given, as well as a reference and a general statement about the meaning of the formulas. Likewise, any potentially unfamiliar terms used in the discussions shall be defined.

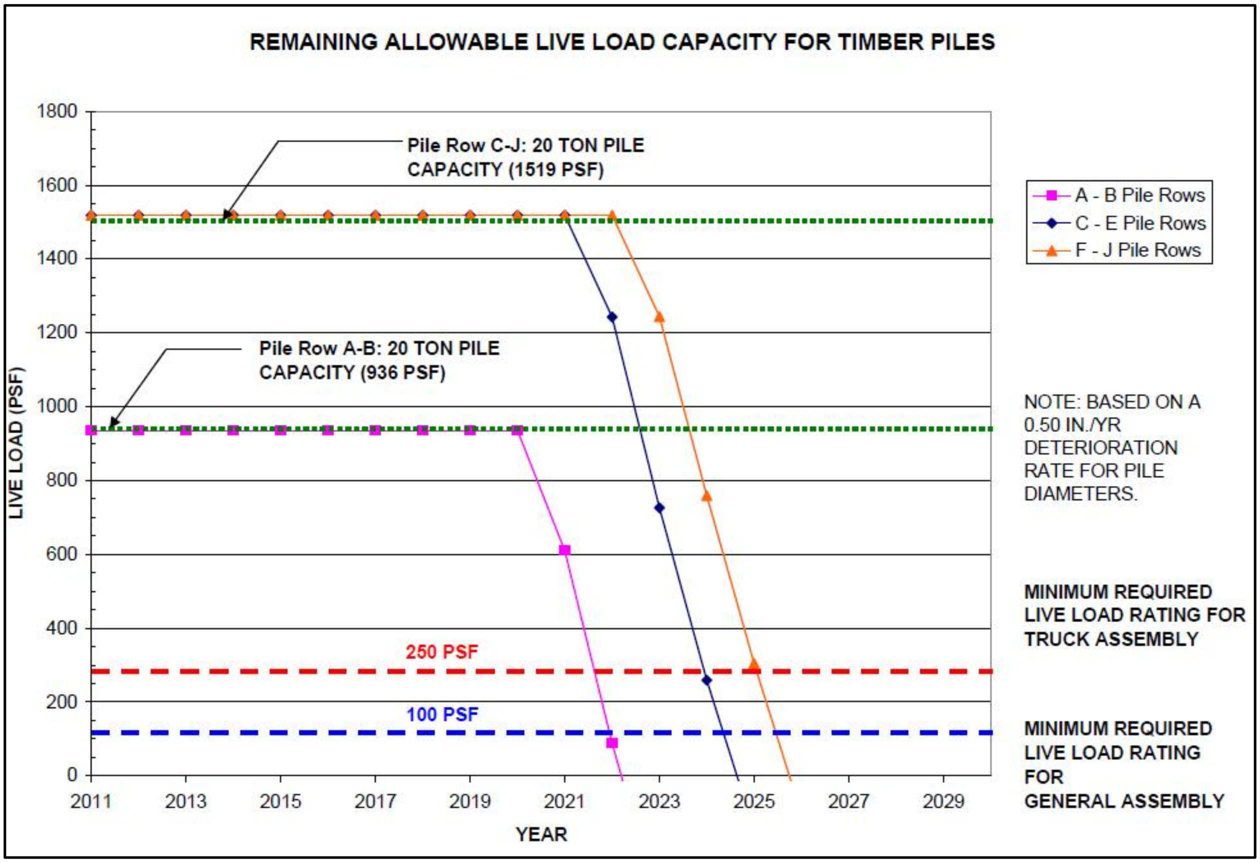


FIGURE 6-4. SAMPLE FIGURE: REMAINING ALLOWABLE LIVE LOAD CAPACITY

Measurements that were made during an inspection, such as thickness of steel, amounts of deterioration, and spalling of structural members, used in the structural condition assessment shall have been tabulated and presented in the Observed Conditions section of the inspection report.

(ii) Berthing Assessment

Under this subsection, an assessment of the berthing capacity of the structure shall be made. Although a berthing or mooring analysis is not part of the scope for a Baseline or Routine Level Inspection, based on the level of observed deterioration and current usage, the consultant shall assess whether the existing structure and its fender system are adequate for berthing operations. If significant structural deterioration is observed or the fenders are severely damaged, and the system is actively used for berthing or mooring, an Engineering Analysis may be recommended to determine whether restrictions are required.

If the system is a revetment or is not meant for berthing or mooring, then this shall be so stated in this section.

(iii) Resiliency to the Effects of Climate Change

Under this subsection, the structure's overall resiliency to the effects of climate change shall be assessed. Climate change is expected to result in more severe weather conditions, rising sea levels, and warmer temperatures. All these conditions will ultimately result in an increased risk of flooding along the City's waterfront. The structure's highest, lowest, and typical deck (where applicable) elevations shall be compared with the most current base flood elevation (100-year flood) from FEMA to determine its vulnerability to flooding. In addition, the stillwater elevations for the 10-year, 50-year, 100-year, and 500-year flood, as per FEMA's Flood Insurance Study (FIS), shall be presented in this subsection for reference and comparison purposes. For sea level rise, the latest sea level rise projections by the New York City Panel on Climate Change (NPCC) shall be considered. Both the middle and high end ranges shall be included in the assessment.

The intent of this assessment is not for the development of a flood protection scheme or to assess the structure's capacity to resist loads associated with flooding, but rather to get a better understanding on the structure's vulnerability so that any recommendations for repairs, upgrades, or replacement take into consideration the effects of climate change.

(2) Shorelines

This section includes the interpretation and analysis of the data obtained during the inspection and identifying any short and long term trends affecting the shoreline. If there is insufficient long term data to make this assessment, it should be clearly stated. In addition, the shoreline's overall resiliency to the effects of climate change shall be assessed. This may include increased risk of coastal flooding and/or erosion due to more frequent and intense extreme storm events and sea level rise. The beach and/or dune crest elevations shall be compared with the most current base flood elevation (100-year flood) from FEMA to determine its ability to protect upland areas from coastal flooding. For sea level rise, the latest sea level rise projections by the New York City Panel on Climate Change (NPCC) shall be considered. Both the middle and high end ranges shall be included in the assessment.

The consultant shall provide tables, graphs, or charts, as appropriate, to support the analysis findings.

(3) Wetlands

This section includes the interpretation and analysis of the data obtained during the inspection and identifying any short and long term trends affecting the following aspects of the wetland:

- Overall health of the wetland
- Ability to prevent coastal erosion
- Compliance with permit or other specific requirements for the wetland

If there is insufficient long term data to make this assessment, it should be clearly stated. In addition, the wetland's overall resiliency to the effects of climate change shall be assessed. This may include increased risk of coastal flooding and/or erosion due to more frequent and intense extreme storm events and sea level rise. The wetland's highest and lowest elevations (along its shoreline) shall be compared with the most current base flood elevation (100-year flood) from FEMA to determine its ability to protect upland areas from coastal flooding. For sea level rise, the latest sea level rise projections by the New York City Panel on Climate Change (NPCC) shall be considered. Both the middle and high end ranges shall be included in the assessment.

The consultant shall provide tables, graphs, or charts, as appropriate, to support the analysis findings.

(E) RECOMMENDATIONS

This section shall be divided into the following subsections for each recommended action for the inspected system:

- Immediate Actions
- Priority Actions
- Routine Actions

A general description of the recommended action(s), date in which the recommended action(s) needs to be implemented by, and the associated cost estimate shall be included in this section. The implementation date is the date in which actual construction of the recommended action needs to have started by. For the immediate/priority level actions in particular, additional explanation and justification on why the rehabilitation is needed shall be provided in the narrative. Any corrections of design deficiencies that are included in the recommendations shall be explicitly explained. If no actions are recommended, this should be clearly stated under each subsection.

In addition to the narrative under each subsection, a summary of all the recommended actions and estimates shall be presented in tabular format after the Routine action subsection. A listing of the major cost elements and their associated prices that comprise the overall cost estimate for repairing or replacing the system shall be cited. Quantities and unit prices are not required at this level but shall be included in the cost estimate backup in the appendix of the report. Table 6-10 is a sample recommended action and cost summary table for a system. A similar table shall be prepared for each inspected system.

The recommended implementation date for Priority and Routine actions shall be the fiscal year (FY) in which construction for the recommended action needs to start by. Unless otherwise noted, the fiscal year starts on July 1st and ends on June 30th of the following year. All funding requests, design, permitting, and other front-end activities shall already be accounted for in the provided date. For Immediate actions, the specific month and year for when the action needs to start being implemented by should be provided. More specific dates or timeframes may be indicated as appropriate for engineering investigations.

TABLE 6-10
SAMPLE TABLE: SUMMARY OF RECOMMENDED ACTIONS AND COST ESTIMATE FOR SYSTEM 1

Action Type	Description	Implementation Date	Total Cost (2015 dollars)
Immediate	No immediate actions recommended	N/A	$ 0
Priority	Post deteriorated timber piles	FY 2017	$25,000
	Repair spalls with exposed deteriorated reinforcing in the deck soffit		$150,000
		Subtotal:	$175,000
Routine	Recoat steel beams	FY 2020	$250,000
	Replace missing joint filler material		$50,000
		Subtotal:	$300,000

Justification of costs associated with implementing each action should be provided in the cost backup included in Appendix C of the inspection report.

The presented costs shall not only include the cost of construction, but also the cost for design and management of the construction (soft costs). The markups included in Table 6-11 shall be part of the presented construction costs to ensure consistency in the cost estimates developed by different consultants.

The markups shall be applied to obtain the final total cost as presented below.

Total Hard Cost = Base Cost × (1+Mob/Demob %) × (1+General Conditions %) × (1+Overhead & Profit %) × (1+Design Contingency %) × (1+Constr. Contingency %)

Total Hard and Soft Costs = Total Hard Cost × (1+Design/RE Services % + CM %)

Final Total Cost = Total Hard and Soft Costs × (1+10% Overall Project Contingency)

A separate table summarizing the applied markups must be presented together with the estimates for the recommended actions along with a general explanation on how the markups were applied. A listing of all assumptions, including which year's dollars were used in developing the cost estimates, shall be clearly presented. All costs presented in the report must be inclusive of hard and soft costs, as well as overall project contingency.

TABLE 6-11
MARKUPS TO BE INCLUDED IN CONSTRUCTION COST ESTIMATE

Item	Description	Percentage Markup on Base Cost
Mobilization/Demobilization	Cost to mobilize/demobilize labor and equipment to the project site	6%*
General Conditions	On-site PM costs, project office costs, site security, survey, housekeeping, etc. incurred by the contractor	8%*
Overhead & Profit	Home office/corporate costs for the contractor and profit for the contractor	21%*
Design Contingency	Contingency to account for any changes to the recommended (and priced) repair design and may include additional investigations, surveys, special inspections, etc.	10%-25%*
Construction Contingency	Contingency to account for unforeseen conditions during construction	10%-25%*
Design and Resident Engineering (RE) Services	Cost for the engineer to develop construction drawings and provide resident engineering services during construction	10%*
Construction Management (CM)	Cost of construction manager to manage the construction	10%*
Overall Project Contingency	Overall contingency added to the project's hard and soft costs	10%
* A recommended markup or range of markup has been provided, however, the consultant may select a different percentage as appropriate. Overall project contingency of 10% cannot be changed.		

The following items are specifically excluded from the costs and shall be clearly stated in the report and estimate backup:

- Cost of mitigation
- Operations and maintenance costs
- Escalation

When developing rehabilitation recommendations, it is important to remember that replacing in-kind is often not the most effective repair procedure, and that it may not be necessary for the repair to have the same durability as the original, much older, construction. The recommended actions should be based on the strength required for present or future use of the system, resilience to coastal flooding and future expected sea level rise, and not necessarily on restoring the original capacity. Where appropriate, for the immediate/priority level actions, different options shall be provided for the recommended rehabilitation scheme.

The basis for each rehabilitation option shall be substantiated by referring to specific findings from the inspection, particularly those that involve the integrity of the system. It is important to be unequivocal in stating the merits of a repair. If rehabilitation of a system is not feasible, so state and give the justification for such a conclusion.

The explanation of each option shall be augmented by appropriate sketches illustrating the concepts and arrangements, and other modifications attendant to each option. The criteria for evaluating the options shall be delineated and a clear comparison of the pros and cons for each option shall be presented in tabular form. The comparison shall also include order-of-magnitude costs. Backup for the costs developed for the options shall be included in Appendix C of the report. Finally, the best option for rehabilitation shall be identified and a justification for its selection presented.

For Baseline Inspection reports only, provide an order-of-magnitude cost for the in-kind replacement of the facility. This information will be useful in helping to determine whether rehabilitation is cost-effective and may also be used by FEMA or other agencies for planning purposes.

6.1.5 Summary of Recommended Actions and Estimates

This section summarizes the recommended actions and cost estimates for all the facilities and systems at the site.

A summary table with the overall condition assessment ratings for the facilities that comprise the site and the total costs for the recommended actions should be provided at the beginning of this section.

TABLE 6-12. SAMPLE TABLE: SUMMARY OF CONDITIONS AND COSTS FOR RECOMMENDED ACTIONS FOR SITE

Facility	Condition Assessment Rating	Cost of Recommended Action (2015 dollars)			
		Immediate	Priority	Routine	Total
Facility 1	**Good**				
System 1-1	Fair	$ 0	$ 150,000	$50,000	$200,000
System 1-2	Good	$ 0	$ 150,000	$50,000	$200,000
Subtotal for Facility 1:		**$0**	**$300,000**	**$100,000**	**$400,000**
Facility 2	**Poor**				
System 2-1	Poor	$ 50,000	$750,000	$250,000	$1,050,000
Subtotal for Facility 2:		**$ 50,000**	**$750,000**	**$250,000**	**$1,050,000**
Facility 3	**Fair**				
System 3-1	Good	$ 0	$ 150,000	$50,000	$200,000
System 3-2	Poor	$ 0	$ 150,000	$50,000	$200,000
Subtotal for Facility 3:		**$0**	**$300,000**	**$100,000**	**$400,000**
Total for Site:		**$50,000**	**$1,350,000**	**$450,000**	**$1,850,000**

Following the summary table for the site, additional summary tables for each facility that includes the immediate, priority, and routine action items, the recommended implementation date, and total cost shall be prepared. A listing of the major cost elements and their associated prices that comprise the overall cost estimate for rehabilitating each facility shall be included. A sample summary table for a facility is presented in Table 6-13.

TABLE 6-13. SAMPLE TABLE: SUMMARY OF RECOMMENDED ACTIONS AND COST ESTIMATE FOR FACILITY 1

Action Type	Description	Implementation Date	Total Cost (2015 dollars)
System 1			
Immediate	No immediate actions recommended	N/A	$ 0
	Subtotal for Immediate Actions:		**$ 0**
Priority	Post 4 deteriorated timber piles	FY 2017	$25,000
	Repair 250 SF of spalls with exposed deteriorated reinforcing in the deck soffit		$150,000
	Subtotal for Priority Actions:		**$175,000**
Routine	Recoat steel beams	FY 2020	$250,000
	Replace 250 LF of missing joint filler material		$50,000
	Subtotal for Routine Actions:		**$300,000**
	TOTAL FOR SYSTEM 1		**$475,000**
System 2			
Immediate	No immediate actions recommended	N/A	$ 0
	Subtotal for Immediate Actions:		**$ 0**
Priority	Replace timber pile cap	FY 2017	$25,000
	Repair spalls with exposed deteriorated reinforcing in the deck soffit		$150,000
	Subtotal for Priority Actions:		**$175,000**
Routine	Recoat steel beams	FY 2020	$250,000
	Replace missing joint filler material		$50,000
	Subtotal for Routine Actions:		**$300,000**
	TOTAL FOR SYSTEM 2		**$475,000**

A recommendation for the next inspection that should be performed for the system and when it should be undertaken should also be included in this section. The recommended type and interval till the next inspection should be based on guidance provided in Chapter 7 of this Manual. For sites with multiple facilities and systems, the recommendation for inspection shall be presented in tabular format.

6.1.6 Appendices

The appendices shall be designated alphabetically, beginning with the letter "A". They shall be clearly divided into sections and indexed to the extent necessitated by the degree of detail and the number of separate subjects treated within each individual appendix.

By constructing the reports according to the master outline presented in Section 6, the natural evolution of the narrative should, in most cases, lead to the introduction of the appendices in the order shown above.

All lengthy calculations, data, tables, computer printouts, and records of important correspondence during the inspection are to be included in the appendices on 8-1/2 in. by 11 in. or 11 in. by 17 in. sheets. All information included in an appendix must be accompanied by sufficient introductory information to explain its relevance and importance to the findings of the inspection.

(A) APPENDIX A – KEY PERSONNEL

The key personnel involved in the inspection and evaluation shall be listed in Appendix A of the report. This list includes the following individuals' names, organizations, e-mail addresses, and telephone numbers:

- Project Manager, EDC or property owner/manager
- Project Manager, Consultant Firm
- Team Leader (Project Engineer), Consultant Firm
- Inspectors, Consultant Firm
- Divers (Engineer-Divers), Consultant Firm
- Environmental Engineer, Consultant Firm
- Coastal Engineer, Consultant Firm
- Surveyor, Consultant Firm
- Tenant Point-Of-Contact (If Applicable.)

In addition, personnel who contributed in various capacities to the inspection effort may also be listed.

(B) APPENDIX B – CALCULATIONS

Appendix B includes manual and computer calculations to determine vertical, horizontal, or lateral load-bearing capacities of structural elements. Also to be presented are the calculations that predict the overall assessment of a facility's load carrying capacity. All assumptions, definitions of terms, and definitions of nomenclature must be clearly stated. The meanings of formulas used must be stated, as well as the reference from which they were obtained. The computations must be presented in a manner and format such that an engineer who is not intimately familiar with the project or the underwater inspection program can readily understand them. Such calculations shall be adequately labeled, checked, and dated, and shall include sufficient notes, sketches, and diagrams so that a reader can confidently follow the logic and procedures employed. Calculations made by computer analysis must include a cover sheet explaining the analysis performed and the program used.

All calculations must be checked and initialed by the engineer who performed the calculations and by the engineer who checked the calculations. Appendix E of this Manual presents a sample set of calculations.

(C) APPENDIX C – BACKUP DATA FOR COST ESTIMATES

Backup data for cost estimates shall be presented in Appendix C and shall include itemized listings of elements involved in developing major categories of costs.

(D) APPENDIX D – REFERENCES

A listing of references shall be included in Appendix D. References pertain to works wherein the reader is referred to a specific page or section for particular information, or general information used throughout the report. Previous inspection reports and drawings of the facilities inspected are typically included in the reference appendix.

(E) APPENDIX E – FIELD NOTES / BEACH PROFILES

Field notes from the inspection, such as data sheets used to log conditions, working papers, or other miscellaneous items and beach profiles developed for each transect should be included in Appendix E of the Baseline or Routine Inspection Report. If the inclusion of the field notes makes the report too voluminous, then this information should be bound separately.

6.2 RAPID LEVEL INSPECTION LETTER REPORT

Rapid Level inspections do not require the preparation of a full inspection report with the same level of detail as a Baseline or Routine Inspection report. The preparation of a letter report is sufficient for a Rapid Level Inspection provided that it contains the information outlined in this section.

The guidelines pertaining to the arrangement of information to be presented in the letter report are discussed immediately following this outline. The letter report outline is as follows:

Introductory Paragraph
Section 1.0 – Summary of Findings
Section 2.0 – Description of Site
Section 3.0 – Observed Conditions and Ratings
Section 4.0 – Comparison with Previous Inspection Results
Section 5.0 – Recommended Actions and Estimates
Appendices
- **A – Backup for Cost Estimates**
- **B – Field Notes and/or Beach Profiles**

6.2.1 Summary of Findings

This section is similar to the Executive Summary in the Baseline or Routine Inspection reports. The Summary of Findings should be a clear and concise narrative of the scope of work, inspection findings, conclusions, recommendations, and associated cost estimate.

6.2.2 Description of Site

This section is similar to the Description of Site section in the Baseline or Routine Inspection reports. An overall plan showing the inspected facility(ies) and photographs depicting the overall topside view of the facility should be provided. Drawings and figures may be used to supplement the narrative, plan, and photographs, but are not specifically required as part of the Rapid Level Inspection letter report.

6.2.3 Observed Conditions and Ratings

This section is similar to the Observed Conditions and Ratings section in the Baseline or Routine Inspection reports. The level of detail presented in this section shall be commensurate with the inspection effort for the Rapid Level Inspection. To the extent possible, photographs and tables shall be presented within the letter report to convey to the reader the prevailing condition of the inspected system(s). For shorelines and wetlands, Beach Profiles and wetland components exhibiting change, shall be provided in the appendix of the letter report as needed to support the narrative. Any additional field data shall also be included in the appendix as appropriate.

Separate subsections shall be provided for each inspected facility with clear condition assessment ratings assigned to each. A summary table with the condition assessment ratings for all facilities and systems shall be provided prior to starting the subsections covering each facility.

6.2.4 Comparison with Previous Inspection Results

This section is similar to the Comparison with Previous Inspection Results section in the Baseline or Routine Inspection reports. The level of detail presented in this section shall be commensurate with the inspection effort for the Rapid Level Inspection and the collected data. For shorelines and wetlands, beach profiles and wetland components showing change, respectively, shall be provided in the appendix of the letter report as needed to support the narrative.

6.2.5 Recommended Actions and Estimates

This section is similar to the Recommended Actions and Estimates section in the Baseline or Routine Inspection reports. The level of detail presented in this section shall be commensurate with the inspection effort for the Rapid Level Inspection and the collected data.

6.2.6 Appendices

The requirements for the appendices to be included in a Rapid Level Inspection report are the same as those for a Baseline and Routine Inspection report, except that only the backup for cost estimates and field notes are required.

6.3 DESIGN LEVEL INSPECTION REPORT

Design Level Inspections require the preparation of a Design Report. Design Reports are prepared prior to the preparation of the construction drawings and technical specifications and shall contain the following sections:

Front Information
Report Cover
Title Page
Table of Contents
List of Figures and Drawings
List of Photographs
List of Tables/Data
Section 1.0 – Description of Site
Section 2.0 – Scope of Design and Inspection Findings
Section 3.0 – Design Criteria
Section 4.0 – Recommended Design and Estimates
Appendices
- **A – Backup Data for Cost Estimates**
- **B – Reference Information**
- **C – Field Notes**

6.3.1 Description of Site

This section is similar to the Description of Site section in the Baseline or Routine Inspection reports. An overall plan showing the inspected facility(ies) and photographs depicting the overall topside view of the facility should be provided.

6.3.2 Scope of Design and Inspection Findings

This section summarizes the overall scope of the proposed repairs, rehabilitation, or replacement. Following a description of the proposed work, the consultant shall describe the scope and findings of the design level inspection that was performed. At minimum, the narrative shall include the following information:

- Dates of previous inspection and current design-level inspection
- Description of scope of design (ie. priority actions only, priority and routine actions, available construction budget, etc.)

- Scope of design level inspection, including any additional investigations that were performed
- Comparison of findings from design-level inspection and previous inspection
- Confirmation or revision of previously recommended priority action(s)
- Description of performed analyses, if any, to determine recommended actions
- Description of new recommended actions, if any, and justification as to why these should be included in the proposed rehabilitation scope
- Estimated quantities for repair

Reference shall be made to the most previous inspection report recommendations and it should be clearly stated, in tabular form, which recommended actions are being addressed in the proposed design scope. A sample summary table is shown below.

TABLE 6-14. SAMPLE TABLE: SUMMARY OF PREVIOUSLY RECOMMENDED ACTIONS AND PROPOSED DESIGN SCOPE

2015 Recommended Action		Status of Action
Action Type	Description	
Immediate	Cordon off offshore end of pier	Already completed
Priority	Encase 52 timber piles in concrete	To be included in design scope
	Replace 250 LF of deteriorated timber pile cap	Increase repair quantity to 275 LF
Routine	None	N/A

A separate table summarizing any new recommended actions, if any, should be provided. A sample summary table is shown below.

TABLE 6-15. SAMPLE TABLE: SUMMARY OF NEW RECOMMENDED ACTIONS

New Recommended Actions	Reason for Recommendation
Encase 52 timber piles in concrete	Significant deterioration was found on these components during the Design Level inspection and will need to repaired to maintain the pier's current load rating of 250 PSF.
Replace 250 LF of deteriorated timber pile cap	

6.3.3 Design Criteria

This section shall describe the design criteria that will be adopted for the project. At minimum, the design criteria shall address the following as it relates to the scope of work:

- Project datum
- Tide levels
- Environmental/Hydrodynamic conditions

- Geotechnical parameters
- Design life
- Design water levels (including effects of climate change)
- Design loads
- Design vessel(s)
- Utilities
- Material properties
- Applicable codes and standards
- Monitoring requirements (for wetlands)
- Special project requirements or conditions

For parameters that are not applicable to the project, it should be so stated.

6.3.4 Recommended Design and Estimates

This section summarizes the recommended design scope with all associated repair quantities, a preliminary construction schedule, and construction cost estimate. In addition, 11 in. by 17 in. conceptual level design drawings shall be provided that clearly convey to the reader the following information:

- Overall plan(s) showing the extent of rehabilitation, demolition, or replacement
- Typical repair sections, elevations, or details
- Non-typical repair details or sections that will need to be developed for the construction drawings

The presented costs shall not only include the cost of construction, but also the cost for design and management of the construction (soft costs). The markups included in Table 6-16 shall be part of the presented construction costs to ensure consistency in the cost estimates developed by different consultants. The markups shall be applied and compounded in the order presented in Section 6.1.4(E). A separate table summarizing the applied markups must be presented together with the estimates for the recommended actions along with a general explanation on how the markups were applied. A listing of all assumptions, including which year's dollars were used in developing the cost estimates, shall be clearly presented. All costs presented in the report must be inclusive of hard and soft costs, as well as overall project contingency.

TABLE 6-16. MARKUPS TO BE INCLUDED IN CONSTRUCTION COST ESTIMATE

Item	Description	Percentage Markup on Base Cost
Mobilization/Demobilization	Cost to mobilize/demobilize labor and equipment to the project site	6%*
General conditions	On-site PM costs, project office costs, site security, survey, housekeeping, etc. incurred by the contractor	8%*
Overhead & Profit	Home office/corporate costs for the contractor and profit for the contractor	21%*
Design Contingency	Contingency to account for any changes to the recommended (and priced) repair design and may include additional investigations, surveys, special inspections, etc.	5%-10%*
Construction Contingency	Contingency to account for unforeseen conditions during construction	10%-25%*
Design and Resident Engineering (RE) Services	Cost for the engineer to develop construction drawings and provide resident engineering services during construction	10%*
Construction Management (CM)	Cost of construction manager to manage the construction	10%*
Overall Project Contingency	Overall contingency added to the project's hard and soft costs	10%
* A recommended markup or range of markup has been provided, however, the consultant may select a different percentage as appropriate. Overall project contingency of 10% cannot be changed.		

The following items are specifically excluded from the costs and shall be clearly stated in the report and estimate backup:

- Cost of mitigation
- Operations and maintenance costs
- Escalation

6.3.5 Appendices

The requirements for the appendices to be included in a Design Level Inspection report are the same as those for a Baseline and Routine Inspection report, except that only the backup for cost estimates, list of reference information, and field notes are required.

6.4 CONSTRUCTION INSPECTION REPORT

The Construction Inspection Report is sometimes referred to as a daily, weekly, or monthly construction report. The timeframe covered by the report is flexible and is typically dictated by the project requirements. Regardless of the timeframe, the Construction Inspection Report shall, at minimum, contain the following information:

- Project name and number
- Project site

- Date and time of work
- Inspector(s) on site
- Weather
- Water levels (tide conditions)
- Contractor/Subcontractor name
- Contractor/Subcontractor crew and equipment
- Deliveries to site
- Summary of construction activities (quantities of complete work, completed testing, etc.)
- Summary of upcoming construction activities
- Quality issues or other concerns that need to be addressed
- Supporting photographs and other documentation (concrete batch tickets, plans, etc.)

Additional project specific information shall be added as required. For instance, some projects may require vibration monitoring. The data collected from the vibration monitoring instrument(s) may be included in the Construction Inspection Report if this is required under the construction contract.

Depending on the project requirements, the Construction Inspection Reports will be consolidated into a single Post-Construction Report at the end of the construction project.

6.5 POST-CONSTRUCTION REPORT

Post-Construction Reports are prepared at the end of a construction project and shall contain the following sections:

Front Information
Report Cover
Title Page
Table of Contents
Section 1.0 – Description of Site and Construction
Section 2.0 – Comparison with Previous Recommendations and Current Status
Section 3.0 – Recommended Actions and Estimates
Appendices
A – As-Built Drawings
B – Construction Inspection Reports

6.5.1 Description of Site and Construction

This section is similar to the Description of Site section in the Baseline or Routine Inspection reports, except that the narrative shall also include a description of the completed construction work.

A detailed listing with quantities of the completed work shall be provided along with typical photographs of the new construction. Where applicable, an overall plan showing the extent of new construction should be provided.

Any deviations from the original design or changes made during the construction shall be clearly identified and described with detailed explanations as to why the change(s) was made.

For newly constructed facilities, the Post-Construction Report serves a similar function as a Baseline Inspection report. An asset inventory shall be completed and the consultant shall include all the necessary information to facilitate the completion of the next Rapid or Routine Level inspection. For an existing facility that was repaired or upgraded, the asset inventory and facility hierarchy breakdown shall be updated as applicable and presented in this section and the status of the previous recommendations shall be updated. Any changes from the previous inventory or hierarchy breakdown shall be clearly identified and highlighted.

6.5.2 Comparison with Previous Recommendations and Current Status

The purpose of this section is to clearly present which previously recommended actions have been addressed, which actions still remain, and to update the condition assessment rating for the entire facility or facilities based on the completed work. This information shall be presented in tabular form with a separate table prepared for each facility. A sample table is presented below.

TABLE 6-17. SAMPLE TABLE: SUMMARY OF PREVIOUSLY RECOMMENDED ACTIONS AND STATUS FOR FACILITY 1

Action Type	Description	Current Status	Remaining Cost (2015 dollars)
System 1			
Immediate	No immediate actions recommended	N/A	$ 0
	Subtotal for Remaining Immediate Actions:		**$ 0**
Priority	Post 6 deteriorated timber piles	Completed	N/A
	Repair 250 SF of spalls with exposed deteriorated reinforcing in the deck soffit		
	Subtotal for Remaining Priority Actions:		**$ 0**
Routine	Recoat steel beams	Not Completed	$250,000
	Replace 250 LF of missing joint filler material		$50,000
	Recoat bollards		$5,000
	Subtotal for Remaining Routine Actions:		**$305,000**
TOTAL REMAINING RECOMMENDED ACTIONS FOR SYSTEM 1			**$305,000**
System 2			
Immediate	No immediate actions recommended	N/A	$ 0
	Subtotal for Remaining Immediate Actions:		**$ 0**
Priority	Post 10 deteriorated timber piles	Completed	$ 0

Action Type	Description	Current Status	Remaining Cost (2015 dollars)
	Repair 250 SF of spalls with exposed deteriorated reinforcing in the deck soffit		$ 0
	Subtotal for Remaining Priority Actions:		**$ 0**
Routine	Recoat steel beams	Not Completed	$250,000
	Replace missing joint filler material		$50,000
	Subtotal for Remaining Routine Actions:		**$300,000**
TOTAL REMAINING RECOMMENDED ACTIONS FOR SYSTEM 2			**$300,000**

A separate table summarizing the previous and current condition assessment ratings (post-construction) and any remaining or new recommended actions should be prepared. For new construction where there are no previous condition assessment ratings, a condition assessment rating of "Good" shall be assigned to the facility(ies), system(s), and component(s).

TABLE 6-18. SAMPLE TABLE: SUMMARY OF CONDITION ASSESSMENT RATINGS AND RECOMMENDED ACTIONS

Description	Condition Assessment Rating		Current Recommended Action and Implementation Date	
	2015	Current	Priority	Routine
Facility 1	Fair	Good		
System 1-1	Fair	Good		
Component 1	Poor	Good	None	None
Component 2	Satisfactory	Good	None	None
Component 3	Fair	Good	None	None
System 1-2	Poor	Good		
Component 1	Poor	Good	None	None
Component 2	Poor	Good	None	None
Facility 2	Fair	Fair	Perform geotechnical investigation	
System 2-1	Poor	Poor		
Component 1	Satisfactory	Satisfactory	None	None
Component 2	Poor	Poor	Replace bulkhead by FY 2018	None
Component 3	Satisfactory	Satisfactory	None	None
System 2-2	Fair	Good		
Component 1	Satisfactory	Satisfactory	None	None
Component 2	Poor	Good	None	None
Component 3	Satisfactory	Satisfactory	None	Recoat component

6.5.3 Recommended Actions and Estimates

This section shall summarize all the remaining recommended actions and associated cost estimates. A separate table shall be prepared for each facility.

TABLE 6-19. SAMPLE TABLE: SUMMARY OF RECOMMENDED ACTIONS AND COSTS FOR FACILITY 1

Action Type	Description	Implementation Date	Total Cost (2015 dollars)
System 1			
Immediate	No immediate actions are recommended	N/A	$ 0
	Subtotal for Remaining Immediate Actions:		**$ 0**
Priority	No priority actions are recommended	N/A	$ 0
	Subtotal for Remaining Priority Actions:		**$ 0**
Routine	Recoat steel beams	FY 2020	$250,000
	Subtotal for Remaining Routine Actions:		**$250,000**
TOTAL REMAINING RECOMMENDED ACTIONS FOR SYSTEM 1			**$250,000**
System 2			
Immediate	No immediate actions are recommended	N/A	$ 0
	Subtotal for Remaining Immediate Actions:		**$ 0**
Priority	No priority actions are recommended	N/A	$ 0
	Subtotal for Remaining Priority Actions:		**$ 0**
Routine	Recoat steel beams	FY 2020	$250,000
	Subtotal for Remaining Routine Actions:		**$250,000**
TOTAL REMAINING RECOMMENDED ACTIONS FOR SYSTEM 2			**$250,000**

6.5.4 Appendices

(A) APPENDIX A – AS-BUILT DRAWINGS

The as-built drawings developed after the completion of the construction shall be included as part of the Post-Construction Report submission. The report shall contain 11 in. by 17 in. copies of the as-built drawings, however, a separate electronic submission of the CAD and PDF files of the as-built drawings shall also be provided. In cases where the as-built drawings are not available, the original design or issued for construction drawings shall be included. Inclusion of these drawings in the report will ensure that the necessary reference information on the facility will be available for all future inspections.

(B) APPENDIX B – CONSTRUCTION INSPECTION REPORTS

The Construction Inspection Reports prepared throughout the construction phase shall be collated and included in Appendix B. The reports shall be organized sequentially by date. Depending on the number of available reports, a separate volume containing just the Construction Inspection Reports may be needed and submitted together with the Post-Construction Report.

6.6 POST-EVENT INSPECTION REPORT

Post-Event Inspection Reports are prepared after the facility has been inspected after a specific event, and do not require the preparation of a full inspection report with the same level of detail as a Baseline or Routine Inspection report. The preparation of a letter report is sufficient for the Post-Event Inspection Report due to the urgency of the situation.

The guidelines pertaining to the arrangement of information to be presented in the letter report are discussed immediately following this outline. The letter report outline is as follows:

Introductory Paragraph describing event that occurred and scope of the inspection
Section 1.0 – Description of Site
Section 2.0 – Observed Conditions and Ratings
Section 3.0 – Recommended Actions and Estimates
Appendices
- **A – Backup for Cost Estimates**
- **B – Field Notes and/or Beach Profiles**

6.6.1 Description of Site

This section is similar to the Description of Site section in the Baseline or Routine Inspection reports, except that a facility hierarchy breakdown is not required.

6.6.2 Observed Conditions and Ratings

This section is similar to the Observed Conditions and Ratings section in the Rapid Level Inspection report. The level of detail presented in this section shall be commensurate with the inspection effort and the nature of the post-event damage. For shorelines and wetlands, beach profiles and description of affected wetland components, shall be provided in the appendix of the letter report as needed to support the narrative. Any additional field data shall also be included in the appendix as appropriate.

Separate subsections shall be provided for each inspected facility along with clear condition assessment ratings assigned to each. Systems and components that were likely affected by the event shall be clearly identified and the impacts of the event shall be described in detail with supporting photographs or figures. When the relevant information is available, it is important to note and highlight any pre-existing deterioration that may not be directly associated with the event, but which may have contributed to the observed post-event conditions. For instance, if a pile-supported platform is accidentally impacted by a vessel and the inspection reveals that multiple piles are broken, the consultant shall review any previous available inspection reports or obtain information from the facility to verify whether some of the broken piles were already broken prior to the collision.

After the narrative on the observed conditions, a summary table with the overall condition assessment ratings for the facility, its systems, and components both pre and post-event shall be provided. A sample table is provided below. A separate table shall be prepared for each inspected facility.

TABLE 6-20. SAMPLE TABLE: SUMMARY OF CONDITION ASSESSMENT RATINGS FOR FACILITY 1

Description	Condition Assessment Rating		Description of Post-Event Damage
	Pre-Event	Post-Event	
System 1	Fair	Fair	
Timber piles	Good	Good	No visible damage observed.
Timber pile cap	Poor	Poor	No visible damage observed.
Timber decking	Fair	Fair	No visible damage observed.
System 2	Good	Fair	
Timber piles	Good	Poor	Vessel impacted the northeast corner of the pier and broke 2 piles and damaged part of the concrete edge beam
Concrete pile cap	Good	Good	
Concrete edge beam	Good	Satisfactory	
Concrete deck	Good	Good	No visible damage observed.

6.6.3 Recommended Actions and Estimates

This section shall be divided into the following subsections for each recommended action for the inspected system:

- Immediate Actions
- Priority Actions
- Routine Actions

A general description of the recommended action(s), date in which the recommended action(s) needs to be implemented by, and the associated cost estimate shall be included in this section. The implementation date is the date in which actual construction of the recommended action needs to have started by. For the immediate/priority level actions in particular, additional explanation and justification on why the repair is needed shall be provided in the narrative. Any corrections of design deficiencies that are included in the recommendations shall be explicitly explained. If no actions are recommended, this should be clearly stated under each subsection.

In addition to the narrative under each subsection, a summary of all the recommended actions and estimates shall be presented in tabular format after the Priority action subsection. A listing of the major cost elements and their associated prices that comprise the overall cost estimate for repairing the system shall be cited. Quantities and unit prices are not required at this level. A sample recommended action and cost summary table for a facility is provided below. A similar table shall be prepared for each inspected facility.

TABLE 6-21. SAMPLE TABLE: SUMMARY OF RECOMMENDED ACTIONS AND COST ESTIMATE FOR FACILITY 1

Action Type	Description	Implementation Date	Total Cost (2015 dollars)
System 1			
Immediate	No Immediate actions are recommended	N/A	$ 0
		Subtotal:	**$0**
Priority	No Priority actions are recommended	N/A	$0
		Subtotal:	**$0**
Routine	No Routine actions are recommended	N/A	$ 0
		Subtotal:	**$ 0**
		Total for System 1:	**$0**
System 2			
Immediate	Cordon off the northeast corner of the pier	Immediate	$ 0
	Repair 1 broken pile by posting	Within 2 months	$25,000
		Subtotal:	**$25,000**
Priority	Repair broken concrete curb	FY 2017	$25,000
	Repair spalls in the concrete edge beam		$50,000
		Subtotal:	**$75,000**
Routine	No Routine actions are recommended		$ 0
		Subtotal:	**$ 0**
		Total for System 2:	**$100,000**
		TOTAL FOR FACILITY 1:	**$100,000**

Justification of costs associated with implementing each action should be provided in the cost backup included in Appendix A of the letter report.

The presented costs shall not only include the cost of construction, but also the cost for design and management of the construction (soft costs). The markups included in Table 6-11 shall be part of the presented construction costs to ensure consistency in the cost estimate developed by different consultants. The markups shall be applied and compounded in the order presented in Section 6.1.4(E). A separate table summarizing the applied markups must be presented together with the estimates for the recommended actions along with a general explanation on how the markups were applied. A listing of all assumptions, including which year's dollars were used in developing the cost estimates, shall be clearly presented. All costs presented in the report must be inclusive of hard and soft costs, as well as overall project contingency.

6.6.4 Appendices

The requirements for the appendices to be included in a Post-Event Inspection report are the same as those for a Baseline and Routine Inspection report.

7. INSPECTION PROGRAM

7.1 GENERAL

The WFMMS has been developed as an asset management tool for the City's waterfront facilities and is a testament to the City's pro-active approach in managing its assets. Together, these inspection guidelines and the web-based application that comprise the WFMMS will provide the City with valuable information that can be used to determine required remedial actions, develop long-term capital budgets, and help prioritize projects throughout the City. The WFMMS relies on standardized, consistent data that is obtained, analyzed, and inputted into the system by qualified consultants following the guidelines presented in this manual. In addition to the quality of inspection data entered into the WFMMS, one of the key drivers of the WFMMS is the recommended frequency of inspections for each asset. By implementing a well-planned and regular program of inspections the WFMMS will have detailed up-to-date condition assessment and cost information that will help the City proactively manage its waterfront assets and prioritize spending. This section of the manual provides guidance on the recommended frequency and types of inspections that should be performed as part of the WFMMS to preserve and promote the City's waterfront.

7.2 FREQUENCY OF INSPECTION

7.2.1 Hard Structures

As part of the Baseline, Routine Level, and Rapid-Level Inspections, the consultant must recommend the type of inspection to be performed and the interval till the next Routine or Rapid Level Inspection of the facility. The recommended interval between the Routine or Rapid Level Inspections shall be based on the following considerations and judgment by the consultant:

- Condition rating of the facility
- Importance of the structure
- Extent of deterioration and anticipated deterioration
- Construction material type
- Age of facility
- Service environment
- Exposure to hazards, natural forces, etc.

ASCE's Waterfront Facilities Inspection and Assessment manual recommends Routine Level Inspections every 0.5 to 6 years depending on the condition rating from the previous inspection, construction material, and environment. The maximum recommended intervals from ASCE for

Routine Level Inspections are presented in Table 7-1 and may be used by the consultant as a reference. Although ASCE recommends Routine Level Inspections at these intervals, the consultant may recommend Rapid Level Inspections in lieu of Routine Level Inspections, where appropriate. Whenever Rapid Level Inspections are recommended in lieu of Routine Level Inspections as part of an ongoing maintenance program, the rationale for the less intensive inspection shall be clearly stated and justified in the report. For instance, a newly built concrete structure with a low level of importance that is located in a benign environment that was previously rated as Good may warrant a Rapid Level Inspection rather than a Routine Level Inspection.

The different types of inspections in the WFMMS and the typical frequency of inspections for hard structures are summarized in Table 7-2.

TABLE 7-1
MAXIMUM INTERVAL BETWEEN ROUTINE LEVEL INSPECTIONS AS RECOMMENDED BY ASCE

Condition Rating from Previous Inspection	CONSTRUCTION MATERIAL				Channel Bottom or Mudline Scour[e], [f] (Soundings[g] /Direct Observation)	
	Unwrapped Timber or Unprotected Steel (No Coating or Cathodic Protection)[d]		Concrete, Mason, Wrapped Wood, Protected steel, or Composite Materials[d]			
	Benign[b] Environment	Aggressive[c] Environment	Benign[b] Environment	Aggressive[c] Environment	Benign[b] Environment	Aggressive[c] Environment
6 Good	6	4	6	5	6/6	2/5
5 Satisfactory	6	4	6	5	6/6	2/5
4 Fair	5	3	5	4	6/6	2/5
3 Poor	4	3	5	4	6/6	2/5
2 Serious	2	1	2	2	2/2	2/2
1 Critical	0.5	0.5	0.5	0.5	1/1	0.5/1

[a] The maximum interval between routine inspections may be reduced based on extent of deterioration, anticipated deterioration, and importance of the structure. Intervals may be increased for atypical cases where special construction materials are used. Regulations may dictate a maximum inspection interval.
[b] Benign environments include freshwater with low to moderate currents (current <.75 knots).
[c] Aggressive environments include brackish water, seawater, polluted water, or waters with currents >0.75 knots. Facilities that handle chemical containing elements detrimental to the structures durability, such as chlorides, sulfates, or alkalis, are aggressive environments.
[d] The intervals indicate requirements for sounding timbers
[e] The intervals indicate requirements for direct observation of the bottom for scour
[f] Two maximum intervals are shown, one for the assessment of construction material (wood, concrete, steel, etc.) and one for scour (last two columns). The shorter interval should be used.
[g] Soundings may be performed at the time of the above water inspection.

TABLE 7-2
INSPECTION TYPES AND FREQUENCIES FOR HARD STRUCTURES

<table>
<tr><th>Inspection Type</th><th>Frequency of Inspection</th></tr>
<tr><td>Baseline</td><td>Once at start of the inspection program</td></tr>
<tr><td>Routine Level</td><td rowspan="2">Every 3 to 5 years, unless otherwise recommended by the consultant. Interval between Routine Level Inspections may be extended if Rapid Level Inspections are performed very 3 to 5 years and the condition of the structure does not warrant a Routine Level Inspection.</td></tr>
<tr><td>Rapid Level</td></tr>
<tr><td>Design Level</td><td>As needed</td></tr>
<tr><td>Construction</td><td>As needed</td></tr>
<tr><td>Post-Construction</td><td>As needed</td></tr>
<tr><td>Post-Event</td><td>After a specific event</td></tr>
<tr><td>Engineering Investigation</td><td>As needed</td></tr>
</table>

7.2.2 Shorelines

As part of the Baseline, Routine Level, and Rapid-Level Inspections, the consultant must recommend the type of inspection to be performed and the interval till the next Routine or Rapid Level Inspection of the shoreline. The recommended interval between the Routine or Rapid Level Inspections shall be based on the following considerations and judgment by the consultant:

- Condition rating for the shoreline
- Importance and function of the shoreline (ie. public beach, flood protection, etc.)
- Extent of deterioration/erosion and anticipated deterioration/erosion
- Level of exposure to environmental impacts
- Geomorphology and historic shoreline evolution
- Shoreline management policy

By using a risk-based approach, a greater frequency and range of monitoring can be focused on areas where the site's level of exposure to environmental impacts are greater (e.g. where coastal assets are at more risk of erosion or damage), and less frequent/intensive monitoring may occur where the coast is natural, where there are few (if any) assets, and the level of exposure is less severe; thus making best-use of resources.

The different types of inspections in the WFMMS and the typical frequency of inspections for shorelines are summarized in Table 7-3.

TABLE 7-3
INSPECTION TYPES AND FREQUENCIES FOR SHORELINES

Inspection Type	Frequency of Inspection
Baseline	Once at start of the inspection program
Routine Level	Every 3 to 5 years, unless otherwise recommended by the consultant
Rapid Level	Annually, unless otherwise recommended by the consultant (except when Routine Level Inspection is performed)
Design Level	As needed
Construction	As needed
Post-Construction	As needed
Post-Event	After a specific event
Engineering Investigation	As needed

7.2.3 Wetlands

As part of the Baseline, Routine Level, and Rapid-Level Inspections, the consultant must recommend the type of inspection to be performed and the interval till the next Routine or Rapid Level Inspection of the wetland. The recommended interval between the Routine or Rapid Level Inspections shall be based on the following considerations and judgment by the consultant:

- Condition rating for the wetland
- Importance and function of the wetland
- Extent of deterioration/erosion and anticipated deterioration/erosion
- Level of exposure to waves and flooding
- Wetland mitigation requirements
- Wetland management policy

The following inspections and inspection frequencies are recommended for the WFMMS, but may be adjusted as required based on the considerations above.

The different types of inspections in the WFMMS and the typical frequency of inspections for wetlands are summarized in Table 7-4.

TABLE 7-4
INSPECTION TYPES AND FREQUENCIES FOR WETLANDS

Inspection Type	Frequency of Inspection
Baseline	Once at start of the inspection program
Routine Level	Every 5 to 10 years, unless otherwise recommended by the consultant
Rapid Level	Every 3 to 5 years, unless otherwise recommended by the consultant or as required by permitting requirements (except when Routine Level Inspection is performed)
Design Level	As needed
Construction	As needed
Post-Construction	As needed
Post-Event	After a specific event
Engineering Investigation	As needed

Appendix A
Checklist for Waterfront Structure Inspections

List of Tables

Page No.

Table A-1. Open-Piled Timber Structures: Checklist for Inspections

Section or Part	What to Look for	Comments
Piles	Damaged or missing piles, alignment (straightness) of piles from top to bottom, scour pits at mudline, pilehead bearing, fungal rot, and wrap conditions	Accelerated rates of deterioration in the splash zone and wet areas
Pile caps, stringers, and braces	Damaged, loose, or missing members; alignment of members along length (rotation); signs of distress at bearing areas; fungal rot on top surfaces or wet areas; deterioration at connections; condition of wrapping	Underside of low decks may need to be inspected by diver
		Undersides of high decks may need to be inspected by man lifts, snoopers, or other inspection access equipment
Deck	Damaged, loose, or missing members; alignment of members along length (rotation or sagging); rot; wear	Localized removal of deck coatings, surfaces or overlayments may be necessary to assess condition of supporting members
		Underside of low decks may need to be inspected by diver
		Undersides of high decks may need to be inspected by man lifts, snoopers, or other inspection access equipment
Overdredging	Excessive dredging at the face of the structure	Measure mudline depths at the structure face and compare with design dredge depths for the structure

Table A-2. Open-Piled Concrete Structures: Checklist for Inspections

Section or Part	What to Look for	Comments
Piles	Damaged or missing piles, spalling, alignment (straightness) of piles from top to bottom, scour pits at mudline, corrosion, spalling, impact damage, cracking	Accelerated rates of deterioration in the splash zone and wet areas
Pile caps, stringers, and braces	Damaged or missing members, alignment of members along length (rotation), signs of distress at bearing areas, corrosion, spalling, impact damage, cracking	Underside of low decks may need to be inspected by diver
		Undersides of high decks may need to be inspected by man lifts (see Fig. A-2), snoopers, or other inspection access equipment
Deck	Damaged or missing members, alignment of members along length (rotation or sagging), corrosion, spalling, impact damage, cracking, expansion joint condition	Underside of low decks may need to be inspected by diver Undersides of high decks may need to be inspected by man lifts (see Fig. A-2), snoopers, or other inspection access equipment
Overdredging	Excessive dredging at the face of the structure	Measure mudline depths at the structure face and compare with design dredge depths for the structure

Table A-3. Open-Piled Steel Structures: Checklist for Inspections

Section or Part	What to Look for	Comments
Piles	Damaged or missing piles, alignment (straightness) of piles from top to bottom, scour pits at mudline, corrosion, pitting, impact damage, condition of coatings and wraps	Accelerated rates of deterioration in the splash zone and wet areas
Pile caps, deck framing, and bracing	Damaged or missing members, alignment of members along length (rotation), signs of distress at bearing areas, corrosion, pitting, impact damage, condition of coatings	Underside of low decks may need to be inspected by diver
		Undersides of high decks may need to be inspected by man lifts, snoopers, or other inspection access equipment
Overdredging	Excessive dredging at the face of the structure	Measure mudline depths at the structure face and compare with design dredge depths for the structure

Table A-4. Open-Piled Composite Structures: Checklist for Inspections

Section or Part	What to Look for	Comments
Piles	Damaged or missing piles, alignment (straightness) of piles from top to bottom, scour pits at mudline, impact damage, abrasion, wear, UV damage	
Other structural elements	Damaged or missing members, alignment of members along length (rotation), signs of distress at bearing areas, impact damage, abrasion, wear, UV damage, connections	Connections are vulnerable to deterioration
		The composite decking elements are vulnerable to deterioration at supportpoints

Table A-5. Relieving Platforms: Checklist for Inspections

Section or Part	What to Look for	Comments
Piles	Corrosion, spalling, impact damage, cracking, cathodic protection, coating, pile head bearing conditions (timber piles), fungal rot	Look for overstressing at bearing areas and indicators of lateral movement and determine cause of deficiencies
Deck	Spalling, cracking, fungal rot, separation, fill loss	Excavation will be required for examination
Seawall	Alignment, settlement, spalling, cracking	Check the face for plumbness and check joints for alignment and settlement
Sheet pile	Corrosion, spalling, interlock separation, impact damage, cracking, alignment, cathodic protection, coating, fungal rot	Look for gaps and spaces between concrete or timber sheets, check for interlock separation on steel sheets, and check for corrosion holes and associated sinkholes
Pavement	Sinkholes, cracking, settlement	Cracking parallel to the structure face indicates lateral movement
Overdredging	Excessive dredging at the face of the structure	Measure mudline depths at the structure face and compare with design dredge depths for the structure

Table A-6. Bulkheads and Retaining Walls: Checklist for Inspections

Section or Part	What to Look for	Comments
Sheet piling	Corrosion, interlock separation, impact damage, cracking, local overstressing, alignment, cathodic protection, coating, clear weep holes, rot	Identify component sizes, quantify deficiencies noted, and determine cause of deficiencies
Anchorage system	Corrosion, cracking, local overstressing, displacement	Excavation may be required for examination
Backfill	Sinkholes, settlement	Look for associated holes or damage on adjacent sheet piles
Geometry	Plumbness of face, bulges, over-dredging, scour	Changes in structure geometry are indications of failure of one or more structural systems
Concrete cap	Spalling, cracking, alignment	Cracking and misalignment are indications of structural failure

Table A-7. Seawalls and Revetments: Checklist for Inspections

Section or Part	What to Look for	Comments
Seawall face	Erosion, spalling, cracking, missing blocks, cracked blocks	Assess the material condition for structural integrity; additional testing, such as concrete coring, may be warranted
Seawall top	Plumbness of face, bulges, misalignment, settlement	Identify causes of deficiencies
		Additional investigation, such as survey, soil borings, or other testing, may be required Monitoring over time may be required to determine if the anomaly is active or stable
Seawall toe	Scour, undermining, armor stone displacement	The mudline in front of the seawall should be evaluated to ensure that design parameters are maintained; survey and document loss of material in front of the seawall
Backland or paved areas	Sinkholes, settlement, drainage	The deck surface behind a seawall is susceptible to loss of fill through openings in the wall or erosion of soil by overtopping water; drains and scuppers should be inspected to make sure they are able to vent floodwater
Weep holes	Clogging	Weep holes are placed to relieve hydrostatic pressure on the wall and should be observed to make sure they are free-draining

Table A-8. Gravity Block Walls: Checklist for Inspections

Section or Part	What to Look for	Comments
Wall system	Sweeping, bowing, leaning, misalignment, settlement, localized collapse	If identified, the cause should be determined and the inspection should specifically look for secondary damage such as cracking and loss of blocks
		Consider the landward area affected by the loss of lateral support; a survey and periodic monitoring may be required to determine if wall movement is active
Backfill	Depressions, sink holes, surface tensile cracking parallel to wall, joint separation, drainage conditions	Causes of backfill problems may not be evident by visual inspections of the wall; excavations, geotechnical borings, or ground-penetrating radar may be utilized
Blocks	Weathering, cracks, common precast concrete defects, erosion, displacement, reinforcement corrosion, interlock shear	Cracking and displacement of blocks are often the secondary result of other problems; conditions that may affect block interlock or friction should be considered
Mortar	Loss, degradation, shrinkage, crushing, leakage	The results of settlement, unleveling, and differential stresses placed on blocks from mortar loss should be considered
Drains	Obstructions, evidence of activity, direction, adequacy	Drain conditions may be a contributing factor to other problems
Joints	Separation, displacement, leakage, filler condition, vegetation	Water staining at joints may indicate the extent of hydrostatic levels behind the wall; loss of fill through joints may be the cause or contributor to backfill problems
Channel-bottom	Backfill deposits, scour, undermining, heaving	The depths and general contours of the channel bottom should be considered to at least 1× the wall height outboard from the wall
		The actual or likely original design elevation of the channel bottom at the toe of the wall should be compared with current elevations
Foundation	Integrity of members, loose or missing members, voids, loss of ballast, settlement, bearing contact	Both vertical and lateral stability and load-bearing capacity should be considered; degradation of foundation members should also be considered

Table A-9. Caissons, Cofferdams, and Cellular Structures: Checklist for Inspections

Section or Part	What to Look for	Comments
Foundation	Misalignment, bowing, plumbness	Settlement and lateral movement should be considered by observing and monitoring overall structure position
Steel sheet piling or plates	Corrosion, deformation, interlock separation, splitting, cracking, impacts, dents	Identification of the nominal steel section and thickness, interlock separation, and corrosion or damage to interlock is critical
Deck or backfill	Depressions, sink holes, cracking parallel to wall, joint separation, drainage conditions	Causes of backfill problems may not be evident by visual inspections of the wall; excavations, geotechnical borings, or ground-penetrating radar may be utilized
Cell cap	Settlement, cracking, drainage, edge spalling	If hatch in cap exists, it should be opened to observe fill level and composition; cap cracking can indicate settlement or loss of infill
		Edge spalling and deterioration can compromise the cap connection to the supporting wall
Reinforced concrete walls	Cracks, common precast concrete defects, reinforcement corrosion, joint displacement	Caisson or cofferdam walls may exhibit evidence of differential settlement
Channel bottom	Fill loss, scour, undermining, heaving	The depths and general contours of the channel bottom should be measured considering lateral stability if embedment is decreased

Table A-10. Paving Adjacent to Quaywalls, Bulkheads, and Other Retaining Structures: Checklist for Inspections

Section or Part	What to Look for	Comments
Pavement	Localized settlement, depressions, or holes in pavement, ponding when wet, open cracking in the pavement parallel to the face of the retaining structure	An under-deck or underwater inspection will probably be needed to determine the exact cause of the pavement failure; use caution when inspection is close to these areas

Table A-11. Floating Structures: Checklist for Underwater Inspections

Component	Section or Part	What to Look for	Comments
		Floating Bridges	
Pontoon	Submerged surfaces	• Cracks, spalls, and loss of section; waterlogged filler material between steel double walls	• Cracks or deep section loss may allow water infiltration
	Joints	• Torn, loose, or bulging rubber membrane • Exposed and/or deteriorated grout • Excessive pontoon misalignment	
Anchor cable	Pontoon port Cable	• Misalignment and cable abrasion • Coating condition, corrosion, wire section loss, broken and/or braided wires, and potential sources of cable abrasion	• Exterior wire breaks related to stress may suggest comparable numbers of interior broken wires; stress breaks may also indicate end of cable's useful life
	Anchor attachment assembly or jewels	• Corrosion, misalignment, looseness, and cable abrasion or strain	
Anchor	Anchor assembly	• Misalignment or movement, instability, undermining, and inadequate embedment or ballast quantity	
		Floating Piers	
Pontoon	Submerged surfaces	• Material deterioration • Waterlogged Styrofoam filler	• Cracks or deep section loss may allow water infiltration
	Joints	• Damaged and/or deteriorated joint filler • Excessive pontoon misalignment	
Spud pile	Submerged surfaces	• Ordinary pile considerations • Wear or abrasion related to misalignment	
Tension line	Pontoon or anchor attachments	• Corrosion, misalignment, looseness, and line abrasion or strain	
	Cable or chain	• Corrosion, cathodic protection anode consumption (chains), breaks and/or abrasion, and potential sources of abrasion	• Catenary chains may be subject to wear at mudline
Anchor	Anchor assembly	• Misalignment or movement, instability, and inadequate embedment	

Table A-12. Mooring Hardware: Checklist for Inspections

Section or Part	What to Look for	Comments
Bollards, bitts, and cleats	Coating loss, corrosion, abrasion, displacement, cracking	Make sure to check in high-wear areas, such as the base of the hardware where the mooring lines sit. These areas are often the first to experience coating loss and corrosion. It is important to look under mooring lines while no vessels are berthed, as this is the area of most concern.
Fasteners	Corrosion, deformity	May need to conduct Level III inspection to determine full extent of fasteners' deterioration. Check both above and below deck level if fasteners can be accessed from both sides, especially for timber structures.
Supporting structure	Cracks, spalls, displacement	Check below deck level if fasteners go through deck, especially for timber structures.

Table A-13. Fender Systems: Checklist for Inspections

Section or Part	What to Look for	Comments
Absorption element	Deformation, cracking, abrasion, tears	Connections are vulnerable areas
Fender panels	Deformation, deterioration, debris accumulation, blocked drainage, loose or missing hardware	Connections to fenders or chains are vulnerable areas
Supporting piles	Buckling, impact damage, broken sections, material specific deterioration	Not found on all fender systems
Rub surface	Abrasions, impact damage, protruding bolts, missing elements	

Table A-14. Mooring Buoy Systems (Riser and Nonriser Type Moorings): Checklist for Inspections

Component	Section or Part	What to Look for	Comments
Buoy, upper portion	General	• Size; freeboard; physical damage (dents, holes, list); coating condition	
	Fenders, chafing rails or strips	• General condition	
	Top jewelry	• General condition of tension bar, hawse pipe, manhole covers, etc., as applicable	• Check for hardware wear and corrosion, damage, etc.
Buoy, lower portion	Hull	• General condition, physical damage (dents, holes, etc.)	• Check condition of coating
	Bottom jewelry	• Condition of tension bar, hawse pipe, etc., as applicable; condition of chain padeyes (for nonriser moorings)	• Tension bar: Check eye and retaining plate for wear/ distortion • Hawse pipe: Check chain for wear/corrosion, rubbing casting for wear
Riser chain subassembly	Chain links, connecting, hardware, swivel, ground ring	• Type and general condition, wear/corrosion, distortion	• Measure chain links at three locations for each shot of chain, i.e., each end and midway between; at each location, take single and double link measurement
Anchor chain subassembly	Chain links, connecting hardware, swivel (if applicable)	• Type and general condition, wear/ corrosion, distortion, compass bearing of each chain	• Check for pitting corrosion
Anchor subassembly (if visible)	Anchor, connecting hardware	• Type and general condition	• Note orientation of anchor flukes if visible
Cathodic protection system, buoy and chain	See Section A.14		

Table A-15. Wave Screens and Attenuators: Checklist of Inspections

Type	Component	What to Look for	Comments
Fixed wave screens	Support piles	Damaged or "missing" piles, deterioration, alignment (straightness) of piles from top to bottom, exposed length	Check for "ice jacking" in colder climates
	Beams and wales	Damaged or "missing" elements, deterioration, connecting hardware condition	
	Panels or planks	Damaged or "missing" elements, deterioration, connecting hardware condition, length of element below water	Check for fouling from floating debris
Floating wave attenuators	Guide piles	Damaged or "missing" piles, deterioration, alignment (straightness) of piles from top to bottom, exposed length	Check abrasion at pile guides
	Floats	General alignment, condition of attached wave attenuation devices, connection between floats, bottom surface condition	See Section A.9 for general float inspection
	Anchor chain or cables	General condition, wear/corrosion, distortion, connection to float, connection to anchor	
	Anchors	Location of anchor, embedment, general condition	

Table A-16. Waterfront Security Barriers: Checklist for Inspections

Section or Part	What to Look for	Comments
WSB floats	Verify floats are intact, not showing signs of advanced corrosion, and not taking on water internally	The freeboard of multiple floats should be compared to determine if any one buoy is significantly lower in the water, indicating possible water intrusion issues
WSB buoys	Verify buoys are intact, not showing signs of advanced corrosion, and not taking on water internally; verify buoy locations have not changed from the original configuration and mooring chains are not showing greater than 80% wear	Compare the freeboard of multiple buoys to determine if any one buoy is significantly lower in the water, indicating possible water intrusion issues. Typically diving will be required to inspect mooring chains. See Section A.11 for additional information.
Nets	Verify all nets are intact, properly connected to structural members, and hung properly	The lifespan of the WSB nets may be decreased with exposure to natural outdoor environments
Connectors	Verify all connections, both primary and back up (if applicable), are intact and operating properly; verify connections on both ends are secure and properly tightened	Periodically check urethane connectors for cracking and interior deterioration
Kayak guards	Verify all kayak guards are intact and properly connected to the WSB	Kayak guards should be positioned to prevent small vessels from transiting under the WSB
Navigational lights	Verify all navigation lights are properly working and connected securely to the WSB; verify the power supply, if solar, isn't covered by bird guano	Navigational lights may need to be periodically cleaned to prolong life
Warning signs	Verify warning signs are legible, properly mounted to the WSB, and appropriately positioned	Warning signs may need to be periodically cleaned to ensure legibility

Table A-17. Cathodic Protection Systems: Checklist for Inspections

Element	Component	What to Look for	Comments
Coating	Overall	General condition, amount of coverage, amount of bare steel exposed, dry film thickness, adhesion/disbondment	
	Zones	Atmospheric zone condition	
		Splash zone condition	
		Tidal zone condition	Include description of marine growth
		Submerged zone condition	Include description of marine growth
	Edges	Condition of coating at edges of flanges and other members	
	Welds and connections	Condition of coating at welds and other connections	Look for disbondment at welds, bolt heads, and other connections
Galvanizing	Overall	General condition, layer thickness	
	Zones	Atmospheric zone condition	
		Splash zone condition	
		Tidal zone condition	Include description of marine growth
		Submerged zone condition	Include description of marine growth
	Welds and Connections	Condition of galvanizing at welds and other connections	
Galvanic Cathodic protection system	Anodes	Size	Record dimensions and % remaining
		General condition	Describe appearance
	Connection	Welded	
		Bolted	
		Hanging	
		Sled	
		Cables	
Impressed current Cathodic protection system	Rectifier	AC power supply to unit	
		AC power across transformer	
		DC power across rectifier	
		DC power at output taps	
		Voltage and current to anodes	Record voltage and current levels
	Cables	General condition	
		Connections	
		General condition	
	Anodes	Size	

Table A-18. Marinas and Small Craft Harbors: Checklist for Inspections

Component	Section or Part	What to Look for	Comments
Floats	General	Excessive float misalignment, tilt, reduced freeboard	Misalignment may suggest anchor slippage; tilt or loss of freeboard could be caused by leakage, excessive marine growth, etc.
	Decking or surface	Worn, uneven, spalled, loss of nonslip surfacing, corrosion, loose deck members	May result in a tripping or slipping safety hazard
	Shell	Surface deterioration; physical damage (dents, holes, etc.); loose or leaking access hatch covers	Check for waterlogged filler
	Joints between float units	Damaged, loose, and/or deteriorated connecting hardware; excessive float misalignment	
Anchor systems and piles	Anchor chain and connecting hardware	General condition, wear/corrosion, Distortion	
	Anchor cable winches	Secure attachment to deck, verify cables are not binding within winch	
	Pile system	Damaged or "missing" piles, alignment (straightness) of piles from top to bottom	Check for "ice jacking" in colder climates
	Pile surfaces	Deterioration, wear/corrosion, mechanical damage	
	Pile guides	Deterioration, damage, wear/corrosion, missing components, binding	Integrity and condition of pile/float connection
Fenders and appurtenances	Fenders or bumpers	Deterioration, missing/loose members, condition of attachment hardware	Check corner bumpers
	Cleats	Damage, missing connecting hardware	
	Ladders	Damage, missing connecting Hardware	
Roofs and covers	Roof panels	Holes, tears, missing connectors	
	Trusses and columns	General condition, missing or bent members, missing or damaged connecting hardware, column attachments	

Table A-19. Gangways: Checklist for Inspections

Component	What to Look for	Comments
Ramp structural members	Missing or bent members, weld cracks, and damaged coatings	See Section A.21 for utilities
Ramp deck, walking surface	General condition and antislip elements	
Skids, rollers	General condition, freedom of movement	
Guardrails	General condition, height, intermediate rail, attachment to deck	Pay particular attention to splinters (if wood) or burrs (if metal), which may cause hand injury
Connections	Deterioration, signs of overstress, fatigue, or leaks	

Table A-20. Boat Ramps: Checklist for Inspections

Type	Component	What to Look for	Comments
Boarding floats	Grounding skids or blocks	Presence, condition	See Sections A.18 for floats and A.22 for utilities
Ramps	Ramp surface	Concrete condition, undermining, cracking, surface traction	
	Curbs	Damage	
	Abutment	Damage	

Table A-21. Crane Rails, Trenching, and Cables: Checklist for Inspections

Element	Component	What to Look for	Comments
Crane rail	Head	"Mushrooming" or plastic deformation of running surface	Thin layers of steel may be seen as "sliding off" the rail head
		Uneven wear	
		Lateral, out-of-plane deformation	
	Web	Cracking at connection to head	
		Rotation	Indicates rail is insufficient size for loads applied or crane wheels are misaligned
	Joints	Worn connection plates	Look for widened bolt holes
		Loose bolts	
	Support	Cracking or spalling in grout under crane rail base	
	Connection to base	Loose clips or clamps	Rail attachments to concrete
		Loose or missing spikes	Rail attachments to timber ties
Trench, cable, and collector bars	Cable	Cracked insulation	Refer to facility operator immediately
		Burn marks, other signs of an electrical short	STOP! Initiate lockout/tagout process
		Kinked or bent cable	
		Cable in water (on deck or under deck)	
	Trench	Corrosion, concrete spalling	
		Operation of cover plates	
		Cover plates broken, buckled, or corroded	
		Debris in trench	
	Collector bars	Burn marks, other signs of an electrical short	STOP! Initiate lockout/tagout process
		Frayed or worn collector elements	
		Debris in collector trench	

Table A-22. Waterfront Utilities: Checklist for Inspections

Type	Component	What to Look for	Comments
Utility support	Pipe or conduit hangers	Missing, broken, or structurally failed supports; corrosion; bending or distortion; loose hardware or other signs of connection failure	Sagging pipes or conduits are a sign of missing hangers
	Trenches	Water intrusion or ponding, failed drainage or pump systems	
	Cover plates or manholes	Improper seating on the frame, corrosion, leakage, distortion, elongation, distortion of holding clamps, and misalignment	
Utility runs	Piping	Obvious leakage; strain or torsion; excessive corrosion; failed coating; misalignment; lack of support; excessive vibration; broken, loose, deteriorated, or strained connections; and cracks or other breaches	
	Conduits	Breaks, visible wires, corroded or mechanically damaged conduit, loose or missing attachments to structures, failed conduit inspection plates	
	Fittings	Discontinuity from loose, missing, or broken connections; signs of burning or overheating; corrosion	

Appendix B
Glossary

The words or phrases listed below may be encountered when dealing with the inspection, evaluation, and repair of marine structures. The definitions provided are applicable to this context. Some of the words or phrases may have different meanings when used in a different context.

American Association of State Highway and Transportation Officials (AASHTO). A standards setting body that publishes specifications, test protocols, and guidelines that are used in highway design and construction throughout the United States. Despite its name, the association represents not only highways but air, rail, water, and public transportation as well.

Abrasion. A wearing away of surfaces by friction.

Abutment. Typically the section of a seawall or bulkhead which adjoins a pier or bridge.

Accretion. May be either Natural or Artificial. Natural accretion is the buildup of land, solely by the action of the forces of nature, on a Beach by deposition of water- or airborne material. Artificial accretion is a similar buildup of land by reason of an act of man, such as the accretion formed by a groin, breakwater, or beach fill deposited by mechanical means. Also Aggradation.

Acid copper chromate (ACC). Wood preservative used for timber treatment.

Advance (of a beach). (1) A continuing seaward movement of the shoreline. (2) A net seaward movement of the shoreline over a specified time. Also Progression.

Age, Wave. The ratio of wave velocity to wind velocity.

Aggradation. See Accretion.

Alkali-aggregate reaction (AAR). Two most common forms are alkali- silica reaction (ASR) and alkali-carbonate reaction (ACR). Both are caused by a reaction between chemical ions in the alkaline cement solution in concrete and reactive forms of aggregate.

Alkali-carbonate reaction (ACR). A reaction that occurs between some of the dolomitic limestone aggregates and alkalis in the cement; the reaction forms a gel, which swells when sufficient moisture is present, causing cracking around the reacting aggregates

Alkali-silica reaction (ASR). A potentially expansive chemical reaction between siliceous aggregate and the hydroxide ions associated with the ions of sodium and potassium in solution in the paste. The siliceous rocks involved in this reaction are those with an imperfect crystal structure or those that are not crystalline, which can be very deleterious if the forces generated by the expanding silica gels exceed the cohesive forces of the placement.

Allowable Pile Load. The maximum load on a pile that will not cause stress to exceed the limit specified by the applicable code. The APL is determined from the ultimate pile capacity divided by an appropriate safety factor.

Alluvium. Soil (sand, mud, or similar detrital material) deposited by streams, or the deposits formed.

Alongshore. Parallel to and near the shoreline; Longshore.

Aluminum. A structural lightweight metal used in ships and docks and a metal used in sheathing; may be used as a sacrificial anode in cathodic protection against corrosion.

American Society for Testing and Materials (ASTM). A globally recognized leader in the development and delivery of international voluntary consensus standards.

American Wood Preservers Association (AWPA). A nonprofit organization that is responsible for promulgating voluntary wood preservation standards.

Ammoniacal copper arsenate (ACA). A wood preservative used for timber treatment.

Ammoniacal copper zinc arsenate (ACZA). A wood preservative used for timber treatment.

Amphipod. A smaller division (order) of the larger group (class) of invertebrates known as Crustacea. Chelura is an example.

Amphoteric. A metal that is susceptible to corrosion in both acid and alkaline environments. Aluminum is an example of an amphoteric metal.

Amplitude, Wave. (1) The magnitude of the displacement of a wave from a mean value. An ocean wave has an amplitude equal to the vertical distance from still-water level to wave crest. For a sinusoidal wave, the amplitude is one-half the wave height. (2) The semi-range of a constituent tide.

Anode. An element in a cathodic protection system that discharges electrical current either from an external source (impressed current system) or from a self-generated source (sacrificial anode system) to depress the potential of a structure below a value at which corrosion occurs.

Antidunes. Bed Forms that occur in trains and are in phase with, and strongly interact with, gravity water-surface waves.

Antinode. See Loop.

Armor Unit. A relatively large quarrystone or concrete shape that is selected to fit specified geometric characteristics and density. It is usually of nearly uniform size and usually large enough to require individual placement. In normal cases it is used as primary wave protection and is placed in thicknesses of at least two units.

Artificial Nourishment. The process of replenishing a beach with material (usually sand) obtained from another location.

As-Built Drawings. Drawings that show all deviations from the original design and changes made during construction.

ASTM - American Society of Testing Materials.

Atmospheric pressure. Normal pressure of air at sea level, 14.7 pounds per square in. (101.4 kPA).

Atoll. A ring-shaped coral reef, often carrying low sand islands, enclosing a lagoon.

Attenuation. (1) A lessening of the amplitude of a wave with distance from the origin. (2) The decrease of water-particle motion with increasing depth. Particle motion resulting from surface oscillatory waves attenuates rapidly with depth, and practically disappears at a depth equal to a surface wavelength.

Awash. Situated so that the top is intermittently washed by waves or tidal action. Condition of being exposed or just bare at any stage of the tide between high water and chart datum.

Backbeach. See Backshore.

Backfill. Previously dredged or excavated soil reused as leveling fill.

Backrush. The seaward return of the water following the uprush of the waves. For any given tide stage the point of farthest return seaward of the backrush is known as the LIMIT of BACKRUSH or LIMIT BACKWASH.

Backshore. That zone of the shore or beach lying between the foreshore and the coastline comprising the BERM or BERMS and acted upon by waves only during severe storms, especially when combined with exceptionally high water. Also BACKBEACH.

Backwash. (1) See BACKRUSH. (2) Water or waves thrown back by an obstruction such as a ship, breakwater, or cliff.

Bank. (1) The rising ground bordering a lake, river, or sea; or of a river or channel, for which it is designated as right or left as the observer is facing downstream. (2) An elevation of the sea floor or large area, located on a continental (or island) shelf and over which the depth is relatively shallow but sufficient for safe surface navigation; a group of shoals. (3) In its secondary sense, used only with a qualifying word such as "sandbank" or "gravelbank," a shallow area consisting of shifting forms of silt, sand, mud, and gravel.

Bankia. A genus of molluscan marine borers.

Bar. A submerged or emerged embankment of sand, gravel, or other unconsolidated material built on the sea floor in shallow water by waves and currents. See Baymouth Bar, Cuspate Bar.

Bark. The outside layer of a tree, composed of living, inner bark called phloem and an outer bark of dead tissue.

Barnacle. An encrusting fouling organism belonging to the large general group (class) Crustacea.

Barrier Beach. A bar essentially parallel to the shore, the crest of which is above normal high water level. Also called Offshore Barrier and Barrier Island.

Barrier Lagoon. A bay roughly parallel to the coast and separated from the open ocean by barrier islands. Also, the body of water encircled by coral islands and reefs, in which case it may be called an atoll lagoon.

Barrier Reef. A coral reef parallel to and separated from the coast by a lagoon that is too deep for coral growth. Generally, barrier reefs follow the coasts for long distances and are cut through at irregular intervals by channels or passes.

Basin, Boat. A naturally or artificially enclosed or nearly enclosed harbor area for small craft.

Bathymetry. The measurement of depths of water in oceans, seas, and lakes; also information derived from such measurements.

Bathycorrometer. Trade name of a d.c. measuring instrument containing a voltmeter and an electrode assembly enclosed in a watertight casing. Used by divers to measure a structure's electrical potential during a corrosion survey.

Batter Pile. An inclined structural pile installed to resist horizontal forces.

Bay. A recess in the shore or an inlet of a sea between two capes or headlands, not so large as a gulf but larger than a cove. See also Bight, Embayment.

Baymouth Bar. A bar extending partly or entirely across the mouth of a bay.

Bayou. A minor sluggish waterway or estuarial creek, tributary to, or connecting, other streams or bodies of water, whose course is usually through lowlands or swamps. Sometimes called Slough.

Beach. The zone of unconsolidated material that extends landward from the low water line to the place where there is marked change in material or physiographic form, or to the line of permanent vegetation (usually the effective limit of storm waves). The seaward limit of a beach--unless otherwise specified--is the mean low water line. A beach includes Foreshore and Backshore. See also Shore.

Beach Accretion. See Accretion.

Beach Berm. A nearly horizontal part of the beach or backshore formed by the deposit of material by wave action. Some beaches have no berms, others have one or several.

Beach Cusp. See Cusp.

Beach Erosion. The carrying away of beach materials by wave action, tidal currents, littoral currents) or wind.

Beach Face. The section of the beach normally exposed to the action of the wave uprush. The Foreshore of a Beach. (Not synonymous with Shoreface.)

Beach Fill. Material placed on a beach to renourish eroding shores.

Beach Ridge. See Ridge, Beach.

Beach Scarp. See Scarp, Beach.

Beach Width. The horizontal dimension of the beach measured normal to the shoreline.

Beam. A horizontal structural member that primarily resists loads applied perpendicular to the length. In marine structures beams typically span between pile caps or girders and often support the deck.

Beams and stringers. Lumber of rectangular cross section, 5 in. (127 mm) or more thick and 8 in. (203 mm) or more wide, graded with respect to its strength when loaded on the narrow face.

Bearing piles. Those piles in a structure that support the load.

Bed Forms. Any deviation from a flatbed that is readily detectable by eye and higher than the largest sediment size present in the parent bed material; generated on the bed of an alluvial channel by the flow.

Bedload. See Load.

Bench. (1) A level or gently sloping erosion plane inclined seaward. (2) A nearly horizontal area at about the level of maximum high water on the sea side of a dike.

Bench Cap. Timber repair element, placed horizontally on top of a series of cut off timber piles, typically used to realign piles for posting repairs.

Bench capping. A method of replacing damaged piles at higher elevations when more than one pile in line is to be repaired.

Bench Mark. A permanently fixed point of known elevation. A primary bench mark is one close to a tide station to which the tide staff and tidal datum originally are referenced.

Bent. A line of piles which share a common pile cap.

Berm, **Beach**. See Beach Berm.

Berm Crest. The seaward limit of a berm. Also called Berm Edge.

Berth. The water area at the edge of a wharf or pier reserved for a vessel.

Bight. A bend in a coastline forming an open bay. A bay formed by such a bend.

Biological deterioration. Deterioration or damage caused by living organisms.

Biofouling or biological fouling. The accumulation of microorganisms, plants, algae, or animals on wetted surfaces.

Bitt. A single- or double-posted steel fitting on the deck of a ship, pier or wharf to which mooring lines are secured.

Bitumastic. A coating made from higher boiling point materials found in tar.

Bleeding. The exudation of liquid preservative from treated wood, the exudate may evaporate, remain liquid, or harden into a semisolid or solid state.

Block and Mortar. Common construction of older bridge piers and bulkheads consisting of vertically stacked cut stones and concrete.

Blown Sands. See Eolian Sands.

Bluff. A high, steep bank or cliff.

Bold Coast. A prominent landmass that rises steeply from the sea.

Bollard. A single- or double-posted steel fitting on the deck of a pier or wharf around which mooring lines from vessels are tied.

Bore. A very rapid rise of the tide in which the advancing water presents an abrupt front of considerable height. In shallow estuaries where the range of tide is large, the high water is propagated inward faster than the low water because of the greater depth at high water. If the high water overtakes the low water, an abrupt front is presented, with the high-water crest finally falling forward as the tide continues to advance. Also Eager.

Borers, marine. Marine organisms that attack wood in the submerged portions of structures placed in salt or brackish waters. Two general groups of borers are recognized, the Crustacea and the Mollusca.

Boring. A sample taken from wood for detection of deterioration or preservative penetration; the movement of certain organisms through wood.

Bottom. The ground or bed under any body of water; the bottom of the sea.

Bottom (nature of). The composition or character of the bed of an ocean or other body of water (e.g., clay, coral, gravel, mud, ooze, pebbles, rock, shell, shingle, hard, or soft).

Boulder. A rounded rock more than 10 in. in diameter; larger than a cobblestone. See Soil Classification.

Braces. Semi-structural members typically used on marine structures to maintain pile alignment and verticality, reduce the unsupported length of piles, and increase resistance to horizontal forces.

Bracing. Wood or supports supplying additional strength to a structure.

Brackish water. Water that is partly salt and partly fresh.

Branding. Permanent marking on a treated wood product to identify the supplier and date of treatment; other information may be included in a brand when so specified.

Breaker. A wave breaking on a shore, over a reef, etc. Breakers may be classified into four types:

Spilling – bubbles and turbulent water spill down front face of wave. The upper 25 percent of the front face may become vertical before breaking. Breaking generally occurs over quite a distance.

Plunging – crest curls over air pocket; breaking is usually with a crash. Smooth splash-up usually follows.

Collapsing – breaking occurs over lower half of wave, with minimal air pocket and usually no splash-up. Bubbles and foam present.

Surging – wave peaks up, but bottom rushes forward from under wave, and wave slides up beach face with little or no bubble production. Water surface remains almost plane except where ripples may be produced on the beach face during runback.

Breaker Depth. The still-water depth at the point where a wave breaks. Also called Breaking Depth.

Breakwater. A structure protecting a shore area, harbor, anchorage, or basin from waves.

Breasting Dolphin. A structure against which a vessel breasts when moored. Usually fitted with a fender system and may also support mooring fittings.

Brinell hardness test. The oldest of the hardness test methods in common use today, the Brinell test is frequently used to determine the hardness of forgings and castings that have a grain structure too course for Rockwell or Vickers testing. Therefore, Brinell tests are frequently done on large parts. By varying the test force and ball size, nearly all metals can be tested using a Brinell test. Brinell values are considered test-force independent as long as the ball size/test force relationship is the same.

Brown rot. Deterioration caused by a group of fungi producing a brown residue or powder.

Bulkhead. A retaining wall to prevent sliding of earth or fill into water.

Bulkhead. A structure or partition to retain or prevent sliding of the land. A secondary purpose is to protect the upland against damage from wave action.

Bullrail. A wide low curb along the outboard edge of the pier or wharf, it may be cast-in-place concrete, steel or timber; fixed or removable; mooring hardware is often mounted on top of the bullrail.

Buoy. A float moored to the bottom to mark the position of a shoal, channel, or anchorage limit, or a floating element of a ship mooring.

Buoyancy. The resultant of upward forces, exerted by the water on a submerged or floating body, equal to the weight of the water displaced by this body.

Burrow. Tunnel or excavation made by marine borers.

Bypassing, Sand. Hydraulic or mechanical movement of sand from the accreting updrift side to the eroding downdrift side of an inlet or harbor entrance. The hydraulic movement may include natural movement as well as movement caused by man.

Caliper. A compass or divider with curved legs for measuring diameter of pipes, rods, or piles.

Caisson. A concrete structure with a steel or concrete end closure.

Camel. A floating device acting as a fender and used to separate a moored vessel from a pier, wharf, quay, or other vessel, camels are used with ships that have hull configurations that do not match well with typical pier or wharf fender systems, such as submarines or where vessels require an offset from the pier or wharf due to deck or superstructure overhangs, such as an aircraft carrier.

Canal. An artificial watercourse cut through a land area for such uses as navigation and irrigation.

Canyon. A relatively narrow, deep depression with steep slopes, the bottom of which grades continuously downward. May be underwater (submarine) or on land (subaerial).

Cap log. A timber member connecting and protecting the heads of piles; generally not a structural member.

Cape. A relatively extensive land area jutting seaward from a continent or large island which prominently marks a change in, or interrupts notably, the coastal trend; a prominent feature.

Capillary Wave. A wave whose velocity of propagation is controlled primarily by the surface tension of the liquid in which the wave is traveling. Water waves of length less than about 1 in. are considered capillary waves. Waves longer than 1 in. and shorter than 2 in. are in an indeterminate zone between Capillary and Gravity Waves. See Ripple.

Capstan. Vertical axled rotating machine used to apply force to ropes, cables, and hawsers. The principle is similar to that of the windlass, which has a horizontal axle.

Carbonation. Occurs when the calcium in concrete is attacked by carbon dioxide of the air and converted to calcium carbonate.

Catenary. The curve that an idealized hanging chain or cable assumes under its own weight when supported only at its ends.

Cathode. The negative electrode of an electrolytic cell.

Cathodic Protection. An electrical method of controlling corrosion in a conducting medium such as seawater or moist soil where an electrical current is applied to a structure either by the corrosion of an active anode material or an external electrical power supply.

Causeway. A raised road across wet or marshy ground, or across water.

Caustic. In refraction of waves, the name given to the curve to which adjacent orthogonals of waves refracted by a bottom whose contour lines are curved, are tangents. The occurrence of a caustic always marks a region of crossed orthogonals and high wave convergence.

Cay. See Key.

Celerity. Wave speed.

Central Pressure Index (CPI). The estimated minimum barometric pressure in the eye (approximate center) of a particular hurricane. The CPI is considered the most stable index to intensity of hurricane wind velocities in the periphery of the storm; the highest wind speeds are associated with storms having the lowest CPI.

Chafing. Abrasion caused by material rubbing against a structure.

Channel. A steel or concrete structural member having two flanges and a web which form a U-shape when viewed in cross-section.

Characteristic Wave Height. See Significant Wave Height.

Charpy impact test. Also known as the Charpy V-notch test, a standardized high strain-rate test that determines the amount of energy absorbed by a material during fracture. This absorbed energy is a measure of a given material's notch toughness and acts as a tool to study temperature-dependent ductile-brittle transition.

Chart Datum. The plane or level to which soundings (or elevations) or tide heights are referenced (usually Low Water Datum). The surface is called a tidal datum when referred to a certain phase of tide. To provide a safety factor for navigation, some level lower than Mean Sea Level is generally selected for hydrographic charts, such as Mean Low Water or Mean Lower Low Water. See Datum Plane.

Checking. A typical defect found in timber members involving minor cracking of the surface of the member due to shrinkage.

Chelura. A genus of Crustacea borers.

Chemical damage. Deterioration of structural members due to the effect of chemical reactions.

Chock (timber). Timber member used as a spacer between structural members.

Chop. The short-crested waves that may spring up quickly in a moderate breeze, and which break easily at the crest. Also Wind Chop.

Chromated copper arsenate (CCA). A wood preservative used for timber treatment since the mid 1930s.

Clamped. A method of fastening, where one member is sandwiched between two other members.

Clapotis. The French equivalent for a type of Standing Wave. In American usage it is usually associated with the standing wave phenomenon caused by the reflection of nonbreaking wave train from a structure with a face that is vertical or nearly vertical. Full clapotis is one with 100 percent reflection of the incident wave; partial clapotis is one with less than 100 percent reflection.

Clay. See Soil Classification.

Clearwater Box. A glass or plexiglass box used to facilitate the taking of underwater photographs in turbid waters.

Cleat. A metal fitting on the deck of a pier or ship usually with two projecting horns around which a rope may be made fast (as by belaying it).

Cliff. A high, steep face of rock; a precipice. See also Sea Cliff.

Cnoidal Wave. A type of wave in shallow water (i.e., where the depth of water is less than 1/8 to 1/10 the wavelength). The surface profile is expressed in terms of the Jacobian elliptic function cn; hence the term cnoidal.

Coal tar derivative. Preservative obtained from the distillation of coal tar.

Coast. A strip of land of indefinite width (may be several kilometers) that extends from the shoreline inland to the first major change in terrain features.

Coastal Area. The land and sea area bordering the shoreline.

Coastal Plain. The plain composed of horizontal or gently sloping strata of clastic materials fronting the coast, and generally representing a strip of sea bottom that has emerged from the sea in recent geologic time.

Coastal waters. Seawaters bordering the continents subject to tidal flow.

Coastline. (1) Technically, the line that forms the boundary between the Coast and the Shore. (2) Commonly, the line that forms the boundary between the land and the water.

Coatings. Protective covers to prevent corrosion.

Cobble (Cobblestone). See Soil Classification.

Cofferdam. A temporary enclosure built within, or in pairs across, a body of water and constructed to allow the enclosed area to be pumped out, creating a dry work environment for the major work to proceed.

Cold iron. Describes the condition of a ship when all shipboard boilers, engines, and generators are inoperative during repairs or due to intentional shutdown and can furnish none of the ship's required services.

Cold Joint (construction joint). The joint in a concrete member created when two abutting sections are cast at different times.

Cohesive Soil. Soil, typically clay, that is held together by the mutual molecular attraction of its particles.

Comber. (1) A deepwater wave whose crest is pushed forward by a strong wind; much larger than a whitecap. (2) A long-period breaker.

Composite. A structural member or members made up of disparate materials.

Concrete forms. Generally temporary wood or steel structures constructed to retain wet concrete until the concrete sets.

Conditioning. The heating or removal of moisture from unseasoned or partially seasoned wood as a preliminary to preservative treatment and as a means of improving the penetrability and absorptive properties of the wood.

Connectors, timber. Devices, such as metal rings and plate and wood discs that, when embedded in each member, increase the efficiency of a timber joint.

Continental Shelf. The zone bordering a continent and extending from the low water line to the depth (usually about 180 meters) where there is a marked or rather steep descent toward a greater depth.

Contour. A line on a map or chart representing points of equal elevation with relation to a Datum. It is called an Isobath when connecting points of equal depth below a datum. Also called Depth Contour.

Controlling Depth. The least depth in the navigable parts of a waterway, governing the maximum draft of vessels that can enter.

Convergence. (1) In refraction phenomena, the decreasing of the distance between orthogonals in the direction of wave travel. Denotes an area of increasing wave height and energy concentration. (2) In wind-setup phenomena, the increase in setup observed over that which would occur in an equivalent rectangular basin of uniform depth, caused by changes in planform or depth; also the decrease in basin width or depth causing such increase in setup.

Coping. A top course of stone or concrete to tie a structure together or to distribute the pressure from exterior loading.

Copper-copper sulfate. Reference cell for electrolyte potential measurements in seawater.

Copper naphthenate. A toxic chemical preservative particularly effective against insects and destructive fungi.

Coral. (1) (Biology) Marine coelenterates (Madreporaria), solitary or colonial, which form a hard external covering of calcium compounds or other materials. The corals which form large reefs are limited to warm, shallow waters, while those forming solitary, minute growths may be found in colder waters to great depths. (2) (Geology) The concretion of coral polyps, composed almost wholly of calcium carbonate, forming reefs and tree-like and globular masses. May also include calcareous algae and other organisms producing calcareous secretions, such as bryozoans and hydrozoans.

Core. A vertical cylindrical sample of the bottom sediments from which the nature and stratification of the bottom may be determined. The cylinder of wood, removed by means of an increment borer, from which may be determined, by linear measurement, sapwood thickness and preservative penetration, and, by assay, preservative retention and distribution.

Corrosion. The deterioration of a metal by electrochemical action.

Cove. A small, sheltered recess in a coast, often inside a larger embayment.

Crack. A split or separation of material.

Creosote, coal tar. A distillate derived from coal tar. As used in the wood-preserving industry, creosote denotes a distillate of coal tar produced by the high-temperature carbonization of bituminous coal. Creosote consists principally of liquid and solid aromatic hydrocarbons and contains some tar acids and tar bases; it is heavier than water and has a continuous boiling range beginning at about 200 °C.

Creosote-coal tar solution. Solution of coal tar and creosote in selected proportions; usually contains 20 to 50% coal tar.

Creosote, marine grade. A coal tar creosote meeting special requirements as specified for the treatment of materials for marine use.

Crest Length, Wave. The length of a wave along its crest. Sometimes called Crest Width.

Crest of Berm. The seaward limit of a berm. Also called Berm Edge.

Crest of Wave. (1) the highest part of a wave. (2) That part of the wave above still-water level.

Crest Width, Wave. See Crest Length, Wave.

Crevice corrosion. Corrosion of a metal at an area where contact is made with a nonmetallic material.

Crib. A structure of interlocking perpendicular members, typically timber, which is filled with stone and used as a retaining wall or bulkhead.

Crustacea. A large group (class) of invertebrate animals. Barnacles, Limnoria, Sphaeroma, and Chelura are examples.

Curb. On marine structures, a curb is the perimeter barrier, usually 8 in. to 14 in. high, bolted, cast, or otherwise attached to the deck. Curbs can be of timber, steel, or concrete construction.

Current. A flow of water.

Current, Coastal. One of the offshore currents flowing generally parallel to the shoreline in the deeper water beyond and near the surf zone; these are not related genetically to waves and resulting surf, but may be related to tides, winds, or distribution of mass.

Current, Drift. A broad, shallow, slow-moving ocean or lake current. Opposite of Current, Stream.

Current, Ebb. The tidal current away from shore or down a tidal stream. Usually associated with the decrease in the height of the tide.

Current, Eddy. See Eddy.

Current, Feeder. Any of the parts of the Nearshore Current System that flow parallel to shore before converging and forming the neck of the Rip Current.

Current, Flood. The tidal current toward shore or up a tidal stream. Usually associated with the increase in the height of the tide.

Current, Inshore. See Inshore Current.

Current, Littoral. Any current in the littoral zone caused primarily by wave action; e.g. Longshore Current, Rip Current. See also Current, Near-Shore.

Current, Longshore. The littoral current in the breaker zone moving essentially parallel to the shore, usually generated by waves breaking at an angle to the shoreline.

Current, Nearshore. A current in the Nearshore Zone.

Current, Offshore. See Offshore Current.

Current, Periodic. See Current, Tidal.

Current, Permanent. See Permanent Current.

Current, Rip. See Rip Current.

Current, Stream. A narrow, deep, and swift ocean current, as the Gulf Stream.

Current, Drift.

Current System, Nearshore. See Nearshore Current System.

Current, **Tidal**. The alternating horizontal movement of water associated with the rise and fall of the tide caused by the astronomical tide-producing forces. Also Current, Periodic. See also Current, Flood and Current, Ebb.

Cusp. One of a series of low mounds of beach material separated by crescent-shaped troughs spaced at more or less regular intervals along the beach face. Also Beach Cusp.

Cuspate Bar. A crescent-shaped bar uniting with the shore at each end. It may be formed by a single spit growing from shore and then turning back to again meet the shore, or by two spits growing from the shore and uniting to form a bar of sharply cuspate form.

Cuspate Spit. The spit that forms in the lee of a shoal or offshore feature (breakwater, island, rock outcrop) by waves that are refracted and/or diffracted around the offshore feature. It may be eventually grown into a TOMBOLO linking the feature to the mainland. See Tombolo.

Cyclopean masonry. A type of stonework built with huge boulders, roughly fitted together with minimal clearance between adjacent stones and no use of mortar.

Cycloidal Wave. A steep, symmetrical wave whose crest forms an angle of 120 degrees and whose form is that of a cycloid. A trochoidal wave of maximum steepness. See also Trochoidal Wave.

Datum, Chart. See Chart Datum.

Datum, Plane. The horizontal plane to which soundings, ground elevations, or water surface elevations are referred. Also REFERENCE PLANE. The plane is called a Tidal Datum when defined by a certain phase of the tide. The following datums are ordinarily used on hydrographic charts:

Deadman. A block or other heavy item, usually of concrete, buried in the ground to which is attached a steel rod or cable for anchoring objects.

Debris Line. A line near the limit of storm wave uprush marking the landward limit of debris deposits.

Decay. Disintegration of wood substance due to the action of wood destroying Fungi.

Decay Distance. The distance waves travel after leaving the generating area (Fetch).

Decay of Waves. The change waves undergo after they leave a generating area (Fetch) and pass through a calm, or region of lighter winds. In the process of decay, the significant wave height decreases and the significant wavelength increases.

Deck. The working surface of a wharf, pier, or vessel.

Deep Water. Water so deep that surface waves are little affected by the ocean bottom. Generally, water deeper than one-half the surface wavelength is considered deep water. Compare Shallow Water.

Deflation. The removal of loose material from a beach or other land surface by wind action.

Delta. An alluvial deposit, roughly triangular or digitate in shape, formed at a river mouth.

Delamination. A splitting apart into layers.

Delineation: Technique of determining an exact boundary of a wetland. Used for identifying jurisdictional wetlands in the United States.

Delayed ettringite formation (DEF). A type of internal sulfate attack in concrete, which is common in many precast concrete elements that have been heat treated beyond a certain temperature and have suppressed the normal ettringite formation, or, in a concrete that is made using a highsulfate portland cement. Instead of normal formation of ettringite by cement hydration in the plastic state, in these concretes ettringite forms after the hardening of the concrete. In the continued presence of moisture, components of ettringite (i.e., Ca, Al, S) slowly dissolve out and form ettringite in the confined spaces in hardened paste and thereby cause expansion, subsequent separations around the aggregate particles, stresses in the paste due to restrained expansion, and the resultant eventual cracking of concrete.

Depassivate. Remove ability of steel to resist corrosion.

Depth. The vertical distance from a specified tidal datum to the sea floor.

Depth of Breaking. The still-water depth at the point where the wave breaks. Also Breaker Depth.

Depth Contour. See Contour.

Depth, **Controlling**. See Controlling Depth.

Depth Factor. See Shoaling Coefficient.

Derrick Stone. See Stone, Derrick.

Design Hurricane. See Hypothetical Hurricane.

Deterioration (timber). General term used to describe cross-sectional or density loss in a timber member.

Differential global positioning system (DGPS). An enhancement to the global positioning system that provides improved location accuracy, from the 15-m nominal GPS accuracy to about 10 cm in the best case implementations

Differential thermal analysis (DTA). A thermoanalytic technique, similar to differential scanning calorimetry. In DTA, the material under study and an inert reference are made to undergo identical thermal cycles, while recording any temperature difference between sample and reference. This differential temperature is then plotted against time or against temperature (DTA curve or thermogram). Changes in the sample, either exothermic or endothermic, can be detected relative to the inert reference.

Diffraction (of water waves). The phenomenon by which energy is transmitted laterally along a wave crest. When a part of a train of waves is interrupted by a barrier, such as a breakwater, the effect of diffraction is manifested by propagation of waves into the sheltered region within the barrier's geometric shadow.

Dike (Dyke). A wall or mound built around a low-lying area to prevent flooding.

Dimension stock. Square of flat wood, usually in pieces smaller than the minimum sizes admitted by standard lumber grades, that is rough, dressed, green, or dry, and cut to the approximate dimension required for the various products of woodworking factories Dip treatment—the total submergence of a structural member in the preservative.

Disbonding. Coating separating from the protected structure.

Discharge structure. Outfalls at the ends of pipes, where the material flowing in the pipes enters the ocean or lake. Usually concrete or masonry but can be steel or wood.

Diurnal. Having a period or cycle of approximately one Tidal Day.

Diurnal Tide. A tide with one high water and one low water in a tidal day.

Divergence. (1) In refraction phenomena, the increasing of distance between orthogonals in the direction of wave travel. Denotes an area of decreasing wave height and energy concentration. (2) In wind-setup phenomena, the decrease in setup observed under that which would occur in an equivalent rectangular basin of uniform depth, caused by changes in planform or depth. Also the increase in basin width or depth causing such decrease in setup.

Dock. The water area adjacent to a wharf or pier to which a ship can be secured.

Dolphin. A structure usually consisting of a cluster of piles. It is placed at the outward end of piers and wharves, or along shore, to guide vessels into their moorings; to fend vessels away from structures, shoals, or the shore; or to support navigation aids.

Dote. "dote," "doze," and "rot" are synonymous with decay.

Douglas fir, interior. Douglas fir growing east of the summit of the Cascade Mountains; sometimes referred to as "intermountain Douglas fir." Interior Douglas fir growing in Oregon, Washington, Idaho, Wyoming, and Montana is designated "Douglas fir interior north."

Douglas fir, Pacific coast. Douglas fir growing between the Pacific Ocean and the summit of the Cascade Mountains; sometimes referred to as "coastal Douglas fir".

Downcoast. In United States usage, the coastal direction generally trending toward the south.

Downdrift. The direction of predominant movement of littoral materials.

Draft. Depth of vessel hull or buoy below the waterline.

Drift (noun). (1) Sometimes used as a short form for Littoral Drift. (2) The speed at which a current runs. (3) Floating material deposited on a beach (driftwood). (4) A deposit of a continental ice sheet; e.g., a drumlin.

Drift Current. A broad, shallow, slow-moving ocean or lake current.

Drydock. A specialized facility used for repair of ships, where the vessel is removed from the water or placed within a lock and the water is removed, leaving the ship in the dry to facilitate repairs.

Dry rot- A term loosely applied to many types of decay but especially to that which permits the wood to be crushed easily to a dry powder when in an advanced stage. The term is actually a misnomer for any decay, because all fungi require considerable moisture for growth, and the wood must have been moist at the time the rot occurred.

Dunes. (1) Ridges or mounds of loose, wind-blown material, usually sand. (2) Bed Forms smaller than bars but larger than ripples that are out of phase with any water surface gravity waves associated with them.

Durability. As applied to wood, its lasting qualities or permanence in service with reference to its resistance to decay and other forms of deterioration. Decay resistance is a somewhat more specific term indicating resistance to attack by wood-destroying fungi under conditions favorable to their growth.

Duration. In wave forecasting, the length of time the wind blows in nearly the same direction over the Fetch (generating area).

Duration, **Minimum**. The time necessary for steady-state wave conditions to develop for a given wind velocity over a given fetch length.

Eager. See Bore.

Ebb. To recede from the flood, falling tide.

Ebb Current. The tidal current away from shore or down a tidal stream; usually associated with the decrease in height of the tide.

Ebb Tide. The period of tide between high water and the succeeding low water; a falling tide.

Echo Sounder. An electronic instrument used to determine the depth of water by measuring the time interval between the emission of a sonic or ultrasonic signal and the return of its echo from the bottom.

Eddy. A circular movement of water formed on the side of a main current. Eddies may be created at points where the main stream passes projecting obstructions or where two adjacent currents flow counter to each other. Also Eddy Current.

Eddy Current. See Eddy.

Edge Beam. The innermost or outermost beam supporting the deck of a pier or wharf.

Edge Wave. An ocean wave parallel to a coast, with crests normal to the shoreline. An edge wave may be Standing or Progressive. Its height diminishes rapidly seaward and is negligible at a distance of one wavelength offshore.

Efflorescence. A surface encrustation caused by the evaporation of solutions seeping out onto the surface of rock or concrete.

Electrochemical. A phenomenon where chemical change occurs through the indirect exchange of electrons.

Electrolyte. A chemical substance or mixture, usually liquid, containing ions that migrate in an electric field.

Embankment. An artificial bank such as a mound or dike, generally built to hold back water or to carry a roadway.

Embayed. Formed into a bay or bays, as an embayed shore.

Embayment. An indentation in the shoreline forming an open bay.

Embed. To place or fix firmly in surrounding matter; also "imbed" Embrittlement—causing a loss of ductility, such as hydrogen embrittlement, where the introduction of hydrogen into metal reduces its ductility.

Empty cell process. A method of pressure treating wood without use of a preliminary vacuum.

Encasement. Specific to marine repairs, an encasement is the repair of a deteriorated structural member or pile by covering it with reinforced concrete.

Energy Coefficient. The ratio of the energy in a wave per unit crest length transmitted forward with the wave at a point in shallow water to the energy in a wave per unit crest length transmitted forward with the wave in deep water. On refraction diagrams this is equal to the ratio of the distance between a pair of orthogonals at a selected shallow-water point to the distance between the same pair of orthogonals in deep water. Also the square of the Refraction Coefficient.

Entrance. The avenue of access or opening to a navigable channel.

Eolian Sands. Sediments of sand size or smaller which have been transported by winds. They may be recognized in marine deposits off desert coasts by the greater angularity of the grains compared with waterborne particles.

Epoxy Coating. A hard, chemically and environmentally resistant, thermosetting resin-based coating, often used in the marine environment to prevent deterioration of steel members.

Erosion. The wearing away of land by the action of natural forces. On a beach, the carrying away of beach material by wave action, tidal currents, littoral currents, or by deflation.

Erosion (of concrete). A reduction in the size of a structural concrete member due to external abrasive forces.

Escarpment. A more or less continuous line of cliffs or steep slopes facing in one general direction which are caused by erosion or faulting. Also Scarp.

Estuary. (1) The part of a river that is affected by tides. (2) The region near a river mouth in which the fresh water of the river mixes with the salt water of the sea.

Eurocode. A set of harmonized technical rules developed by the European Committee for Standardization for the structural design of construction works in the European Union.

Eutrophic: Nutrient rich.

Evaluation. Statement of value; a spoken or written statement of the value, quality, importance, extent, or condition of something.

Expansion Joint. A transverse joint in a marine structure provided to allow for thermal expansion and contraction.

Eye. In meteorology, usually the "eye of the storm" (hurricane); the roughly circular area of comparatively light winds and fair weather found at the center of a severe tropical cyclone.

Fairway. The parts of a waterway that are open and unobstructed for navigation. The main traveled part of a waterway; a marine thoroughfare.

Fascia. The vertical exterior surface of a pier, wharf, or similar structure.

Fathom. A unit of measurement used for soundings equal to 1.83 meters (6 feet).

Fathometer. The copyrighted trademark for a type of echo sounder.

Fathometric Survey. A hydrographic survey performed with an echo sounding device.

Feeder Beach. An artificially widened beach serving to nourish downdrift beaches by natural littoral currents or forces.

Feeder Current. See Current, Feeder.

Feeling Bottom. The initial action of a deepwater wave, in response to the bottom, upon running into shoal water.

Fender. A device, usually of timber, rubber, or rope, used to prevent impact or abrasion damage to a vessel or shore facility.

Fetch. The area in which Seas are generated by a wind having a fairly constant direction and speed. Sometimes used synonymously with Fetch Length. Also Generating Area.

Fetch Length. The horizontal distance (in the direction of the wind) over which a wind generates SEAS or creates a Wind Setup.

Fiber-reinforced polymer (FRP). Composite materials made of a polymer matrix reinforced with fibers. The fibers are usually fiberglass, carbon, or aramid, whereas the polymer is usually an epoxy, vinyl ester, or polyester thermosetting plastic. FRPs are commonly used in the aerospace, automotive, marine, and construction industries.

Fill. Earth, sod, rubble, or other natural material used for leveling upland of a marine structure.

Fiord (Fjord). A narrow, deep, steep-walled inlet of the sea, usually formed by entrance of the sea into a deep glacial trough.

Fir. A species of wood used in waterfront structures. See Douglas fir.

Firth. A narrow arm of the sea; also, the opening of a river into the sea.

Fish Plate. A timber plate that laps a joint or an area of a pile reduced by deterioration. It is secured to the sides so as to connect the members end to end or to strengthen them.

Flange. The portion(s) of a geometric cross-section furthest from the strong axis about which flexural stresses are imposed. The term flange is most commonly applied to the sides of an H-pile or beam.

Fleet mooring. An offshore anchoring system placed in a fixed location.

Float. A waterborne platform used for disembarking from a boat or working around waterfront structures.

Flood. Rising tide.

Flood Current. The tidal current toward shore or up a tidal stream, usually associated with the increase in the height of the tide.

Flood Tide. The period of tide between low water and the succeeding high water; a rising tide.

Flow. Direction of movement.

Fluke. The barbed shaped part of an anchor that digs into the bottom.

Foam Line. The front of a wave as it advances shoreward, after it has broken.

Following Wind. Generally, the same as a tailwind; in wave forecasting, wind blowing in the direction of ocean-wave advance.

Foredune. The front dune immediately behind the backshore.

Forerunner. Low, long-period ocean swell which commonly precedes the main swell from a distant storm, especially a tropical cyclone.

Foreshore. The part of the shore, lying between the crest of the seaward berm (or upper limit of wave wash at high tide) and the ordinary low-water mark, that is ordinarily traversed by the uprush and backrush of the waves as the tides rise and fall. See **Beach Face**.

Forward Speed (hurricane). Rate of movement (propagation) of the hurricane eye in meters per second, knots, or miles per hour.

Fouling. An accumulation of deposits, especially marine biological growth.

Freeboard. Distance between the deck of a floating vessel or buoy and the waterline.

Freeboard. The additional height of a structure above design high water level to prevent overflow. Also, at a given time, the vertical distance between the water level and the top of the structure. On a ship, the distance from the waterline to main deck or gunwale.

Fringing Reef. A coral reef attached directly to an insular or continental shore.

Front of The Fetch. In wave forecasting, the end of the generating area toward which the wind is blowing.

Froude Number. The dimensionless ratio of the inertial force to the force of gravity for a given fluid flow. It may be given as Fr = V /Lg where V is a characteristic velocity, L is a characteristic length) and g the acceleration of gravity -- or as the square root of this number.

Full. See Ridge, Beach.

Full cell process. A method of pressure treating wood using initial vacuum.

Fungus. A primitive plant in the group that includes molds, mushrooms, and others.

Gabion. Wire mesh units shaped as baskets or blocks and filled with loose stone. Gabions are primarily used as shore protection and retaining walls.

Galvanic. Pertaining to the electrochemical interaction between two metals such as in galvanic couple or galvanic series.

Galvanic anode. A metal that, because of its relative position in the galvanic series, provides sacrificial protection to metal or metals that are more noble in the series, when coupled in an electrolyte. The anodes, such as zinc, magnesium, or aluminum, are the current source in one type of cathodic protection.

Galvanic Corrosion. An accelerated form of corrosion occurring in an electrolyte when a pair of dissimilar metals capable of acting together as a source of electricity are in contact with each other.

Galvanic Potential. A quantity in an electrical field measured (in volts) with reference to some arbitrary level of potential, such as a reference electrode.

Generating Area. In wave forecasting, the continuous area of water surface over which the wind blows in nearly a constant direction. Sometimes used synonymously with Fetch Length. Also Fetch.

Generation of Waves. (1) The creation of waves by natural or mechanical means. (2) The creation and growth of waves caused by a wind blowing over a water surface for a certain period of time. The area involved is called the Generating Area or Fetch.

Geometric Mean Diameter. The diameter equivalent of the arithmetic mean of the logarithmic frequency distribution. In the analysis of beach sands, it is taken as that grain diameter determined graphically by the intersection of a straight line through selected boundary sizes, (generally points on the distribution curve where 16 and 84 percent of the sample is coarser by weight) and a vertical line through the median diameter of the sample.

Geometric Shadow. In wave diffraction theory, the area outlined by drawing straight lines paralleling the direction of wave approach through the extremities of a protective structure. It differs from the actual protected area to the extent that the diffraction and refraction effects modify the wave pattern.

Geomorphology. That branch of both physiography and geology which deals with the form of the Earth, the general configuration of its surface, and the changes that take place in the evolution of landform.

Girder. A large-sized beam used as a main structural member, normally for the support of other beams

Grade. Any of the quality classes into which lumber products are segregated.

Grade mark. Identification of lumber with symbols or lettering to certify its quality of grade, which is based on the presence or absence of defects such as knots, checks, or decay.

Gradient (Grade). See Slope. With reference to winds or currents, the rate of increase or decrease in speed, usually in the vertical; or the curve that represents this rate.

Grain. The direction, size arrangement, appearance, or quality of the fibers in wood.

Grain, close. Wood with narrow and inconspicuous annual rings. The term is sometimes used to designate wood having small and closely spaced pores, but in this sense the term "fine texture" is more often used.

Grain, coarse. Wood with wide and conspicuous annual rings in which there is considerable difference between springwood and summerwood. The term is also used to designate wood with large pores, but in this sense the term "coarse textured" is more often used.

Grain, cross. Wood in which the cells or fibers do not run parallel with the axis or sides of a piece.

Grain, diagonal. Wood in which the annual rings are at an angle with the axis of a piece as a result of sawing at an angle to the axis of the tree.

Grain, edge. Wood in which the rings (so-called grain) form an angle of 45 degrees or more with the surface of the piece; also called "vertical grain" and "quarter sawn".

Grain, flat. Wood in which the rings form an angle of less than 45 degrees with the surface of the piece; also "plain sawn".

Grain, interlocking. Wood in which the fibers are inclined in one direction in a number of rings of annual growth, then gradually reverse and are inclined in an opposite direction in succeeding growth rings, then reverse again.

Grain, open. Common classification of painters for wood with large pores; also called "coarse textured".

Grain, plain-sawn. Another term for flat grain, used generally in hardwoods

Grain, quarter-sawn. Another term for edge grain, used generally in hardwoods.

Grain, spiral. A type of growth in which the fibers take a spiral course about the bole of a tree instead of the normal vertical course. The spiral may extend right handed or left handed around the trunk.

Grain, vertical. Another term for edge grain.

Grain, wavy. Wood in which the fibers collectively take the form of waves or undulations.

Gravel. See Soil Classification.

Gravity Wall. A retaining structure that obtains stability through its own weight.

Gravity Wave. A wave whose velocity of propagation is controlled primarily by gravity. Water waves more than 2 inches long are considered gravity waves. Waves longer than 1 inch and shorter than 2 inches are in an indeterminate zone between Capillary and Gravity Waves. See Ripple.

Green. Unseasoned, wet.

Greenheart. A tropical wood used in marine construction, resistant to marine borer attack.

Greensalt. Chromated copper arsenate (CCA).

Gribble. The common name for the crustacean borer, Limnoria.

Groin (British, Groyne). A narrow structure projecting out from the shoreline, usually at close to a right-angle. It is designed to influence offshore currents and wave action in a manner that will minimize erosion of the shoreline.

Groin System. A series of groins acting together to protect a section of beach. Commonly called a groin field.

Ground-penetrating radar (GPR). A geophysical method that uses radar pulses to image the subsurface. This nondestructive method uses electromagnetic radiation in the microwave band (UHF/VHF frequencies) of the radio spectrum and detects the reflected signals from subsurface structures. GPR can be used in several media, including rock, soil, ice, freshwater, pavements, and structures. It can detect objects, changes in material, and voids and cracks.

Ground Swell. A long high ocean swell; also, this swell as it rises to prominent height in shallow water.

Ground Water. Subsurface water occupying the zone of saturation. In a strict sense, the term is applied only to water below the Water Table.

Group Velocity. The velocity of a wave group. In deep water, it is equal to one-half the velocity of the individual waves within the group.

Grout. Traditionally, a mixture of portland cement and fine aggregate to which is added enough water to make a fluid mixture. Epoxy-resin grouts are also widely available.

Gulf. A large embayment in a coast; the entrance is generally wider than the length.

Gunite. See "Shotcrete."

Gut. (1) A narrow passage such as a strait or inlet. (2) A channel in otherwise shallower water, generally formed by water in motion.

H-Pile. A pile with a cross-section consisting of a web centered on two flanges.

Harbor. In general, a sheltered arm of the sea, easily accessible to maritime routes in which ships may seek refuge, transfer cargo, or undergo repair.

Harbor (British, Harbour). Any protected water area affording a place of safety for vessels. See also Port.

Harbor Oscillation (Harbor Surging). The non-tidal vertical water movement in a harbor or bay. Usually the vertical motions are low; but when oscillations are excited by a tsunami or storm surge, they may be quite large. Variable winds, air oscillations, or surf beat also may cause oscillations. See Seiche.

Hardwoods. The botanical group of trees that are broadleaved. The term has no reference to the actual hardness of the wood.

Headland (Head). A high, steep-faced promontory extending into the sea.

Head Of Rip. The part of a rip current that has widened out seaward of the breakers. See also Current, Rip; Current, Feeder; and Neck (Rip).

Heartwood. The inner core of a woody stem, extending from the center to sapwood and usually of darker color.

Heavy timber construction. Construction composed of planks or laminated floors supported by beams or girders.

Height of Wave. See Wave Height.

Helical anchors. Screwed-in steel anchoring systems used for columns, tie backs, marina anchoring systems, and pipeline tie downs.

High marsh: Upper zone of a salt marsh that is flooded irregularly and generally located between mean high water and extreme high water (mean high high water).

High Tide, High Water (HW). The maximum elevation reached by each rising tide. See Tide.

High Water. See High Tide.

High Water Line. In strictness, the intersection of the plane of mean high water with the shore. The shoreline delineated on the nautical charts of the National Ocean Service is an approximation of the high water line. For specific occurrences, the highest elevation on the shore reached during a storm or rising tide, including meteorological effects.

High Water of Ordinary Spring Tides (HWOST). A tidal datum appearing in some British publications, based on high water of ordinary spring tides.

Higher High Water (HHW). The higher of the two high waters of any tidal day. The single high water occurring daily during periods when the tide is diurnal is considered to be a higher high water.

Higher Low Water (HLW). The higher of two low waters of any tidal day.

Hindcasting, Wave. The use of historic synoptic wind charts to calculate characteristics of waves that probably occurred at some past time.

Honeycombs. Voids or hollows in the concrete.

Hook. A spit or narrow cape of sand or gravel which turns landward at the outer end.

Hotel services. Dockside utilities provided for a ship at a berth (also called "ship's services," "utility services," and "cold iron services").

Hurricane. An intense tropical cyclone in which winds tend to spiral inward toward a core of low pressure, with maximum surface wind velocities that equal or exceed 33.5 meters per second (75 mph or 65 knots) for several minutes or longer at some points. TROPICAL STORM is the term applied if maximum winds are less than 33.5 meters per second.

Hurricane Path or Track. Line of movement (propagation) of the eye through an area.

Hurricane Stage Hydrograph. A continuous graph representing water level stages that would be recorded in a gage well located at a specified point of interest during the passage of a particular hurricane) assuming that effects of relatively short-period waves are eliminated from the record by damping features of the gage well. Unless specifically excluded and separately accounted for, hurricane surge hydrographs are assumed to include effects of astronomical tides, barometric pressure differences, and all other factors that influence water level stages within a properly designed gage well located at a specified point.

Hurricane Surge Hydrograph. A continuous graph representing the difference between the hurricane stage hydrograph and the water stage hydrograph that would have prevailed at the same point and time if the hurricane had not occurred.

Hurricane Wind Pattern or Isovel Pattern. An actual or graphical representation of near-surface wind velocities covering the entire area of a hurricane at a particular instant. Isovels are lines connecting points of simultaneous equal wind velocities, usually referenced 9 meters (30 feet) above the surface, in meters per second, knots, or meters per hour; wind directions at various points are indicated by arrows or deflection angles on the isovel charts. Isovel charts are usually prepared at each hour during a hurricane, but for each half hour during critical periods.

Hydraulically Equivalent Grains. Sedimentary particles that settle at the same rate under the same conditions.

Hydrographic (Bathymetric) Survey. A study of an area of water to establish water depths and bottom contours.

Hydrography. (1) A configuration of an underwater surface including its relief, bottom materials, coastal structures, etc. (2) The description and study of seas, lakes, rivers, and other waters.

Hydrology. The study of the movement, distribution, and quality of water throughout the Earth.

Imbed. See "embed".

Impermeable Groin. A groin through which sand cannot pass.

Impressed Current. Electrical direct current energy impressed upon a metallic structure to depress its potential to a level lower than normal corrosion potentials, thus reversing current flow and curtailing corrosion of the member.

Increment Borer. A tool for extracting a small plug from a timber element.

Indian Spring Low Water. The approximate level of the mean of lower low waters at spring tides, used principally in the Indian Ocean and along the east coast of Asia. Also Indian Tide Plane.

Indian Tide Plane. The datum of Indian Spring Low Water.

Inertial measurement unit (IMU). An electronic device that measures and reports on a craft's velocity, orientation, and gravitational forces, using a combination of accelerometers and gyroscopes, sometimes also magnetometers,

Infilling. The somewhat slow replacement of scoured-out material with softer, finer silt.

Inland. That part of the land above the waterline (shore line).

Inlet. (1) A short, narrow waterway connecting a bay, lagoon, or similar body of water with a large parent body of water. (2) An arm of the sea (or other body of water) that is long compared to its width and may extend a considerable distance inland. See also Tidal Inlet.

Inlet Gorge. Generally, the deepest region of an inlet channel.

Inshore. Term used to distinguish an object or an area from another by its nearer proximity to the shoreline.

Inshore (Zone). In beach terminology, the zone of variable width extending from the low water line through the breaker zone. Also Shoreface.

Inshore Current. Any current in or landward of the breaker zone.

Inspection (of construction materials). The scrutiny and supervision of the purchasing, acquiring, manufacturing, treating, and handling of material for compliance with specification requirements

Inspection (of structures). The method by which structures are examined for determination of the presence and extent of deterioration.

Insular Shelf. The zone surrounding an island extending from the low water line to the depth (usually about 183 meters (100 fathoms)) where there is a marked or rather steep descent toward the great depths.

Intake structure. At the opposite end of the conduit from the discharge end; can be of the same materials as the discharge.

Interlock. The connection or joint between two adjacent steel sheet piles

Internal Waves. Waves that occur within a fluid whose density changes with depth, either abruptly at a sharp surface of discontinuity (an interface), or gradually. Their amplitude is greatest at the density discontinuity or, in the case of a gradual density change, somewhere in the interior of the fluid and not at the free upper surface where the surface waves have their maximum amplitude.

Intertidal. The area between mean low water and mean high water.

Investigation. To inspect carefully, systematically, and thoroughly a complex or hidden structure and to evaluate or set the value of the structure and/or repairs needed.

Ion. An electrically charged atom or group of atoms.

Irrotational Wave. A wave with fluid particles that do not revolve around an axis through their centers, although the particles themselves may travel in circular or nearly circular orbits. Irrotational waves may be Progressive, Standing, Oscillatory, or Translatory. For example, the Airy, Stokes, cnoidal, and solitary wave theories describe irrotational waves. Compare Trochoidal Wave.

Isobath. A contour line connecting points of equal water depths on a chart.

Isopod. A smaller division (order) of the larger group (class) of invertebrates known as Crustacea, which includes Limnoria and Sphaeroma.

Isovel Pattern. See Hurricane Wind Pattern.

Isthmus. A narrow strip of land, bordered on both sides by water that connects two larger bodies of land.

Jet. To place (a pile, slab, or pipe) in the ground by means of a jet of water acting at the lower end.

Jetty. A dock or breakwater that projects into the water to prevent formation of sandbars, normally located near harbor entrances and river estuaries

Jewelry. The hardware fittings on a buoy to which the mooring lines/chains are attached.

Joists and planks. Lumber of rectangular cross section, from 2 in. up to but not including 5 in. thick, and 4 in. or more wide, graded with respect to its strength in bending when loaded either on the narrow face (joist) or on the wide face (plank). If 5 in. or more thick, the lumber is known as beams and stringers.

Kenter joining link. Constructed in three parts: two half links and a stud. The stud slides in place and locks the whole link. The stud is secured by hammering a tapered pin into the hole drilled diagonally through all three parts of the joining link.

Kerf. The width of the cut produced during a cutting process.

Key. A wedge in rock used as an anchor.

Kiln-dried. Lumber or other materials that have been dried in drying kilns to a moisture content, usually below that obtained in air drying, by the application of artificially supplied controlled heat, humidity, and air circulation.

Kinetic Energy (of Waves). In a progressive oscillatory wave, a summation of the energy of motion of the particles within the wave.

Knoll. A submerged elevation of rounded shape rising less than 1000 meters from the ocean floor and of limited extent across the summit. Compare Seamount.

Knot. The unit of speed used in navigation equal to 1 nautical mile (6,076.115 feet or 1,852 meters) per hour.

Lagging. See Tides, Daily Retardation Of.

Lagoon. A shallow body of water, like a pond or lake, usually connected to the sea.

Laitance. Soft, punky weak layer of cement and aggregate fines on a concrete surface that is usually caused by an overwet mixture, overworking the mixture, improper excessive finishing, combination thereof, or on concrete during tremie pours. Often found in layers at the face of concrete piers/abutments.

Laitant Concrete. A condition created when concrete that is pumped underwater is not allowed to overflow the formwork. This causes the upper layers of concrete to cure with too high a water content.

Laminate. A single layer of wood or plastic in an assembly of layers.

Land Breeze. A light wind blowing from the land to the sea, caused by unequal cooling of land and water masses.

Land-Sea Breeze. The combination of a land breeze and a sea breeze as a diurnal phenomenon.

Landlocked. Enclosed, or nearly enclosed, by land--thus protected from the sea, as a bay or a harbor.

Landmark. A conspicuous object, natural or artificial, located near or on land, which aids in fixing the position of an observer.

Leaching. The process of removing a soluble substance from a heterogeneous material by means of a solvent (usually water).

Lead Line. A line, wire, or cord used in sounding. It is weighted at one end with a plummet (sounding lead). Also Sounding Line.

Lead wool. Lead that is spun to form a wool-like material and pounded into masonry joints that are still found in older structures.

Lee. (1) Shelter, or the part or side sheltered or turned away from the wind or waves. (2) (Chiefly nautical) The quarter or region toward which the wind blows.

Leeward. The direction toward which the wind is blowing; the direction toward which waves are traveling.

Length of Wave. The horizontal distance between similar points on two successive waves measured perpendicularly to the crest.

Levee. A dike or embankment to protect land from inundation.

Lighterage. Small craft designed to transport cargo or personnel from ship to shore; includes amphibians, landing craft, discharge lighters, causeways, and barges.

Limit of Backrush (Limit of Backwash). See Backrush, Backwash.

Limnoria. The common "gribble," a genus of Crustacea borers causing serious destruction to marine structures.

Littoral. Of or pertaining to a shore, especially of the sea.

Littoral Current. See Current, Littoral.

Littoral Deposits. Deposits of littoral drift.

Littoral Drift. The sedimentary material moved in the littoral zone under the influence of waves and currents.

Littoral Transport. The movement of littoral drift in the littoral zone by waves and currents. Includes movement parallel (longshore transport) and perpendicular (on-offshore transport) to the shore.

Littoral Transport Rate. Rate of transport of sedimentary material parallel or perpendicular to the shore in the littoral zone. Usually expressed in cubic meters (cubic yards) per year. Commonly synonymous with Longshore Transport Rate.

Littoral Zone. In beach terminology, an indefinite zone extending seaward from the shoreline to just beyond the breaker zone.

Load. The quantity of sediment transported by a current. It includes the suspended load of small particles and the bedload of large particles that move along the bottom.

Loading Platform. A structure used to support cargo transfer equipment and ancillary facilities. Usually one of the structures that make up a tanker berth.

Locks. An enclosed chamber in a canal, dam, etc. with gates at each end, for raising or lowering vessels from one level to another by admitting or releasing water.

Longshore. Parallel to and near the shoreline; Alongshore.

Longshore Bar. A bar running roughly parallel to the shoreline.

Longshore Current. See Current, Longshore.

Longshore Transport Rate. Rate of transport of sedimentary material parallel to the shore. Usually expressed in cubic meters (cubic yards) per year. Commonly synonymous with Littoral Transport Rate.

Loop. That part of a Standing Wave where the vertical motion is greatest and the horizontal velocities are least. Loops (sometimes called Antinodes) are associated with Clapoti and with Seiche action resulting from wave reflections. Compare Node.

Low Level Platform. A type of wharf construction where the structural deck is at or near the waterline and on which fill is placed to achieve the finished surface elevation.

Low Marsh: Intertidal or lower marsh in sal marsh that is located in the intertidal zone and is flooded daily.

Low Tide (Low Water, LW). The minimum elevation reached by each falling tide. See Tide.

Low Water Datum. An approximation to the plane of mean low water that has been adopted as a standard reference plane. See also Datum, Plane and Chart Datum.

Low Water Line. The intersection of any standard low tide datum plane with the shore.

Low Water of Ordinary Spring Tides (LWOST). A tidal datum appearing in some British publications, based on low water of ordinary spring tides.

Lower High Water (LHW). The lower of the two high waters of any tidal day.

Lower Low Water (LLW). The lower of the two low waters of any tidal day. The single low water occurring daily during periods when the tide is diurnal is considered to be a lower low water.

Magnesium. A metal that may be used as a sacrificial anode in cathodic protection against corrosion

Mangrove. A tropical tree with interlacing prop roots, confined to low-lying brackish areas.

Marigram. A graphic record of the rise and fall of the tide.

Marine Borer. Any of a number of species of organisms in seawater that attacks untreated or poorly treated wood; especially active in warm waters.

Marine organisms. Living entities normally found in natural waters containing measurable salinity.

Marsh: A frequently flooded or continuously inundated wetland characterized by emergent herbaceous vegetation adapted to saturate soil conditions.

Marsh. An area of soft, wet, or periodically inundated land, generally treeless and usually characterized by grasses and other low growth.

Marsh, Salt. A marsh periodically flooded by salt water.

Masonry. A structure built with stones, bricks, and other materials, usually held together with mortar.

Mass Transport. The net transfer of water by wave action in the direction of wave travel. See also Orbit.

Mean Diameter, Geometric. See Geometric Mean Diameter.

Mean high water (MHW). A tidal datum: the average of all the high water heights observed over the National Tidal Datum Epoch

Mean High Water (MHW). The average height of the high waters over a 19-year period. For shorter periods of observations, corrections are applied to eliminate known variations and reduce the results to the equivalent of a mean 19-year value. All high water heights are included in the average where the type of tide is either semidiurnal or mixed. Only the higher high water heights are included in the average where the type of tide is diurnal. So determined, mean high water in the latter case is the same as mean higher high water.

Mean Higher High Water (MHHW). The average height of the higher high waters over a 19-year period. For shorter periods of observation, corrections are applied to eliminate known variations and reduce the result to the equivalent of a mean 19-year value.

Mean High Water Springs. The average height of the high waters occurring at the time of spring tide. Frequently abbreviated to High Water Springs.

Mean low water (MLW). The average of all the low water heights observed over the National Tidal Datum Epoch.

Mean Low Water Springs. The average height of low waters occurring at the time of the spring tides. It is usually derived by taking a plane depressed below the half-tide level by an amount equal to one-half the spring range of tide, necessary corrections being applied to reduce the result to a mean value. This plane is used to a considerable extent for hydrographic work outside of the United States and is the plane of reference for the Pacific approaches to the Panama Canal. Frequently abbreviated to Low Water Springs.

Mean Lower Low Water (MLLW). The average height of the lower low waters over a 19-year period. For shorter periods of observations, corrections are applied to eliminate known variations and reduce the results to the equivalent of a mean 19-year value. Frequently abbreviated to Lower Low Water.

Mean sea level (MSL). The arithmetic mean of hourly heights observed over the National Tidal Datum Epoch.

Mean Sea Level. The average height of the surface of the sea for all stages of the tide over a 19-year period, usually determined from hourly height readings. Not necessarily equal to Mean Tide Level.

Mean Tide Level. A plane midway between Mean High Water and Mean Low Water. Not necessarily equal to Mean Sea Level. Also Half-Tide Level.

Median Diameter. The diameter which marks the division of a given sand sample into two equal parts by weight, one part containing all grains larger than that diameter and the other part containing all grains smaller.

Megaripple. See Sand Wave.

Microbial-induced corrosion (MIC). Caused by the presence of microbes whose metabolism produces acids and sulfides; microbes and their by-products in the presence of metals can produce a film conducive to accelerated local corrosion.

Middle-Ground Shoal. A shoal formed by ebb and flood tides in the middle of the channel of the lagoon or estuary end of an inlet.

Mill scale. The heavy oxide layer resulting from hot fabrication or heat treatment of metals.

Minimum Duration. See Duration, Minimum.

Minimum Fetch. The least distance in which steady-state wave conditions will develop for a wind of given speed blowing a given duration of time.

Mitigation wetland: A wetland constructed to replace the functions lost by human development, usually in the same or adjacent watershed.

Mixed Tide. A type of tide in which the presence of a diurnal wave is conspicuous by a large inequality in either the high or low water heights, with two high waters and two low waters usually occurring each tidal day. In strictness, all tides are mixed, but the name is usually applied without definite limits to the tide intermediate to those predominantly semidiurnal and those predominantly diurnal.

Moisture content. As related to wood, the weight of water contained in wood, usually expressed as a percentage of the oven-dry weight of the wood.

Moisture, free. Moisture that is held inside the cell cavities of wood in contrast to that within the cell walls.

Mole. In coastal terminology, a massive land-connected, solid-fill structure of earth (generally revetted), masonry, or large stone, which may serve as a breakwater or pier.

Mollusca. One of the 11 main divisions (phylla) used in animal classification that includes several of the destructive marine borers.

Monochromatic Waves. A series of waves generated in a laboratory; each wave has the same length and period.

Monolithic. Like a single stone or block. In coastal structures, the type of construction in which the structure's component parts are bound together to act as one.

Monopile dolphin. A single pile dolphin usually consisting of a large diameter concrete or steel pipe pile filled with concrete, used as a mooring or breasting dolphin.

Mooring Dolphin. A structure that supports fittings to which a vessel's mooring lines are secured.

Mud. A fluid-to-plastic mixture of finely divided particles of solid material and water.

Mudline. General term used in marine engineering to designate the elevation of the seabed or riverbed.

Multibeam. A device typically used by hydrographic surveyors to determine the depth of water and the nature of the sea bed. Most modern systems work by transmitting a broad acoustic fan-shaped pulse from a specially designed transducer across the full swath across track with a narrow along track then forming multiple receive beams (beamforming) that is much narrower in the across track (around 1 degree depending on the system). From this narrow beam a two-way travel time of the acoustic pulse is then established utilizing a bottom detection algorithm. If the speed of sound in water is known for the full water column profile, the depth and position of the return signal can be determined from the receive angle and the two-way travel time.

Mushroomed. The head of a pile that has been subjected to excessive axial load and/or deterioration such that the timber fibers have separated, causing the pile head to flatten, resulting in reduced load capacity.

Mussels. Molluscan fouling organisms.

Nacerda. A beetle that can cause damage to the superstructure of wharves.

Nail, dating. A nail with a date or symbol on its head that is driven into wood to indicate the year of treatment, or the date of installation.

National Geodetic Vertical Datum (NGVD). Reference mean sea level elevation measured in 1929.

National Tidal Datum Epoch (NTDE). The specific 19-year period adopted by the National Ocean Service as the official time segment over which tide observations are taken and reduced to obtain mean values (e.g., mean lower low water, etc.) for tidal data. It is necessary for standardization because of periodic and apparent secular trends in sea level. The present NTDE is 1983 through 2001 and is actively considered for revision every 20 to 25 years. Tidal data in certain regions with anomalous sea level changes (Alaska, Gulf of Mexico) are calculated on a Modified 5-Year Epoch.

Nautical Mile. The length of a minute of arc, 1/21,600 of an average great circle of the Earth. Generally one minute of latitude is considered equal to one nautical mile. The accepted United States value as of 1 July 1959 is 1,852 meters (6,076.115 feet), approximately 1.15 times as long as the U.S. statute mile of 5,280 feet. Also geographical mile.

Neap Tide. A tide occurring near the time of quadrature of the moon with the sun. The neap tidal range is usually 10 to 30 percent less than the mean tidal range.

Nearshore. Area of the water next to the shoreline.

Nearshore Circulation. The ocean circulation pattern composed of the Currents, Nearshore and Currents, Coastal. See Current.

Nearshore Current System. The current system caused primarily by wave action in and near the breaker zone, and which consists of four parts: the shoreward mass transport of water; longshore currents; seaward return flow, including rip currents; and the longshore movement of the expanding heads of rip currents. See also Nearshore Circulation.

Neat cement. Cement mortar without added sand.

Neck. (1) The narrow band of water flowing seaward through the surf. Also RIP. (2) The narrow strip of land connecting a peninsula with the mainland.

Nip. The cut made by waves in a shoreline of emergence.

Nodal Zone. An area in which the predominant direction of the Longshore Transport changes.

Node. That part of a Standing Wave where the vertical motion is least and the horizontal velocities are greatest. Nodes are associated with Clapotis and with Seiche action resulting from wave reflections. Compare Loop.

Nominal dimension. The dimension of lumber corresponding approximately to the size before dressing to actual size and used for convenience in defining size and in computing quantities.

Nonbearing pile. A pile that is not connected to a pile cap such that the pile is not carrying any axial load.

Noncohesive Soil. A soil that resists deformation by the mechanical interlocking of its particles (gravel, sand, silt).

Nondestructive testing (NDT). Testing such as ultrasonic thickness measurement of steel.

Nourishment. The process of replenishing a beach. It may be brought about naturally by longshore transport, or artificially by the deposition of dredged materials.

Oak. A species of hardwood used in waterfront structures.

Oceanography. The study of the sea, embracing and indicating all knowledge pertaining to the sea's physical boundaries, the chemistry and physics of seawater, and marine biology.

Offshore. Term used to designate the direction of something moving away from land. On marine structures the term is used to distinguish a thing or an area from another by its further proximity from the shoreline.

Offshore Barrier. See Barrier Beach.

Offshore Current. (1) Any current in the offshore zone. (2) Any current flowing away from shore.

Offshore Wind. A wind blowing seaward from the land in the coastal area.

Ogee washer. A special cast washer used in waterfront construction to distribute the load from a bolt and nut to a timber face to prevent the wood from being crushed as the nut is tightened.

Oil borne. Chemical capable of dissolving in an oil solvent.

Onshore. Designates the direction of something moving onto or toward the shore, as well as something situated or operating on land.

Onshore Wind. A wind blowing landward from the sea in the coastal area.

Opposing Wind. In wave forecasting, a wind blowing in a direction opposite to the oceanwave advance; generally, a headwind.

Opposite hand. Mirror image.

Orbit. In water waves, the path of a water particle affected by the wave motion. In deepwater waves the orbit is nearly circular, and in shallow-water waves the orbit is nearly elliptical. In general, the orbits are slightly open in the direction of wave motion, giving rise to Mass Transport.

Orbital Current. The flow of water accompanying the orbital movement of the water particles in a wave. Not to be confused with wave-generated Littoral Currents.

Orthogonal. On a wave-refraction diagram, a line drawn perpendicularly to the wave crests. Wave Ray.

Oscillation. (1) A periodic motion backward and forward. (2) Vibration or variance above and below a mean value.

Oscillatory Wave. A wave in which each individual particle oscillates about a point with little or no permanent change in mean position. The term is commonly applied to progressive oscillatory waves in which only the form advances, the individual particles moving in closed or nearly closed orbits. Compare Wave Of Translation. See also Orbit.

Outfall. A structure extending into a body of water for the purpose of discharging sewage, storm runoff, or cooling water.

Overburden. Soil that is above another strata of soil or an object.

Overtopping. Passing of water over the top of a structure as a result of wave runup or surge action.

Overwash. That portion of the uprush that carries over the crest of a berm or of a structure.

Oxidation (metal members). The loss of electrons by the atoms making up a metal member, typically ferrous, initiating the corrosion process.

Pachometer. A device designed to specifically locate reinforcing steel in concrete and to assist in the determination of the size of the hidden reinforcing steel.

Parapet. A low wall built along the edge of a structure such as a seawall or quay.

Partially destructive testing (PDT). Tests carried out to the specimen's failure to understand a specimen's structural performance or material behavior under different loads. These tests are generally much easier to carry out, yield more information, and are easier to interpret than nondestructive testing. Examples of specimens may be concrete cores or steel coupons taken from existing structures.

Particle Velocity. The velocity induced by wave motion with which a specific water particle moves within a wave.

Pass. In hydrographic usage, a navigable channel through a bar, reef, or shoal, or between closely adjacent islands.

Passivation. In physical chemistry and engineering, refers to a material becoming "passive," that is, being less affected by environmental factors such as air or water. It involves a shielding outer layer of corrosion that can be applied as a microcoating or found occurring spontaneously in nature.

Pebbles. See Soil Classification.

Penetration. The depth to which preservative enters the wood.

Peninsula. An elongated body of land nearly surrounded by water and connected to a larger body of land.

Penstock. Enclosed pipe that delivers water to hydraulic turbines or sewerage systems

Penta preservative. A wood-preserving solution made of pentachlorophenol, C_6Cl_5OH, dissolved in hydrocarbon solvent. Often an auxiliary solvent is added to increase the solubility of the "penta."

Pentachlorophenol. A toxic chemical preservative particularly effective against destructive fungi.

Perched Beach. A beach or fillet of sand retained above the otherwise normal profile level by a submerged dike.

Percolation. The process by which water flows through the interstices of a sediment. Specifically, in wave phenomena, the process by which wave action forces water through the interstices of the bottom sediment and which tends to reduce wave heights.

Periodic Current. A current caused by the tide-producing forces of the moon and the sun; a part of the same general movement of the sea that is manifested in the vertical rise and fall of the tides. See also Current, Flood and Current, Ebb.

Permanent Current. A current that runs continuously, independent of the tides and temporary causes. Permanent currents include the freshwater discharge of a river and the currents that form the general circulatory systems of the oceans.

Permeable Groin. A groin with openings large enough to permit passage of appreciable quantities of Littoral Drift.

Petrographic analysis. For concrete this analysis is used to determine the quality of the aggregate, concrete paste, bonding, etc.

Petrography. The systematic description and classification of rocks.

Petroleum, oil, lubricant (POL). A broad term used to describe all petroleum-containing products.

Pfisteria. A skin and nervous system disease that may be passed to human beings by infected fish. Symptoms in fish are massive fish kills and ulcerated lesions in the fish.

Phase. In surface wave motion, a point in the period to which the wave motion has advanced with respect to a given initial reference point.

Phase Inequality. Variations in the tides or tidal currents associated with changes in the phase of the Moon in relation to the Sun.

Phase Velocity. Propagation velocity of an individual wave as opposed to the velocity of a wave group.

Phi Grade Scale. A logarithmic transformation of the Wentworth grade scale for size classifications of sediment grains based on the negative logarithm to the base 2 of the particle diameter: $\phi = -\log2d$. See Soil Classification.

Pholad. A molluscan marine borer.

Photogrammetry. The science of making measurements from photographs.

Pier. An open- or closed-type structure usually extending perpendicularly from the shore into sheltered navigable water, designed for berthing, loading or unloading cargo, repair, fueling, and general servicing of vessels. It normally provides berthing space on both sides for its entire length.

Pierhead. The end of a pier furthest offshore. The pierhead line indicates the limits a pier can protrude into navigable waters.

Pile. A long, slender timber, steel, or reinforced concrete structural element driven, jetted, or otherwise embedded into the ground to support a vertical load, to resist a lateral force, or to resist water or earth pressure.

Pile adrift. An old or structurally inadequate pile that has been abandoned for load-carrying capacity and is generally not connected to other members in the structure

Pile bent. See “bent”.

Pile Cap. The horizontal structural member atop a row of piles or sheet piles. The cap aligns and secures the piles, and transfers loading from the deck to the piles.

Pile Cluster. A grouping of piles designed to support concentrated loads.

Pilehead. The top (driven end) of a pile.

Pile, marine. A pile that is partly embedded in bottom soil and partly exposed to salt seawater

Pile, Sheet. A pile with a generally slender flat cross section to be driven into the ground or seabed and meshed or interlocked with like members to form a diaphragm, wall, or bulkhead.

Pile Toe. The bottom (penetrating end) of a pile. Also known as the "tip" or "foot".

Pile top cap. Any cover fastened over the cut surface of a pile to prevent exposure to the atmosphere.

Piling. A group of piles.

Pipe Pile. A hollow metal pile with a circular cross-section. The pile can be filled to provide additional strength.

Pit. A localized area of a ferrous metal surface where the extent of metal loss due to corrosion is much greater than that in the surrounding area.

Plain, Coastal. See Coastal Plain.

Planform. The outline or shape of a body of water as determined by the still-water line.

Plateau. A land area (usually extensive) having a relatively level surface raised sharply above adjacent land on at least one side; table land. A similar undersea feature.

Plug, tie. A wood plug used for filling an old spike hole. The plug is usually treated with preservative.

Plumbness. The quality or state of being plumb or vertical.

Plunge Point. (1) For a plunging wave, the point at which the wave curls over and falls. (2) The final breaking point of the waves just before they rush up on the beach.

Plunging Breaker. See Breaker.

Pocket Beach. A beach, usually small, in a coastal reentrant or between two littoral barriers.

Point. The extreme end of a cape; the outer end of any land area protruding into the water, usually less prominent than a cape.

Pointing. Filling joints or defects in the face of a masonry structure.

Polychlorinated biphenyls (PCBs). A carcinogenic chemical compound formerly used as insulating and cooling liquids in electrical equipment often found in sediments where waste products from industry have been released into the water. A PCB count is now required, prior to all dredging operations.

Polyethylene. A plastic material used for sheathing.

Polyvinyl chloride (PVC). A plastic material used for sheathing.

Pop-outs. Shallow, cone-shaped holes in the surface of the concrete.

Port. An expanded opening in a crack that allows grout to be introduced into the crack.

Port. A place where vessels may discharge or receive cargo; it may be the entire harbor including its approaches and anchorages, or only the commercial part of a harbor where the quays, wharves, facilities for transfer of cargo, docks, and repair shops are situated.

Post. A piece of timber used to replace a portion of a pile that has deteriorated or been damaged.

Posts and timbers. Lumber of square or approximately square crosssection, 5 × 5 and larger, graded primarily for use as posts or columns carrying axial load.

Potential Energy of Waves. In a progressive oscillatory wave, the energy resulting from the elevation or depression of the water surface from the undisturbed level.

Pounds per cubic foot (PCF). A way of expressing a material's density, weight divided by volume.

Pounds per square inch (PSI). Unit of pressure.

Pounds per square inch absolute (PSIA). Pressure measured relative to a vacuum.

Pounds per square inch gauge (PSIG). A unit of pressure relative to the surrounding atmosphere.

Preservative. A chemical compound that creates a protective mechanism against destructive organisms.

Preservative, oil-borne. A wood preservative that is introduced into wood in the form of a solution in oil.

Preservative, oil type. Preservatives such as creosote, creosote-coal tar solutions, creosote-petroleum solutions, and oil-borne preservatives, or other preservatives strictly of an oily nature that are generally insoluble in water.

Preservative, waterborne. A wood preservative that is introduced into wood in the form of a solution in water.

Preservative, water repellent. A solution of one or more chemicals and water-repellent materials that preserves the wood and retards changes in moisture content and the accompanying changes in dimensions.

Preservative, wood. The term "preservative" is intended to include such chemicals or combinations thereof that will protect wood against deterioration from any one or combination of the following: decay, insects, marine borers, fire, weathering, absorption of water, and chemical action.

Pressure treatment. Impregnation of wood with a preservative applied under pressure.

Pretreatment seasoning. The removal of water from the wood before treatment to make the entrance and retention of the preservative possible.

Prism. See Tidal Prism.

Probable Maximum Water Level. A hypothetical water level (exclusive of wave runup from normal wind-generated waves) that might result from the most severe combination of hydrometeorological, geoseismic, and other geophysical factors and that is considered reasonably possible in the region involved, with each of these factors considered as affecting the locality in a maximum manner. This level represents the physical response of a body of water to maximum applied phenomena such as hurricanes, moving squall lines, other cyclonic meteorological events, tsunamis, and astronomical tide combined with maximum probable ambient hydrological conditions such as wave setup, rainfall, runoff, and river flow. It is a water level with virtually no risk of being exceeded.

Probing. The penetrating through the surface with a probe to detect deterioration.

Profile, Beach. The intersection of the ground surface with a vertical plane; may extend from the top of the dune line to the seaward limit of sand movement.

Progression (of a beach). See Advance.

Progressive Wave. A wave that moves relative to a fixed coordinate system in a fluid. The direction in which it moves is termed the direction of wave propagation.

Promontory. A high point of land projecting into a body of water; a Headland.

Propagation of Waves. The transmission of waves through water.

Prototype. In laboratory usage, the full-scale structure, concept, or phenomenon used as a basis for constructing a scale model or copy.

Pulse velocity/pulse echo testing. Use of ultrasonic signals for measuring distances/ thickness.

Punky. An area of decay in a timber member exhibiting a soft spongy appearance; structural integrity is lost in these areas.

Punt. A small flat bottomed boat with square ends.

Quarrystone. Any stone processed from a quarry.

Quay (Pronounced Key). A stretch of paved bank, or a solid artificial landing place parallel to the navigable waterway, for use in loading and unloading vessels.

Quaywall. Any one of a number of wharf constructions consisting of a soil retaining bulkhead and a narrow platform.

Quicksand. Loose, yielding, wet sand which offers no support to heavy objects. The upward flow of the water has a velocity that eliminates contact pressures between the sand grains and causes the sand-water mass to behave like a fluid.

Radius of Maximum Winds. Distance from the eye of a hurricane, where surface and wind velocities are zero, to the place where surface wind speeds are maximum.

Ray, Wave. See Orthogonal.

Rebar. Abbreviation for "Reinforcing Bar," the steel bar used to reinforce concrete.

Recession (of a beach). (1) A continuing landward movement of the shoreline. (2) A net landward movement of the shoreline over a specified time. Also Retrogression.

Rectifier. An external d.c. energy source that impresses electrical current upon a protected structure as part of an impressed current cathodic protection system. Commonly located on the deck of a marine structure.

Reef. An offshore consolidated rock hazard to navigation, with a least depth of about 20 meters (10 fathoms) or less.

Reef, Atoll. See Atoll.

Reef, Barrier. See Barrier Reef.

Reef, Fringing. See Fringing Reef.

Reef, Sand. Bar.

Reference Electrode. A single electrode that, when immersed in an electrolyte solution, produces a fixed, known electrical potential; it is used as a standard for the measurement of potential differences.

Reference Plane. See Datum Plane.

Reference Station. A place for which tidal constants have previously been determined and which is used as a standard for the comparison of simultaneous observations at a second station. Also, a station for which independent daily predictions are given in the tide or current tables from which corresponding predictions are obtained for other stations by means of differences or factors.

Reflected Wave. That part of an incident wave that is returned seaward when a wave impinges on a steep beach, barrier, or other reflecting surface.

Refraction (of water waves). (1) The process by which the direction of a wave moving in shallow water at an angle to the contours is changed: the part of the wave advancing in shallower water moves more slowly than that part still advancing in deeper water, causing the wave crest to bend toward alinement with the underwater contours. (2) The bending of wave crests by currents.

Refraction Coefficient. The square root of the ratio of the distance between adjacent orthogonals in deep water to their distance apart in shallow water at a selected point. When multiplied by the Shoaling Factor and a factor for friction and percolation, this becomes the Wave Height Coefficient or the ratio of the refracted wave height at any point to the deepwater wave height. Also, the square root of the Energy Coefficient

Refraction Diagram. A drawing showing positions of wave crests and/or orthogonals in a given area for a specific deepwater wave period and direction.

Relieved edges. The exposed edges of a timber plank cut on an angle to reduce edge splintering, i.e., chamfering.

Relieving Platform. A type of wharf construction that features a low level platform and batter piles to resist horizontal forces and fill placed on the platform to resist the vertical component of the batter pile forces.

Repair. The restoring or replacing to a sound or good condition after damage.

Resilient. Capable of withstanding shock without permanent damage

Resonance. The phenomenon of amplification of a free wave or oscillation of a system by a forced wave or oscillation of exactly equal period. The forced wave may arise from an impressed force upon the system or from a boundary condition.

Retaining wall. a wall for sustaining the pressure of earth or fill deposited behind it.

Retardation. The amount of time by which corresponding tidal phases grow later day by day (about 50 minutes).

Retention. Per unit volume the quantity of preservative in the wood.

Retrogression (of a beach). (1) A continuing landward movement of the shoreline. (2) A net landward movement of the shoreline over a specified time. Also Recession.

Revetment. A facing of stone, concrete, etc., built to protect a scarp, embankment, or shore structure against erosion by wave action or currents.

Revetment. Sloping structures placed on banks or cliffs in such a way as to absorb the energy of incoming water

Reynolds Number. The dimensionless ratio of the inertial force to the viscous force in fluid motion, where L is a characteristic length, v the kinematic viscosity, and V a characteristic velocity. The Reynolds number is of importance in the theory of hydrodynamic stability and the origin of turbulence.

Ria. A long, narrow inlet, with depth gradually diminishing inward.

Ridge, Beach. A nearly continuous mound of beach material that has been shaped by wave or other action. Ridges may occur singly or as a series of approximately parallel deposits. British usage, Full.

Rill Marks. Tiny drainage channels in a beach caused by the flow seaward of water left in the sands of the upper part of the beach after the retreat of the tide or after the dying down of storm waves.

Rip. A body of water made rough by waves meeting an opposing current, particularly a tidal current; often found where tidal currents are converging and sinking.

Rip Current. A strong surface current flowing seaward from the shore. It usually appears as a visible band of agitated water and is the return movement of water piled up on the shore by incoming waves and wind. With the seaward movement concentrated in a limited band its velocity is somewhat accentuated. A rip consists of three parts: the Feeder Currents flowing parallel to the shore inside the breakers; the Neck, where the feeder currents converge and flow through the breakers in a narrow band or "rip"; and the Head, where the current widens and slackens outside the breaker line. A rip current is often miscalled a rip tide. Also Rip Surf. See Nearshore Current System.

Riprap. Stones or boulders of miscellaneous size placed without order on the surface of an earthen structure or embankment to act as protection against erosion.

Rip Surf. See Rip Current.

Riparian. Pertaining to the banks of a body of water.

Riparian Rights. The rights of a person owning land containing or bordering on a watercourse or other body of water in or to its banks, bed, or waters.

Ripple. (1) The ruffling of the surface of water; hence, a little curling wave or undulation. (2) A wave less than 0.05 meter (2 in.) long controlled to a significant degree by both surface tension and gravity. See Capillary Wave and Gravity Wave.

Ripples (bed forms). Small bed forms with wavelengths less than 0.3 meter (1 ft) and heights less than 0.03 meter (0.1 ft).

Riprap. A protective layer or facing of quarrystone, usually well graded within wide size limit, randomly placed to prevent erosion, scour, or sloughing of an embankment of bluff; also the stone so used. The quarrystone is placed in a layer at least twice the thickness of the 50 percent size, or 1.25 times the thickness of the largest size stone in the gradation.

Roller. An indefinite term, sometimes considered to denote one of a series of ong-crested, large waves which roll in on a shore, as after a storm.

Rope. A line; a long flexible assembly of steel wires or fiber yarns, twisted, braided, or bundled together to serve as a tensile strength member.

Row. A line of piles perpendicular to a bent in a structure with a uniform pile layout.

Rubble. Rough and uncut stones, irregularly shaped and of various sizes, ranging up to 1,000 cu ft each and up to 90 tons each.

Rubble-Mound Structure. A mound of random-shaped and random-placed stones protected with a cover layer of selected stones or specially shaped concrete armor units. (Armor units in a primary cover layer may be placed in an orderly manner or dumped at random.)

Runnel. A corrugation or trough formed in the foreshore or in the bottom just offshore by waves or tidal currents.

Runup. The rush of water up a structure or beach on the breaking of a wave. Also UPRUSH,

Sacrificial Anode. An anode that supplies its own electrons for cathodic protection, thereby consuming or "sacrificing" itself.

Safety Factor. An industry term denoting theoretical reserve capability. Usually computed by dividing the catalog stated ultimate load by the catalog stated working load limit and generally expressed as a ratio, for example, 5 to 1.

Salinity. The amount of total salt content in proportion to a unit volume of water.

Saltation. That method of sand movement in a fluid in which individual particles leave the bed by bounding nearly vertically and, because the motion of the fluid is not strong or turbulent enough to retain them in suspension, return to the bed at some distance downstream. The travel path of the particles is a series of hops and bounds.

Salt Marsh. A marsh periodically flooded by salt water.

Sand. See Soil Classification.

Sandbar. (1) See Bar. (2) In a river, a ridge of sand built up to or near the surface by river currents.

Sand Bypassing. See Bypassing, Sand.

Sand Reef. Bar.

Sand Wave. A large wavelike sediment feature composed of sand in very shallow water. Wavelength may reach 100 meters; amplitude is about 0.5 meter. Also Megaripple.

Sapwood. The outer light-colored wood of the tree stem.

Scab. Wood member used in posting to provide a positive connection between the post and pile and/or pile cap.

Scaling. Gradual and constant loss of surface mortar and aggregates from an area of concrete.

Scale (corrosion). By-product from the oxidation of a ferrous metal member which has hardened and become stratified.

Scarp. See Escarpment.

Scarp, Beach. An almost vertical slope along the beach caused by erosion by wave action. It may vary in height from a few centimeters to a meter or so, depending on wave action and the nature and composition of the beach.

Schmidt hammer. A mechanical device utilizing a standard hammer for testing the condition of a concrete surface.

Scour. Erosion of the seabed or riverbed caused by wave or current action.

Sea Breeze. A light wind blowing from the sea toward the land caused by unequal heating of land and water masses.

Sea Change. (1) A change wrought by the sea. (2) A marked transformation.

Sea Cliff. A cliff situated at the seaward edge of the coast.

Sea Level. See Mean Sea Level.

Seamount. An elevation rising more than 1,000 meters above the ocean floor, and of limited extent across the summit. Compare Knoll.

Sea Puss. A dangerous longshore current; a rip current caused by return flow; loosely, the submerged channel or inlet through a bar caused by those currents.

Seas. Waves caused by wind at the place and time of observation. Seashore. The Shore of a sea or ocean.

Seasoned, air-dried, or air-seasoned. Dried by exposure to the atmosphere, usually in a yard, without artificial heat.

Seasoned, kiln-dried. Dried in a kiln with the use of artificial heat.

Seasoning. The evaporation or extraction of moisture from green or partially dried wood.

Sea State. Description of the sea surface with regard to wave action. Also called state of sea.

Seawall. A massive gravity-type structure built along, and generally parallel to, the shoreline; designed to protect the shore against erosion resulting from wave action.

Seiche. (1) A standing wave oscillation of an enclosed waterbody that continues, pendulum fashion, after the cessation of the originating force, which may have been either seismic or atmospheric. (2) An oscillation of a fluid body in response to a disturbing force having the same frequency as the natural frequency of the fluid system. Tides are now considered to be seiches induced primarily by the periodic forces caused by the Sun and Moon. (3) In the Great Lakes area, any sudden rise in the water of a harbor or a lake whether or not it is oscillatory (although inaccurate in a strict sense, this usage is well established in the Great Lakes area)

Seismic Sea Wave. See Tsunami.

Semidiurnal Tide. A tide with two high and two low waters in a tidal day with comparatively little diurnal inequality.

Set of Current. The direction toward which a current flows.

Setup, Wave. Superelevation of the water surface over normal surge elevation due to onshore mass transport of the water by wave action alone.

Setup, Wind. See Wind Setup. Shallow Water. (1) Commonly, water of such a depth that surface waves are noticeably affected by bottom topography. It is customary to consider water of depths less than one half the surface wavelength as shallow water. See Transitional Zone and Deep Water. (2) More strictly, in hydrodynamics with regard to progressive gravity waves, water in which the depth is less than 1/25 the wavelength; also called Very Shallow Water.

Shake. A separation along the grain of the wood; the separation usually occurring between the annual rings.

Shank. The long, straight part of an anchor, to which the anchor line attaches at one end and the fluke(s) at the other end.

Sheathing. The exposed face material used in bulkhead construction.

Sheeting. A lining of planks or boards for supporting an embankment, usually placed vertically and supported by walers, braces, and piles.

Sheet Pile. Interlocking structural elements driven into the ground to form a retaining structure. Sheet piles can be timber, steel, or concrete.

Shim. A small piece of wood placed between two members of a structure to bring them to a desired relative position.

Shingle. (1) Loosely and commonly, any beach material coarser than ordinary gravel, especially any having flat or flattish pebbles. (2) Strictly and accurately, beach material of smooth, well-rounded pebbles that are roughly the same size. The spaces between pebbles are not filled with finer materials. Shingle often gives out a musical sound when stepped on.

Shiplapped lumber. Lumber that is edge dressed to make a lapped joint.

Shoal (noun). A detached elevation of the sea bottom, comprised of any material except rock or coral, which may endanger surface navigation.

Shoal (verb). (1) To become shallow gradually. (2) To cause to become shallow. (3) To proceed from a greater to a lesser depth of water.

Shoaling Coefficient. The ratio of the height of a wave in water of any depth to its height in deep water with the effects of refraction, friction, and percolation eliminated. Sometimes

Shoaling Factor or Depth Factor. See also Energy Coefficient and Refraction Coefficient.

Shoaling Factor. See Shoaling Coefficient.

Shock Load. A resulting load or force from the rapid change of movement, such as impacting or jerking, of a static load. A shock load is generally significantly greater than the static load.

Shore. The narrow strip of land in immediate contact with the sea, including the zone between high and low water lines. A shore of unconsolidated material is usually called a Beach.

Shoreface. The narrow zone seaward from the low tide Shoreline, covered by water, over which the beach sands and gravels actively oscillate with changing wave conditions. See Inshore (Zone).

Shoreline. The intersection of a specified plane of water with the shore or beach (e.g., the high water shoreline would be the intersection of the plane of mean high water with the shore or beach). The line delineating the shoreline on National Ocean Service nautical charts and surveys approximates the mean high water line.

Shotcrete. Shotcrete (or gunite) is a concrete that is pneumatically placed in layers usually from 1 in. to 2 in. thick. Water is mechanically added to the dry mixture at the nozzle that shoots the freshly mixed concrete (really a mortar) at the surface prepared for its reception.

Side-scan sonar. A category of sonar system that is used to efficiently create an image of large areas of the sea floor. It may be used to conduct surveys for maritime archaeology; in conjunction with seafloor samples it can provide an understanding of the differences in material and texture type of the sea bed. Side-scan sonar imagery is also a commonly used tool to detect debris items and other obstructions on the sea floor that may be hazardous to shipping or to sea floor installations by the oil and gas industry.

Significant Wave. A statistical term relating to the one-third highest waves of a given wave group and defined by the average of their heights and periods. The composition of the higher waves depends upon the extent to which the lower waves are considered. Experience indicates that a careful observer who attempts to establish the character of the higher waves will record values which approximately fit the definition of the significant wave.

Significant Wave Height. The average height of the one-third highest waves of a given wave group. Note that the composition of the highest waves depends upon the extent to which the lower waves are considered. In wave record analysis, the average height of the highest one-third of a selected number of waves, this number being determined by dividing the time of record by the significant period. Also Characteristic Wave Height.

Significant Wave Period. An arbitrary period generally taken as the period of the onethird highest waves within a given group. Note that the composition of the highest waves depends upon the extent to which the lower waves are considered. In wave record analysis, this is determined as the average period of the most frequently recurring of the larger well-defined waves in the record under study.

Silt. See Soil Classification.

Silver-silver chloride. Reference cell for electrolyte potential measurements in seawater.

Sinkhole. A hole or void in the upland area of a soil retaining structure that is formed due to the loss of fill.

Sinusoidal Wave. An oscillatory wave having the form of a sinusoid.

Skiff. A small boat.

Slack Tide (Slack Water). The state of a tidal current when its velocity is near zero, especially the moment when a reversing current changes direction and its velocity is zero. Sometimes considered the intermediate period between ebb and flood currents during which the velocity of the currents is less than 0.05 meter per second (0.1 knot). See Stand Of Tide.

Slip. A berthing space between two piers.

Slope. The degree of inclination to the horizontal. Usually expressed as a ratio, such as 1:25 or 1 on 25, indicating 1 unit vertical rise in 25 units of horizontal distance; or in a decimal fraction (0.04); degrees (2^{o} 18'); or percent (4 percent).

Slough. See Bayou.

Sloughing. Slippage of the slope of an embankment or excavation.

Soft rot. Deterioration of wood components—often without visual distortion or apparent damage to the wood—by certain molds and other fungi that are outside of the common wood-destroying group. The affected wood is likely to be extremely brittle and break without splinters.

Softwoods. The botanical group of trees with needle-like or scale-like leaves often referred to as "conifers." The term softwood has no reference to the softness of the wood.

Soil Classification (Size). An arbitrary division of a continuous scale of grain sizes such that each scale unit or grade may serve as a convenient class interval for conducting the analysis or for expressing the results of an analysis.

Soil resistivity. A measure of how much the soil resists the flow of electricity.

Solitary Wave. A wave consisting of a single elevation (above the original water surface), whose height is not necessarily small compared to the depth, and neither followed nor preceded by another elevation or depression of the water surfaces.

Sonar, multi-beam. Sonar transmitted in a 180-degree pattern to record bottom topography, scour, or depth over a wide swath in a single pass.

Sonar and side-scan sonar. An ultra-high frequency sound wave generating device for measuring distances by reference to time intervals between sending and receiving any pulse. Usual sonar transmits signals vertically, side-scan transmits signals at an angle less than 90 degrees.

Sorting Coefficient. A coefficient used in describing the distribution of grain sizes in a sample of unconsolidated material. It is defined as $So = Q1/Q3$, where Q1 is the diameter (in millimeters) which has 75 percent of the cumulative size-frequency (by weight) distribution smaller than itself and 25 percent larger than itself, and Q3 is that diameter having 25 percent smaller and 75 percent larger than itself.

Sound (noun). (1) A wide waterway between the mainland and an island, or a wide waterway connecting two sea areas. See also Strait. (2) A relatively long arm of the sea or ocean forming a channel between an island and a mainland or connecting two larger bodies, as a sea and the ocean, or two parts of the same body; usually wider and more extensive than a strait.

Sound (verb). To measure the depth of the water.

Sounding. (1) A measured depth of water. On hydrographic charts the soundings are adjusted to a specific plane of reference (Sounding Datum). (2) A method used to determine interior deterioration in wood and concrete; a method used to determine the depth of water.

Sounding Datum. The plane to which soundings are referred. See also Chart Datum.

Sounding Line. A line, wire, or cord used in sounding, which is weighted at one end with a plummet (sounding lead). Also Lead Line.

Spalling. Deterioration of a concrete surface usually caused by the expansion of corroding reinforcing steel.

Specific gravity. As applied to preservatives, the ratio of weight of a given volume of a preservative to the weight of an equal volume of water.

Spilling Breaker. See Breaker.

Spit. A small point of land or a narrow shoal projecting into a body of water from the shore.

Spit, Cuspate. See Cuspate Spit.

Splash Zone. The portion of a marine structure subject to alternate wetting and drying due to tide and wave action.

Splicing. The replacement of the damaged portion of a pile Split—a lengthwise separation of the wood extending completely through the piece from one surface to another.

Spring Tide. A tide that occurs at or near the time of new or full moon and which rises highest and falls lowest from the mean sea level.

Spud piles. Piles driven at an angle to develop horizontal resistance to loading.

Staining. The discoloration of wood indicating the presence of fungus activity.

Stand of Tide. An interval at high or low water when there is no sensible change in the height of the tide. The water level is stationary at high and low water for only an instant, but the change in level near these times is so slow that it is not usually perceptible. See Slack Tide.

Standard Project Hurricane. See Hypothetical Hurricane.

Standing Wave. A type of wave in which the surface of the water oscillates vertically between fixed points, called nodes, without progression. The points of maximum vertical rise and fall are called antinodes or loops. At the nodes, the underlying water particles exhibit no vertical motion, but maximum horizontal motion. At the antinodes, the underlying water particles have no horizontal motion, but maximum vertical motion. They may be the result of two equal progressive wave trains traveling through each other in opposite directions. Sometimes called Clapotis or Stationary Wave.

Stationary Wave. A wave of essentially stable form which does not move with respect to a selected reference point; a fixed swelling. Sometimes called Standing Wave.

Steel sheet pile wall. A bulkhead composed of driven vertical or near vertical steel sheet sections interlocked to form a continuous wall, sometimes tied back to anchors.

Still-Water Level. The elevation that the surface of the water would assume if all wave action were absent.

Stockpile. Sand piled on a beach foreshore to nourish downdrift beaches by natural littoral currents or forces. See Feeder Beach.

Stone, Derrick. Stone heavy enough to require handling individual pieces by mechanical means, generally weighing 900 kilograms (1 ton) and up.

Storm Surge. A rise above normal water level on the open coast due to the action of wind stress on the water surface. Storm surge resulting from a hurricane also includes that rise in level due to atmospheric pressure reduction as well as that due to wind stress. See Wind Setup.

Storm Tide. See Storm Surge.

Strait. A relatively narrow waterway between two larger bodies of water. See also Sound.

Stream. (1) A course of water flowing along a bed in the Earth. (2) A current in the sea formed by wind action, water density differences, etc.; e.g. the Gulf Stream. See also Current, Stream.

Stringer. A horizontal framing member used to support a floor or deck.

Structural deterioration. The failure or damage to a structure due to biological, chemical, or mechanical means.

Structural lumber. Lumber that is 2 in. or more thick and 4 in. or more wide, intended for use where working stresses are required. The grading of structural lumber is based on both the strength of the piece and the use of the entire piece.

Sub-decking. Area beneath the surface decking.

Sulfate attack. Exposure of concrete to sulfates; the most common sulfates are sodium, potassium, magnesium, and calcium sulfates, which react with various hydration products in the presence of moisture to form ettringite, which leads to softening of the concrete.

Surf. The wave activity in the area between the shoreline and the outermost limit of breakers.

Surf Beat. Irregular oscillations of the nearshore water level with periods on the order of several minutes.

Surf Zone. The area between the outermost breaker and the limit of wave uprush.

Surface treatment. The applying of a preservative to the surface by means of a brush, swab, or spray gun.

Surge. (1) The name applied to wave motion with a period intermediate between that of the ordinary wind wave and that of the tide, say from 1/2 to 60 minutes. It is low height; usually less than 0.9 meter (0.3 ft). See also Seiche. (2) In fluid flow, long interval variations in velocity and pressure, not necessarily periodic, perhaps even transient in nature. (3) See Storm Surge.

Surging Breaker. See Breaker.

Survey. A detailed study or inspection to determine the location, form, boundaries, or condition of a structure, an area of water, or tract of land.

Suspended Load. (1) The material moving in suspension in a fluid, kept up by the upward components of the turbulent currents or by colloidal suspension. (2) The material collected in or computed from samples collected with a Suspended Load Sampler. Where it is necessary to distinguish between the two meanings given above, the first one may be called the "true suspended load."

Suspended Load Sampler. A sampler which attempts to secure a sample of the water with its sediment load without separating the sediment from the water.

Swale. The depression between two beach ridges.

Swash. The amount of runup is the vertical height above still-water level to which the rush of water reaches.

Swash Channel. (1) On the open shore, a channel cut by flowing water in its return to the present body (e.g., a rip channel). (2) A secondary channel passing through or shoreward of an inlet or river bar.

Swash Mark. The thin wavy line of fine sand, mica scales, bits of seaweed, etc., left by the uprush when it recedes from its upward limit of movement on the beach face.

Swell. Wind-generated waves that have traveled out of their generating area. Swell characteristically exhibits a more regular and longer period and has flatter crests than waves within their fetch.

Synoptic Chart. A chart showing the distribution of meteorological conditions over a given area at a given time. Popularly called a weather map.

Synthetic resin. A chemical sometimes used for impregnating piles.

Syzygy. The two points in the Moon's orbit when the Moon is in conjunction or opposition to the Sun relative to the Earth; time of new or full Moon in the cycle of phases.

Tar. A generic term applied to nonaqueous liquids obtained as residue in the destructive distillation of organic materials such as coal, lignite, petroleum, wood, and others.

Tar, coal. The nonaqueous portion of the liquid distillate obtained during the carbonization of bituminous coal.

Tender. The individual responsible for the diver's welfare during an inspection; also a small boat.

Teredo. A genus of molluscan marine borers, commonly called the “shipworm”.

Teredo tube. A tubular residue left by teredo borers.

Terrace. A horizontal or nearly horizontal natural or artificial topographic feature interrupting a steeper slope, sometimes occurring in a series.

Thalweg. In hydraulics, the line joining the deepest points of an inlet or stream channel.

Tidal. Of, relating to, caused by, or having tides.

Tidal creeks: Small streams that serve as important conduits for material and energy transfer between salt marshes and adjacent water bodies.

Tidal Current. See Current, Tidal.

Tidal Datum. A vertical reference based on a specific stage of tide that serves as a baseline elevation to which sounding depths or topographic heights are referenced.

Tidal Day. The time of the rotation of the Earth with respect to the Moon, or the interval between two successive upper transits of the Moon over the meridian of a place, approximately 24.84 solar hours (24 hours and 50 minutes) or 1.035 times the mean solar day. Also called lunar day.

Tidal Flats. Marshy or muddy land areas which are covered and uncovered by the rise and fall of the tide.

Tidal Inlet. (1) A natural inlet maintained by tidal flow. (2) Loosely, any inlet in which the tide ebbs and flows. Also Tidal Outlet.

Tidal Period. The interval of time between two consecutive, like phases of the tide.

Tidal Pool. A pool of water remaining on a beach or reef after recession of the tide.

Tidal Prism. The total amount of water that flows into a harbor or estuary or out again with movement of the tide, excluding any freshwater flow.

Tidal Range. The difference in height between consecutive high and low (or higher high and lower low) waters.

Tidal Rise. The height of tide as referred to the datum of a chart.

Tidal Wave. (1) The wave motion of the tides. (2) In popular usage, any unusually high and destructive water level along a shore. It usually refers to Storm Surge or Tsunami.

Tide. The periodic rising and falling of the water that results from gravitational attraction of the Moon and Sun and other astronomical bodies acting upon the rotating Earth. Although the accompanying horizontal movement of the water resulting from the same cause is also sometimes called the tide, it is preferable to designate the latter as Tidal Current, reserving the name Tide for the vertical movement.

Tide, Daily Retardation Of. The amount of time by which corresponding tides grow later day by day (about 50 minutes). Also Lagging.

Tide, Diurnal. A tide with one high water and one low water in a day.

Tide, Ebb. See Ebb Tide.

Tide, Flood. See Flood Tide.

Tide, Mixed. See Mixed Tide.

Tide, Neap. See Neap Tide.

Tide, Semidiurnal. See Semidiurnal Tide.

Tide, Slack. See Slack Tide.

Tide, Spring. See Spring Tide.

Tide Station. A place at which tide observations are being taken. It is called a primary tide station when continuous observations are to be taken over a number of years to obtain basic tidal data for the locality. A secondary tide station is one operated over a short period of time to obtain data for a specific purpose.

Tide, Storm. See Storm Surge.

Tie back, tie rod. Generally, a tension rod with anchorage used to restrain a wall from movement or displacement.

Tie Rod. A steel rod used to secure a bulkhead or retaining wall to a deadman.

Timber. A broad term including standing trees and certain products cut from them, including lumber 5 in. or larger in least nominal dimension.

Timber Pile. A timber member, usually round, driven or otherwise embedded into the ground to serve as a structural support.

Tip Elevation. The required driving depth for piles. (Driving criteria dictates tip elevation.)

Tombolo. A bar or spit that connects or "ties" an island to the mainland or to another island. See Cuspate Spit.

Tongue and Groove. A method of interlocking adjacent members whereby one edge of a member has a projection (tongue) to fit into a recess (groove) in the adjacent member. Design often used to interlock timber or concrete sheet piles.

Topography. The configuration of the physical features of a place or region.

Topping. The finished surface (wearing surface) provided on top of an existing surface.

Training Wall. A wall or jetty to direct current flow.

Transitional Zone (Transitional Water). In regard to progressive gravity waves, water whose depth is less than 1/2 but more than 1/25 the wavelength. Often called Shallow Water.

Translatory Wave. See Wave of Translation.

Transposed Hurricane. See Hypothetical Hurricane.

Treatment, dual. Treatment of wood to be used under severe conditions of exposure with two dissimilar synergistic preservatives in two separate treating cycles, e.g., treatment of marine piles and wood for areas of extreme borer hazard. Usually, the first treatment is with a waterborne salt preservative, the second with creosote or creosote-coal tar solution.

Treatment, empty-cell. A treatment in which air imprisoned in the wood is employed to force out part of the preservative when treating pressure is released and a final vacuum is applied.

Treatment, fire-retardant. Treatment of wood under pressure with chemical to reduce its flame spread, fuel contribution, and smoke development.

Treatment, full-cell. A treatment involving a preliminary vacuum followed by pressure impregnation such that the cell cavities in the treated portion of the wood remain partially or completely filled with preservative.

Tremie. A steel tube used for depositing concrete underwater, having at its upper end a hopper for filling.

Trochoidal Wave. A theoretical, progressive oscillatory wave first proposed by Gerstner in 1802 to describe the surface profile and particle orbits of finite amplitude, nonsinusoidal waves. The wave form is that of a prolate cycloid or trochoid, and the fluid particle motion is rotational as opposed to the usual irrotational particle motion for waves generated by normal forces. Compare Irrotational Wave.

Tropical Cyclone. See Hurricane.

Tropical Storm. A tropical cyclone with maximum winds less than 34 meters per second (75 mile per hour). Compare Hurricane.

Trough of Wave. The lowest part of a waveform between successive crests. Also, that part of a wave below still-water level.

Tsunami. A long-period wave caused by an underwater disturbance such as a volcanic eruption or earthquake. Also Seismic Sea Wave. Commonly miscalled "tidal wave."

Tunicate. Sea grape: a semitransparent organism the size of a grape that often exists in polluted waters. Some cause rashes on divers.

Typhoon. See Hurricane.

Ultimate Load. The average load or force at which the item fails or no longer supports a load.

Ultrasonic Thickness Meter. Any one of a number of remote and hand-held devices which use a timed pulse-echo signal to gauge the wall thickness of a metal member.

Underdeck. The portion of a pier or wharf structure between the bottom of the deck and the waterline.

Undertow. A seaward current near the bottom on a sloping inshore zone. It is caused by the return, under the action of gravity, of the water carried up on the shore by waves. Often a misnomer for Rip Current.

Underwater Gradient. The slope of the sea bottom. See also Slope.

Undulation. A continuously propagated motion to and fro, in any fluid or elastic medium, with no permanent translation of the particles themselves.

Unified Facilities Criteria (UFC). Documents that provide planning, design, construction, sustainment, restoration, and modernization criteria and apply to military departments, defense agencies, and Department of Defense field activities.

United States Geological Survey (USGS). A science organization that provides impartial information on the health of ecosystems and environment, natural hazards, natural resources, the impacts of climate and landuse change, and the core science systems that provide timely, relevant, and usable information.

Upcoast. In United States usage, the coastal direction generally trending toward the north.

Updrift. The direction opposite that of the predominant movement of littoral materials.

Uplift. The upward water pressure on the base of a structure or pavement.

Uprush. The rush of water up onto the beach following the breaking of a wave. Also Swash, Runup.

Valley, Sea. A submarine depression of broad valley form without the steep side slopes which characterize a canyon.

Valley, Submarine. A prolongation of a land valley into or across a continental or insular shelf, which generally gives evidence of having been formed by stream erosion.

Variability of Waves. (1) The variation of heights and periods between individual waves within a Wave Train. (Wave trains are not composed of waves of equal height and period, but rather of heights and periods which vary in a statistical manner.) (2) The variation in direction of propagation of waves leaving the generating area. (3) The variation in height along the crest, usually called "variation along the wave."

Velocity of Waves. The speed at which an individual wave advances. See Wave Celerity.

Vertical Accretion. The building up of a wetland surface through the deposition and accumulation of sediments.

Very Shallow Water. See Shallow Water.

Viscosity (or internal friction). That molecular property of a fluid that enables it to support tangential stresses for a finite time and thus to resist deformation

Wale. A long, horizontal structural member of timber or steel used for bracing vertical members. Also known as a "waler" or "ranger."

Wane. Bark on the edge or corner of a piece, or the absence of wood in a piece from any cause.

Waterborne. A preservative soluble in water.

Waterline. A juncture of land and sea. This line migrates, changing with the tide or other fluctuation in the water level. Where waves are present on the beach, this line is also known as the limit of backrush. (Approximately, the intersection of the land with the Stillwater level.)

Wave. A ridge, deformation, or undulation of the surface of a liquid.

Wave Age. The ratio of wave speed to wind speed.

Wave, **Capillary**. See Capillary Wave.

Wave Celerity. Wave speed.

Wave Crest. See Crest Of Wave.

Wave Crest Length. See Crest Length, Wave.

Wave, **Cycloidal**. See Cycloidal Wave.

Wave Decay. See Decay Of Waves.

Wave Direction. The direction from which a wave approaches.

Wave Forecasting. The theoretical determination of future wave characteristics, usually from observed or predicted meteorological phenomena.

Wave Generation. See Generation Of Waves. Wave, Gravity. See Gravity Wave.

Wave Group. A series of waves in which the wave direction, wavelength, and wave height vary only slightly. See also Group Velocity.

Wave Height. The vertical distance between a crest and the preceding trough. See also Significant Wave Height.

Wave Height Coefficient. The ratio of the wave height at a selected point to the deepwater wave height. The Refraction Coefficient multiplied by the shoaling factor.

Wave Hindcasting. See Hindcasting, Wave.

Wave, **Irrotational**. See Irrotational Wave.

Wave, **Monochromatic**. See Monochromatic Waves.

Wave, **Oscillatory**. See Oscillatory Wave.

Wave Period. The time for a wave crest to traverse a distance equal to one wavelength. The time for two successive wave crests to pass a fixed point. See also Significant Wave Period.

Wave, **Progressive**. See Progressive Wave.

Wave Propagation. The transmission of waves through water.

Wave Ray. See Orthogonal.

Wave, **Reflected**. That part of an incident wave that is returned seaward when a wave impinges on a steep beach, barrier, or other reflecting surface.

Wave Refraction. See Refraction (of water waves).

Wave Setup. See Setup, Wave.

Wave, **Sinusoidal**. An oscillatory wave having the form of a sinusoid.

Wave, **Solitary**. See Solitary Wave.

Wave Spectrum. In ocean wave studies, a graph, table, or mathematical equation showing the distribution of wave energy as a function of wave frequency. The spectrum may be based on observations or theoretical considerations. Several forms of graphical display are widely used.

Wave, **Standing**. See Standing Wave.

Wave Steepness. The ratio of the wave height to the wavelength.

Wave Train. A series of waves from the same direction.

Wave of Translation. A wave in which the water particles are permanently displaced to a significant degree in the direction of wave travel. Distinguished from an Oscillatory Wave.

Wave, **Trochoidal**. See Trochoidal Wave.

Wave Trough. The lowest part of a wave form between successive crests. Also that part of a wave below still-water level.

Wave Variability. See Variability Of Waves.

Wave Velocity. The speed at which an individual wave advances.

Wave, **Wind**. See Wind Waves.

Wavelength. The horizontal distance between similar points on two successive waves measured perpendicular to the crest.

Waves, **Internal**. See Internal Waves.

Web. The portion(s) of a geometric cross-section parallel to the weak axis of bending. The term web is most commonly applied to that portion flanges of an H-pile or beam.

Weir Jetty. An updrift jetty with a low section or weir over which littoral drift moves into a predredged deposition basin which is dredged periodically.

Wetland restoration: The return of a wetland from a condition disturbed or altered by human activity to a previously existing condition.

Wharf. An open-type marginal platform structure, usually parallel to the shoreline, that is used primarily for berthing of vessels. It is usually connected to the shore at more than one point but may also have continuous access along the shore.

Whitecap. On the crest of a wave, the white froth caused by wind.

Wind Chop. See Chop.

Wind, **Following**. See Following Wind.

Wind, **Offshore**. A wind blowing seaward from the land in a coastal area.

Wind, **Onshore**. A wind blowing landward from the sea in a coastal area.

Wind, **Opposing**. See Opposing Wind.

Wind Setup. On reservoirs and smaller bodies of water (1) the vertical rise in the Stillwater level on the leeward side of a body of water caused by wind stresses on the surface of the water; (2) the difference in still-water levels on the windward and the leeward sides of a body of water caused by wind stresses on the surface of the water. Storm Surge (usually reserved for use on the ocean and large bodies of water).

Wind Tide. See Wind Setup, Storm Surge.

Wind Waves. (1) Waves being formed and built up by the wind. (2) Loosely, any wave generated by wind.

Windward. The direction from which the wind is blowing.

Windsor probe. A device used to determine the strength of concrete by shooting a standardized probe into the concrete and measuring the depth of embedment.

White rot. Deterioration caused by a group of fungi that cause “bleaching” of the wood.

Wolman Salts. Fluor Chrome Arsenate Phenol Type A.

Wood. A broad term including standing trees and certain products cut from them, including lumber 5 in. or larger in least nominal dimension.

Wood preservation. The art of protecting wood against the action of destructive agents; usually refers to the treatment of wood with chemical substances (preservatives), which reduce its susceptibility to deterioration by fungi, insects, or marine borers

Xylophaga. A genus of wood boring pholads.

Zinc. A metal as a sacrificial anodes in cathodic protection against corrosion.

Appendix C
Report Formatting, Sample Figures, and Writing Styles

APPENDIX C

TABLE OF CONTENTS

Page No.

LIST OF FIGURES

Page No.

LIST OF TABLES

Page No.

C.1 FORMAT AND ARRANGEMENT

The purpose of this section is to provide for consistency in the Baseline, Routine, Design-Level, and Post-Construction Inspection report formats. Categories of information shall be found in the same sections of all reports. The arrangement and style, including the size of type and width of margins, are to be consistent in all reports. Facility assessments, recommendations, and cost estimates in all reports are consistent in presentation, degree of detail, and overall style.

C.1.1 Typeset and Margins

The body of the report shall be printed in "Times New Roman" font, regular style, 12 point (the style of type used in this narrative) or a like substitute. For ease of reading, line spacing should be set at 1.35 with a 12 point space before each paragraph.

Margins on the left-hand side of the sheet shall be 1-1/2 in. Margins on the right side shall be 1 in. Each line of text should be left and right justified. Two spaces should be placed between the last word of one sentence and the first word of the next sentence. Top and bottom margins shall be 1 in. for a full page of text. In instances where the text of a final paragraph in a section of the report exceeds the intended last page, a minimum of two sentences should be carried onto an additional page.

C.1.2 Numbering Systems

The numbering system has been designed so that each chapter of the Routine Inspection report stands alone. This will allow additional material to be added to or deleted from a section without disturbing material on every page of the report.

(A) PAGE NUMBERING

The inside title page shall be presumed to be page i, but shall not be labeled. The pages following the inside title page and preceding Section 1 shall be labeled with lower case Roman numerals. Therefore, the Executive Summary shall be labeled ii, (assuming that it occupies only one page), because it is positioned within the report immediately following the inside title page.

All section page numbers within each tabbed section shall consist of the section number and the page number within the section, separated by a dash. For example, pages in Section 1 should be numbered 1-1, 1-2, 1-3, etc.

The appendices shall be similarly numbered, with the exception that the first character will be the letter designating a particular appendix. For example, page numbers in Appendix A, beginning with the Appendix title page, should be preceded by the letter A: A-1, A-2, A-3, etc.

All page numbers shall be positioned in the lower margin of the page, 3/4 in. from the bottom of the page. The page numbers shall be centered between the left and right margins, except on 11 in. by 17 in. pages where they shall be located 4 in. from the right edge of the paper.

(B) SECTION NUMBERING

The section numbering system shall follow that of the page system with the exception that numbers shall be separated by a period. For example, within Section 1, the subsections shall be numbered as follows: 1.1, 1.2, 1.3, etc. This system can be expanded further if the narrative dictates the need for lower-tier subsections. For example, if in section 2.1, there are four subsections required, the numbering shall be 2.1.1, 2.1.2, 2.1.3, 2.1.4; the section 2.2 shall be divided into 2.2.1, 2.2.2, etc. If it is necessary to subdivide further, first use uppercase letters, then Arabic numerals, and finally, lower case Roman numerals. Leave two spaces between the number of a section and its title. The format for headings is listed in Table C-1.

TABLE C-1.
HEADING FORMAT

Type of heading	Numbering	Format
Chapter (Heading 1)	1.	TIMES NEW ROMAN 14 BOLD, ALL CAPS
Section (Heading 2)	1.1	TIMES NEW ROMAN 12 BOLD, ALL CAPS
Sub-section (Heading 3)	1.1.1	Times New Roman 12 Bold, Initial Caps
(Heading 4)	(A)	TIMES NEW ROMAN 12, ALL CAPS
(Heading 5)	(1)	Times New Roman 12, Initial Caps
(Heading 6)	(i)	Times New Roman 12, Initial Caps

Chapter headings (Heading 1) start on a new page. Leave two lines between section headings (Heading 2) and the preceding text and one line between Subsection or lower order headings (Heading 3, 4, etc.) and the preceding text. Leave one line between headings and the following text.

C.1.3 Binding

All Baseline, Routine, Design Level, and Post Construction Inspection reports shall be assembled using GBC binding with a clear plastic cover, and white hard stock paper as the back cover.

Separator sheets with ½-inch wide tabs (1/5 cut) shall be placed at the beginning of each chapter and appendix of the report. The tab shall show the chapter number or appendix letter and its title. Abbreviations may also be used. The information shall be placed on the front of the tab and oriented so that the bottom of the writing is toward the inside of the report. Text on the tabs shall be 10 point Times New Roman font, bold.

The separator sheets shall be light blue “cover stock” weight paper with five tabs per bank. The tabs shall be laminated on each side of the sheet. The lamination shall extend a minimum of ½ in. above and below the tab and ¼ in. in from the edge of the sheet.

C.2 FRONT INFORMATION PREPARATION

C.2.1 Report Cover

The format for the specific information to appear on the report cover is presented on Figure C-1. The report cover includes color graphics and should be printed on a color printer with a minimum of 600 x 600 dpi and 256 colors. All text on the report cover is right-justified, spaced 1 in. from the right edge of the paper. The following items shall be included on the cover:

- NYC EDC logo - The top of the EDC logo shall be positioned 3/4 in. below the top of the page and right justified with the report cover text. The logo shall be 1 in. high and the provided height to width ratio shall be in the same aspect ratio as provided by EDC.

- System Title - The first text item to appear on the page is the title "WATERFRONT FACILITIES MAINTENANCE MANAGEMENT SYSTEM," in boldface, all caps, 18-point type. This text shall be provided on two lines with the top line located 2-1/2 in. below the top of the page.

- Name - The name of the site and facility inspected is positioned below the title in boldface, all caps, 24-point type. This line of type is located 3-3/4 in. below the top of the page.

- Location - The location of the site and facility inspected is positioned directly below the name using the same font. The location should indicate the borough or city that the site is located.

- Inspection Type - Specify the type of inspection performed in boldface, all caps, 24-point type. This line of type is located 5 in. below the top of the page.

- Date - Specify the month and year the report is submitted, in boldface, all caps, 18-point type.

- Consultant logo - The top of the consultant's logo shall be positioned 8-1/2 in. below the top of the page and right justified with the report cover text.

C.2.2 Title page

The format for the specific information to appear on this page is presented on Figure C-2, which depicts a typical title page. All text is centered on the page and the type size is the same as used on the report cover. The descriptions of items on the title page are similar to those on the report cover.

C.3 FIGURES AND DRAWINGS

The inspection reports describe the physical condition of a facility, and thereby forms a basis for justifying requests for the funding of repairs. Therefore, it is imperative that figures and drawings, as well as the accompanying narrative material, be accurately, clearly, and completely presented.

High-quality figures and drawings are indispensable in conveying the physical arrangements of elements of a facility, as well as illustrating the findings from the investigations. The level of detail used in figures should be sufficient to independently provide the reader with a graphical representation of the essential information presented within the written portions of the report.

At times, design or as-built drawings for some facilities will not be available, or the existing drawings will be outdated and will not represent a structure in its present form. In such cases, the consultant must generate new drawings.

The term "figure" will be used to refer to all graphic illustrations other than photographs. Some figures will depict information that is normally included in, and referred to in engineering terms as, "drawings".

WATERFRONT FACILITIES
MAINTENANCE MANAGEMENT SYSTEM

SITE
FACILITY
LOCATION

INSPECTION TYPE

1 in.

1.25 in.

MONTH YEAR

New York City Economic Development Corp.

CONSULTANT'S NAME AND LOGO

**FIGURE C-1.
REPORT COVER
FORMAT**

NEW YORK CITY
ECONOMIC DEVELOPMENT CORPORATION

WATERFRONT FACILITIES
MAINTENANCE MANAGEMENT SYSTEM

SITE
FACILITY
LOCATION

INSPECTION TYPE

MONTH YEAR

Submitted by:

Consultant's Name
Address
City, State Zip

FIGURE C-2.
TITLE PAGE FORMAT

The figures required for illustrating the descriptions, findings, or recommendations of inspection reports take several forms. The most common types are described below:

- Conventional drawings including vicinity maps, site plans, location plans, general plans, deck plans, framing plans, pile plans, elevations, cross sections, shoreline profiles, and details. Figures of this type give physical arrangements of the components and the relevant dimensions of both the facility and its systems.

Sketches depicting locations, geometric patterns, and extent of existing conditions, such as marine growth, cracks, and regions of deterioration on or within a structural member.

- Schematic diagrams depicting recommended repair details.
- Other illustrations as appropriate, such as diagrams graphically depicting the live load limits on various portions of a pier, or plots of selected parameters required in analyses of data.

C.3.1 Types of Figures

The basic layout of a facility must be illustrated to a level of detail sufficient to permit the reader to easily determine which structure, or portion thereof, is being illustrated, and what is being illustrated. Each figure must contain the minimum required information to graphically represent the structure, including observed conditions, independently of the narrative portions of the report. For example, on a pier involving the inspection of piles, every pile should be shown, even though groups of piles may not have been inspected or conditions for particular piles were not observed. Furthermore, all piles must be shown even though the pattern of structural elements might be repetitious over a lengthy span of the pier. As a general rule, a sufficient number of figures must be presented so that the information conveyed on each figure is uncluttered, legible, and concise.

Typical figures presented in the inspection reports are described below. At a minimum, the following information must be shown for each of the various figures listed below:

(A) LOCATION PLAN

The Location Plan illustrates the overall vicinity of the site. This figure should include: a north arrow; the name and location of the site; major roadways, highways or cross-streets; geographic features such as bodies of water; and any other feature that is characteristic of the area within and around the site. An example of a Location Plan is shown in Section 6.1.3 on Figure 6-1.

(B) SITE PLAN

The Site Plan illustrates a general plan of the site in which the facility is located ("bird's eye view"). Included in this figure are: a north arrow; the name and location of the facility; the names and locations of various geographic and man-made features such as bodies of water, buildings, local roads, property lines, and bulkhead lines; and any other feature that is characteristic of the area within the site. An example of a Site Plan is shown in Section 6.1.3 on Figure 6-2.

(C) FACILITY PLAN

The Facility Plan illustrates a plan of the facility itself. This plan includes a north arrow; an outline of the structures; overall and structure dimensions; and the names of the facility's major structures, with overall dimensions. A Facility Plan must be included in the report. An example of a Facility Plan is shown in Section 6.1.3 on Figure 6-3.

(D) DECK PLAN

The Deck Plan illustrates an overall plan of the structure or a major portion of the structure. This figure includes: a north arrow; an outline of the structure; overall and element dimensions; a numbered grid system; and the name and location of features on or adjacent to the structure, such as the deck, expansion joints, buildings, mooring elements, curbs, utilities, fender systems, and long term mooring of vessels and barges. The Deck Plan also includes relevant information pertaining to these features, such as soundings, deck subsidence, sinkholes, and missing, broken, or deteriorated elements. Soundings must be referenced to a known datum such as the deck elevation or MLLW elevation. Repetitive information and conditions are graphically represented by symbols, which must be identified in an appropriate legend. Isolated information and conditions are to be called out specifically in writing. A Deck Plan must be included in the report. An example of a Deck Plan is shown on Figure C-3.

(E) FRAMING PLAN

The Framing Plan illustrates the overall structural framing of the structure or its major elements. This figure includes: a north arrow; an outline of the structure; overall and element dimensions; a numbered grid system; and the name and location of deck supporting elements such as pile caps, deck beams, edge beams, and bulkheads. The scale of the Framing Plan must match the scale of the Deck Plan. A Framing Plan, when used, is often combined with a Pile Plan. However, the Framing Plan shall be separate from the Pile Plan if the information presented tends to clutter the overall appearance. Additionally, the Framing Plan may include a reflected soffit plan. Repetitive information and conditions are graphically represented by symbols, which must be identified in an appropriate legend. Isolated information and conditions are to be called out specifically in writing. An example of a framing plan is shown on Figure C-4.

(F) PILE PLAN

The Pile Plan illustrates the overall pile layout of the structure or its major elements. This figure includes: a north arrow; an outline of the structure; overall and element dimensions; a numbered grid system; and a graphical representation of each pile, with observed conditions graphically represented at the pile locations. The scale of the Pile Plan must match the scale of the Deck Plan. The Pile Plan also includes relevant information pertaining to piles such as the level of inspection for each pile, dimensions, pile conditions, or the presence of pile stubs. Repetitive information and conditions are graphically represented by symbols, which must be identified in an appropriate legend. Isolated information and conditions are to be called out specifically in writing. Water depths or soundings should be presented at regular intervals around the perimeter and centerline of the structure.

A Pile Plan allows the viewer to distinguish a vertical pile from a batter pile by the way in which it is depicted. The shape of vertical piles shall be the same shape as the piles supporting the waterfront facility. A batter pile, which is intentionally driven out of plumb, shall be indicated in plan by the shape of the pile's cross-section and by a small arrow in the direction of the batter, as illustrated on Figure C-5. If the structure is supported on piles, a Pile Plan must be included in the report.

(G) ELEVATIONS

Elevations illustrate vertical elevations, to scale, of a portion of the structure or its major elements. These figures, when used, identify relevant information or conditions pertaining to the structural elements such as: overall and element dimensions; and missing, broken, or deteriorated elements. Repetitive information and conditions are graphically represented by symbols, which must be identified in an appropriate legend. Isolated information and conditions are to be called out specifically in writing.

Elevations are also typically prepared for structures such as sheet pile bulkheads, gravity walls, or other types of retaining wall-type structures to depict their overall configuration, including the stationing used in the inspection, general position of the mudline, tidal levels, and the position of key components such as tie rods, wales, or outfalls. An example of an elevation view is shown on Figure C-6.

(H) CROSS-SECTIONS

Cross-sections illustrate the physical arrangement, to scale, of the components for each typical cross-section for various portions of the system. Cross-sections identify the overall and component dimensions, the name and location of various components, the top of deck elevations, and water levels. The quantity of typical cross-sections will vary depending on the configuration of each system or its major components. Typical cross-sections must be included in the report. An example of a cross-section is shown on Figure C-7.

(I) DETAILS

Details illustrate the physical arrangement, to scale, of structural elements. Details should be provided to clarify the existing typical and non-typical configurations or conditions, particularly at connections, as well as depicting recommended repair systems. Details identify the materials used, the names and proportions of the various components, and any other information pertaining to the condition or assemblage of components. An example showing an existing condition detail is shown on Figure C-8. The detail shown on Figure C-8 is for a cross-section view, however, details may also be developed for specific plan or elevation views.

(J) REPAIR DETAIL

Repair details illustrate the physical arrangement, to scale, of the proposed recommended action. The repair detail may be presented as a plan, cross-section, elevation view, or a combination of these formats. The repair detail(s) included in the report is/are not intended to be used for construction and are only intended as graphical representations of what a typical repair might look like. Not all recommended actions require accompanying repair details. Each repair detail shall include a sufficient level of detail for the reader to understand the intent of the repair and for the development of an order-of-magnitude cost estimate. Examples showing repair details are shown on Figure C-9.

(K) LOAD RATING PLAN

The load rating plan is used to graphically illustrate the different load ratings that may exist at a facility. A load rating plan is required when the facility has varying degrees of deterioration and the structural condition assessment demonstrates that the original load carrying capacity of the needs to be reduced in certain areas of the facility. An example of a load rating plan is shown on Figure C-10. In cases where the load rating is consistent throughout the facility or is clearly delineated by the structures, a load rating plan is not required.

(L) SURVEY PLAN

The survey plan presents the overall extent of the inspected shoreline or wetland and includes the elevations (referenced to NAVD88), the stationing adopted for the inspection, transect locations, and the location of any reference points. For wetlands, the assessment area(s) shall be clearly shown. Sample survey plans for a shoreline and wetland are shown on Figure C-11 and Figure C-12, respectively. In cases where the load rating is consistent throughout the facility or is clearly delineated by the structures, a load rating plan is not required.

The wetland survey plan is the same as used for NACSMA. Individual, random plots along a variable-sized random grid will be considered the sampling unit with all of the possible plot locations within the salt marsh being the statistical population of interest. A sample total of fifty (50) 5 m^2 plots will be spaced evenly across each marsh; spacing will be systematic with a random start and will depend on the size of the marsh and the calculated sample size. Plots will be located in a systematic grid design (Figure C-12); the first transect location, forming the basis of the grid, is selected randomly. The subsequent plots will be spaced a set number of meters apart; however, given that grid lines are of varying length (i.e., the marsh is not a uniform width), when the end of one grid line is reached, the plot will fall on the following parallel grid line the remaining number of meters from the study area edge (i.e., upland or water) ("snaking around"). Plot data can be post-stratified into subpopulations of interest (for example, use the plots adjacent to shoreline for shoreline condition assessments). The wetland components will be measured at the sampling plots randomly or systematically selected from these plots.

The sampling plots are temporary, but the locations of transects should be recorded with GPS. The sampling scheme will create the possibility of statistical evaluation of change between years.

(M) SHORELINE POSITION PLAN

The shoreline position plan graphically illustrates the position of the shoreline as observed during the inspection. An example of a shoreline position plan is shown on Figure C-13. Depending on the scale and clarify of the presented information, the shoreline position plan may be combined with the Survey Plan.

(N) BEACH PROFILES

Beach profiles are prepared for each transect along the inspected shoreline and depicts the profile of the beach from behind the shoreline berm/dune to at least MLW. The tide levels and base flood elevation (100-year flood) must be presented on each profile. An example of a beach profile is shown on Figure C-14.

(O) ELEVATION CHANGE PLAN

The elevation change plan graphically illustrates the change in elevation over a specified area. Elevation change plans require that appropriate and compatible survey data be available. The elevation change plan shows either contour lines or colored shading to represent the magnitude of the change in elevation. An example of an elevation change plan is shown on Figure C-15.

(P) WETLAND SHORELINE PROFILE

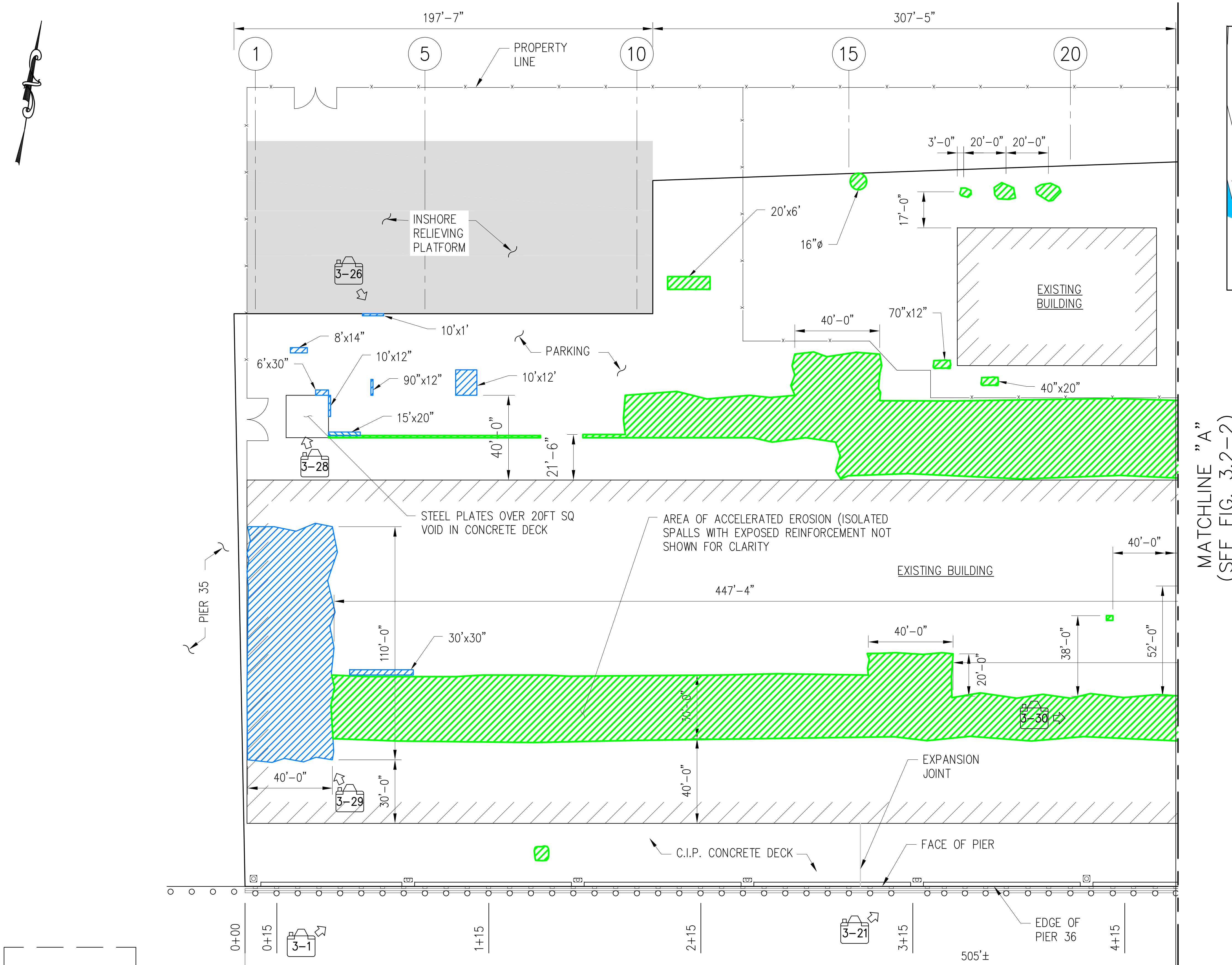
The wetland shoreline profile graphs are prepared for each transect along the inspected shoreline and depicts the profile of the marsh from subtidal area at MLLW to the wetland-upland transition zone. The tide levels must be presented on each profile. The base flood elevation (100-year flood) can be also presented on each profile depending on specific inspection scope. An example of a wetland shoreline profile is shown on Figure C-16.

(Q) WETLAND SHORELINE POSITION PLAN

The wetland shoreline position plan graphically illustrates the position of the shoreline as observed during the inspection. An example of a wetland shoreline position plan is shown on Figure C-17. Depending on the scale and clarify of the presented information, the shoreline position plan may be combined with the Survey Plan.

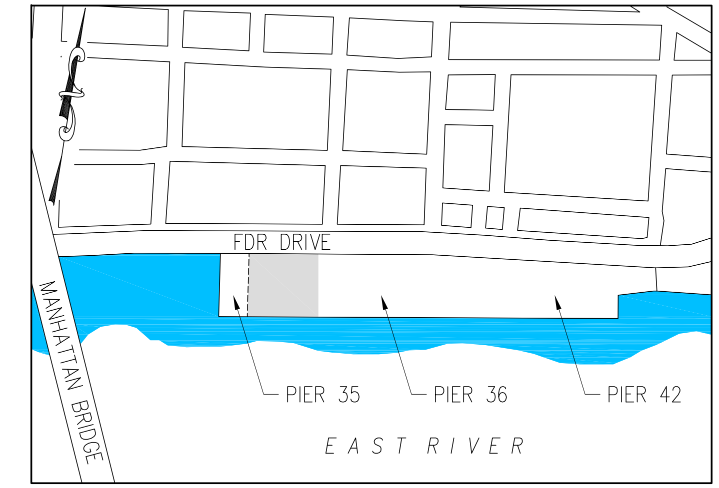
C.3.2 Legends

When required, legends are placed on a figure to indicate the geometric shape (square, round, etc.), the type of material (timber, steel, concrete, etc.), and the level (degree of thoroughness) of the inspection. Every symbol used on a figure must be identified in the legend, and the legend should not include any symbol that is not used on the figure. Figure C-5 shows an example of a Pile Plan with an acceptable legend relevant to the facility. Figure C-18 illustrates some suggested symbols to be used in a legend.



PLAN

SCALE 1"=50'



KEY PLAN

LEGEND

- AREA NOT INSPECTED
- EROSION/SPALL WITH EXPOSED REINFORCEMENT IN TOP OF CONC. DECK
- CRACK IN TOP OF CONCRETE DECK
- EROSION/SPALL IN TOP OF CONC. DECK
- CHAIN-LINK FENCE
- 2-10 PHOTO LOCATION
- BOLLARD 40"x40"
- BOLLARD 24"x48"

0 50 100 FT.

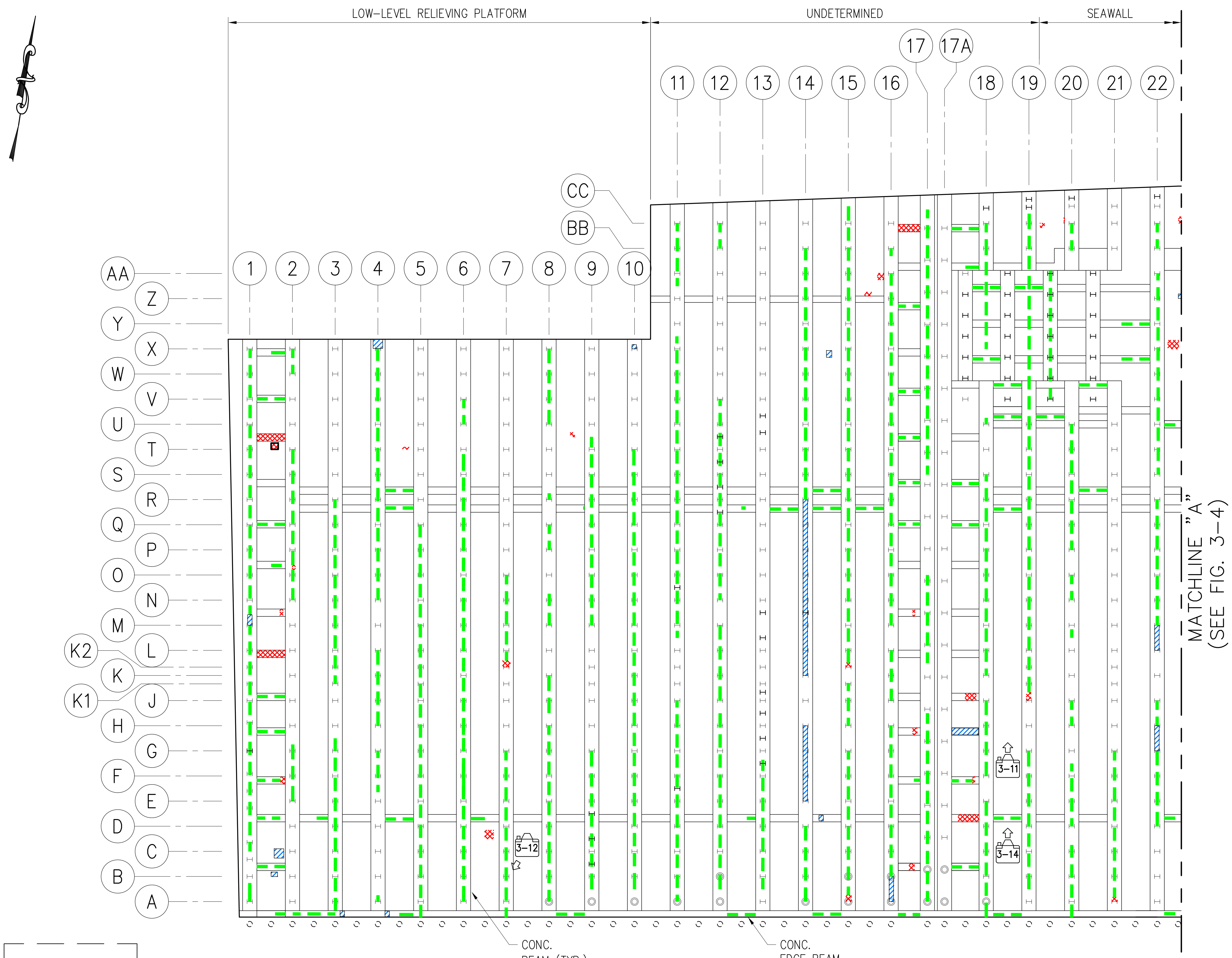
1"=50'

CONSULTANT'S NAME AND LOGO

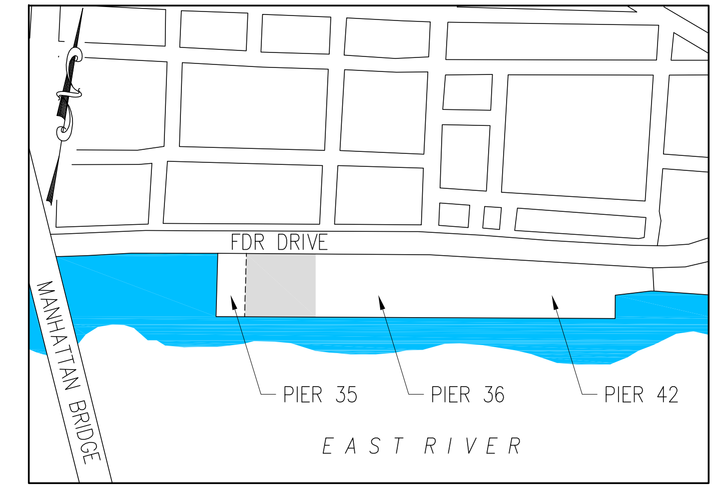
NEW YORK CITY
ECONOMIC DEVELOPMENT CORPORATION
PIER 36, MANHATTAN

PIER 36
DECK PLAN (SHEET 1 OF 2)

FIGURE C-3
SAMPLE DECK PLAN



PLAN
SCALE 1"=50'



KEY PLAN

LEGEND

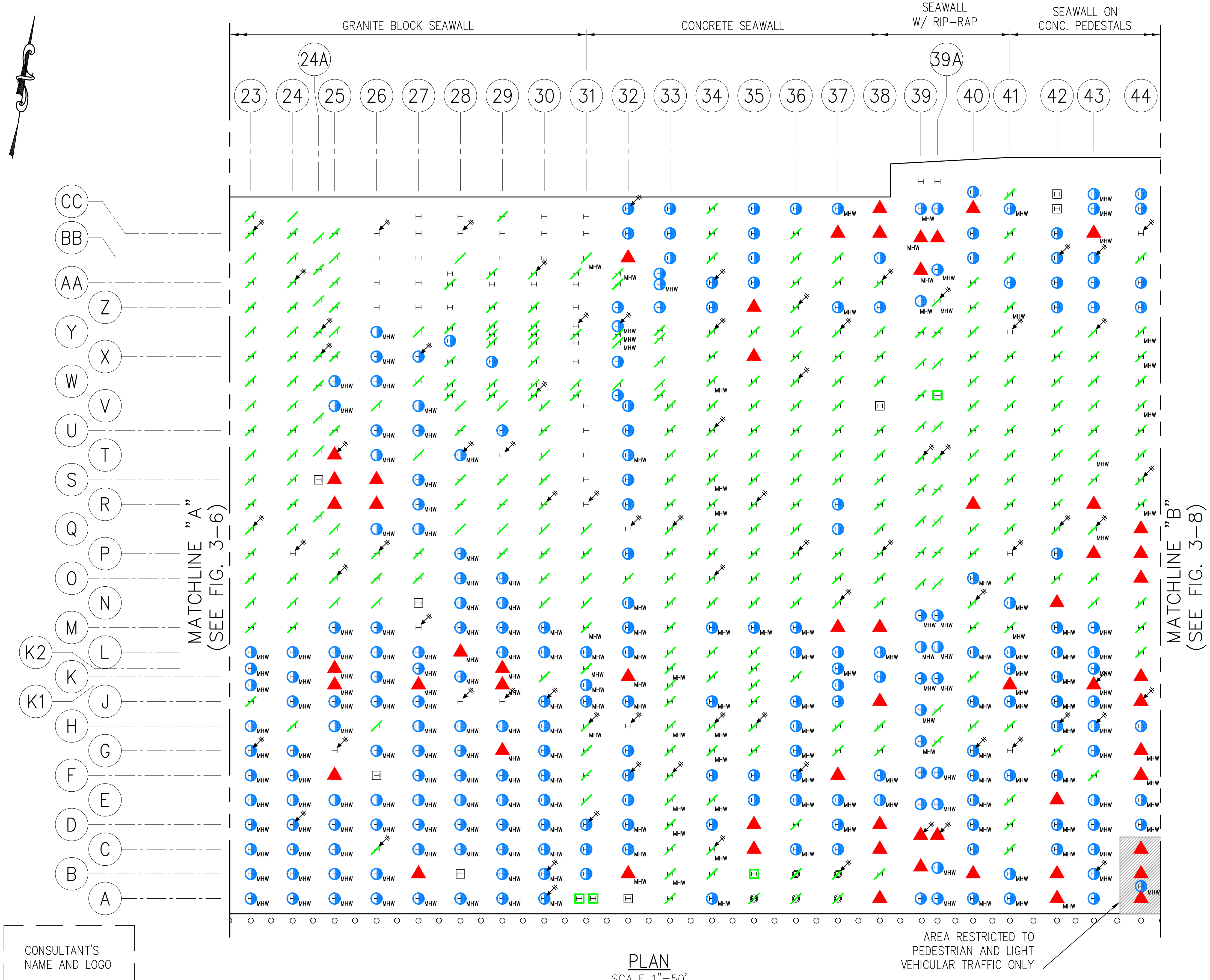
- CONCRETE PILE CAP/BEAM WITH MODERATE DEFECTS
- CONCRETE PILE CAP/BEAM WITH ADVANCED DEFECTS
- CONCRETE PILE CAP/BEAM WITH SEVERE DEFECTS
- ADVANCED DETERIORATION ON UNDERSIDE OF CONC. DECK (OPEN SPALL)
- 2-10 PHOTO LOCATION
- SEVERE DETERIORATION ON UNDERSIDE AND CONCRETE DECK (OPEN SPALL)

1"=50' 0 50 100 FT.

NEW YORK CITY
ECONOMIC DEVELOPMENT CORPORATION
PIER 36, MANHATTAN
PIER 36 FRAMING PLAN
BENTS 1 TO 22 (SHEET 1 OF 3)

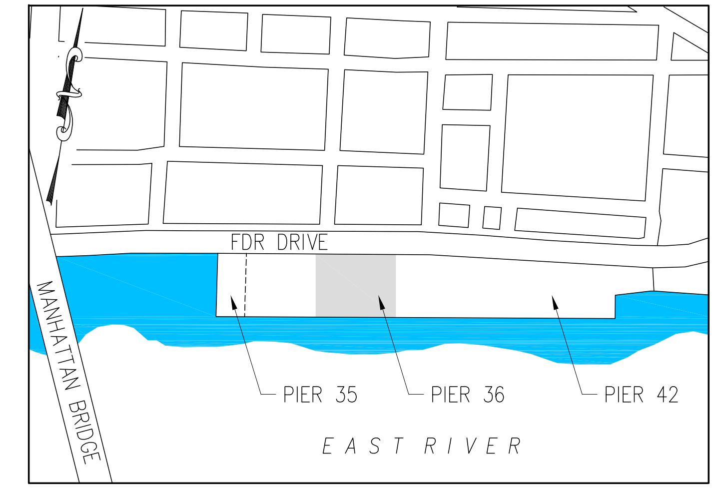
FIGURE C-4
SAMPLE FRAMING PLAN

CONSULTANT'S
NAME AND LOGO



PLAN

SCALE 1"=50'



KEY PLAN

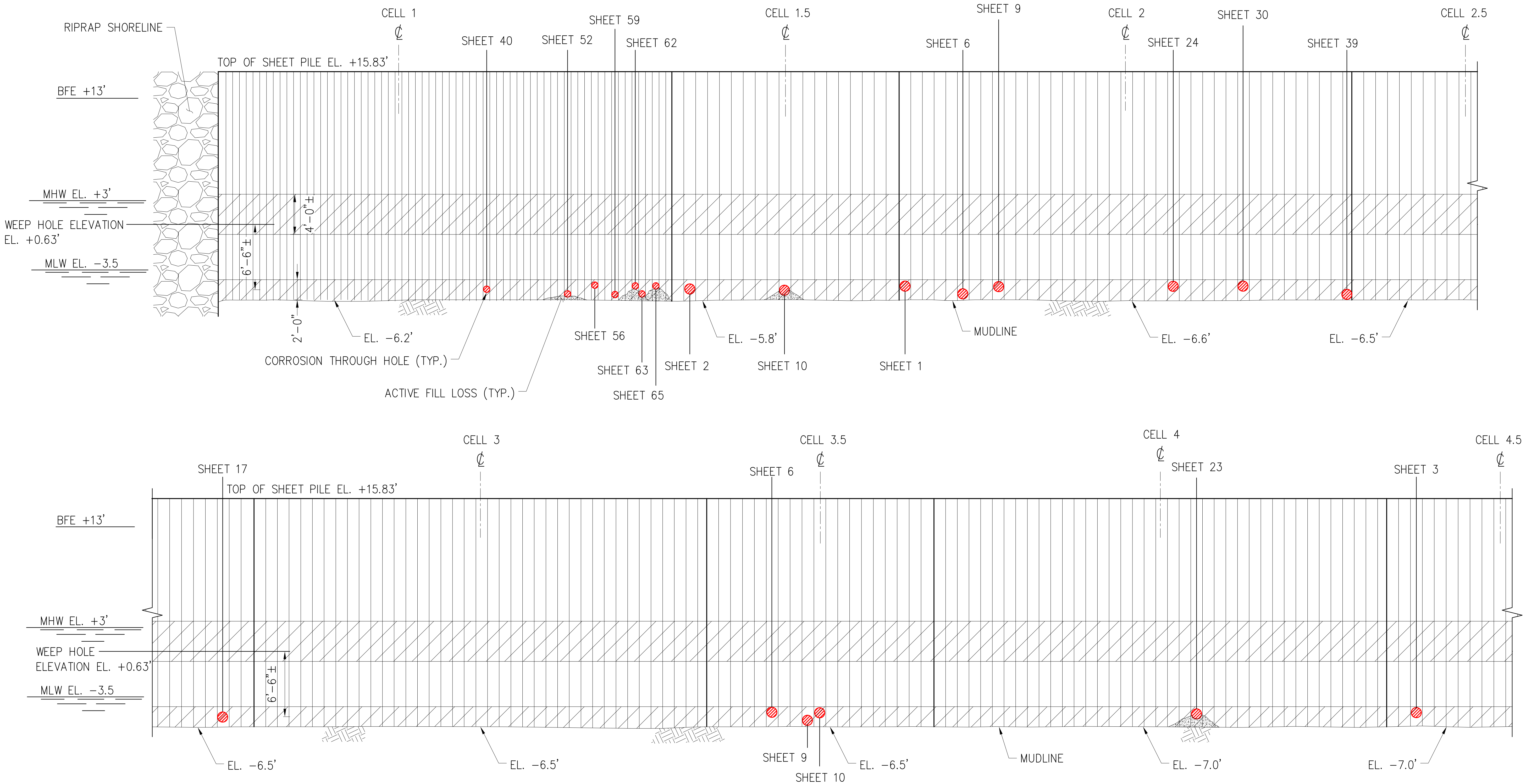
LEGEND

- STEEL H-PILE WITH MINOR DETERIORATION
- STEEL H-PILE WITH MODERATE DETERIORATION
- STEEL H-PILE WITH ADVANCED DETERIORATION
- STEEL H-PILE WITH SEVERE DETERIORATION
- STEEL H-PILE WITH MODERATE DETERIORATION ABOVE THE MHW ELEVATION
- STEEL H-PILE WITH ADVANCED DETERIORATION ABOVE THE MHW ELEVATION
- STEEL H-PILE WITH SEVERE DETERIORATION ABOVE THE MHW ELEVATION
- ENCASEMENT REPAIR WITH MINOR DETERIORATION
- ENCASEMENT REPAIR WITH MODERATE DETERIORATION
- ENCASEMENT REPAIR WITH ADVANCED DETERIORATION
- ENCASEMENT REPAIR WITH SEVERE DETERIORATION
- STEEL PIPE PILE WITH MODERATE DETERIORATION
- STEEL PIPE PILE WITH MODERATE DETERIORATION ABOVE THE MHW ELEVATION
- STEEL PIPE PILE WITH ADVANCED DETERIORATION ABOVE THE MHW ELEVATION
- TIMBER FENDER PILE WITH MINOR DEFECTS
- TIMBER FENDER PILE WITH SEVERE DEFECTS
- LOCATION OF LEVEL 2 INSPECTION
- LOCATION OF LEVEL 3 INSPECTION
- 2-10 PHOTO LOCATION

1"=50' — 0 50 100 FT.

NEW YORK CITY
ECONOMIC DEVELOPMENT CORPORATION
PIER 36, MANHATTAN
PILE PLAN BENTS 23 TO 44
(SHEET 2 OF 3)

FIGURE C-5
SAMPLE PILE PLAN



NOTE:

FOR CORROSION THROUGH HOLE SIZE, SEE TABLE 3.2-1

LEGEND

ZONE OF CORROSION

CORROSION THROUGH HOLE

CONSULTANT'S NAME AND LOGO

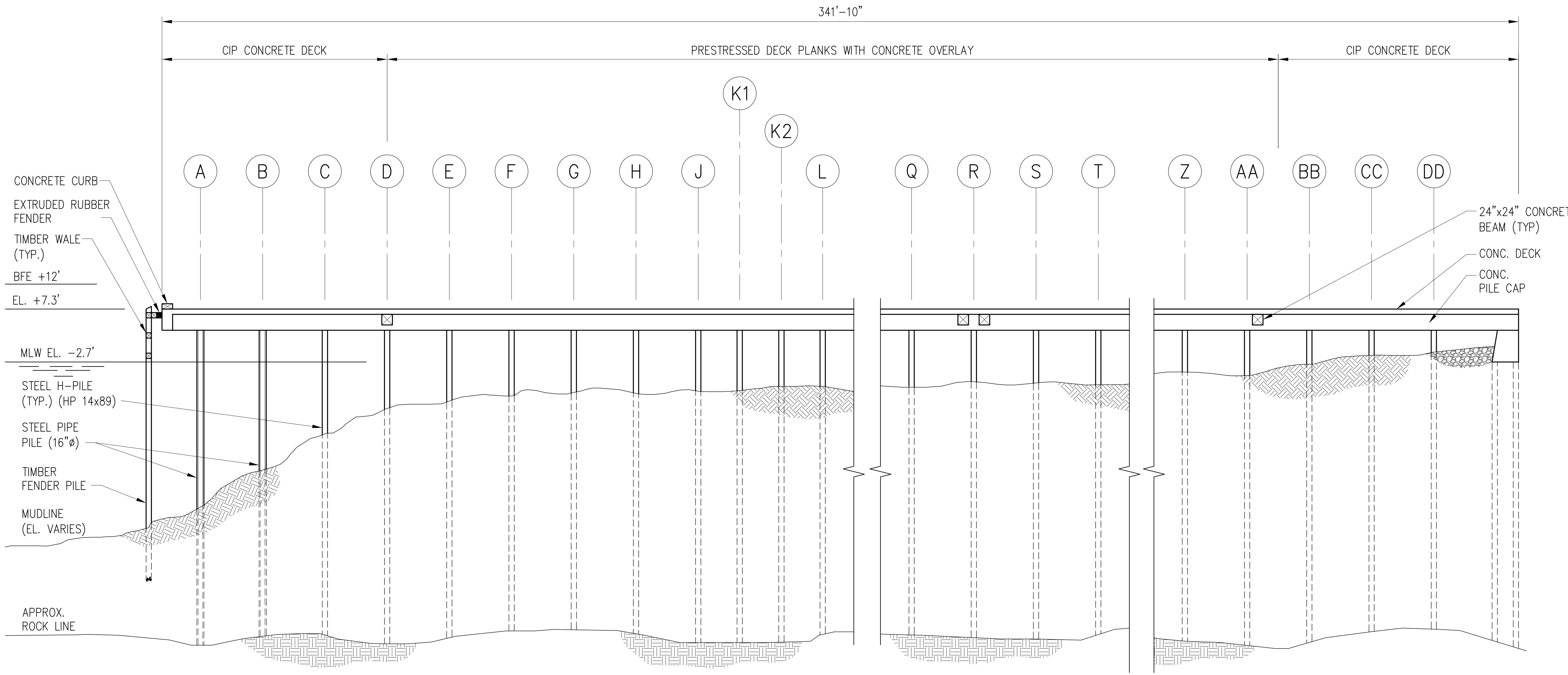
ELEVATION

SCALE 1"=10'

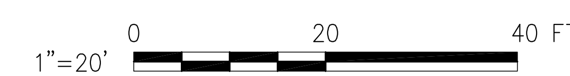
1"=10' 0 10 20 FT.

NEW YORK CITY
ECONOMIC DEVELOPMENT CORPORATION
HUNTS POINT PENINSULA BULKHEADS, BRONX
STEEL CIRCULAR CELL BULKHEAD
CELL DEFICIENCIES – SHEET 1 OF 3

FIGURE C-6
SAMPLE ELEVATION VIEW



NOTES:
1. ELEVATIONS SHOWN ARE REFERENCED TO NAVD88.
2. CUT EAST OF BENT 37, BUILDINGS NOT SHOWN FOR CLARITY

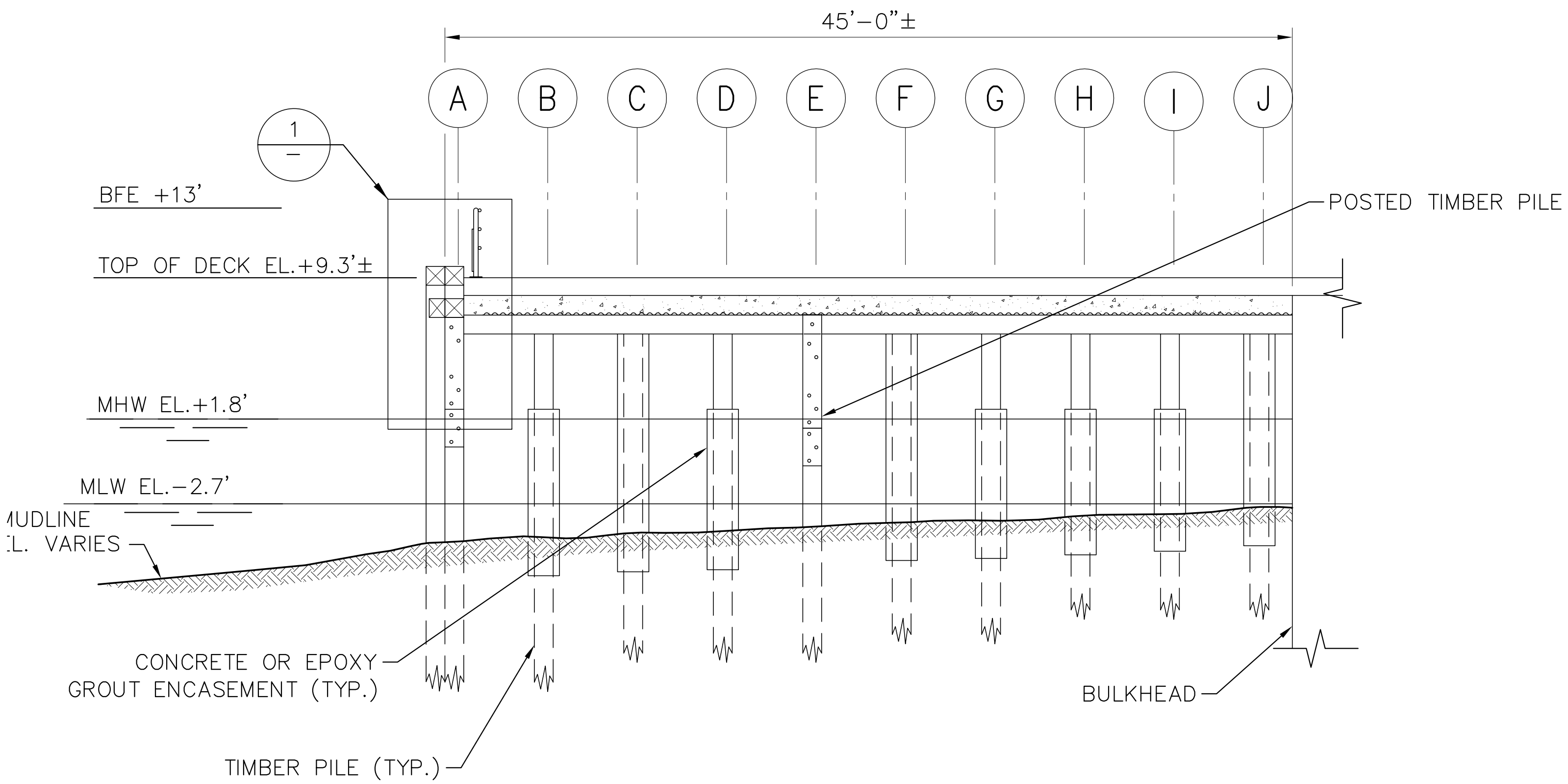


NEW YORK CITY
ECONOMIC DEVELOPMENT CORPORATION
PIER 36, MANHATTAN
TYPICAL CROSS SECTION

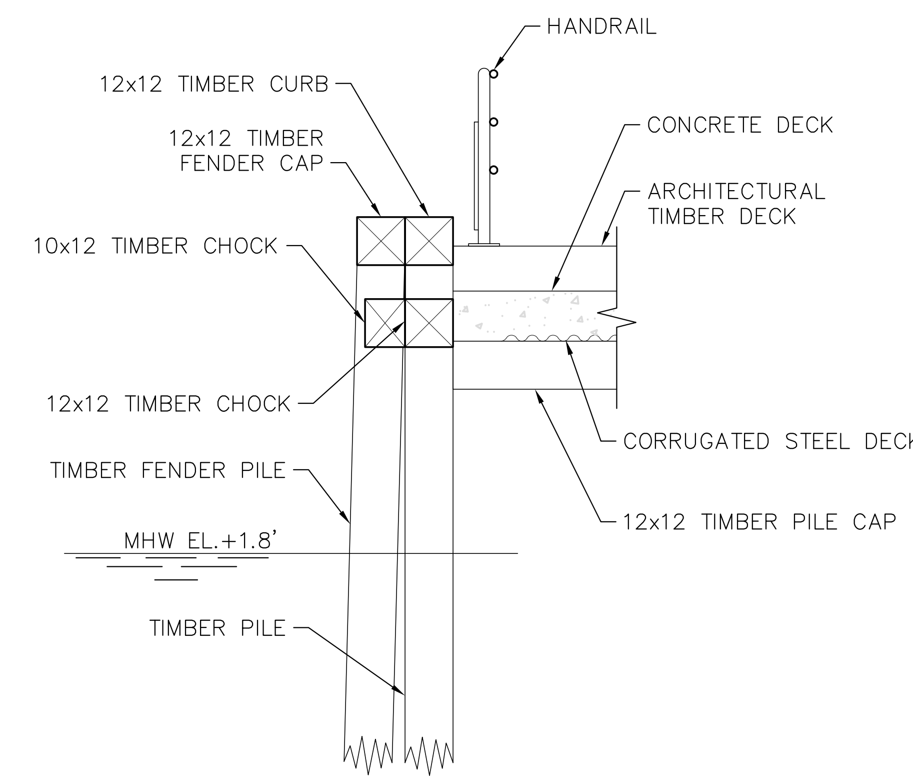
TYPICAL SECTION
SCALE 1"=20'

CONSULTANT'S NAME AND LOGO

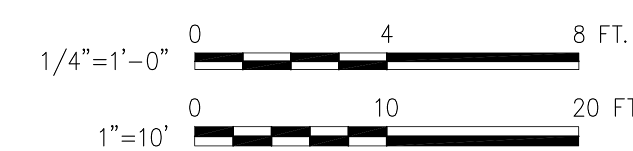
FIGURE C-7
SAMPLE CROSS-SECTION



TYPICAL SECTION
SCALE: 1"=10'



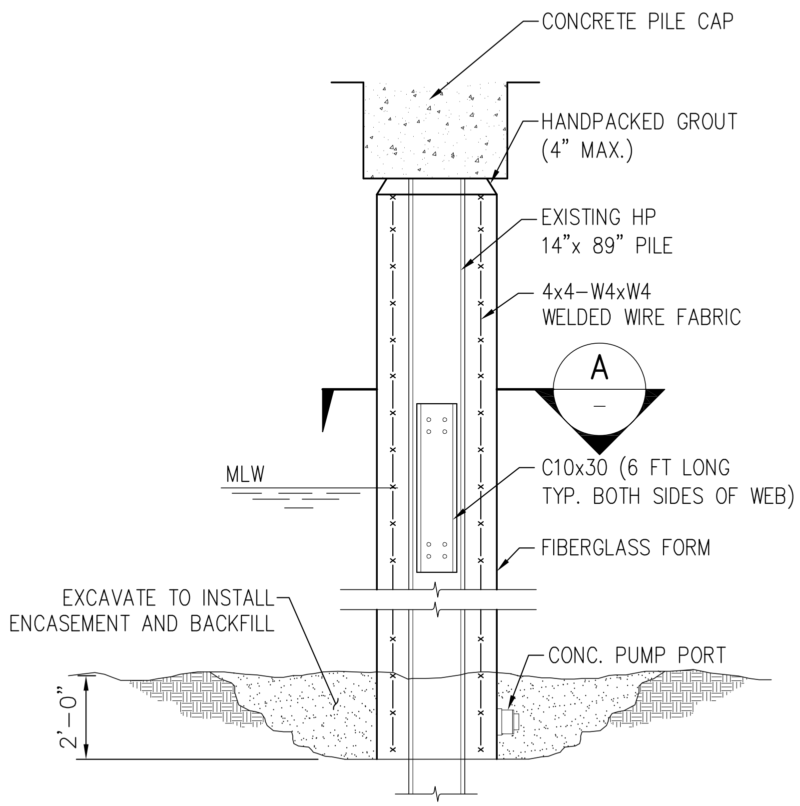
1 DETAIL
SCALE: 1/4"= 1'-0"



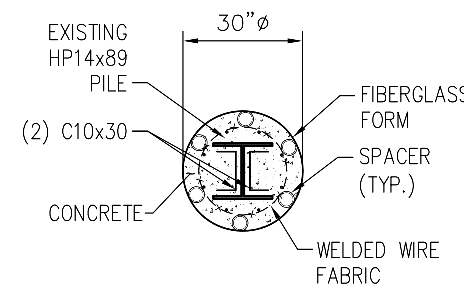
NEW YORK CITY
ECONOMIC DEVELOPMENT CORPORATION
PIER 16, MANHATTAN
MARGINAL WHARF
TYPICAL SECTION AND DETAIL

FIGURE C-8
SAMPLE DETAIL

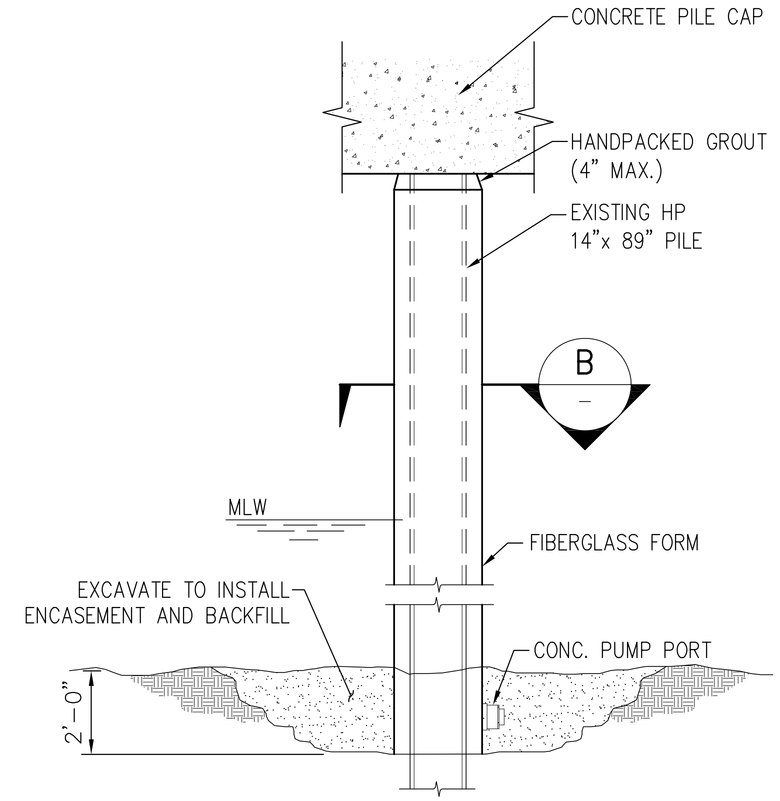
CONSULTANT'S
NAME AND LOGO



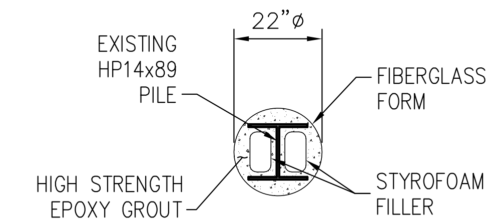
SEVERE PILE REPAIR
SCALE 1/4"=1'-0"



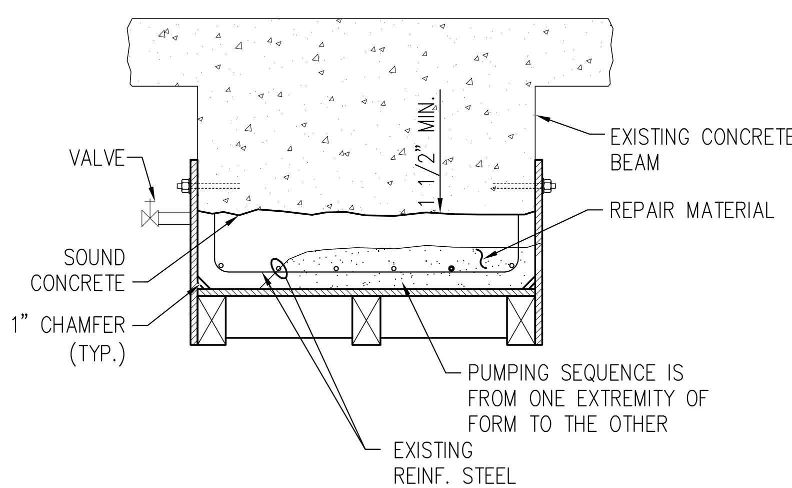
A SECTION
SCALE 1/4"=1'-0"



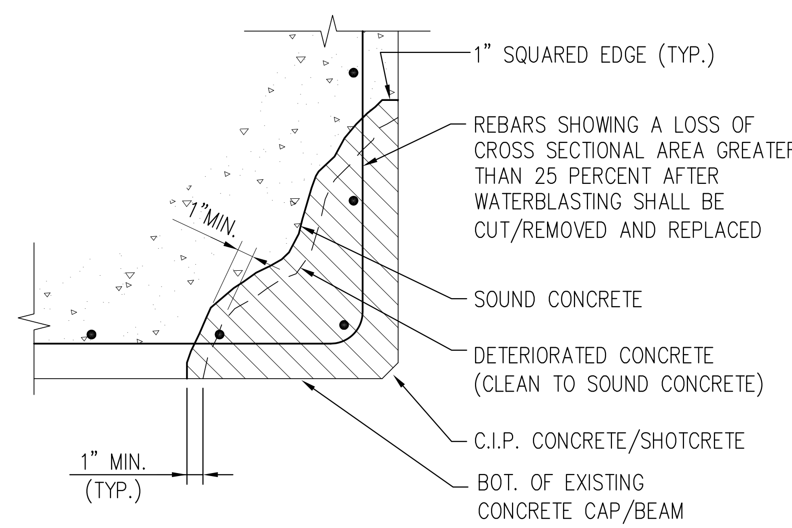
ADVANCED PILE REPAIR
SCALE 1/4"=1'-0"



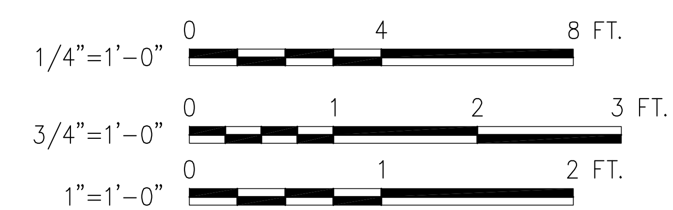
B SECTION
SCALE: 1/4" = 1'-0"



CONCRETE CAP/BEAM
FULL WIDTH SPALL REPAIR
SCALE 3/4"=1'-0"



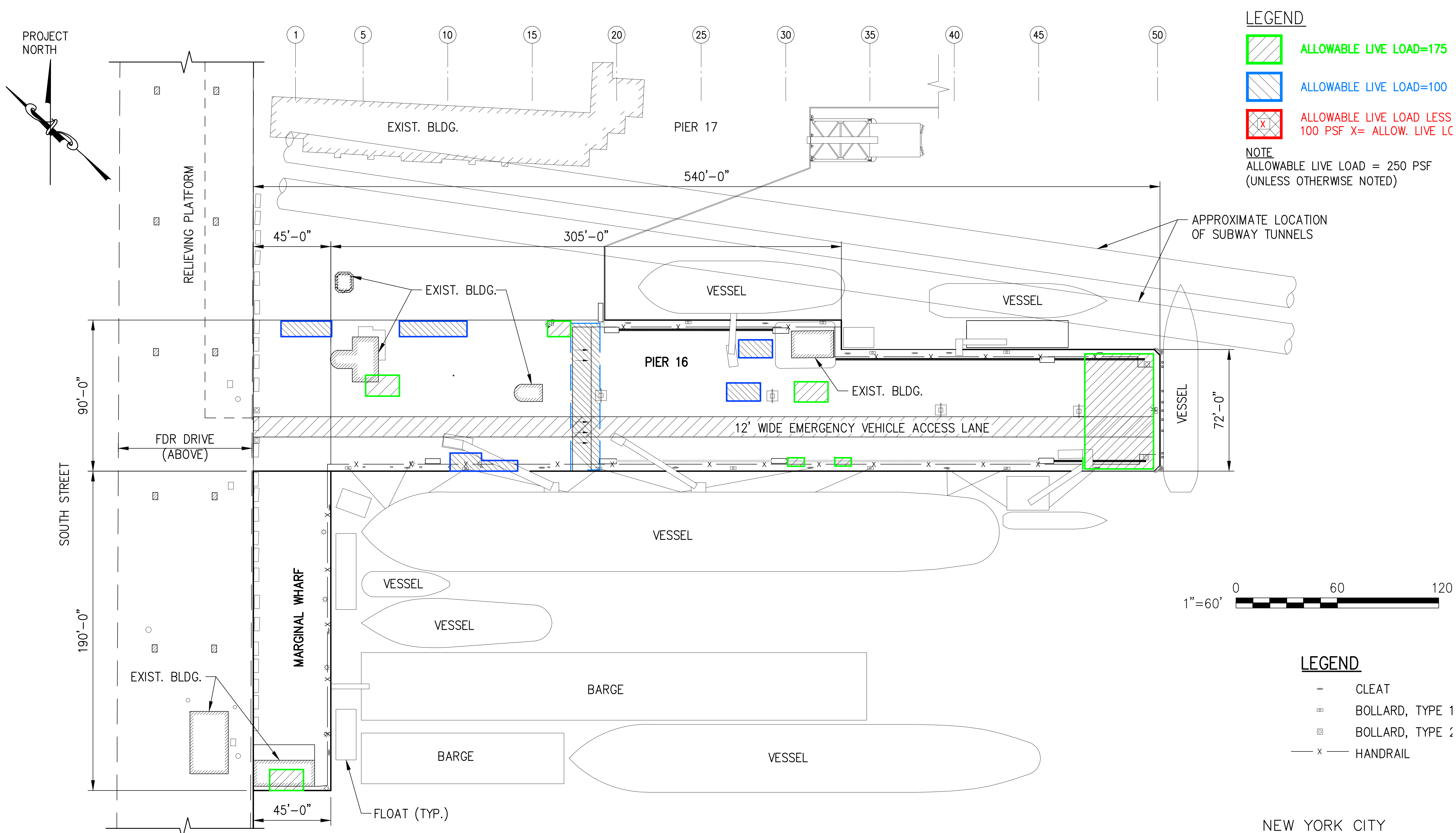
CONCRETE BEAM CORNER SPALL REPAIR
SCALE 1"=1'-0"



CONSULTANT'S NAME AND LOGO

NEW YORK CITY
ECONOMIC DEVELOPMENT CORPORATION
PIER 36, MANHATTAN
PIER 36 CONCEPTUAL REPAIR DETAILS

FIGURE C-9
SAMPLE REPAIR DETAILS

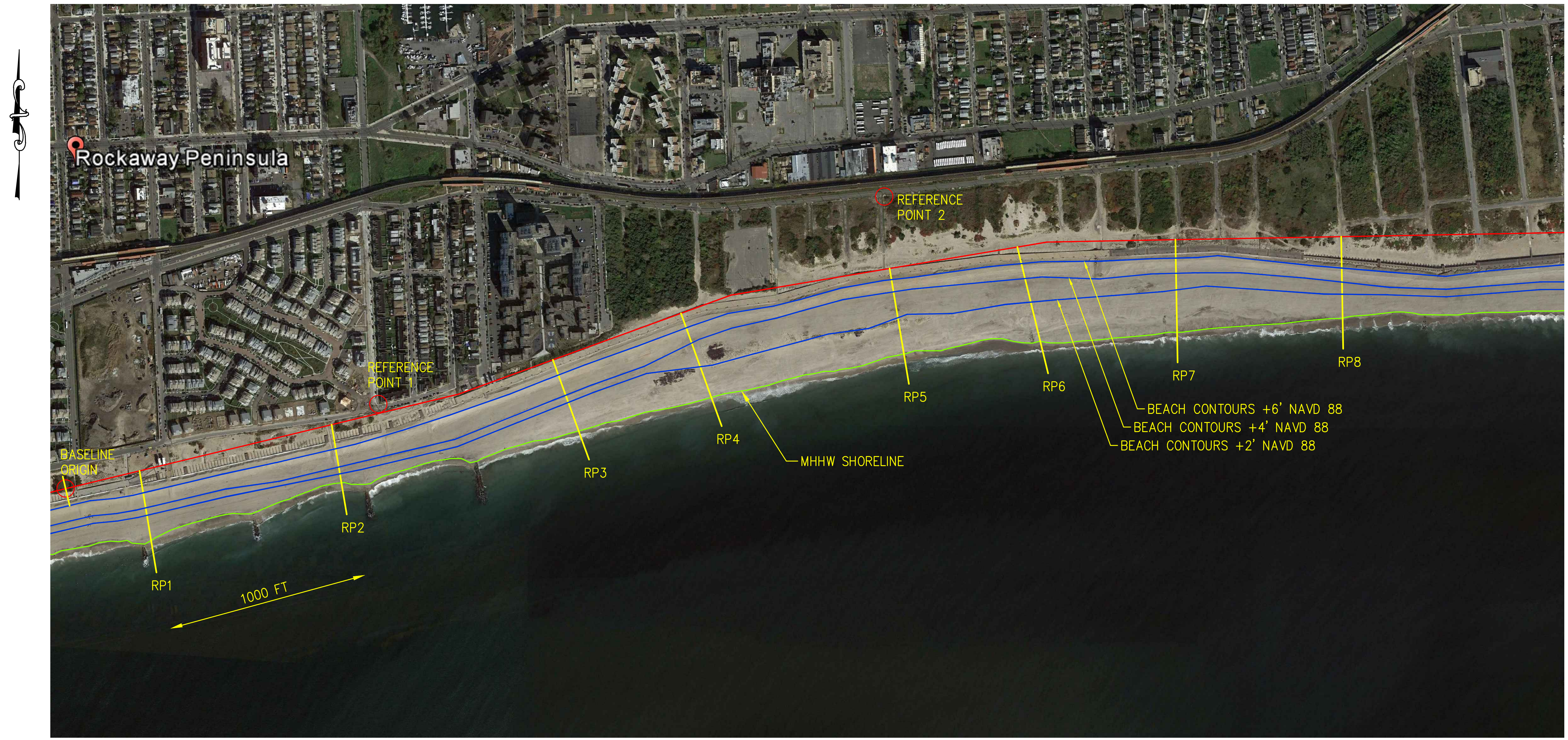


LOAD RATING PLAN
SCALE 1"=60'

CONSULTANT'S NAME AND LOGO

NEW YORK CITY
ECONOMIC DEVELOPMENT CORPORAT
PIER 16, MANHATTAN
LIVE LOAD RATING PLAN

FIGURE C–10
SAMPLE LOAD RATING PLAN

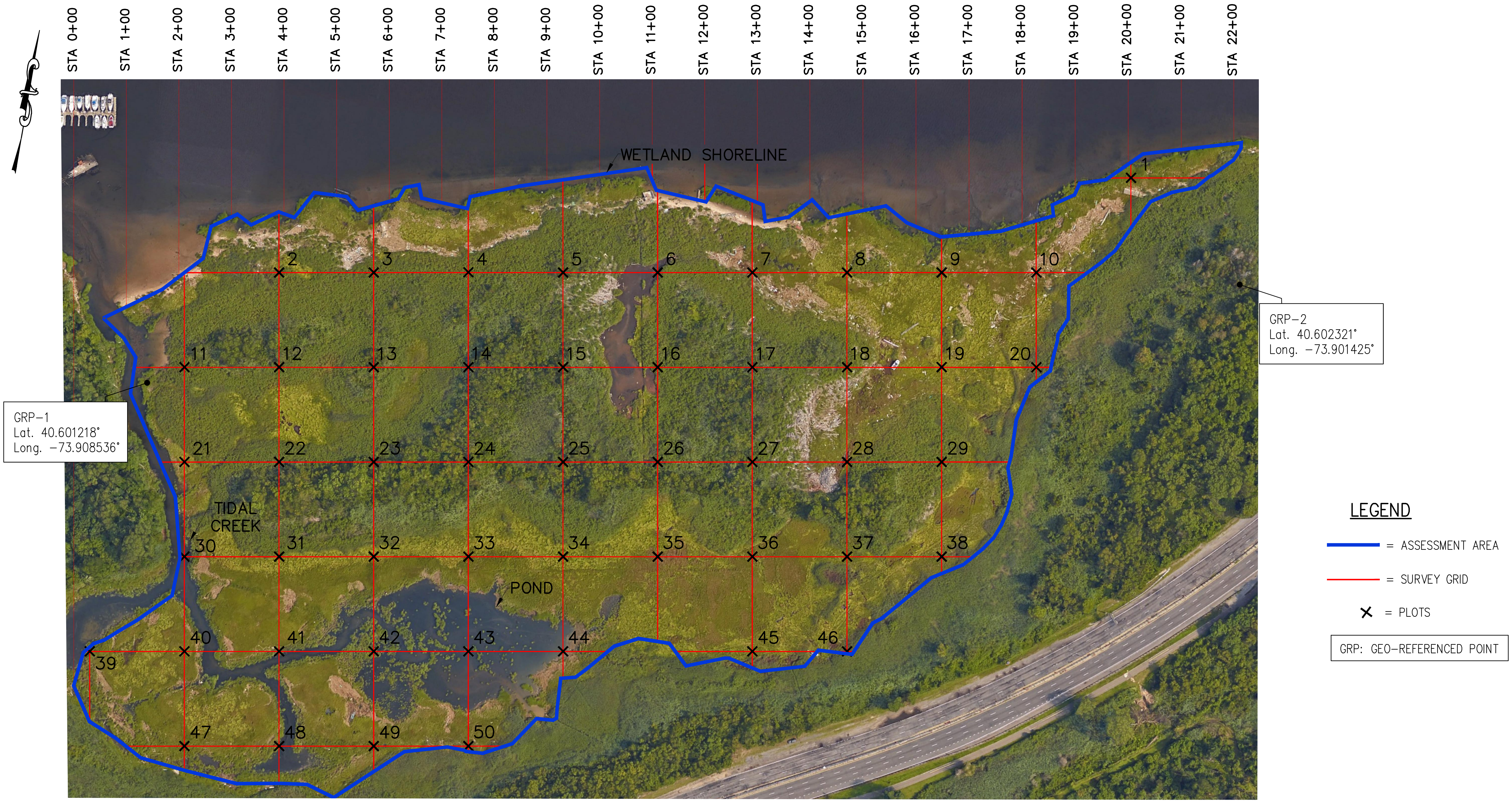


PLAN
SCALE 1"=60'

1"=60' 0 60 120 FT.

NEW YORK CITY
ECONOMIC DEVELOPMENT CORPORATION
BEACH STREET 105th, QUEENS

FIGURE C–11
SAMPLE SURVEY PLAN FOR SHORELINE



PLAN

SCALE 1"=200'

1"=200' 0 200 400 FT.

NEW YORK CITY
ECONOMIC DEVELOPMENT CORPORATION
FOUR SPARROW MARSH, BROOKLYN

FIGURE C-12
WETLAND SURVEY PLAN

LEGEND

= SURVEY GRID

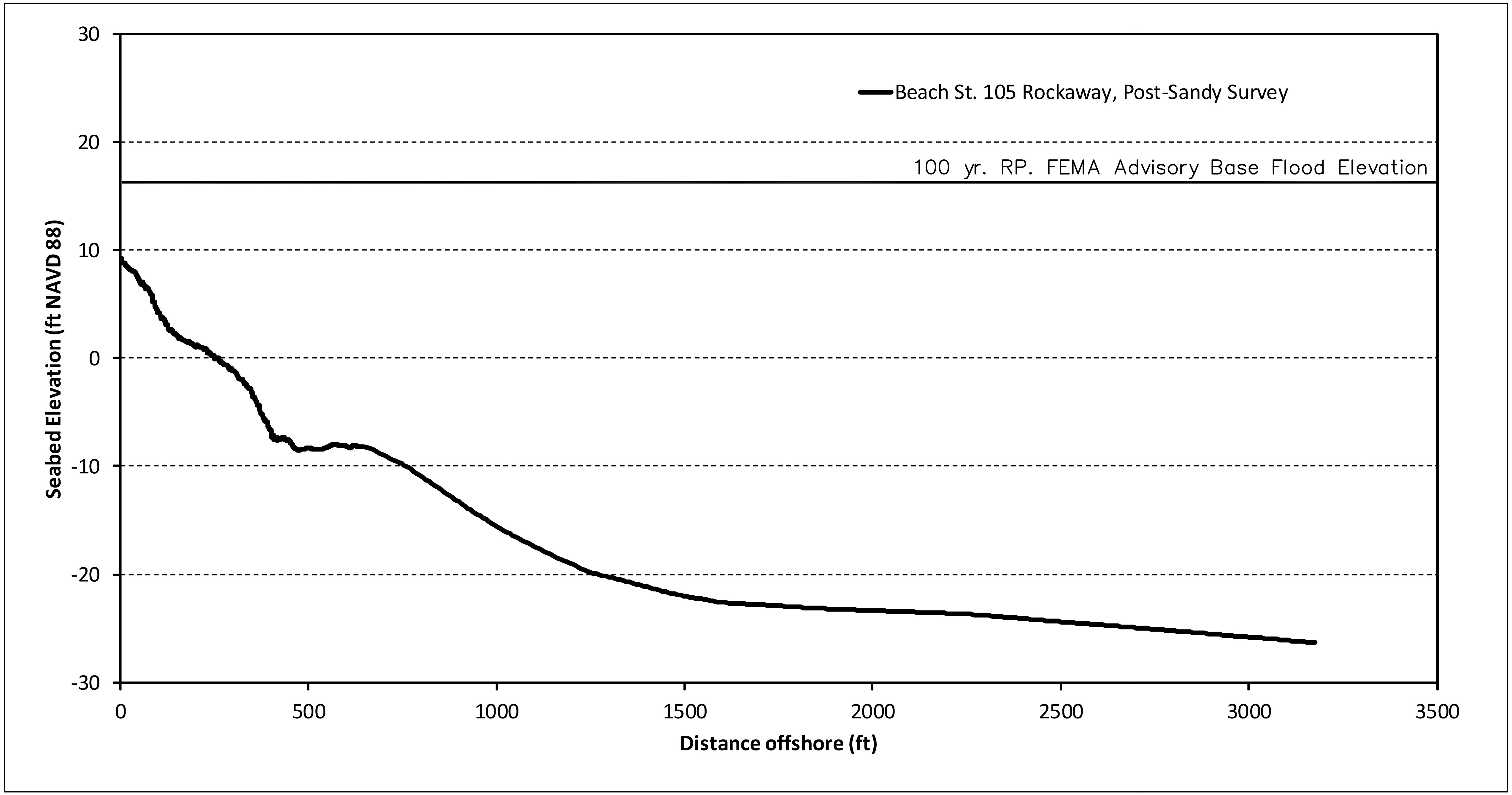
PLAN

SCALE 1"=60'

1"=60' 0 60 120 FT.

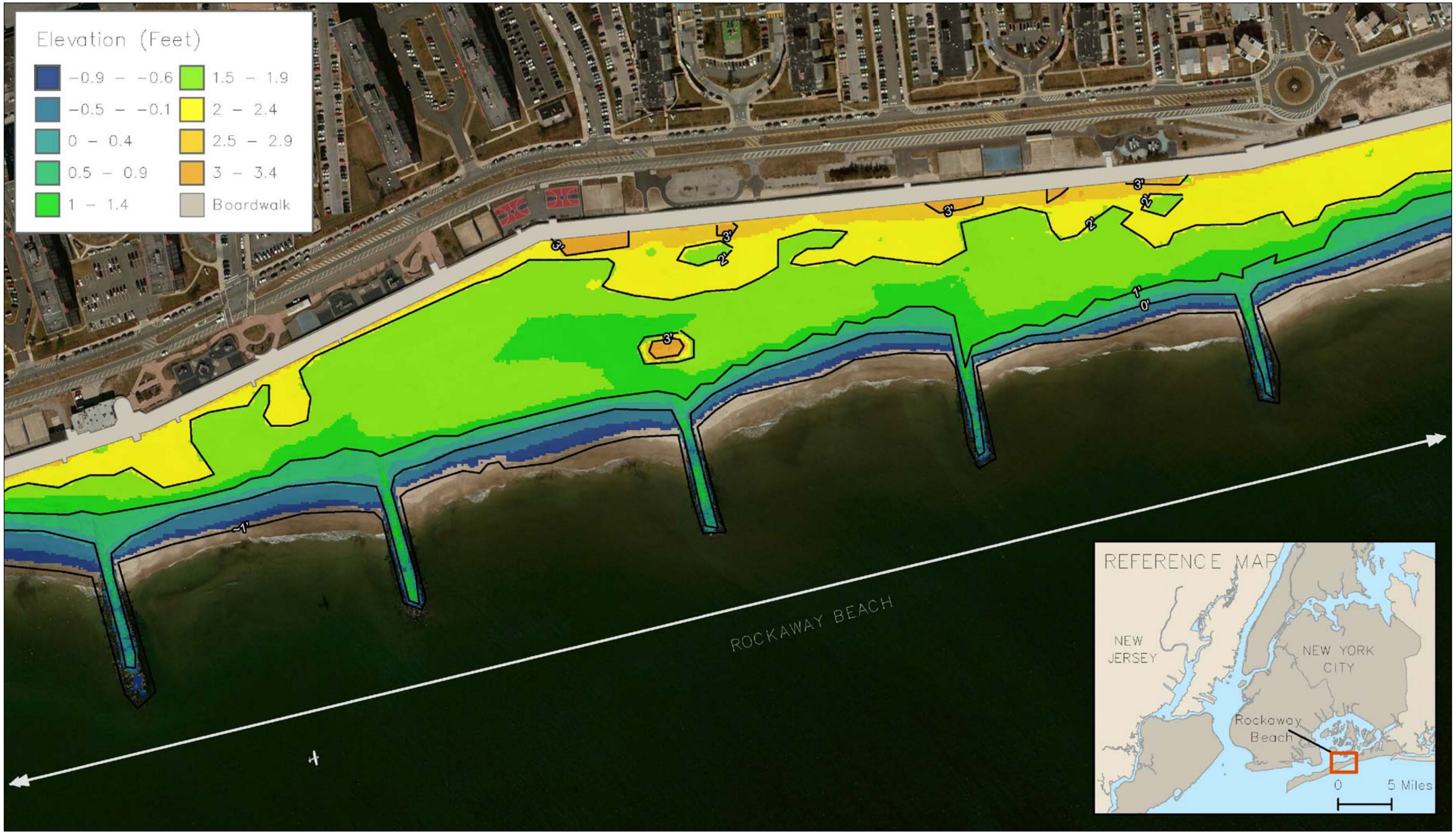
NEW YORK CITY
ECONOMIC DEVELOPMENT CORPORATION
BEACH STREET 105th, QUEENS

FIGURE C–13
SAMPLE SHORELINE POSITION PLAN



BEACH PROFILE

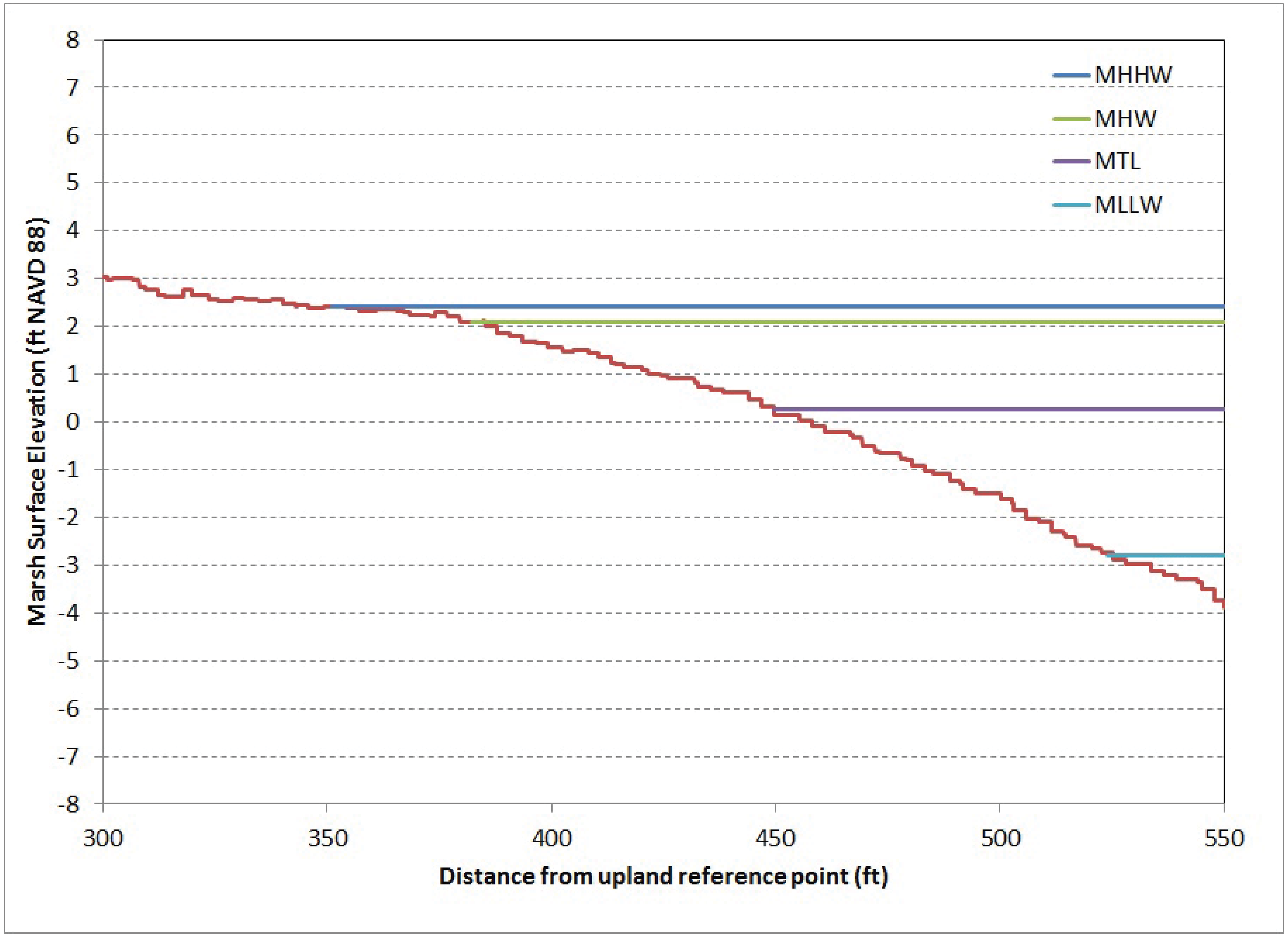
FIGURE C–14
SAMPLE BEACH PROFILE



1"=250' 0 250 500 FT.

NEW YORK CITY
ECONOMIC DEVELOPMENT CORPORATION
BEACH STREET 105th, QUEENS

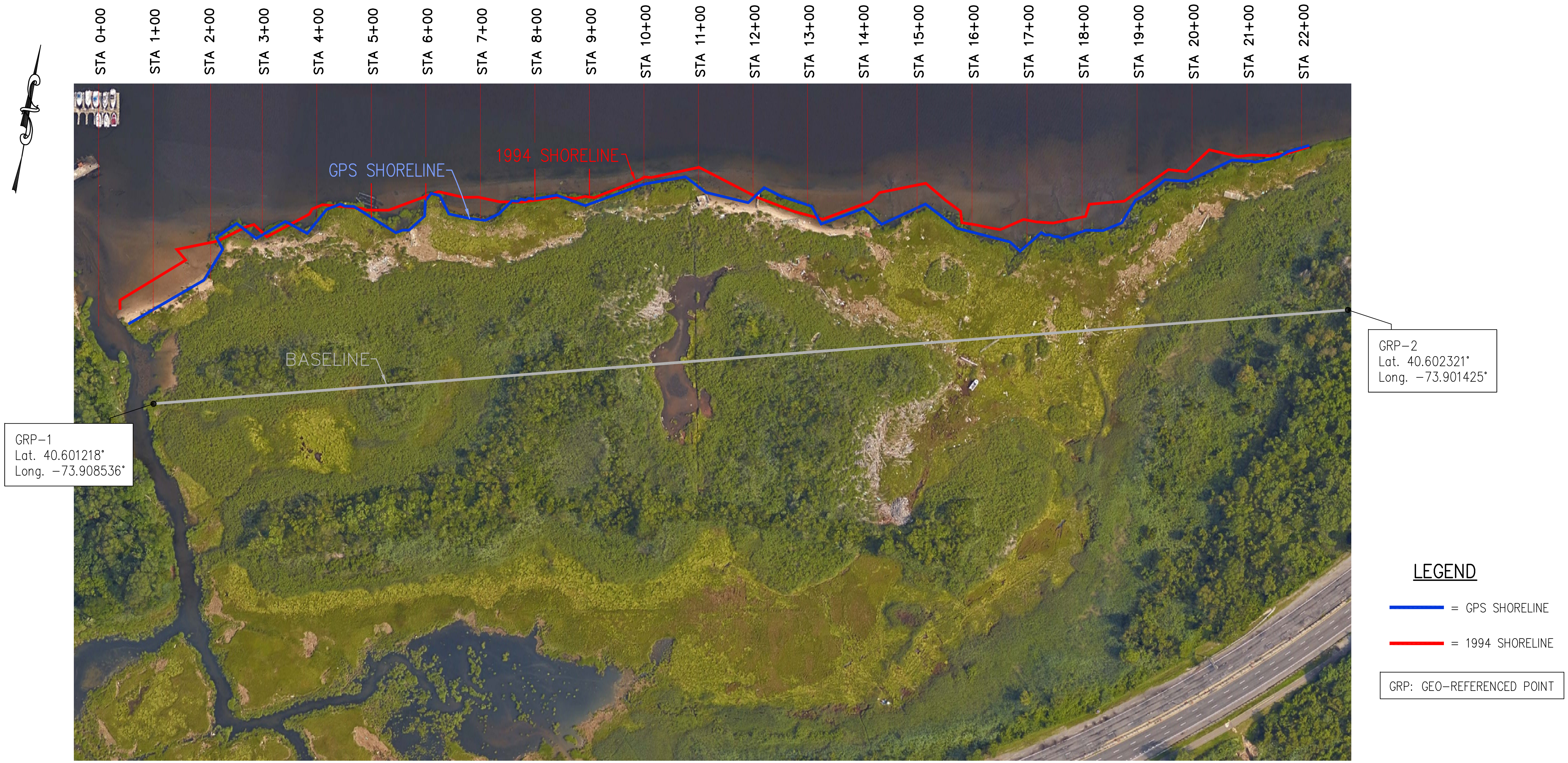
FIGURE C-15
SAMPLE ELEVATION CHANGE PLAN



NEW YORK CITY
ECONOMIC DEVELOPMENT CORPORATION
FOUR SPARROW MARSH, BROOKLYN

WETLAND PROFILE

FIGURE C–16
SAMPLE WETLAND SHORELINE PROFILE



PLAN
SCALE 1"=200'

1"=200' 0 200 400 FT.

NEW YORK CITY
ECONOMIC DEVELOPMENT CORPORATION
FOUR SPARROW MARSH, BROOKLYN

FIGURE C-17
WETLAND SHORELINE POSITION
POSITION PLAN

VERTICAL PILE
(VARIOUS CROSS SECTIONS)

BATTER PILE

POSTED PILE

ENCASED PILE

BROKEN PILE

MISSING PILE

REPLACED OR NEW PILE

SPLIT PILE

CRACKED OR CHECKED PILE

NON-BEARING PILE

DETERIORATED OR MISSING HARDWARE

LOSS IN CROSS-SECTIONAL DIAMETER
(LOSS 25% OF ø)

LOSS IN CROSS-SECTIONAL DIAMETER
(25% < LOSS 50% ø)

LOSS IN CROSS-SECTIONAL DIAMETER
(50% < LOSS 75% ø)

LOSS IN CROSS-SECTIONAL DIAMETER
(75% < LOSS 100% ø)

PILE WITH MARINE BORER ACTIVITY

OPTIONAL SYMBOL

OPTIONAL SYMBOL

OPTIONAL SYMBOL

OPTIONAL SYMBOL

LEVEL II INSPECTION

LEVEL III INSPECTION

PILE CAP SPLICE
(CAP, CLAMPS, FISH PLATES,
AND/ OR BOLTS TO BE REPAIRED)

PILE CLAMPS SPLICE
(CAP, CLAMPS, FISH PLATES,
AND/ OR BOLTS TO BE REPAIRED)

SINGLE LINE FRAMING
DETERIORATED PILE CAP

PILE CAP
DETERIORATED PILE CAP

PILE CLAMPS
DETERIORATED PILE CAP

SINGLE LINE FRAMING
MISSING PILECAP

PILE CAP
MISSING PILE CAP

PILE CLAMPS
MISSING PILE CAP

SINGLE LINE FRAMING SPLICE
(CAP, CLAMPS, FISH PLATES,
AND/ OR BOLTS TO BE REPAIRED)

DECK PLANKS WITH GAPS

BROKEN DECK PLANKS

DETERIORATED DECK

SPALLED DECK

GAPS BETWEEN SHEET PILES

6" GAP IN SHEET PILES WITH
18" DEEP CAVITY BEHIND SHEETS

MB MISSING BOLLARD

BB BROKEN BOLLARD

MC MISSING CLEAT

BC BROKEN CLEAT

2" SUBSIDENCE WITH MAXIMUM
DEPRESSION OF 2"

12" SINKHOLE

18 SOUNDING TO SEABED FROM MLLW

NOTE

SYMBOLS ARE TYPICAL FOR ROUND PILES. HOWEVER, VARIOUS PILE SHAPES SHOULD BE USED TO REPRESENT THE ACTUAL PILES INSPECTED.

NEW YORK CITY
ECONOMIC DEVELOPMENT CORPORATION
INSPECTION GUIDELINES MANUAL

TYPICAL SYMBOLS

FIGURE C-18

C.3.3 Color

The use of color can greatly enhance the presentation of information shown on figures. Color can be used to signify the degree of damage and corresponding urgency of repair of a particular condition. The following colors are typically used in the inspection report:

Red: Indicates conditions of severe deterioration or damage for which repairs are required on an immediate basis to prevent imminent collapse. Additionally red is used to indicate deck areas to be barricaded, restricted, or limited in use.

Blue: Indicates conditions of moderate to advanced deterioration for which repairs are required on a priority basis in order to prevent continued deterioration or maintain safe loading conditions.

Green: Indicates conditions for which repairs are required to remove safety hazards.

Note: Yellow and other colors of similar hue, do not contrast well with white paper and shall not be used in the inspection report.

The colors listed above serve as a standard for the use of color and are to be followed throughout all inspection reports. In addition, each color used on the figures should have a different linetype or hatch pattern so that the information is visible in black and white copies or printouts of the report. When colors are used on figures the significance of the color should be clearly stated in the legend of the figure.

C.3.4 Format

All figures shall have a 5/8 in. margin on the left, right, and top of the page and 1 in. on the bottom of the page. An information block shall be provided along the lower edge of the page. The information block shall include the consultant's name/logo, the client "NEW YORK CITY ECONOMIC DEVELOPMENT CORPORATION", the facility's name and location, the figure title, and the figure number. A page number shall be positioned in the lower margin, 3/4 in. from the bottom of the page and 4 in. from the right edge of the paper. The electronic CAD file path and name is located at the lower left corner of the sheet and should be the same name as the figure in the report.

Information blocks shall have the format shown on Figures C-1 through C-18. In no case shall the lettering that designates the consultant's name be larger than the letters used to write "NEW YORK CITY ECONOMIC DEVELOPMENT CORPORATION."

Figures are to be presented on either 8-1/2 in. by 11 in. or 11 in. by 17 in. sheets, as necessary. Sheets larger than 11 in. by 17 in. are not to be used. If a figure is presented on an 11 in. by 17 in. sheet, then, when binding this sheet, it is to be folded with two vertical creases so that the edges of the folded and bound sheet does not extend beyond the edges of a bound 8-1/2 in. by 11 in. sheet. Folding the sheet in this manner lends itself to greater usability by the reader. In addition, the visible portion of the folded sheet should display, at a minimum, the portion of the information block with the figure number, the figure's title, and the page number.

The use of section cut marks in plans, elevations, or cross-sections allows the reader to correlate various portions of an illustration with other illustrations or figures. When used, section cut marks shall be alphanumerically labeled in an increasing pattern as they progress from left to right and down on a sheet, or in a clockwise progression, starting from the upper left corner, and around the perimeter of a structure. The arrow tips of section cut marks shall always point either to the left side of the sheet or to the top of the sheet.

The alphanumeric labeling of section cut marks shall always begin with its lowest order, (i.e., A-A or 1-1), on every sheet in which they are used as if each sheet is independent of other sheets, provided that the section to which they refer is shown on the same sheet. Otherwise, the labeling of section cut marks shall progress in an increasing manner if the sections to which they refer fall on separate sheets. In all cases, the alphanumeric labeling of section cut marks shall begin with its lowest order for different structures as presented in each section or subsection of the report.

Figures shall be placed immediately after the page on which the figure is first mentioned. In cases where more than one figure is first mentioned, the respective figures should follow in the same order they are introduced in the text. All figures should be on white paper. All figures are to be produced using a current computer generated drafting program.

C.3.5 Figure Numbering and Titling

All illustrations shall be given figure numbers and titles. The numbers shall signify the section of the report in which the figure appears and the numerical order of the figure within the section. Thus a figure designated "Figure 3-3, Plan View of Pier 16," would be the third figure appearing in Section 3 of the report.

C.4 PHOTOGRAPHS

Good photographs are an excellent means of documenting a structure's condition. Photographs provide dramatic evidence of damage and deterioration to a structure and can strengthen the justification for funds necessary to support repairs to the facility. Therefore, the photographs must be of high quality, in focus, and of sufficient contrast. Captions and accompanying narrative material should reinforce each other in presenting engineering observations. Captions must provide detailed descriptions of where each picture was taken and what it represents.

Each photograph should have one central point of interest. The composition of the photograph should naturally and immediately lead the reader's eye to the central focal point. Photographs should be simple and uncluttered. In many photographs, particularly those showing damaged areas, it is desirable to have a measuring scale or some other reference object included in the photograph to give the viewer an idea of the scale and the extent of damage. Where possible, some dimensional reference and a card identifying the particular element should be placed in view of the camera and photographed along with the subject. Arrows and reference lines should be used to emphasize specific characteristics that may not be readily evident to the viewer. This can be accomplished with rub on arrows for conventional photographs or placed on digital images with computer graphics programs.

Marine growth should typically be removed from structural elements being photographed underwater. For areas that are badly damaged, photographs showing the condition of the structure both before and after cleaning (removal of marine growth, corrosion scale, latent material, etc.) should be taken.

If the water conditions provide little visibility, a clear-water box, electronic flash, extreme-wide angle lens, or some other appropriate apparatus, must be used to obtain photographs with identifiable features. In these cases, the water turbidity and method of photography should be described in the narrative.

One or two general overview photographs of each system shall be included in order to orient the reader to the structure. Photographs shall show both typical existing conditions and specific conditions encountered, and shall provide examples of items described in the report text. Additional photographs beyond the minimum specified in the Scope of Work may be required in cases where a variety of unique circumstances are encountered and photographs are needed to adequately document the condition of the facility. Such additional photographs are essential and are encouraged. In addition to their value as documentation, they will greatly enhance a reader's understanding of the findings during the inspection.

C.4.1 Photo Arrangement

Photographs should be neatly arranged on the page to present a professional quality to the report. Typical page layouts are provided on Figures C-19 through C-21. The most common size photograph used in the report is typically a standard 4 in. by 6 in. print. This size is preferred over 3 in. by 5 in. prints due to the greater detail in the larger format photograph. Photographs should be oriented either vertically or horizontally, as the subject dictates. Cropping may be required to fit vertical photographs on the same page as other photographs. If it is not possible for a photograph to be cropped, than it should be mounted on a separate page. The size of the photograph that provides the clearest representation of the subject should be used. The use of panoramic photographs or other enlargements can also help illustrate a condition.

Each photograph shall be introduced and discussed at that point in the narrative where it will be most effective in adding to the clarity of the findings from the investigations. A photograph should be located in the report on a page as soon as feasible after the page on which it is first introduced in the text. Thus, photographs will be intermingled with figures and text. Each photograph must be explained and it must be positioned in its proper orientation so as to enhance the reader's understanding of the inspection. A photograph may, of course, be referred to as often as needed in later portions of the report.

C.4.2 Photo Numbers and Captions

For ease of reference, photographs shall be designated as "photo" instead of "figures." Each picture shall be given a photo number which, along with a caption, shall be placed on the same page with the photo and located either beneath or beside the photograph as space, logic, and aesthetics deem best.

A caption must include the specific location where the photograph was taken. For example, in the case of a pier, the location would be identified by the pier, bent, pile, and elevation. In most instances, a brief explanation or interpretation of key features depicted in the photograph should be included in the caption to assure complete understanding by the reader. If a photo is included to be representative of typical conditions of a structure, this should be clearly stated.

5”

1-1/4” 1-1/4”

PHOTO 7-1. General view of parking lot above the relieving platform at the former Pier 80.

4-3/4”

PHOTO 7-2. Non-bearing timber pile cap at offshore end of bent.

FIGURE C-19. EXAMPLE OF PHOTO PAGE

PHOTO 7-3.

Pile J', Bent 49. Severe rot has reduced remaining diameter to approximately 1 in. Pile is effectively non-bearing.

Crop photos to fit. If cropping is not feasible, mount photo on a separate page.

3/4"

3/4"

PHOTO 7-4.

Pile I, Bent 109. Severe rot has reduced the effective pile bearing area, resulting in preliminary crushing failure.

FIGURE C-20. PHOTO LAYOUT (TWO VERTICAL PHOTOS)

1"

1/2”

1-1/2”

PHOTO 7-5.

Localized region between Bents 92 and 94 is spalled to a depth of 3 in. Region is approximately 25 ft by 15 ft in area.

Crop photos to fit. If cropping is not feasible, mount photo on a separate page.

1-1/4”

1-1/4”

PHOTO 7-6. Southern perimeter piles in region of Bents 108 and 109 have suffered severe impact damage.

FIGURE C-21. PHOTO LAYOUT (COMBINATION OF PHOTOS)

1-1/2”

Photos shall be numbered by section, giving first the section number, then a dash followed by the sequential number of the photo appearing in that particular section of the report. Thus, "Photo 3-5. Broken portion of timber pile at elevation 10 ft above the mudline; Pile 3, Bent 7, Pier I," would be the fifth photo included in Section 3 of the report.

C.5 TABLES

Information or data that is best presented in tabular form should be formally presented as such. A table shall have a number and a title and adequate column headings, including physical units when applicable.

Each table shall be presented in the narrative, and adequate discussion shall be provided to make clear to the reader the purpose of the table and to explain and interpret the information or data contained therein.

C.5.1 Table Arrangement

Tables shall be included in the report either within the text or immediately after the page in the narrative on which the table is first mentioned. If possible, the continuation of a table on a second page should be avoided. In cases where more than one table is mentioned on a page of narrative, then the tables should follow the narrative page in the order in which they are introduced in the text. Exhaustive tables of data should be included in the appendix of the report and should be introduced and referenced in the narrative.

C.5.2 Table Numbering

Tables shall be numbered by section, giving first the section number followed by a dash and then the numerical order of the table for that particular section of the report.

In the case of tables in the Executive Summary, the tables shall be designated simply by number corresponding to the numerical order of the table. In the case of appendices, the table number shall be designated by a capital letter, designating the appendix, followed by a dash and a number corresponding to the numerical order of the table within that particular appendix. The number of a table and its title shall be centered above the table.

C.6 DOCUMENT FORMATS

The completed inspection report shall be submitted to EDC electronically. All files generated in the course of the project should be saved on a DVD or thumb drive using the directory format shown on Figure C-22. The format for preparing and saving these files is presented in the following subsections.

FIGURE C-22. DIRECTORY FORMAT

C.6.1 Original Documents

In addition to the hard copy, all reports and letters shall be converted to Portable Document Format (file extension PDF) using Adobe Acrobat and included on the CD-ROM. These files should be prepared exactly as presented to EDC including company logo, figures, photographs, and signature. For ease of navigation, links should be created that tie pertinent information together. At a minimum the following links should be created in the PDF version of the report:

- Each section heading in the Table of Contents should be linked to the corresponding section in the report.
- In the text, any reference to a photograph, figure, or table should be linked to the referenced item.
- Additional links should be added throughout the text as deemed necessary to improve navigation through the document, such as linking references to material listed in appendices or linking damage grades to the definition of the ratings.

C.6.2 AutoCAD Files

All CAD files generated for the inspection report shall be provided in the "AutoCAD" directory of the CD in AutoCAD R15 format (file extension DWG). These files must contain only standard AutoCAD fonts and have all externally referenced drawings bound to the submitted drawings included on the electronic medium used.

Files shall be named with their reference to the report and with a short description of the contents so that they are identifiable by their filename alone. For example "Figure3-2_FacilityPlan.dwg" would be Figure 3-2 in the inspection report, and a facility plan at the site. Within the filename, spaces should be avoided and instead replaced with the underscore character '_'. The filename can contain up to 255 characters, but cannot contain any of the following characters: \ / : * ? " < > |

C.6.3 Photographs and Figures

All photographs and figures included in the hard copy of the report should be scanned or created in JPEG (File extension JPG) format. In addition, all figures created using AutoCAD shall be exported as a PDF and saved in this directory. A single PDF file consolidating all figures shall also be provided. Files shall be named with their reference to the report and with a short description of the contents so that they are identifiable by their filename alone. For example "Photo3-1_WetRotInTidalZone_Bent17_RowA.jpg" would be Photo 3-1 in the inspection report, and a photo of wet rot in the tidal zone at Bent 17, Row A. Within the filename, spaces should be avoided and instead replaced with the underscore character '_'. The filename can contain up to 255 characters, but cannot contain any of the following characters: \ / : * ? " < > |

C.7 WRITING STYLE

Consultants are selected and retained for the expertise of the firms and their employees. The writing style used for inspection reports should convey a feeling of this expertise. It should provide positive statements of findings and recommendations and instill the reader with confidence in the consultant's work.

Avoid long complicated sentences and use relatively short paragraphs to divide various thoughts and subjects. Be consistent and correct with verb tenses. Use clear and concise language, full sentences, and correct grammar. Make generous use of subheadings. Subheadings force the writer to write in an orderly way, to avoid repetition, and to keep to the point. For the reader, they break up the text into identifiable pieces, and provide comfortable milestones.

C.7.1 Terminology

Term definition should be completely consistent throughout the report, in both text and figures, as should the choice of terms. Avoid slang and never use terms such as "besides" and "anyway." Avoid using contractions (can't, won't, etc.). Bear in mind the background of potential users of the report and select terminology that will be readily understandable by these users.

Do not misuse or misspell words. Commonly misused or misspelled words include:

INCORRECT	CORRECT
abovewater	above water
back up	backup
breakbulk	break bulk
center line	centerline
cross section	cross-section

INCORRECT	CORRECT
cut off	cutoff (adj, as in cutoff elevation)
drydock	dry dock
duplicity	duplication
hand rail	handrail
in shore	inshore
in-situ	in situ
irregardless	regardless
mud line	mudline
non-shrink	nonshrink
off shore	offshore
on shore	onshore
out board	outboard
pier head	pierhead
pile head	pilehead
quay wall	quaywall
rip rap	riprap
river bed	riverbed
river bottom	riverbed
sea bed	seabed
seabottom	seabed
sea wall	seawall
sea water	seawater
sheetpile	sheet pile
shore line	shoreline
sink hole	sinkhole
stay lathing	staylathing
tierod	tie rod
Tieback	tie back
under water	underwater (adj)

INCORRECT	CORRECT
water line	waterline

Be careful in the use of "shall" and "will." Use "shall" to indicate something that should be done by others, e.g., "The contractor shall cut the bolts." Use "will" to indicate something that is to be done by you or EDC, e.g., "*EDC* will review the preliminary drawings. "

Reports often include a discussion of a number of alternative schemes, not alternate schemes.

Information is often provided in a table and on a figure.

C.7.2 Voice

Use the active voice when possible. *Example:*

Incorrect

> "The draft of dredging equipment can be restricted by shallow water depths."
> "The draft of dredging equipment is sometimes restricted by shallow water depths."

Correct

> "Shallow water depths sometimes restrict the draft of dredging equipment."

The third sentence uses the active voice, making it the preferred option.

Write reports in the third person and avoid personal references. Phrases to avoid include: we, the consultant's name or abbreviation, the monitor, the consultant, the inspector, and so forth, unless it is specifically necessary for identification. *Example:*

Incorrect

> "The consultant calculated the stress in the beam."

Correct

> "The stress in the beam was calculated."

The second sentence is preferable to the first because it avoids personal references.

C.7.3 Conciseness

Do not use wordy qualifying clauses that overwhelm and confuse the subject of the sentence. Eliminate unnecessarily complicated sentences and state facts directly when possible. *Example:*

Incorrect

> "It was observed that the timber is rotten."
> "It appears that the timber is rotten."

Correct

"The timber is rotten."

All three sentences convey the same information, but stylistically the last is superior and is to be used.

C.7.4 Commas

Use commas liberally to make sentences easier to read and understand. When listing a number of items in a sentence, use commas to separate the items, including before the word "and." *Example:*

"The timber was secured by a bolt, nail, and lag bolt."

"The timber was secured by a bolt, hook and eye, and lag bolt."

C.7.5 Unit Abbreviations

Always use abbreviations for units of measure. However, do not use abbreviations when referring to a unit within the text. *Example:*

"The pier is 100 ft long."

"The length of the pier was measured in feet."

An abbreviation requires a period only if it spells a word. For example, the abbreviation for inch (in.) requires a period, whereas the abbreviation for foot (ft) does not. Below is a list of proper abbreviations. The abbreviations imply both singular and plural. Do not add an "s" to indicate plural.

TERM	ABBREVIATION
1,000 board measure	mbm
1,000 pounds	kip
acre-foot	acre-ft
Alternating current	a-c
Amp	A
ante meridiem	a.m.
Barrel	bbl
barrels per day	bpd
barrels per hour	bph
board measure	bm
british thermal unit	Btu
center to center	c to c
centimeter	cm
cubic centimeter	cm^3

TERM	ABBREVIATION
cubic feet per hour	cu ft/hr
cubic feet per minute	cu ft/min
cubic feet per second	cfs
cubic foot	cu ft
cubic inch	cu in.
cubic meter	m^3
cubic yard	cu yd
Deadweight	dwt
Decibel	dB
Degree	deg
Diameter	diam
direct current	d-c
Elevation	El
Equation	Eq
feet per minute	fpm
feet per second	fps
Figure	Figure
Foot	ft
foot-kip	ft-kip
foot-pound	ft-lb
Gallon	gal
gallons per day	gal/day
gallons per hour	gal/hr
gallons per minute	gal/min
Gram	g
Gravitational acceleration	g
Hectare	ha
Hertz	Hz

TERM	ABBREVIATION
Horsepower	hp
hydrogen ion concentration	pH
Inch	in.
inches per minute	in./min
inches per second	in./sec
inch-pound	in.-lb
inside diameter	ID
Joule	J
Kilogram	kg
kilogram-force	kgf
kilogram-meter	kg-m
Kilometer	km
Kilowatt	kW
kilowatt-hour	kWh
Kip	kip
kip-foot	kip-ft
kips per square foot	ksf
kips per square inch	ksi
Knots	kt
linear foot	lin ft
Liter	L
Maximum	max
mega-ampere	MA
megavolt	MV
megawatt	MW
meter	m
mile	mile
miles per hour	mph

TERM	ABBREVIATION
milliampere	mA
milligram	mg
milliliter	ml
millimeter	mm
million	MM
million gallons per day	mgd
millivolt	mV
milliwatt	mW
newton	N
number	no.
ounce	oz
outside diameter	OD
parts per million	ppm
pascal	Pa
post meridiem	p.m.
pound	lb
pound-foot	lb-ft
pound-force	lbf
pound-inch	lb-in.
pounds per cubic foot	pcf
pounds per square foot	psf
pounds per square inch	psi
radian	rad
revolutions per minutes	rpm
revolutions per second	rps
reynolds number	R
square centimeter	cm^2
square foot	sq ft
square inch	sq in.

TERM	**ABBREVIATION**
square meter	m^2
square mile	sq mile
Square millimeter	mm^2
thousand	M
tons (english)	ton
tons (metric)	tonne
tons per hour	tph
tons per year	tpy
volt	V
watt	W
yard	yd
year	yr

C.7.6 Integers

Spell out integers of less than ten, unless units of measure are given. Always write integers of ten or greater in numeral form. Avoid starting a sentence with an integer in numeral form. *Example:*

"A support beam is needed every 8 ft."

"A total of eight beams will be needed."

"A total of 110 beams will be needed."

Hyphenate numbers, which are used as compound adjectives before a noun. *Example*:

"The 15-yr-old structure."

"the 300-ft pier"

Do not hyphenate numbers used elsewhere in a sentence. *Example:*

"This structure is only 15 years old."

"the pier is 300 ft long."

When referring to the numbering of a group of numbered items, such as column lines, bents, and figures, avoid using "no." whenever practical. For example, "Bent 12" is preferable to "Bent no. 12."

C.7.7 Measurements

Units of measurement should be expressed in numeral form. There are many ways to write measurements within a text:

10' x 10'	6'-3"	5.5"
10 ft x 10 ft	6' 3"	5.5 in.
10' by 10'	6ft-3in.	5 1/2 in.
10 ft by 10 ft	6 ft 3 in.	5-1/2 in.

Samples of the preferred style are as follows:

10 ft by 10 ft	6 ft 3-1/2 in.	5 ft OD
8-1/2 in. by 11 in.	6 ft 3 in.	5-1/2 in.
18 in. diam	4.75 ft	

7 ft 4-1/4 in. by 5 ft 2-1/8 in.

C.8 REFERENCE MATERIALS

For stylistic and grammatical questions that are not addressed in this chapter, the consultant should refer to a recognized English usage manual. Some appropriate reference materials include; the GPO

Style Manual, ASCE Author's Guide, The Gregg Reference Manual, Strunk & White's Elements of Style, and Shipley Associates Style Guide.

Appendix D
Corrosion Rates for Steel Components

LIST OF TABLES

Page No.

The tables below provide guidance on the corrosion rates for steel components and have been reproduced from the ASCE Waterfront Facilities Inspection and Assessment Manual. Unless historic data or other more reliable data is available, these corrosions rates shall be used for remaining service life estimation.

TABLE D-1
Recommended Value for the Loss of Thickness (mm) Due to Corrosion for Piles and Sheet Piles in Soils, With or Without Groundwater

Type of Soil	Required Working Life				
	5 years	25 years	50 years	75 years	100 years
Undisturbed natural soils (sand, silt, clay, schist, etc.)	0.00	0.30	0.60	0.90	1.20
Polluted natural soils and industrial sites	0.15	0.75	1.5	2.25	3.00
Aggressive natural soils (swamp, marsh, peat, etc.)	0.20	1.00	1.75	2.50	3.25
Non-compacted and nonaggressive fills (clay, schist, sand, silt, etc.)	0.18	0.70	1.20	1.70	2.20
Non-compacted and aggressive fills (ash, slag, etc.)	0.50	2.00	3.25	4.50	5.75

Notes: Corrosion rates in compacted fills are lower than in non-compacted ones. In compacted fills, the figures in the table should be divided by two.

The values given for 5 and 25 years are based on measurements, whereas the other values are extrapolated.

Source: ASCE Waterfront Facilities Inspection and Assessment Manual, Table 4-4.

TABLE D-2
Recommended Value for the Loss of Thickness (mm) Due to Corrosion for Piles and Sheet Piles in Freshwater or in Seawater

Type of Water	Required Working Life				
	5 years	25 years	50 years	75 years	100 years
Common fresh water (river, ship canal, etc.)	0.15	0.55	0.90	1.15	1.40
Very polluted freshwater (sewage, industrial effluent, etc.) in the zone of high attach (water line)	0.30	1.30	2.30	3.30	4.30
Seawater in temperate climate in the zone of high attach (low water and splash zones)	0.55	1.90	3.75	5.60	7.50
Seawater in temperate climate in the zone of permanent immersion or in the intertidal zone	0.25	0.90	1.75	2.60	3.50

Source: ASCE Waterfront Facilities Inspection and Assessment Manual, Table 4-5.

TABLE D-3
Summary of Corrosion Rates in Splash Zone

Zone	in./year (ipy)	mils/year (mpy)	mm/year (mmy)
High	0.06	60	1.50
Low	0.003	3	0.08
Average	0.016	16	0.41
Source: ASCE Waterfront Facilities Inspection and Assessment Manual, Table 4-6.			

Appendix E
Sample Calculations

Sample Calculations of Load Restrictions on a Pier Due to Loss of Pile Diameter

Inventory

Bent #	7	31	50	72	93	108	135
Average Pile Diameter (in)	10.8	9.5	9.3	9.2	9.1	9.0	8.4
Average loss Rate ($^{in}/_{yr}$)	0.3	0.4	0.4	0.4	0.5	0.5	0.5

For the outboard end of the pier : bent # 135

$\phi := 8.4\ \text{in}$ $\quad r := \frac{\phi}{4}$ $\quad r := 2.1\ \text{in}$ $\quad kL := 25.6\ \text{ft}$ $\quad A := \pi \frac{(\phi^2)}{4}$ $\quad A := 55.4\ \text{in}^2$

$$F'_c := 3.6 \frac{(1500000)}{\left[(kL)\frac{(12)}{r}\right]^2} \qquad F'_c := 252.3\ \text{psi}$$

$F_a = F'_c * A = 252.3*55.4 = 14.0$ kips

$F_u = 14.0*1.66 = 23.2$ kips

$FS := \frac{F_u}{F}$ $\quad FS := \frac{23.2}{22.5}$ $\quad FS = 1.03$, barely adequate

If the load is reduced to a 3 pallet high stack, $F = 18.5$ kips

$FS := \frac{23.2}{18.5}$ $\quad FS = 1.25$, acceptable for short term use pending repairs

Check the capacity in one year assume a loss of $0.5 \frac{\text{in}}{\text{year}}$

$\phi := 7.9\ \text{in}$ $\quad r := \frac{7.9}{4}$ $\quad r := 1.975\ \text{in}$ $\quad kL := 25.6\ \text{ft}$

$$F'_c := 3.6 \frac{(1500000)}{\left[(25.6)\frac{(12)}{1.975}\right]^2} \qquad F'_c := 223.2\ \text{psi}$$

$A := \pi \frac{(7.92)}{4}$ $A := 49.0 \text{ in}^2$

F_a = 223.2*49.0= 10.9 kips F_u = 10.9*1.66=18.1 kips

Therefore, for 3 pallet high stacks,

$FS := \frac{18.1}{18.5}$ FS=0.98, repairs or further load restrictions are necessary by the end of the first year.

Therefore, reduce loading in this area to 3 pallets high at the end of the pier (from approximately bent # 120 outward.)

Scenario 1: Decision now, repair work commences immediatly.

Scenario 2: Decision is made to repair at the end of first year, work commences at the end of the following year.

Load Restrictions for Scenario 2

Bent #120+:.

After 1year, $\phi = 7.9$ in, at which point the safety factor FS = 0.98.

Therefore loading must be limited to a stack 2 pallets high (F = 14.5 kips).

$FS := \frac{18.1}{14.5}$ FS=1.25, acceptable for short term.

Bent #80 to #120:

After 1year, $\phi = 9.1 - 0.5 = 8.6$ in.

$\phi := 8.6 \text{ in}$ $r := \frac{8.6}{4}$ $r := 2.15 \text{ in}$ $kL := 25.6 \text{ ft}$

$F'_c := 3.6 \frac{(1500000)}{\left[(25.6)\frac{(12)}{2.15}\right]^2}$ $F'_c := 264.5 \text{ psi}$

$A := \pi \cdot \frac{(8.6)^2}{4}$ $A := 58.1 \text{ in}^2$

F_a = 264.5*58.1= 15.4 kips F_u = 15.4*1.66=25.5 kips After 2 yrs ϕ = 8.1 in , Fu = 20.1 kips

$FS := \frac{25.5}{22.5}$ FS=1.13, for 4 pallet loading $FS := \frac{25.5}{18.5}$ FS=1.39, for 3 pallet loading

3 pallet loading is better because there is more tan 1 year until repairs.

Therefore if decision to repair is delayed by one year additional load restrictions will be necessary: Reduce the maximum loading to 2 pallets outboard of bent # 120; Reduce the maximum loading to 3 pallets high between bents # 80 and #120.

This pier should be reispected in 1 year.

For 4 pallet loading, the required ϕ = 9.5 in.

If the decision to repair is delayed by one year, and it is assumed that rehabilitaion will not commence until one year from that time. Based on a 0.5 $^{in}/_{yr}$ loss rate, all piles with existing ϕ < 10.5 in. will need to be concrete encased to restore sufficient section.

$$\frac{\text{\# of piles w/ } \phi < 10.5 \text{ in}}{\text{\# investigated}} = \frac{284}{347} = \quad = 81.8\% \text{ of piles}$$

# of piles = (7400)(0.818) = 6053 piles to be encased.

# of piles = 7400 - 6053 = 1347 piles to be wrapped.

However, if rehabilitaion will commence in one year from that time. Based on a 0.5 $^{in}/_{yr}$ loss rate, all piles with existing ϕ < 10.0 in. will need to be concrete encased to restore sufficient section.

$$\frac{\text{\# of piles w/ } \phi < 10.0 \text{ in}}{\text{\# investigated}} = \frac{235}{347} = \quad = 67.7\% \text{ of piles}$$

# of piles = (7400)(0.677) = 5012 piles to be encased.

# of piles = 7400 - 5012 = 2388 piles to be wrapped.

With a reduced live load of 100 psf, the bracing will not need to be restored and only 50% of the piles are necessary.

DL + LL = 125 + 100 = 225 psf

The load per pile 22.5 kips.

The tributary area per pile is 10 ft by 10 ft.

For an unbraced length = 40 ft, the reqired existing diameter is ϕ = 11".

$$\frac{\text{\# of piles w/ } \phi < 11.0 \text{ in}}{\text{\# investigated}} = \frac{310}{347} = \quad = 89.3\% \text{ of piles}$$

# of piles = (3700)(0.893) = 3305 piles to be encased.

# of piles = 3700 - 3305 = 395 piles to be wrapped.

Therefore the revised load restrictions are as follows:

Scenario 1:.

	4 Pallets		3 Pallets		2 Pallets	
	Now	In 1 Yr	Now	In 1 Yr	Now	In 1 Yr
Bent # 120+	1.03	0.80	1.25	0.98	1.60	1.25

ϕ = 8.4 in Fu = 23.2 kips

ϕ = 7.9 in Fu = 18.1 kips

If the safety factor at the time of repair is 1.2, the loading must be reduced to 2 pallets high.

	4 Pallets		3 Pallets		2 Pallets	
	Now	In 1 Yr	Now	In 1 Yr	Now	In 1 Yr
Bent # 80 to #120	1.42	1.16	1.73	1.41	2.21	1.79

ϕ = 9.1 in Fu = 32.0 kips ϕ = 8.6 in Fu = 18.1 kips

A safety factor of 1.16 after 1 year is acceptable beause either repaires will begin or further load restrictions will be imposed. No reduction currently required.

Scenario 2:.

	2 Pallets		1 Pallet	
	In 1 yr	In 2 Yrs	In 1 yr	In 2 Yrs
Bent # 120+	1.25	0.97	1.72	1.33

ϕ = 7.4 in   Fu = 14.0 kips

A safety factor of 0.97 is unacceptable, therefore the loading must be reduced to 1 pallet stacks.

	3 Pallets		2 Pallets	
	In 1 yr	In 2 Yrs	In 1 yr	In 2 Yrs
Bent # 80 to #120	1.41	1.09	1.79	1.39

ϕ = 8.1 in   Fu = 20.1 kips

A safety factor of 1.09 is unacceptable, therefore the loading must be reduced to 2 pallet high stacks.

	4 Pallets		3 Pallets		
	In 1 yr	In 2 Yrs	In 1 yr	In 2 Yrs	
Bent # 40 to #80	1.24	0.98	1.51	1.19	1.41

ϕ = 8.1 in   Fu = 20.1 kips

A safety factor of 0.98 is unacceptable, therefore the loading must be reduced to 3 pallet high stacks. The safety factor of 1.19 is acceptable because loading will be reduced or rehabilition will begin.

Appendix F
Wetland Functions

HYDROLOGIC FLUX AND STORAGE

Water balance

Wetlands play a critical role in regulating the movement of water within watersheds as well as in the global water cycle (Richardson 1994; Mitsch and Gosselink 1993). Wetlands, by definition, are characterized by water saturation in the root zone, at, or above the soil surface, for a certain amount of time during the year. This fluctuation of the water table (hydroperiod) above the soil surface is unique to each wetland type.

Wetlands store precipitation and surface water and then slowly release the water into associated surface water resources, ground water, and the atmosphere. Wetland types differ in this capacity based on a number of physical and biological characteristics, including: landscape position, soil saturation, the fiber content/degree of decomposition of the organic soils, vegetation density and type of vegetation (Taylor et al. 1990):

During the growing season, plants actively take up water and release it to the atmosphere through evapotranspiration. This process reduces the amount of water in wetland soil and increases the capacity for absorption of additional precipitation or surface water flow. As a result, water levels and outflow from the wetland are less than when plants are dormant. Larger plants and plants with more surface area will transpire more.

Climate control

Climate control is another hydrologic function of wetlands. Many wetlands return over two-thirds of their annual water inputs to the atmosphere through evapotranspiration (Richardson and McCarthy 1994). Wetlands may also act to moderate temperature extremes in adjacent uplands (Brinson 1993).

Oxidation-Reduction

The fluctuating water levels (also known as hydrologic flux) that are characteristic of wetlands control the oxidation-reduction (redox) conditions that occur. These redox conditions governed by hydroperiod play a key role in: nutrient cycling, availability, and export; pH; vegetation composition; sediment and organic matter accumulation; decomposition and export; and metal availability and export.

Wetland plants are adapted to changing redox conditions. Wetland plants often contain arenchymous tissue (spongy tissue with large pores) in their stems and roots that allows air to move quickly between the leaf surface and the roots. Oxygen released from wetland plant roots oxidizes the rhizosphere (root zone) and allows processes requiring oxygen, such as organic compound breakdown, decomposition, and denitrification, to occur (Steinberg and Coonrod 1994).

Hydrologic flux and life support

Changes in frequency, duration, and timing of hydroperiod may impact spawning, migration, species composition, and food chain support of the wetland and associated downstream systems (Crance 1988). Normal hydrologic flux allows exchange of nutrients, detritus, and passage of aquatic life between systems.

Ecological (and economic services) of wetlands as a result of the functions of hydrologic flux and storage include: water quality, water supply, flood protection, erosion control, fish and wildlife habitat, recreation, culture, and commercial benefits.

BIOGEOCHEMICAL CYCLING AND STORAGE

Wetlands may be a sink for, or transform, nutrients, organic compounds, metals, and components of organic matter. Wetlands may also act as filters of sediments and organic matter. A wetland may be a permanent sink for these substances if the compounds become buried in the substrate or are released into the atmosphere; or a wetland may retain them only during the growing season or under flooded conditions. Wetland processes play a role in the global cycles of carbon, nitrogen, and sulfur by transforming them and releasing them into the atmosphere.

The ecological and economic services associated with the wetland functions related to biogeochemical cycling and storage include: water quality and erosion control.

BIOLOGICAL PRODUCTIVITY

Wetlands are among the most productive ecosystems in the world (Mitsch and Gosselink 1993). Immense varieties of species of microbes, plants, insects, amphibians, reptiles, birds, fish, and other wildlife depend in some way on wetlands. Wetlands with seasonal hydrologic pulsing are the most productive.

Wetland plants play an integral role in the ecology of the watershed. Wetland plants provide breeding and nursery sites, resting areas for migratory species, and refuge from predators (Crance 1988). Decomposed plant matter (detritus) released into the water is important food for many invertebrates and fish both in the wetland and in associated aquatic systems (Crance 1988). Physical and chemical characteristics such as climate, topography, geology, hydrology, and inputs of nutrients and sediments determine the rate of plant growth and reproduction (primary productivity) of wetlands (Brinson 1993; Mitsch and Gosselink 1993; Weller 1981; Crance 1988).

A wetland with more vegetation will intercept more runoff and be more capable of reducing runoff velocity and removing pollutants from the water than a wetland with less vegetation (Demissie and Khan 1993; Richardson and McCarthy 1994; NC DEM 1993). Wetland plants also reduce erosion as their roots hold the streambank, shoreline, or coastline.

Ecological and economic services associated with biological productivity of wetlands include: water quality, flood control, erosion control, community structure and wildlife support, recreation, aesthetics, and commercial benefits.

DECOMPOSITION

Decomposition rates vary across wetland types, particularly as a function of climate, vegetation types, available carbon and nitrogen, and pH (Johnston 1991).

The nutrients and compounds released from decomposing organic matter may be exported from the wetland in soluble or particulate form, incorporated into the soil, or eventually transformed and released to the atmosphere. Decomposed matter (detritus) forms the base of the aquatic and terrestrial food web.

Decomposition requires oxygen and thus reduces the dissolved oxygen content of the water. High rates of decomposition – such as occur after algae has bloomed – can reduce water quality and impair aquatic life support.

COMMUNITY STRUCTURE AND WILDLIFE SUPPORT

Wetland shape and size affect the wildlife community and the wetland's function as suitable habitat (Kent 1994b; Brinson 1993; Harris 1988). The shape of the wetland varies the perimeter to area ratio. The amount of perimeter versus area has importance for the success of interior and edge species (Kent 1994b). Shape is also important for the possibility of movement of animals within the habitat and between habitats.

Ecological services associated with community structure and wildlife support in wetlands include: fish and wildlife support, recreation, aesthetics, and commercial benefits.

Appendix G
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