MEMORANDUM

FILE NO. 18.0171075

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To: **Saquatucket and Wychmere Harbors Plan Steering Committee**
(distribution below)

From: Gregory G. Robbins, P.E., Project Manager
Russell J. Morgan, P.E., Principal-in-Charge

Date: August 15, 2013

Re: **Design Report**
Saquatucket and Wychmere Harbors Plan

Saquatucket and Wychmere Harbors Plan Steering Committee Members

John Rendon, Harbormaster
David H. Spitz, Town Planner
Robert M. Cafarelli, Town Engineer
W. Matthew Hart, Chairman, Waterways Committee
James R. Merriam, Town Administrator
Jill M. Mason, Ch. 18 Station Manager
Larry G. Ballantine, Selectman

The Town of Harwich has engaged Vine Associates, A Division of GZA GeoEnvironmental, Inc. and The Cecil Group to develop new layouts for certain aspects of Saquatucket Harbor and Wychmere Pier and to provide conceptual engineering services for selected infrastructure.

Utilizing information obtained during interviews with Town officials, interviews with various users, a public discussion forum and meetings with the Steering Committee, a Summary Memorandum of Existing Conditions was prepared to consolidate important information regarding the sites, and a Design Program was developed to form the basis of the conceptual planning. Upon approval of the Design Program by the Town, multiple conceptual designs were developed for improvements to the landside facilities at Saquatucket Harbor and to the watersheet and structural features at Saquatucket Harbor and Wychmere Pier. A Draft Design Report was submitted to the Town presenting the conceptual designs developed for the harbors, our findings regarding structural improvements at the sites, and the results of our structural assessment of Wychmere Pier. The Draft Design Report was subsequently updated to incorporate changes resulting from the Town's reassessment of certain aspects of the Design Program.

For the final phase of the project, we have been tasked with incorporating the Town's comments on the Draft Design Report and presenting the preferred alternatives selected by the Town. The enclosed final Design Report is provided for use in planning and funding the implementation of the selected improvements.

TOWN OF HARWICH

SAQUATUCKET & WYCHMERE HARBORS PLAN

DESIGN REPORT

August 2013

Introduction

The Town of Harwich engaged Vine Associates, A Division of GZA GeoEnvironmental, Inc. (Vine) and The Cecil Group (Cecil) to develop new layouts for certain aspects of Saquatucket Harbor and Wychmere Pier and to provide conceptual engineering services for selected infrastructure. A Summary Memorandum of Existing Conditions was prepared to consolidate important information regarding the sites, and a Design Program was developed to form the basis of the conceptual planning.

A Draft Design Report was then submitted to the Town presenting conceptual designs developed for the harbors, our findings regarding structural improvements at the sites and the results of our structural assessment of Wychmere Pier. The Draft Design Report was subsequently updated to incorporate changes resulting from the Town's reassessment of certain aspects of the Design Program.

For the final phase of the project, the design team has prepared this Design Report which incorporates the Town's comments on the Updated Draft Design Report and identifies the preferred alternatives selected by the Town. This report is arranged as follows:

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Concept Drawings

Structural Assessment of Wychmere Harbor Town Pier

Waterfront Consultants
Vine ASSOCIATES
A Division of GZA GeoEnvironmental, Inc.

The Cecil Group
Planning and Design

SELECTED IMPROVEMENTS

Selected Improvements

Overview

The Town of Harwich has completed a detailed and deliberate process to first identify improvement alternatives for the Saquatucket Harbor watersheet, landside features within 200 feet of Saquatucket Harbor and Wychmere Pier and, second, to develop a strategic plan for the use of those facilities by selecting the most advantageous alternatives for implementation. Consideration was given to the needs, uses and requirements for the two facilities that were expressed by various stakeholders and user groups.

A project team consisting of Vine Associates, A Division of GZA GeoEnvironmental, Inc. and The Cecil Group was selected to provide engineering and planning analysis and design services in support of the Town's efforts. Through meetings with the Steering Committee and Town officials, interviews with various stakeholders and a public comment session, the project team received input from multiple user groups regarding the current use of the facilities and desired improvements. The development of improvement alternatives included efforts to incorporate and balance these varying, and sometimes conflicting, points of view.

Issues surrounding pedestrian, vehicle and trailer maneuvering and circulation associated with use of the land/water interface, vessel operational requirements, vessel berthing requirements and accessibility compliance have been addressed. Programmatic requirements that may be associated with parking areas and their circulation or facilities associated with the Harbormaster's Office were beyond the scope of this process.

After careful consideration and deliberation, the Steering Committee has selected the improvement plan included in this section. A summary discussion of the selected improvements is provided in the paragraphs that follow, and drawings and figures detailing the selected improvements are included at the end of this section. Details and discussion of all considered alternatives are provided in subsequent sections.

Landside Design - Saquatucket Harbor

The selected alternative creates a central viewing area at the upper elevation of the parking area and Harbormaster's Building with an accessible path that leads down the sloping grade to the bulkhead roadway. The accessible path then crosses the bulkhead roadway on a raised crossing to connect to a continuous elevated boardwalk. An elevated speed table with pedestrian crossing is provided at the base of the existing stairway connection to the western parking area. The roadway is expanded slightly by adding a low retaining wall to the bottom of the existing landscaped slope.

Features

By placing the accessible path on an undulating line from the Harbormaster's Building it is able to avoid landscape features and infrastructure elements in the sloping lawn area while maintaining accessible slopes. The accessible path maintains a slope that is less than 5% allowing it to be unencumbered by railings and additional landings. The eastern existing

stairway will be rebuilt with an accessible landing integral to its construction where it intersects with the accessible path. The existing vegetation of the sloped landscape area will be retained as much as possible. The viewing area near the Harbormaster's Building will feature a low wall with guardrail and benches. Rerouting the traffic circulation as indicated on the *Proposed Vehicle Circulation Patterns* diagram (Figure 1) is necessary to accommodate the selected improvements.

The pedestrian crossings at the bulkhead roadway would be reinforced by both raising the elevation of the crossing and adding a textured pattern with stamped asphalt. The first pedestrian crossing would be expanded into a speed table, an elevated portion of the roadway that is flush with the adjacent elevated pedestrian walkway for an expanded pedestrian environment. In the vicinity of the pedestrian crossing at the accessible path, the wood boardwalk would ramp up to a height 9" above the roadway for its remaining length, allowing easy access to the adjacent vessel boarding area. The elevated crossing would be flush with the boardwalk at this height.

Materials

The new accessible paths and stairs will be constructed of concrete. The sidewalk connection along the entry road will be an asphalt walk. The elevated crosswalk and speed table will be constructed of asphalt, and the paving pattern would be created with stamped asphalt. The elevated bulkhead walkway will be built up with a concrete foundation and finished with wood decking. Pedestrian lighting should be added to the paths and boardwalk as pedestrian bollard lights or recessed fixtures that light the ground plane.

Observations

By expanding the flat area at the bottom of the slope with a small retaining wall, more flexibility is gained near the bulkhead. The reconfiguration of the accessible paths minimizes the overall construction of paths and retains an accessible path to both sides of the bulkhead. The lower boardwalk does not allow the use of the top of the bulkhead as part of the pedestrian area and requires a ramped portion to access the bulkhead height which is located at the accessible gangway and speed table and requires steps to access the other gangways over the bulkhead. A fully accessible path is provided for all improved areas.

Watersheet Reconfiguration - Saquatucket Harbor

Marina

The selected alternative locates the passenger vessel berths at the east end of the North Bulkhead with an accessible route which connects to the land side accessible route. Commercial vessels and charter vessels have generally been consolidated into common areas, and charter, party fishing and tour boats are located in areas readily visible from pedestrian gathering areas. The selected alternative maximizes the number of slips with a north-south orientation as preferred by users.

A series of piers, platforms and floats connected via ramps provide the required accessible route to qualifying passenger vessels as well as the recreational marina. Accessible slips are localized and placed along a common accessible float in order to minimize the costs associated with providing multiple accessible routes and minimize the distance required to access the slips.

Three additional slips in the 20 foot class and two additional slips in the 40 foot class are created with the selected alterative although modifications to the portion of the marina located within the turning basin are required. It is anticipated that a request to modify the existing approved float arrangement within the turning basin would be viewed favorably by the U.S. Army Corps of Engineers.

During the preliminary work leading up to the development of these concepts, numerous comments were received from users regarding the condition and stability of the existing floats. Combined with the length of the main float runs, number of vessels being served and prudent design, this results in the inclusion of new 8 foot wide main floats.

Amenities

Both water and electrical service are provided to each slip via power pedestals, each servicing two adjacent vessels. The power pedestals will also provide walkway lighting, and this lighting will be supplemented by lighting bollards as necessary.

East Bulkhead

To address the need for additional tie-up space at the East Bulkhead, a new timber platform and new gangways accessing both existing and new floats are included. One existing float is removed from the bulkhead face to allow increased access to support vehicles while the remaining four floats, located in areas not available to support vessels due to existing structures, are left unchanged. Sixty feet of new floats extending southwest from the southern corner of the bulkhead are included.

A new gravel surface behind the East Bulkhead is proposed. With minimal regular maintenance, this will provide a suitable all-weather surface on which support vehicles can operate.

Dredging

A Dredging Plan has been developed to addresses shoaling within the marina basin. In general marina areas, the plans call for dredging to the previously permitted depth of -6.0 MLLW to minimize the frequency of maintenance dredging. Improvement dredging to a depth of -8.0 MLLW is included to accommodate the ferry berth.

Phasing

The cost estimate for the selected alternative is grouped into the following three areas to allow the Town to evaluate a phased approach to the work.

1. East Side (including accessibility compliance and partial dredging)
2. West Side (including partial dredging)
3. East Bulkhead Float Improvement

Watersheet Reconfiguration – Wychmere Pier

Pile Supported Pier

The design/layout of the pile supported pier does not change from the existing conditions. Structural analysis calculations were performed for the pier, and it is possible that the pier rating could be increased beyond current operational limitations with additional investigation and analysis. Additionally, with some relatively minor structural modifications it is possible that pier rating could be increased even further.

Berth Arrangement

The only change to existing berth arrangements is the relocation of the Fire Department vessel Marine 76 from its current berth at the East Bulkhead in Saquatucket Harbor to Wychmere Pier. Relocation of Marine 76 to Wychmere Pier will better serve the use, allow easy access to the vessel and free up valuable berthing at the East Bulkhead. One Commercial Vessel is displaced by this relocation and can be accommodated without additional displacement in Saquatucket Harbor.

Pier Electrical Service

Installation of an electrical system specialized to work in the marine environment is included in the selected alternative. The service will be conveyed from the landside feeder to a dockside power pedestal. The dock side services lines will be watertight and meet applicable regulatory standards for submerged and watertight service lines. The services lines will be installed along the dock rim joist and will be submerged during high tidal levels.

Layout of Dinghy Float

A new float layout which improves the use of the existing dinghy area has been selected. The new layout includes a ramp to access the floats from the bulkhead and provides appropriate access to the Marine 76 vessel.

Southeast Corner of Bulkhead

A new berth for outfitting/offloading/fueling of commercial fishing vessels is provided at the southeast corner of the solid filled pier. This berth would be in addition to those available along the south side of the pier and will both increase available tie-up space during low tide conditions and allow support vehicles direct access to vessels outside of the weight restrictions currently imposed on the pier.

To accommodate the new berth, the inside corner of the bulkhead will be dredged and the bulkhead will be replaced. Replacement of the entire Wychmere bulkhead has been selected due to the poor condition of the existing timber portion and the anticipated cost savings associated with concurrent replacement.

Conceptual Cost Estimates

The table below contains an estimate of cost for each design feature of the selected alternatives. These cost estimates are based upon typical labor and material costs, recent bid results for similar projects and/or typical product options for the selected alternative and are suitable for conceptual planning.

Permitting, design and engineering fees are not included in the cost estimates but can generally be estimated to be approximately 10% of construction costs (this does not include construction support services). Dredging permitting costs may be higher.

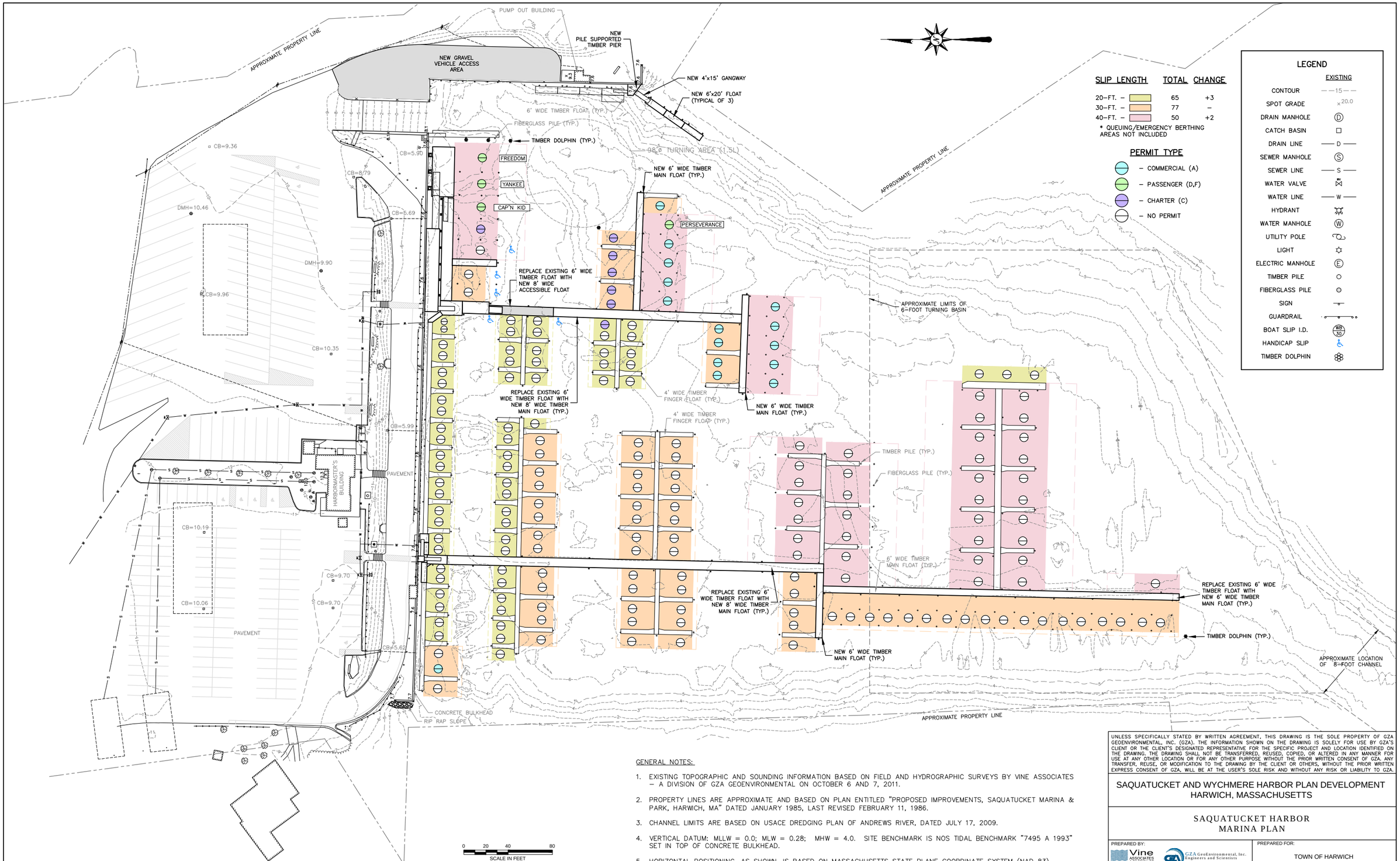
Saquatucket Harbor Improvement Costs	
Design Feature	Estimated Cost
Landside Improvements	$600,000
Marina Plan – East Side	$970,000
Accessible Main Float	$30,000
Timber Pier	$225,000
Passenger Floats/Gangways/Piles	$625,000
Dredging[1, 2] – East Side	$500,000-$1,400,000
Marina Plan – West Side	$1,980,000
General Marina Access	$65,000
Dredging[1, 2] – West Side	$250,000 - $1,330,000
East Bulkhead Float Improvements	$55,000

[1] Dredging costs are highly variable and dependent upon sediment composition, level of contamination, disposal location and requirements imposed during the permitting process. Determining one or more of these variables would allow for more precise cost estimates to be prepared.

[2] Presumes that East Side dredging occurs first and that the sampling and testing required for offshore disposal is performed for the entire site at that time.

Wychmere Pier Improvement Costs	
Design Feature	Estimated Cost
Upgrade Electrical Service	$8,000
New Dinghy Docks	$47,000
New Bulkhead	$380,000
Dredging[1]	$15,000-$25,000

[1] Dredging costs are highly variable and dependent upon sediment composition, level of contamination, disposal location and requirements imposed during the permitting process. Determining one or more of these variables would allow for more precise cost estimates to be prepared.



SLIP LENGTH		TOTAL	CHANGE
20-FT. –		65	+3
30-FT. –		77	–
40-FT. –		50	+2

* QUEUING/EMERGENCY BERTHING AREAS NOT INCLUDED

PERMIT TYPE

- COMMERCIAL (A)
- PASSENGER (D,F)
- CHARTER (C)
- NO PERMIT

LEGEND

	EXISTING
CONTOUR	15
SPOT GRADE	20.0
DRAIN MANHOLE	D
CATCH BASIN	
DRAIN LINE	D
SEWER MANHOLE	S
SEWER LINE	S
WATER VALVE	WV
WATER LINE	W
HYDRANT	
WATER MANHOLE	W
UTILITY POLE	
LIGHT	
ELECTRIC MANHOLE	E
TIMBER PILE	
FIBERGLASS PILE	
SIGN	
GUARDRAIL	
BOAT SLIP I.D.	WB 30
HANDICAP SLIP	
TIMBER DOLPHIN	

GENERAL NOTES:

1. EXISTING TOPOGRAPHIC AND SOUNDING INFORMATION BASED ON FIELD AND HYDROGRAPHIC SURVEYS BY VINE ASSOCIATES – A DIVISION OF GZA GEOENVIRONMENTAL ON OCTOBER 6 AND 7, 2011.
2. PROPERTY LINES ARE APPROXIMATE AND BASED ON PLAN ENTITLED "PROPOSED IMPROVEMENTS, SAQUATUCKET MARINA & PARK, HARWICH, MA" DATED JANUARY 1985, LAST REVISED FEBRUARY 11, 1986.
3. CHANNEL LIMITS ARE BASED ON USACE DREDGING PLAN OF ANDREWS RIVER, DATED JULY 17, 2009.
4. VERTICAL DATUM: MLLW = 0.0; MLW = 0.28; MHW = 4.0. SITE BENCHMARK IS NOS TIDAL BENCHMARK "7495 A 1993" SET IN TOP OF CONCRETE BULKHEAD.
5. HORIZONTAL POSITIONING, AS SHOWN, IS BASED ON MASSACHUSETTS STATE PLANE COORDINATE SYSTEM (NAD 83).
6. UTILITY INFORMATION SHOWN IS BASED ON BOTH FIELD SURVEY AND THE LATEST PLANS OF RECORD. THE LOCATIONS OF ALL STRUCTURES AND UTILITIES IS APPROXIMATE AND SHALL BE VERIFIED BY CONTRACTOR PRIOR TO CONSTRUCTION. THE ENGINEER SHALL BE NOTIFIED OF ANY DISCREPANCIES WHICH WILL EFFECT SITE DESIGN. NO CHANGES IN THE FIELD SHALL BE MADE WITHOUT PRIOR NOTIFICATION OF THE DESIGN ENGINEER.

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SAQUATUCKET AND WYCHMERE HARBOR PLAN DEVELOPMENT
HARWICH, MASSACHUSETTS

SAQUATUCKET HARBOR MARINA PLAN

PREPARED BY: Vine ASSOCIATES A DIVISION OF GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com

PREPARED FOR: TOWN OF HARWICH

PROJ MGR: GGR	REVIEWED BY: GGR	CHECKED BY: RJM	DRAWING 1
DESIGNED BY:	DRAWN BY: MAG	SCALE: AS SHOWN	
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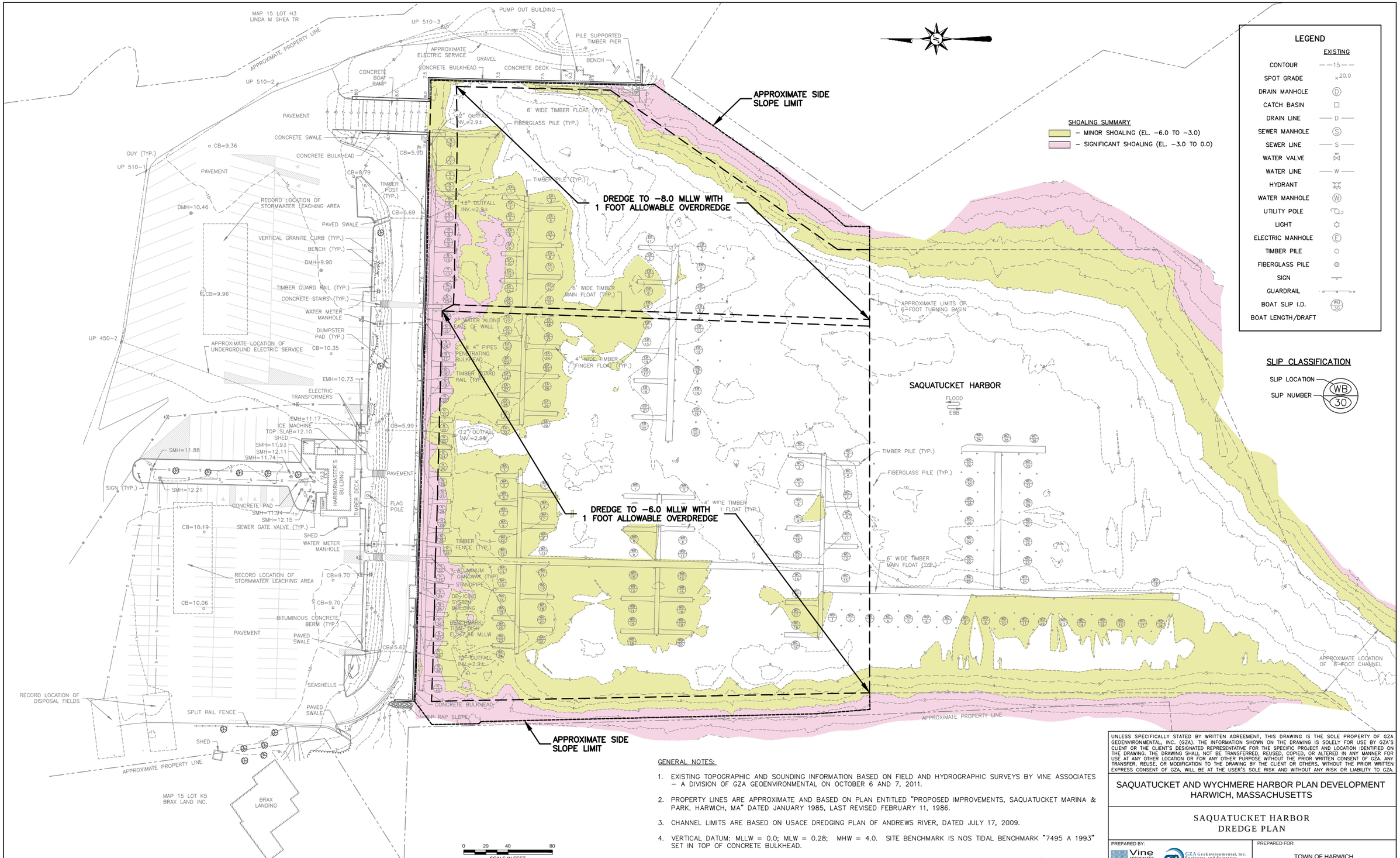

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3. CHANNEL LIMITS ARE BASED ON USACE DREDGING PLAN OF ANDREWS RIVER, DATED JULY 17, 2009.
4. VERTICAL DATUM: MLLW = 0.0; MLW = 0.28; MHW = 4.0. SITE BENCHMARK IS NOS TIDAL BENCHMARK "7495 A 1993" SET IN TOP OF CONCRETE BULKHEAD.
5. HORIZONTAL POSITIONING, AS SHOWN, IS BASED ON MASSACHUSETTS STATE PLANE COORDINATE SYSTEM (NAD 83).
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SAQUATUCKET AND WYCHMERE HARBOR PLAN DEVELOPMENT
HARWICH, MASSACHUSETTS

SAQUATUCKET HARBOR
DREDGE PLAN

PREPARED BY: Vine ASSOCIATES A DIVISION OF GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com

PREPARED FOR: TOWN OF HARWICH

PROJ MGR: GGR	REVIEWED BY: GGR	CHECKED BY: RJM	DRAWING 2
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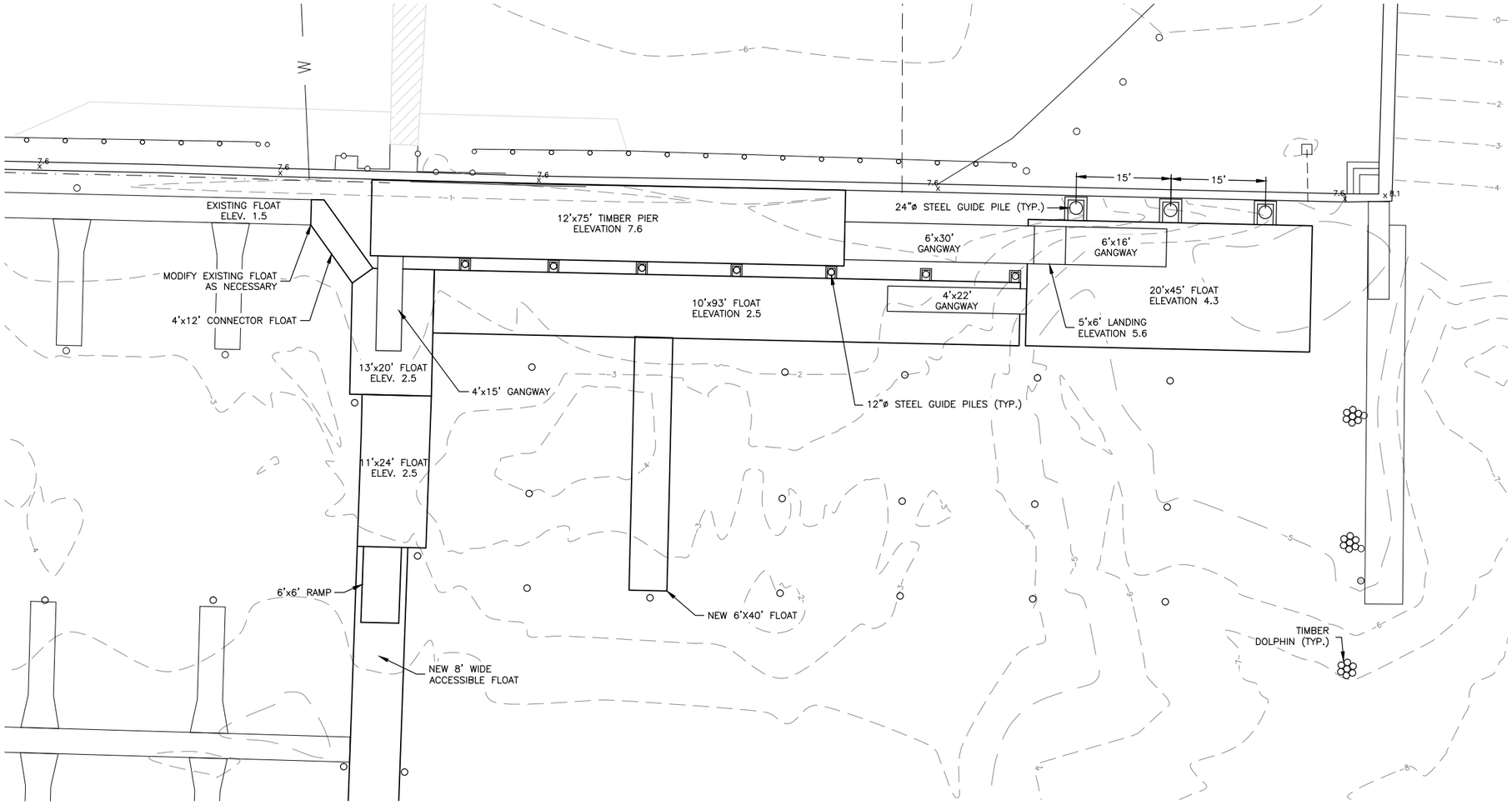

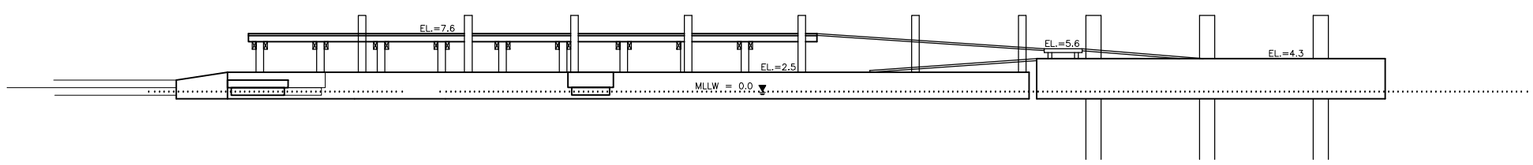

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SAQUATUCKET AND WYCHMERE HARBOR PLAN DEVELOPMENT
HARWICH, MASSACHUSETTS

SAQUATUCKET HARBOR
ACCESSIBLE ROUTE IMPROVEMENTS
PLAN AND ELEVATION

PREPARED BY:
Vine ASSOCIATES A DIVISION OF
GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com

PREPARED FOR:
TOWN OF HARWICH

PROJ MGR: GGR	REVIEWED BY: GGR	CHECKED BY: RJM	DRAWING 3
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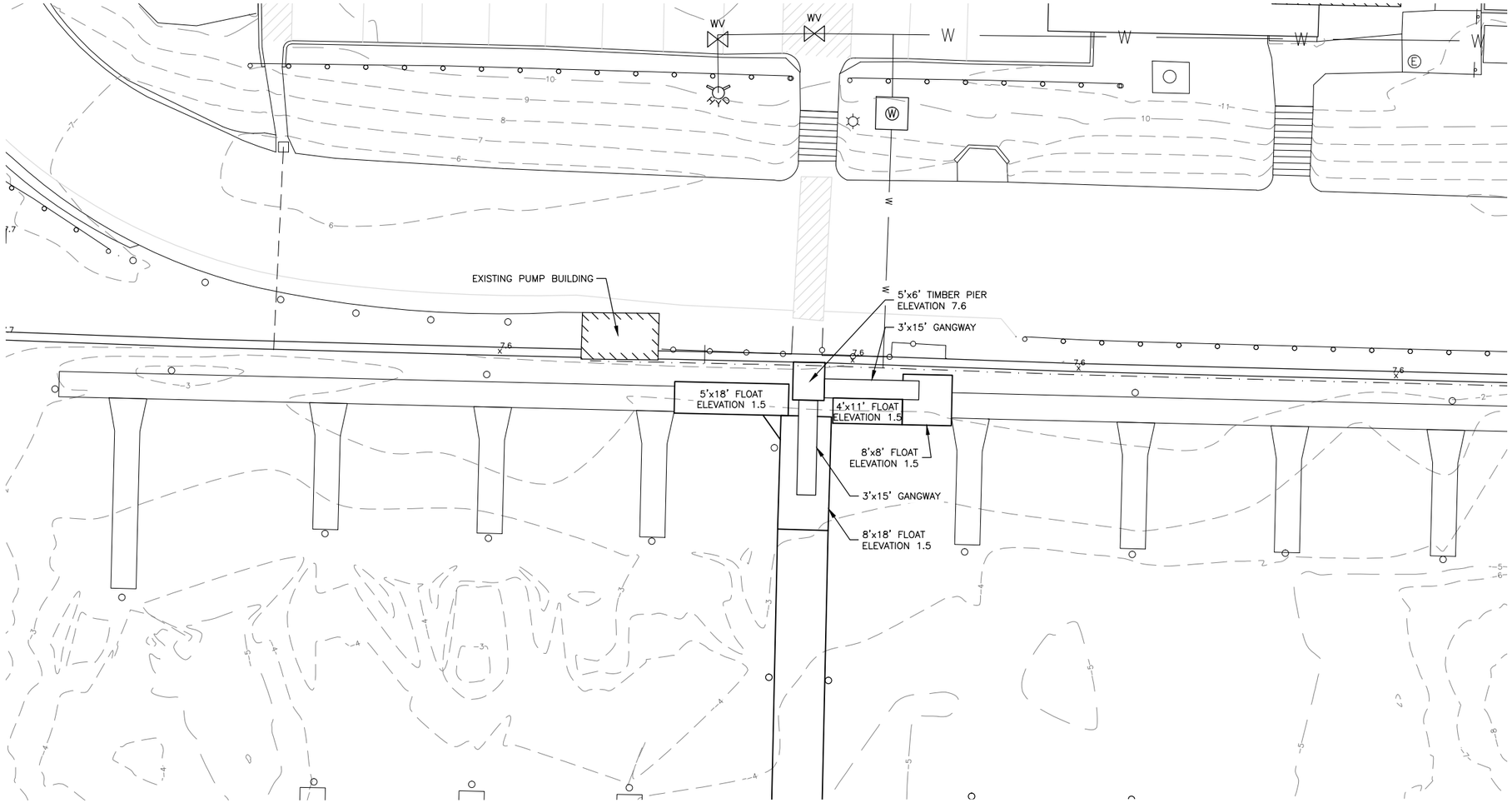

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SAQUATUCKET AND WYCHMERE HARBOR PLAN DEVELOPMENT
HARWICH, MASSACHUSETTS

SAQUATUCKET HARBOR
GANGWAY IMPROVEMENT PLAN

PREPARED BY:
Vine ASSOCIATES A DIVISION OF
GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com

PREPARED FOR:
TOWN OF HARWICH

PROJ MGR: GGR	REVIEWED BY: GGR	CHECKED BY: RJM	DRAWING 4
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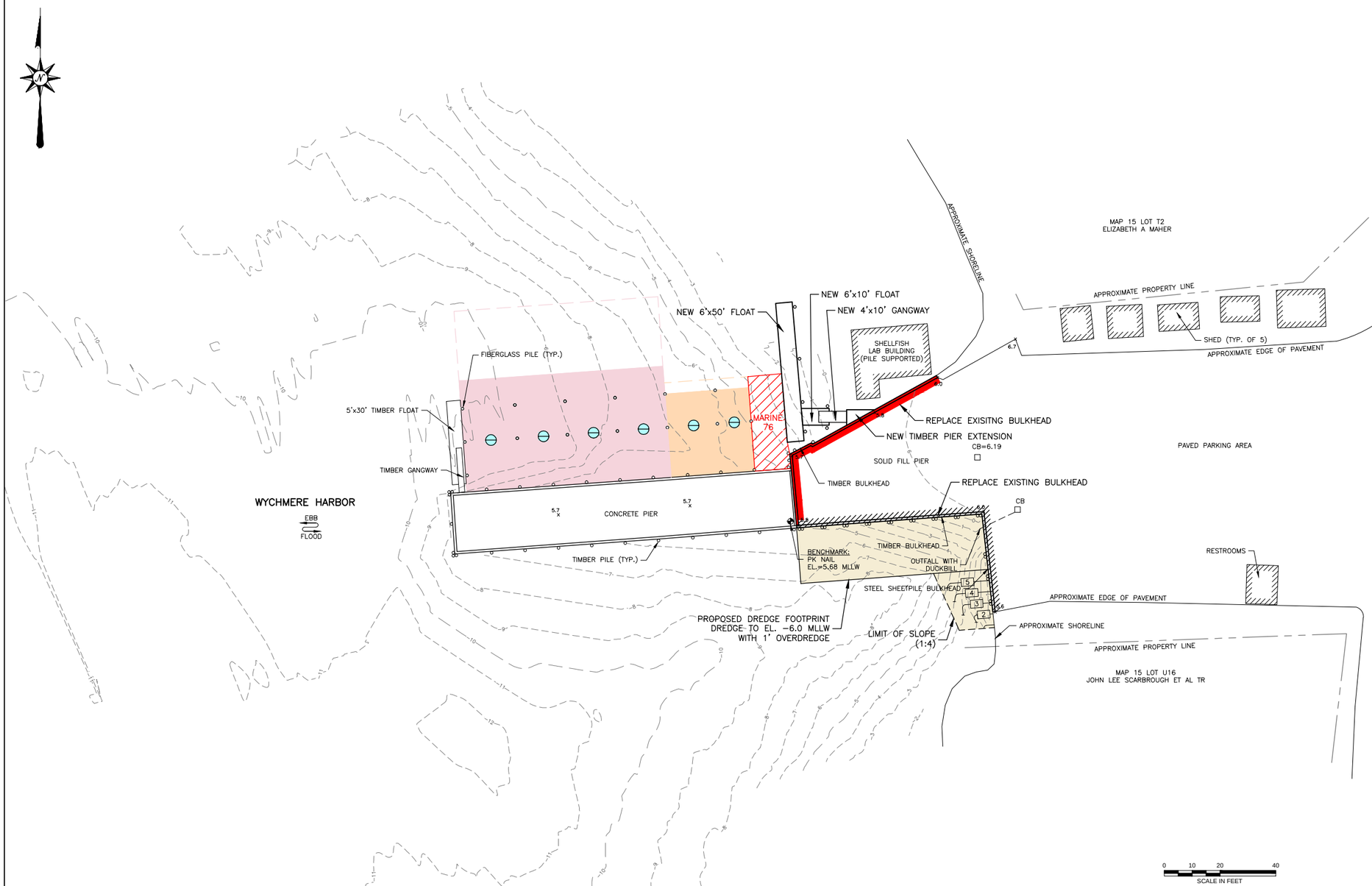
SLIP LENGTH	TOTAL	CHANGE
20-FT. –	0	–
30-FT. –	3	-1
40-FT. –	4	–

PERMIT TYPE

- COMMERCIAL (A)
- PASSENGER (D,F)
- CHARTER (C)
- NO PERMIT



LEGEND

	EXISTING
CONTOUR	15
SPOT GRADE	×20.0
DRAIN MANHOLE	D
CATCH BASIN	□
DRAIN LINE	D
SEWER MANHOLE	S
SEWER LINE	S
WATER VALVE	WV
WATER LINE	W
HYDRANT	
WATER MANHOLE	W
UTILITY POLE	
LIGHT	
ELECTRIC MANHOLE	E
TIMBER PILE	○
FIBERGLASS PILE	○
SIGN	
GUARDRAIL	
BOAT SLIP I.D.	WB 30
HANDICAP SLIP	
TIMBER DOLPHIN	

GENERAL NOTES:

1. EXISTING TOPOGRAPHIC AND SOUNDING INFORMATION BASED ON FIELD AND HYDROGRAPHIC SURVEYS BY VINE ASSOCIATES – A DIVISION OF GZA GEOENVIRONMENTAL ON OCTOBER 7, 2011.
2. PROPERTY LINES ARE APPROXIMATE AND BASED ON PLAN ENTITLED "WYCHMERE HARBOR DRAINAGE IMPROVEMENTS" PREPARED BY THE TOWN OF HARWICH ENGINEERING DEPARTMENT DATED DECEMBER 2010, LAST REVISED MAY 2011.
3. VERTICAL DATUM: MLLW = 0.0; MLW = 0.28; MHW = 4.0. SITE BENCHMARK IS NGS TIDAL BENCHMARK "M 28 BA", A SURVEY DISK SET IN THE TOP OF A CONCRETE MONUMENT NEAR 621 STATE HIGHWAY 28, ELEVATION = 16.82 MLLW. LOCAL SITE BENCHMARK IS "PK NAIL" SET IN CONCRETE PIER, ELEVATION = 5.68 MLLW.
4. HORIZONTAL POSITIONING, AS SHOWN, IS BASED ON MASSACHUSETTS STATE PLANE COORDINATE SYSTEM (NAD 83).
5. UTILITY INFORMATION SHOWN IS BASED ON BOTH FIELD SURVEY AND THE LATEST PLANS OF RECORD. THE LOCATIONS OF ALL STRUCTURES AND UTILITIES IS APPROXIMATE AND SHALL BE VERIFIED BY CONTRACTOR PRIOR TO CONSTRUCTION. THE ENGINEER SHALL BE NOTIFIED OF ANY DISCREPANCIES WHICH WILL EFFECT SITE DESIGN. NO CHANGES IN THE FIELD SHALL BE MADE WITHOUT PRIOR NOTIFICATION OF THE DESIGN ENGINEER.

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SAQUATUCKET AND WYCHMERE HARBOR PLAN DEVELOPMENT
HARWICH, MASSACHUSETTS

WYCHMERE PIER MARINA PLAN

PREPARED BY: Vine ASSOCIATES A DIVISION OF GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com

PREPARED FOR: TOWN OF HARWICH

PROJ MGR: GGR	REVIEWED BY: GGR	CHECKED BY: DBV	DRAWING 5
DESIGNED BY: MAG	DRAWN BY: MAG	SCALE: AS SHOWN	
DATE: AUGUST 2013	PROJECT NO. 18.0171075	REVISION NO.	SHEET NO. 5 of 5

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Typical passenger vehicle/parking loop

Pick-up/drop-off passenger vehicle loop

Vehicles with trailers, trucks and pick-up and drop-off route

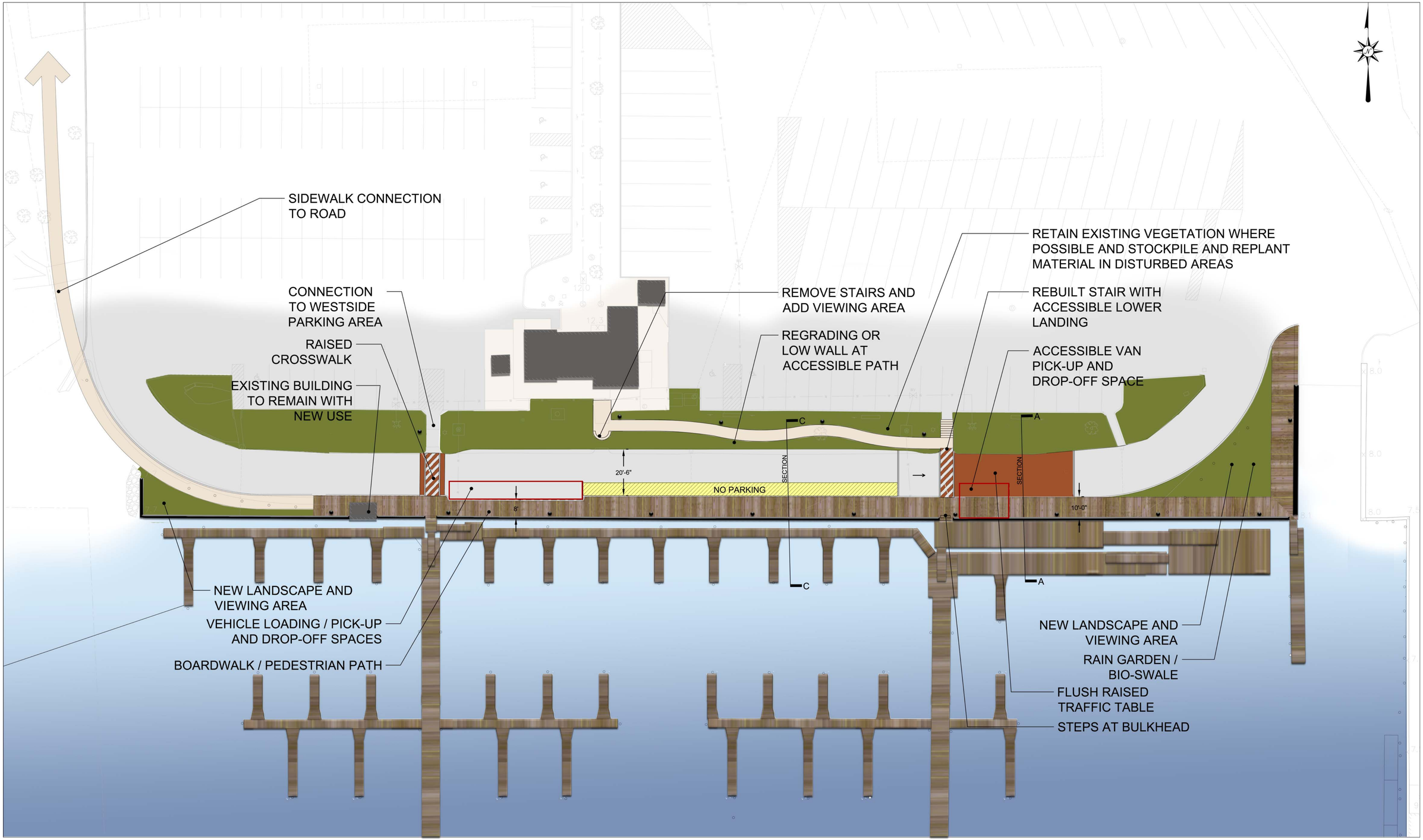
Trailer backing pattern

Truck backing pattern

Figure 1

Proposed Vehicle Circulation Patterns

Saquatucket Harbor



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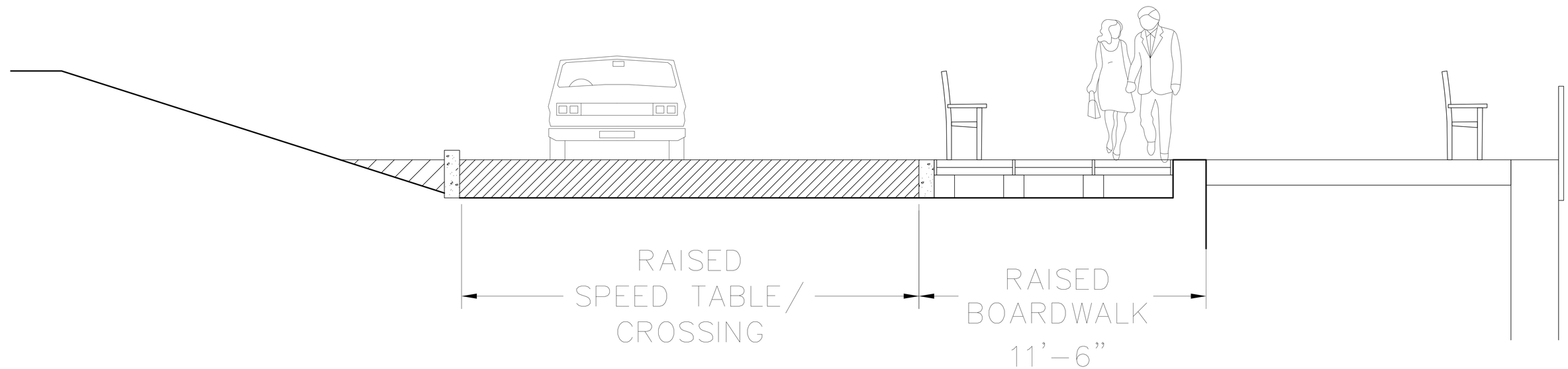
0 20 40 80
SCALE IN FEET

SAQUATUCKET HARBOR
LANDSIDE APPROACH

Figure 2



RAISED BOARDWALK FLUSH WITH BULKHEAD

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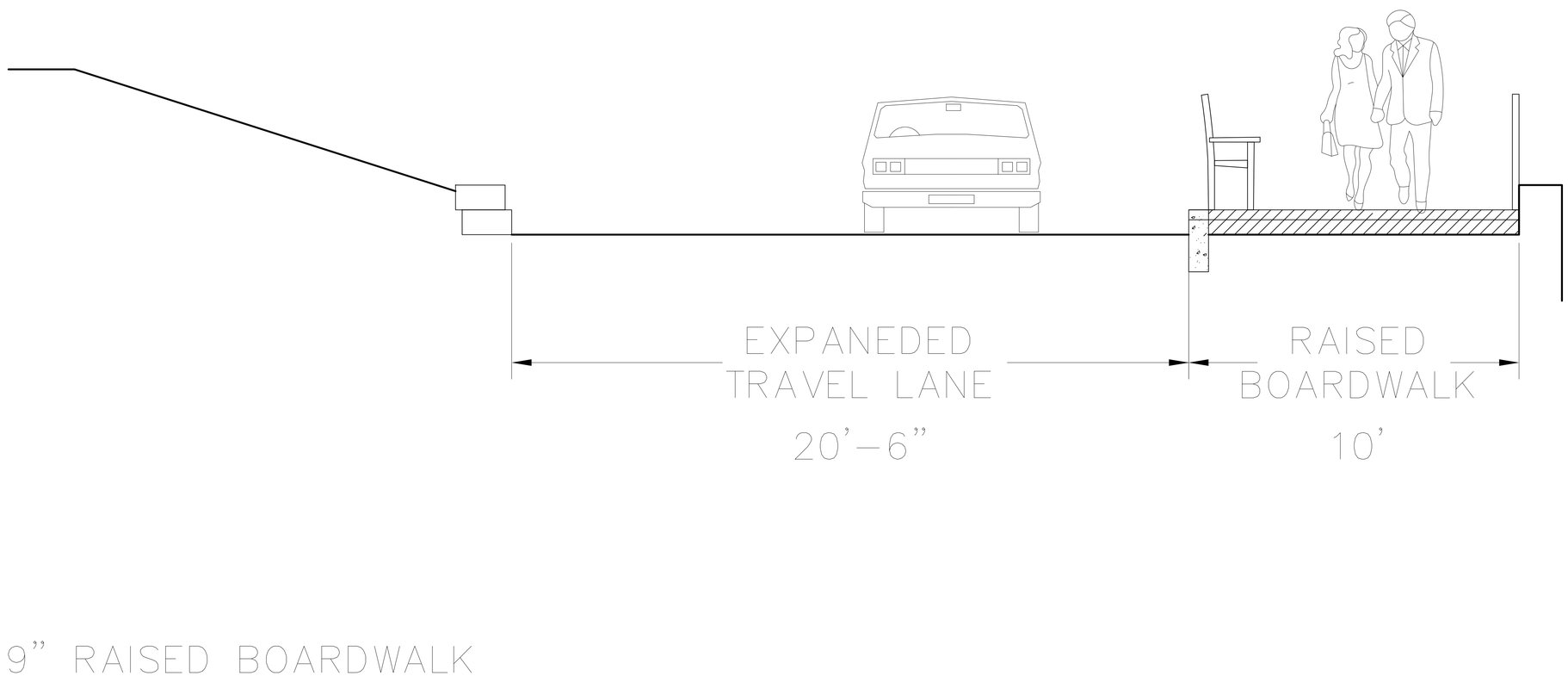
SAQUATUCKET HARBOR

LANDSIDE BULKHEAD SECTION A

Figure 3



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SAQUATUCKET HARBOR

LANDSIDE BULKHEAD SECTION C

Figure 4

TOWN OF HARWICH

SAQUATUCKET & WYCHMERE HARBORS PLAN

Waterfront Consultants
Vine ASSOCIATES
A Division of GZA GeoEnvironmental, Inc.

The Cecil Group
Planning and Design

SAQUATUCKET HARBOR

Landside Design Studies – Saquatucket Harbor

Overview

Design studies of three alternative approaches have been prepared for Saquatucket Harbor to fulfill the program requirements that have been defined along the waterside, with varying implications relative to cost, character and relationship to the larger area. All alternatives focus on the marina edge, and have been coordinated with the waterside alternatives, so that any of the waterside concepts can be combined with any of the landside options. Illustrative plans and explanatory sections, along with supporting cost information are also provided.

The scope of the design alternatives includes the waterside immediately adjacent to the marina, rather than an investigation of the entire landing. However, the studies have addressed where changes in waterside circulation will lead to other needs or recommendations (signage, re-organized vehicle circulation, extension of pedestrian paths accessible to street and crosswalk, and accessible routes). In this way, the focus area of these waterside alternatives is coordinated and linked to the broader context.

Common Elements and Observations

Traffic Circulation

All alternatives assume rerouting traffic circulation as indicated on the *Proposed Vehicle Circulation Patterns* diagram (Figure 1). The implications include:

- Boat trailer circulation – A new pick-up and drop-off route for vehicles with trailers and delivery trucks has been defined that will avoid circulation of these vehicles along the bulkhead drive. The new route sends these vehicles straight into the parking area from Main Street, running past the Harbormaster's Building to the trailer parking area. In the trailer parking area the parking configuration may need to be adjusted near the Harbormaster's Building to accommodate vehicle turning radii for vehicles with large boat trailers. For very large boat/trailers, the lower drive may be required for occasional use to reduce the number of parking spaces that will be lost in the trailer parking area. The process for queuing vehicles and trailers prior to letting-in (getting parking passes) should be anticipated and built into the reconfiguration of this parking area so as to include a new stop line adjacent to the Harbormaster's Building, signage and procedures.
- Function of lower drive – The function of the lower access drive at the bulkhead has been refined as a passenger vehicle and pedestrian pick-up/drop-off place with a character that is more indicative of a pedestrian-friendly waterfront. The pick-up/drop-off functions include a dedicated handicap accessible space and additional space for others for temporary loading and unloading. The travel lane clearances are designed to maintain emergency vehicle access with enough width to pass any

stopped vehicles. Operation requirements should be confirmed with the Fire Marshall.

- Other vehicle access patterns – Other vehicle access patterns remain unchanged from existing patterns of use.
- Directional and Information Signage – The revised circulation patterns for vehicles with boats and deliveries will need to be expressed with new directional and information signage on the site. The signage should be strategically located to clearly define the desired circulation patterns for each vehicle type and pedestrians. Additional signage should be used to define any parking restrictions, such as time limitations on the bulkhead pick-up/drop-off spaces.

Pedestrian Circulation

All alternatives assume the following improvements to pedestrian circulation:

- A fully accessible path for all improved areas
- Completion of an accessible path to street/crosswalk

Design Alternatives

A discussion of the landside alternatives is presented in the paragraphs below. The layout of each alternative is illustrated in Figures 2 through 10, and relevant section details are presented in Figures 11 through 14. Figures 4, 7 and 10 depict Option 1, 2 and 3 respectively as modified to accommodate waterside Concept 3 (passenger vessels adjacent to the boat ramp). All Figures are included as an attachment to this report.

Option 1

Description

Option 1 creates a central viewing area at the upper elevation of the parking areas and Harbormaster's Building with two nearly symmetrical accessible paths that lead down the sloping grade to the bulkhead roadway. The accessible paths then cross the bulkhead roadway on raised crossings to connect to an elevated boardwalk that is continuous and flush with the top of the bulkhead wall.

Features

By placing the accessible paths on undulating lines from the Harbormaster's Building, it is possible to avoid landscape features and infrastructure elements in the sloping lawn area while maintaining accessible slopes. The accessible paths maintain a slope that is less than 5% allowing them to be unencumbered by railings and additional landings. The two existing stairs would be rebuilt with an accessible landing integral to their construction where they intersect with the accessible path. The existing vegetation of the sloped landscape area would be retained as much as possible. The viewing area near the Harbormaster's Building would feature a low wall with guardrail and benches. The pedestrian crossings at the bulkhead roadway would be reinforced by both raising the elevation of the crossing and adding a textured pattern with stamped asphalt. The first pedestrian crossing would be expanded into a speed table, an elevated portion of the

roadway that is flush with the adjacent pedestrian walkways. This area would also be a textured pattern with stamped asphalt to reinforce the pedestrian orientation of this bulkhead area. The extended speed table also helps to capture the landing of the accessible path in that vicinity. The speed table and the boardwalk would both be elevated to be level with the top of the bulkhead, allowing easy access and an expanded pedestrian environment. The wood boardwalk would continue at this elevation, equal to the top of the bulkhead for its remaining length.

Materials

The new accessible paths and stairs would be constructed of concrete. The sidewalk connection along the entry road would be an asphalt walk. The elevated crosswalk and speed table would be constructed of asphalt, and the paving pattern would be created with stamped asphalt. The elevated bulkhead walkway would be built up with a concrete foundation and finished with wood decking.

Observations

While raising the boardwalk to the level of the bulkhead will be an added cost, this configuration allows the width of the bulkhead to be used as part of the waterfront promenade. The centralized configuration of the viewing area reinforces the Harbormaster's Building as a key feature of the waterfront. The length of the accessible paths is a cost that may not have much benefit as compared to the other alternatives and it disturbs a larger portion of the existing landscaped slope.

Option 2

Description

Option 2 creates a central viewing area at the upper elevation of the parking areas and Harbormaster's Building with one accessible path that leads down the sloping grade to the bulkhead roadway. The accessible path then crosses the bulkhead roadway on raised crossings to connect to a continuous elevated boardwalk. The second accessible path follows the entry drive down to the pedestrian walkway along the bulkhead and is connected to an elevated speed table and pedestrian crossing. The roadway is expanded slightly by adding a low retaining wall to the bottom of the existing landscaped slope.

Features

By placing the accessible path on an undulating line from the Harbormaster's Building it is able to avoid landscape features and infrastructure elements in the sloping lawn area while maintaining accessible slopes. The accessible path maintains a slope that is less than 5% allowing it to be unencumbered by railings and additional landings. One existing stairway would be rebuilt with an accessible landing where it intersects with the accessible path. The existing vegetation of the sloped landscape area would be retained as much as possible. The viewing area near the Harbormaster's Building would feature a low wall with guardrail and benches. The pedestrian crossings at the bulkhead roadway would be reinforced by both raising the elevation of the crossing and adding a textured pattern with stamped asphalt. The first pedestrian crossing would be expanded into a speed table, an elevated portion of the roadway that is flush with the adjacent pedestrian walkways. This area would also be a textured pattern with stamped asphalt to reinforce the pedestrian orientation of this bulkhead area. The extended speed table also

helps to capture the landing of the accessible path in that vicinity. The speed table would be elevated to be level with the top of the bulkhead, allowing easy access and an expanded pedestrian environment. The wood boardwalk would ramp down to a height 6" above the roadway for its remaining length. The second elevated crossing would be flush with the boardwalk at this height.

Materials

The new accessible paths and stairs would be constructed of concrete. The sidewalk connection along the entry road would be an asphalt walk. The elevated crosswalk and speed table would be constructed of asphalt, and the paving pattern would be created with stamped asphalt. The elevated bulkhead walkway would be built up with a concrete foundation and finished with wood decking. Pedestrian lighting should be added to the paths and boardwalk as pedestrian bollard lights or recessed fixtures that light the ground plane.

Observations

By expanding the flat area at the bottom of the slope with a small retaining wall, more flexibility is gained near the bulkhead. The reconfiguration of the accessible paths reduces the overall construction of paths compared to Option 1 and retains an accessible path to both sides of the bulkhead. The lower elevation boardwalk does not allow for the top of the bulkhead to be utilized as part of the pedestrian area. A ramped portion is required to reach the bulkhead height at the accessible gangway and speed table, and steps up to the bulkhead are necessary to access other gangways.

Option 3

Description

Option 3 creates a central viewing area at the upper elevation of the parking areas and Harbormaster's Building that is integral to a new accessible route. The new accessible route is configured with a switchback that minimizes the amount of the existing landscaped slope that is modified. The accessible path then crosses the bulkhead roadway on a raised crossing to connect to an elevated boardwalk.

Features

By placing the accessible path in a compact area with a switchback it is possible to avoid landscape features and infrastructure elements in the sloping lawn area while maintaining accessible slopes. The accessible path maintains a slope that is less than 5% allowing it to be unencumbered by railings and additional landings. One existing stairway would be rebuilt with an accessible landing where it intersects with the accessible path. The existing vegetation of the sloped landscape area would be retained as much as possible. The pedestrian crossings at the bulkhead roadway would be reinforced by both raising the elevation of the crossing and adding a textured pattern with stamped asphalt. The first pedestrian crossing would be expanded into a speed table, an elevated portion of the roadway that is flush with the adjacent pedestrian walkways. This area would also be a textured pattern with stamped asphalt to reinforce the pedestrian orientation of this bulkhead area. The extended speed table also captures the landing of the accessible path there. The speed table would be elevated to be level with the top of the bulkhead, allowing easy access and an expanded pedestrian environment. The wood boardwalk

would ramp down to a height 6 inches above the roadway for its remaining length. The second elevated crossing would be flush with the boardwalk at this height. No secondary accessible path would be provided in this alternative.

Materials

The new accessible path and stairs would be constructed of concrete. The sidewalk connection along the entry road would be an asphalt walk. The elevated crosswalk and speed table would be constructed of asphalt and the paving pattern would be created with stamped asphalt. The elevated bulkhead walkway would be built up with a concrete foundation and finished with wood decking. Pedestrian lighting should be added to the paths and boardwalk as pedestrian bollard lights or recessed fixtures that light the ground plane.

Observations

The reconfiguration of the accessible path with a central switchback reduces the overall construction of paths compared to Options 1 and 2 and provides an accessible path to the accessible gangway. The lower elevation boardwalk does not allow the use of the top of the bulkhead as part of the pedestrian area. A ramped portion is required to access the boardwalk area at the accessible gangway which is flush with the bulkhead height and speed table. Steps up to the bulkhead elevation are required to access other gangways. This approach, with a single accessible path, may be a reasonable tradeoff given that there is only one location with an accessible gangway and this path leads directly to it.

Watersheet Reconfiguration – Saquatucket Harbor

Our design team developed multiple design concepts to meet the design requirements identified in the Design Program. Multiple locations for relocating the ferry service to a landside berth were assessed including the area targeted in the Design Program, a more central location along the North Bulkhead and at the extreme east end of the North Bulkhead. However, the requirement for a fully accessible route from shore to the ferry, geometric limitations of the site, the requirement to maintain the existing number of slips and distance from available parking not associated with boat ramp operations resulted in a focus on the area targeted in the Design Program. In response to the Draft Design Report presented to the Town in March, 2012, the project team was tasked with developing a new concept which located the passenger vessels at the extreme east end of the North Bulkhead.

The configuration and condition of the North and East Bulkheads are addressed in this evaluation. The two bulkheads are considered to be in the most practical locations given the geometry of the harbor, property line configurations, presence of resource areas on and adjacent to the site and the location of upland structures. Relocating the North Bulkhead farther inland would result in greater watersheet area becoming available for use but would require significant changes to the landside layout and structures resulting in a reduction in available parking and a significant increase in costs.

The design alternatives are based upon the North Bulkhead being considered to be in serviceable condition. The bulkhead should be assessed for deterioration every 5 years with repairs made as necessary.

The previous evaluations of the East Bulkhead indicate that the structure is in poor condition and has experienced movement. Given the conditions of the structure and the heavy use of the area to fit-out, and at times fuel, a large number of various types of vessels we included a bulkhead replacement in our design. A preliminary design of a replacement bulkhead was completed and is presented at the end of this section. The new bulkhead would be capable of supporting the high surface loading applied to the area behind the wall such as cranes and large trucks. The land side area behind the bulkhead would be re-graded with a crushed stone surface to accommodate the anticipated uses.

Marina

As indicated above, facilities servicing waterborne passenger vessels with a length of 40 feet or greater must provide an accessible route from shore to the vessel (521 CMR) under the majority of tidal conditions. At the time of this report, three vessels which utilize Saquatucket Harbor Marina fall into that category: the passenger ferry Freedom and the charter vessels Yankee and Cap'n Kid.

In addition, any alteration to the marina triggers the requirement for a minimum of 5 accessible recreational slips connected to shore via an accessible route (521 CMR, 28 CFR 35 and 36 CFR 1191). To qualify as an accessible route, the route must comply with strict requirements for properties such as clear width, obstructions, changes in level, slope and slope length.

To meet these requirements, the design team developed a series of piers, platforms and floats connected via ramps to provide an accessible route to the qualifying passenger vessels as well as to the recreational marina. The accessible slips were localized and placed along a common accessible float in order to minimize both the costs associated with providing multiple accessible routes and the distance required to access the slips.

With the location of the passenger vessel berths at the west end of the North Bulkhead as a common feature, two alternatives (Concept 1 & 2) for the marina layout were developed. A third alternative (Concept 3) was subsequently developed which located the passenger vessel berths at the east end of the North Bulkhead with an accessible route similar to that included in the first two concepts. All three alternatives comply with the design requirement to consolidate commercial vessels, consolidate charter vessels and locate charter, party fishing and tour boats in areas readily visible from shore.

The relocation/consolidation of the passenger vessels and the installation of an accessible route to reach them combine to impact the number of slips that can be accommodated in the marina. In order to maintain the number of existing slips or minimize the loss of slips, modifications to the portion of the marina located within the turning basin isrequired. It is anticipated that a request to modify the existing approved float arrangement within the turning basin would be viewed favorably by the U.S. Army Corps of Engineers.

During the preliminary work leading up to the development of these concepts, numerous comments were received from users regarding the condition and stability of the existing

floats. This, combined with the length of the main float runs, number of vessels being served and prudent design resulted in new 8 foot wide main floats being proposed in each concept. Floats greater than 8 feet in width were considered; however, due to space limitations reducing the total number of slips and economic concerns, they were rejected.

Significant efforts were made to alter slip, float and fairway dimensions to adhere to the recommendations contained in Tobiasson, B. O., Kollmeyer, R. C. (2000). *Marinas and small craft harbor (2nd Edition).* Medfield, MA: Westviking Press. However, the geometric constraints of the harbor result in significantly fewer slips if the recommendations are followed. In order to maintain the existing number of slips and minimize the loss of slips, existing marina dimensions were maintained as necessary. Existing dimensions were increased where feasible, especially with regard to fairway widths.

Two watersheet concepts (Concepts 1 & 2) locate commercial vessels along a main float with direct water access to the East Bulkhead. The East Bulkhead is readily visible from this location providing information regarding the availability of tie-up space and presence of support vehicles such as fuel trucks and fish trucks with a quick glance. This location is also in close proximity to the parking areas frequented by commercial crews. One concept (Concept 3) locates commercial vessels in proximity to the East Bulkhead but with a north/south slip orientation.

Two watersheet concepts (Concepts 1 & 2) provide for a 180 foot queuing and emergency berthing area alongside an 8 foot wide float. This area will accommodate emergency berthing of vessels as may be necessary and provide a queuing area in close proximity to the entrance channel for vessels waiting to coordinate the offloading of catch.

Concept 1 (Drawing 1)

In this concept, charter vessels are located in a common area immediately adjacent to the North Bulkhead and in close proximity to the eastern access point. While readily visible from shore and public viewing areas, this location is a significant distance away from the majority of non-trailer parking. All vessels are directly visible from shore.

In order to collocate similarly sized vessels, this alternative places a number of slips in the 30 foot class adjacent to the charter vessels. The displaced slips in the 20 foot class are relocated to the central portion of the marina.

In this concept the width of the fairway accessing the passenger vessel berths is maximized by orienting adjacent slips perpendicular to the fairway and the adjacent main float.

Concept 1 results in a gain of one additional slip in the 20 foot class, a gain of three additional slips in the 30 foot class and no change to the number of slips in the 40 foot class.

Concept 2 (Drawing 2)

In this concept, charter vessels are located in a common area directly across from the passenger vessel berths and timber pier overlooking that portion of the harbor. This location is in close proximity to the largest parking lot available to potential patrons as

well as the proposed pedestrian connections to Main Street. The slips are adjacent to the accessible route extending from the west access point which could be readily expanded to provide an accessible route to each charter vessel. In this configuration, the slips in this area are configured perpendicular to shore to increase the number of vessels that are directly visible from shore.

This orientation of the slips results in a narrower fairway for passenger vessels but does allow for a slightly larger turning basin adjacent to the passenger vessel berths.

This concept allows collocation of slips in the 20 foot class along east end of the North Bulkhead and allows slips in the 30 foot class to be collocated in the central portion of the marina, closer to entrance channel. The narrower fairway requirement along the east end of the North Bulkhead allows more slips in the 40 foot class to be located directly across from the East Bulkhead.

Concept 2 results in a gain of three additional slips in the 20 foot class, a gain of one additional slip in the 30 foot class and no change to the number of slips in the 40 foot class.

Concept 3 (Drawing 3)

In this concept, the passenger vessel berth has been relocated to the eastern end of the North Bulkhead, immediately adjacent to the boat ramp. Although this location is not centrally located to visitor parking or pedestrian access to Main Street, input from user groups led the Committee to request further investigation of this alternative. In addition to moving the passenger berths, this concept also maintains the north/south orientation of slips along the eastern access point.

Charter vessels are located in a common area directly across from the passenger vessel berths and timber pier overlooking that portion of the harbor, much like the arrangement in Concept 2. In this configuration, the slips are configured perpendicular to shore to increase the number of vessels that are directly visible from the timber pier. Also, the charter slips are located just beyond the extent of the accessible route which could be readily expanded to include each charter vessel in the future.

Commercial vessels are located in a common area at the seaward end of the float system. In addition, the passenger vessel Perseverance, which is not subject to accessibility requirements due to its length, remains in the vicinity of its current berth.

While the overall layout and orientation of the slips located along the western main float remains relatively unchanged, more recreational slips become accessible from the west side, a more defined channel to the inner marina is provided, and dredging along the western property line is reduced.

Concept 3 results in the gain of three additional slips in the 20 foot class and no change to the number of slips in the 30 foot and 40 foot classes.

Amenities

All concepts anticipate both water and electrical service being provided to each slip via power pedestals which each service two adjacent vessels. The power pedestals will provide walkway lighting and this lighting will be supplemented by lighting bollards as necessary.

East Bulkhead

To address the need for additional tie-up space at the East Bulkhead, all Concepts include a new timber platform and new gangways accessing both existing and new floats. The existing float is removed from the bulkhead face to allow increased access to support vehicles while the remaining four floats, located in areas not available to support vessels due to existing structures, are left unchanged. Sixty feet of new floats extending southwest from the southern corner of the bulkhead are proposed.

Encroachments into the de facto channel connecting the Turning Basin to the East Bulkhead and Boat Ramp were minimized. While recommended fairway width could not be accommodated, available widths are in keeping with the existing conditions at the site.

The location of the pump out facility remains unchanged in all Concepts. This is due to the storage tank being located within the privacy berm along the eastern property line and the lack of a site suitable for relocation. However, should reconstruction of the East Bulkhead be pursued, it would be prudent for the Town to include a reconfiguration of the pump out facilities within the layout of the East Bulkhead. Because the pump out equipment will be significantly impacted by construction activities, it becomes an opportune time to make any configuration changes that would contribute to the efficient use of the site.

In each Concept a new gravel surface is proposed. With minimal regular maintenance, this will provide a suitable all-weather surface on which support vehicles can operate. Asphalt pavement was considered as it would provide a more durable surface and prevent infiltration behind the bulkhead. Drawbacks associated with asphalt include generating additional stormwater which would require development of a treatment system, economics and the lack of support for this alternative received from users. For these reasons it was not pursued further.

Dredging

Conceptual Dredging Plans (Drawings 4 & 5) were developed in accordance with the Design Program to address shoaling within the marina basin. In general marina areas, the plans call for dredging to the previously permitted depth of -6.0 MLLW plus a 1-foot overdredge allowance (typical payment tolerance) to minimize the frequency of maintenance dredging. To accommodate the existing ferry vessel (5.5 foot draft), the plans include improvement dredging to a depth of -8.0 MLLW plus a 1-foot overdredge as needed to provide access to the ferry berth.

Estimates of the quantity of dredge spoils generated by the above plans vary from 12,150 cubic yards in Concept 3 to 15,250 cubic yards in Concepts 1 and 2. The costs associated with dewatering and upland disposal of such a large volume of material result

in off-shore disposal being a preferred alternative. However, the feasibility of off-shore disposal cannot be determined without extensive and costly testing of the sediments prior to dredging. We recommend exploring the possibility of limited physical and environmental testing of the sediments being performed to determine if pursuing the more extensive testing required for off-shore disposal is a worthwhile endeavor.

Phasing

All of the Concepts presented in this report can be implemented in phases. This would allow the Town to spread the proposed work over multiple funding cycles. While there may be benefits to this approach from a capital planning standpoint, there are also drawbacks associated with implementing the project in phases. For example, slips displaced from the new passenger vessel berthing areas are to be relocated to other parts of the marina and implementing the work in phases will result in a period of time between the beginning of one phase and completion of another when the number of available slips is reduced significantly (up to 10%). This could result in the displacement of current customers as well as a loss of revenue. Additional drawbacks include the following:

- Multiple procurement processes.
- Additional mobilization costs.
- Additional construction oversight costs.
- Additional permitting costs (depending on the period of time between projects)
- Prolonged impacts to marina users and operators.

In each Concept, the accessible route to the marina and passenger vessel berths would have to be performed in the first phase. This is because accessibility requirements apply once any improvements to the marina begin.

The cost estimate for Concept 3 presented later in this report is grouped into three areas to allow the Town to evaluate a phased approach to the work.

1. East Side (including accessibility compliance and partial dredging)
2. West Side (including partial dredging)
3. East Bulkhead Float Improvement.

Preliminary Engineering – Saquatucket Harbor

East Bulkhead

A conceptual design of a replacement bulkhead along the eastern side of Saquatucket Harbor was completed based on assumed soil and backland usage parameters. These parameters included an assumed soil profile, where conservative engineering properties were applied in the analysis, and a very general loading scenario consisting of HS20-44 surcharge loading, corresponding to approximately 500 pounds per square foot (psf). We also assumed a 5 foot

thick very weak soil layer directly below the mudline. This assumption significantly impacts the required stiffness of the wall and the installation costs. We recommend that borings be completed along the bulkhead to better model the ground conditions, develop a more accurate design, and develop more representative costs.

Existing top of wall and mudline elevations were taken from the Saquatucket Harbor Existing Conditions Plan, developed by Vine Associates-A Division of GZA dated November, 2011. Maximum water differentials were assumed to be between Mean High Water (MHW) and Mean Lower Low Water (MLLW).

The conceptual design also included two alternatives. In Option 1, the new bulkhead would be a new and independent cantilevered sheet pile wall. In Option 2, the new bulkhead would consist of a new anchored steel sheet pile wall that utilizes the existing deadman. There are significant cost differences associated with the reuse of the existing deadman, as much less steel would be required for the new bulkhead; however, the feasibility of this alternative is questionable as the dimensions and condition of the existing deadman is unknown. It is recommended that a condition survey of the existing deadman, tie rods, and wale be conducted as part of the design phases of the project to assess the potential reuse of the anchor system. It was assumed for this design, however, that the existing deadman was originally designed adequately and could sustain the lateral loads.

Marina Structures

For the purposes of developing cost estimates, it was assumed that all new marina piles would be timber and that half of the required piles would be reset piles currently in use at the site and the remaining piles would be new.

Passenger Vessel Accessible Route/Boarding System

In order to accommodate the various configurations of the passenger vessels currently berthing in Saquatucket Marina, provide an accessible route to those vessels and allow for flexibility with regard to future uses, a three-level berthing area was developed. For the berthing area located at the east end of the North Bulkhead, a modified version of the system was used with dimensions and elevations varying slightly.

The upper level of the passenger vessel berthing area consists of a pile-supported pier with timber deck which matches the elevation of the bulkhead cap. This structure serves as a connection point for the gangways used to access the marina areas, a queuing and staging area for passengers boarding or disembarking from passenger vessels, a gathering and viewing area for pedestrians, and the interface between landside and waterside accessible routes.

The upper level is connected to a steel float with a deck 4.3 feet above the water surface. This elevation coincides with the boarding elevation of the vessels Freedom and Yankee and allows the float to serve as an intermediate level in the accessible route. In order to accommodate the slope and run requirements for accessible routes, the connection between the upper level pier and this float consists of a gangway measuring 30 feet long x 6 feet wide affixed to both the pier and an aluminum landing elevated 1.3 feet above the float deck. A ramp measuring 16 feet long x 6 feet wide connects the landing with the float deck.

In two alternatives (Concepts 1 & 2), the lower level consists of a timber float with a deck 2.0 feet above the water surface. This elevation was selected as a best-fit compromise between the boarding elevations of the Cap'n Kid and the Perseverance. In Concept 3, the lower level deck is 2.5 feet above the water surface as the Perseverance would be located elsewhere. Additional berths are provided at the passenger berthing area to meet accessibility requirements and to accommodate a charter boat in the 40 foot class.

The lower timber float is connected to the intermediate steel float by an aluminum gangway 28 feet long x 4 feet wide. This narrower gangway accommodates space limitations and will be subject to lower pedestrian volumes than the upper gangway which services the ferry, all passenger boats and all accessible slips located within the marina.

This combination of elements provides an accessible route under the range of spring tide conditions while simultaneously providing suitable berthing options for a variety of passenger vessels.

Electrical & Water Service

A number of assumptions were required regarding the level, type and distribution of water and electrical services for the new configurations. In addition, available options vary widely in durability, price and features.

Sea Level Rise

Although assessing the impacts of sea level rise on the sites was beyond the scope of this project, the potential impact of sea level rise was considered during our evaluation. The current elevation at the top of the bulkhead caps is approximately equal to the current predicted 100-year flood elevation. The surface of the roadway adjacent to the North Bulkhead is approximately 1.5 feet below the seawall cap. Modifying the site to accommodate even the lowest estimates of sea level rise over the next 100 years would require raising the roadway several feet and reconstructing the North Bulkhead due to the increased structural loading imposed by the additional fill material required to raise the roadway. These accommodations would result in significant changes to the character and usability of the site.

Cost Estimates – Saquatucket Harbor

The tables below contain an estimate of cost for each conceptual design alternative. These cost estimates are based upon typical labor and material costs, recent bid results for similar projects and/or typical product options for the conceptual designs developed and are suitable for comparative analysis and conceptual planning.

Permitting, design and engineering fees are not included in the cost estimates provided below but can generally be estimated to be approximately 10% of construction costs (this does not include construction phase services). Dredging permitting costs may be higher.

Landside Design Studies

Design Alternatives	Estimated Cost
Option 1	$680,000
Option 2	$665,000
Option 3	$430,000

Watersheet Reconfiguration

Concept 1	
Design Feature	Estimated Cost
Marina Plan	$2,700,000
Passenger Vessel Berths/ Accessible Route	$850,000
General Marina Access	$35,000
East Bulkhead Float Improvements	$55,000
Dredging[1]	$850,000 -$3,400,000

Concept 2	
Design Feature	Estimated Cost
Marina Plan	$2,700,000
Passenger Vessel Berths/ Accessible Route	$850,000
General Marina Access	$35,000
East Bulkhead Float Improvements	$55,000
Dredging[1]	$850,000 -$3,400,000

Concept 3	
Design Feature	Estimated Cost
Marina Plan – East Side	$1,000,000
Passenger Vessel Berths/ Accessible Route	$850,000
Dredging[1, 2] – East Side	$500,000-$1,400,000
Marina Plan – West Side	$1,900,000
General Marina Access	$65,000
Dredging[1, 2] – West Side	$250,000 - $1,330,000
East Bulkhead Float Improvements	$55,000

[1] Dredging costs are highly variable and dependent upon sediment composition, level of contamination, disposal location and requirements imposed during the permitting process. Determining one or more of these variables would allow for more precise cost estimates to be prepared.

[2] Presumes that East Side dredging occurs first and that the sampling and testing required for offshore disposal is performed for the entire site at that time.

East Bulkhead Replacement

Conceptual Design	New Bulkhead Sheet Piles	Sheet Pile Length (feet)	Total Installation Cost
Option 1	Cantilevered AZ36-700N	50	$750,000
Option 2	Anchored PZ-22	30	$500,000

Concept Drawings

The following drawings have been prepared to illustrate the various design alternatives and are provided in a separate section:

Landside Design Studies

- Figure 1 - Saquatucket Harbor Proposed Vehicle Circulation Patterns
- Figure 2 - Saquatucket Harbor Landside Approach – Option 1 Plan
- Figure 3 - Saquatucket Harbor Landside Approach – Option 1 Rendering

- Figure 4 - Saquatucket Harbor Landside Approach – Option 1 Rendering - Modified
- Figure 5 - Saquatucket Harbor Landside Approach – Option 2 Plan
- Figure 6 - Saquatucket Harbor Landside Approach – Option 2 Rendering
- Figure 7 - Saquatucket Harbor Landside Approach – Option 2 Rendering - Modified
- Figure 8 - Saquatucket Harbor Landside Approach – Option 3 Plan
- Figure 9 - Saquatucket Harbor Landside Approach – Option 3 Rendering
- Figure 10 - Saquatucket Harbor Landside Approach – Option 3 Rendering - Modified
- Figure 11 - Saquatucket Harbor Landside Bulkhead – Section A
- Figure 12 - Saquatucket Harbor Landside Bulkhead – Section B
- Figure 13 - Saquatucket Harbor Landside Bulkhead – Section C
- Figure 14 - Saquatucket Harbor Landside Bulkhead – Section D

Watersheet Reconfiguration

- Drawing 1 - Saquatucket Harbor Marina Plan – Concept #1
- Drawing 2 - Saquatucket Harbor Marina Plan – Concept #2
- Drawing 3 - Saquatucket Harbor Marina Plan – Concept #3
- Drawing 4 - Saquatucket Harbor Marina Plan – Conceptual Dredge Plan 1
- Drawing 5 - Saquatucket Harbor Marina Plan – Conceptual Dredge Plan 2
- Drawing 6 - Saquatucket Harbor Proposed Accessible Route Improvements Plan 1
- Drawing 7 - Saquatucket Harbor Proposed Accessible Route Improvements Plan 2
- Drawing 8 - Saquatucket Harbor Proposed Gangway Improvement Plan 1
- Drawing 9 - Saquatucket Harbor Proposed Gangway Improvement Plan 2

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WYCHMERE PIER

Watersheet Reconfiguration – Wychmere Pier

To meet the design requirements identified in the Design Program, our design team developed multiple layout/design alternatives for the Wychmere Pier. The design alternatives were vetted and several viable alternatives were identified. The alternatives were further evaluated and developed to address each design requirement. A discussion of the design requirements, tasks completed, and recommendations are presented in the following paragraphs.

Pile Supported Pier

In general, the layout and use of the pile supported pier structure (pile supported section of the Wychmere Pier) is satisfactory for the existing use. The commercial fleet is the most frequent user of the facility; however, recreational boaters also make use of the pile supported pier. The prime design requirement for this structure is to maintain the structure to support the current use and, if practical, upgrade the structure to support larger (heavier) support vehicles.

The allowable use of a pier is typically expressed in terms of a "Load Rating" (LR). The LR for a structure is established by determining the existing conditions of the structure and determining at what load, either uniform load or wheel load, the structure no longer meets current design requirements. This design/evaluation process was performed and is summarized below in the Preliminary Engineering section.

The results of our review and analysis indicate that the "as is" LR for the pier is 100 psf (uniform load) and H-6, 4.8 kip wheel load (point load) which is serviceable with vehicle weight limits recommended herein. Therefore the design/layout of the pile supported pier does not change from the existing conditions.

As described below in greater detail, the evaluation made assumptions regarding pier construction elements that could not be field-verified by above-water visual inspection. Should the Town commission a detailed conditions survey (above and below water) and non-intrusive exploration to determine the actual pier construction, it is possible the pier rating could be increased to allow a wheel load of 9,600 lbs. Additionally, with some relatively minor structural modifications it is possible that the allowable uniform load could be increased even further.

Berth Arrangement

The layout of the existing berths (permanent and temporary) and vessel tie-up space currently meets the needs of the commercial fleet. In addition, the western end of the pier is used by both recreational boaters and the commercial fleet, and this mutual use is reportedly well-tolerated. The Design Program dictates that both the western end of the pier and the southern face of the pier remain open for temporary tie-up.

The only potential change discussed during our meetings with the Steering Committee was the relocation of the Fire Department vessel Marine 76 from its current berth at the East

Bulkhead in Saquatucket Harbor to Wychmere Pier. After consideration, it is believed that relocation of Marine 76 to Wychmere Pier will better serve the use, allow easy access to the vessel and free up valuable berthing at the East Bulkhead. This alternative is presented on the attached Concept 2 plan. The Commercial Vessel displaced by this relocation can be accommodated without additional displacement in all three Concepts prepared for Saquatucket Harbor.

Pier Electrical Service

We reviewed information from our site visits and discussions with pier users, the utility is no longer functioning. The solution to this design requirement is to install an electrical system specialized to work in the marine environment. The service should be conveyed from the landside feeder to a dockside power pedestal. The dock side services lines should be watertight and meeting applicable regulatory standards for submerged and watertight service lines. The services lines would be installed along the dock rim joist and will be submerged during high tidal levels.

Layout of Dinghy Float

We reviewed the available area for a dinghy float between the Shellfish lab structure and the first pier berth. The available footprint is very limited and water depth is shallow. However, a float layout was developed allow best use of this area. The new layout also includes a ramp to access the floats from the bulkhead. Two different configurations are presented. The float layout in Concept 1 also accommodates the Marine 76 vessel.

Development of New Berth at Southeast Corner of Bulkhead

The design requirements for this facility included development of a new berth for outfitting/offloading/fueling of commercial fishing vessels. This berth would be in addition to that available along the south side of the pier. It would both increase available tie-up space during all tide conditions, and allow support vehicles direct access to vessels outside of the weight restrictions currently imposed on the pier. Based on the site plan developed for this project it is possible to locate this berth at the southeast corner of the solid filled pier.

To create this berth, the inside corner of the bulkhead will require minor dredging and the bulkhead will require replacement from the southern bulkhead limit to the southeast corner of the solid filled pier. Based on previous studies this steel bulkhead is severely deteriorated and will require replacement soon. The new bulkhead would be cantilevered or anchored steel sheet piles.

In addition to addressing these design issues, we recommend the Town also consider replacement of the existing timber bulkhead located along the western and northern perimeter of the solid filled pier. This bulkhead consists of timber sheets that are in relatively poor condition. The timber members will continue to deteriorate eventually requiring replacement. The replacement cost can be minimized if this section of bulkhead is replaced concurrently with the above recommend bulkhead replacement. We further recommend that the timber sheets be replaced with either steel or composite (resin) sheets to provide long term functionality of Wychmere Pier.

The designs/layouts described above are presented in the attached Drawing 6 and Drawing 7. The layouts include berth layout, relocated berth for Marine 76, Dinghy Dock

configuration, installation of a new bulkhead, and dredging in the southeast corner of the solid filled pier to elevation -6.0 feet (MLLW).

Preliminary Engineering – Wychmere Pier

Bulkheads

Three conceptual designs of replacement bulkhead alternatives for Wychmere Pier were completed. The conceptual designs were based on assumed soil and backland usage parameters. These parameters included an assumed soil profile, where conservative engineering properties were applied, and a very general loading scenario consisting of HS20-44 surcharge loading, corresponding to approximately 500 pounds per square foot (psf). We also assumed a 5 ft. thick very weak soil layer directly below the mud line. This assumption significantly impacts the required stiffness of the wall and the installation costs. We recommend that boring be completed along the bulkhead to better model the ground conditions to provide a more accurate design and develop representative costs.

Top of wall and mud line elevations were taken from the Wychmere Harbor Existing Conditions Plan, developed by Vine Associates-A Division of GZA dated November, 2011. Maximum water differentials were assumed to be between Mean High Water (MHW) and Mean Lower Low Water (MLLW). The conceptual design alternatives are described in the following paragraphs.

Option 1 – New South Cantilever Bulkhead (New Berth)

A new cantilevered steel sheet pile bulkhead would be installed along the south side of the wharf. The new bulkhead is approximately 105 feet long and would replace the existing timber bulkhead. It has been designed to accommodate a dredge elevation of -6.0 feet MLLW. Dredging to this elevation would accommodate an additional berth adjacent to the south side of the existing pier.

Option 2 – New North and West Cantilevered Bulkhead

Total replacement of the existing timber bulkhead with cantilevered steel sheet piles along the north and west faces of the solid filled pier. The assumed mud line elevation is -2.0 feet MLLW. The cost estimate for this alternative assumes that the work would be completed concurrently with Option 1 and additionally mobilization costs would not be required.

Option 3 – New Internally Braced Bulkhead (All sides of Solid Filled Pier)

Full replacement of all bulkheads (timber and steel) supporting the solid filled pier. Alternative 3 also includes a system of internal tierods providing cross bracing between bulkheads which results in a decrease in sheet section and length relative to the cantilevered configuration. The anchors would span between the northern, southern, and western sides of the solid filled pier beneath the existing paved parking area.

Pile Supported Pier

Structural analysis calculations for the pile caps were completed to estimate the approximate vertical live load capacity of the as-is condition. To perform the calculations, assumptions regarding the size and quantity of reinforcing steel were made due to the lack of available information regarding the construction of the pier and regarding average concrete loss at the time of the analysis. These assumptions were based upon on observations by Vine and others and the results of core testing performed by others. The results of our analysis are summarized in this section and fully documented in the attached report titled St*ructural Assessment of Wychmere Harbor Town Pier* and dated February 2012.

Our analysis indicates that the current operational procedures limiting pier traffic to "heavy pick-up trucks" should remain in place until additional analysis using confirmed size and quantity of reinforcing steel. We recommend that a "heavy pick-up truck" be more specifically defined as a 2-axle vehicle with a gross weight less than 6 tons (12,000 lbs) and a corresponding maximum wheel load of 4,800 lbs.

The analysis also indicated that increasing operational restrictions to allow truck weight limits of 15 tons for 2-axle trucks (maximum wheel load of 12,000 lbs) and 21 tons for 3-axle trucks (maximum wheel load of 9,600 lbs) appears to be attainable if the presence of adequate shear reinforcing steel in the pile caps can be confirmed.

Recently, the Town was able to obtain as-built drawings which indicate the size and quantity of reinforcing steel utilized during construction. For budgeting purposes, the cost to revise the structural analysis calculations using the as-built information is estimated to be approximately $3,500.

An "as-constructed" analysis was also performed using assumptions regarding conditions at the time of construction. This analysis yielded live load capacities for the pile caps that approximate the typical 250 psf and AASHTO HS 20 truck design live loads for light duty fishing piers. However, the current level of deterioration and assumptions regarding reinforcing steel are such that the pier does not currently meet these minimum design loadings. Considering the approximate age of the pier, the current level of deterioration and other factors, structural improvements to the pier are recommended.

Further studies would be required to evaluate if complete replacement is warranted or if replacement of specific pier elements, such as the pile caps, could be implemented to restore the pier to near-design capacity. Based upon the information currently available, it is estimated that repairs in the range of $50,000 - $100,000 could prove adequate for extending the usable life of the pier. For budgeting purposes, the cost to perform the necessary analysis and design of such repairs is estimated to be approximately $15,000 depending upon the scope of work and coordination with other field investigations.

Cost Estimates – Wychmere Pier

The tables below contain a conceptual estimate of cost for each conceptual design alternative. While we have made every attempt to provide accurate estimates, these cost estimates are based upon recent bid results for similar projects and/or typical product options and do not represent the actual cost of the project. In some cases additional information is required in order to provide cost estimates specific to these sites. As such, the below costs are presented solely for conceptual purposes.

Permitting, design and engineering fees are not included in the cost estimates provided below but can generally be estimated to be between 10% and 20% of the estimated project cost.

The cost estimate we have developed for the Wychmere Layout includes the rehabilitation of the pier, installation of the electrical service, installation of new dinghy docks, dredging at the southeast corner of the bulkhead, installation of new sheeting around the entire perimeter of the solid filled pier, and installation of pedestrian viewing amenities.

Conceptual Design Alternative	Estimated Cost
Upgrade Electrical Service	$8,000
New Dinghy Docks – Concept 1	$47,000
New Dinghy Docks – Concept 2	$32,000
New Bulkhead – Southeast Corner	$260,000
New Bulkhead – West & North Faces	$200,000
New Bulkheads – All Concurrently	$380,000
Dredging[1]	$15,000-$25,000

[1] Dredging costs are highly variable and dependent upon sediment composition, level of contamination, disposal location and requirements imposed during the permitting process. Determining one or more of these variables would allow for more precise cost estimates to be prepared.

These cost estimates are based on our preliminary layout and understanding of the site. The costs for the bulkhead are based on assumed subsurface conditions. The subsurface conditions significantly impact the costs and the actual costs may be larger or smaller than our estimates. A more accurate cost estimate could be developed if one to two test borings were completed at the site.

Concept Drawings

The following drawings have been prepared to illustrate the various design alternatives and are provided in a separate section:

Watersheet Reconfiguration

- Drawing 10 - Wychmere Pier Marina Plan – Concept #1
- Drawing 11 - Wychmere Pier Marina Plan – Concept #2

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OUTER HARBOR

Outer Harbor – Protected Mooring Space

Overview

In response to inquiries from area property holders, the Town requested a discussion of typical improvements to the Outer Harbor that would be required to provide additional protected mooring space.

Existing Conditions

The Outer Harbor is a portion of Nantucket Sound immediately adjacent to the entrances to Wychmere Harbor and Saquatucket Harbor.

Its western limit is defined by an accreted prominence created by the western jetty protecting the entrance to Wychmere Harbor. This jetty extends southward some distance into Nantucket Sound and turns to the east. The eastern limit of the Outer Harbor is defined by the eastern jetty protecting the entrance to Saquatucket Harbor. This partially protected area is approximately 28 acres in size.

Improvements

In order to develop a protected mooring area in this location, it will be necessary to construct over 1,200 feet of new rubble mound breakwater. Due to the exposure of the site, wave fencing or floating wave attenuators are not expected to be viable alternatives.

In addition, it is expected that some degree of shoaling exists in the area and dredging will be required to achieve suitable depths for the mooring area.

Discussion

Our experience indicates that a project of this scope will face significant permitting challenges due to the scale of anticipated impacts to resource areas and that the project cost will be approximately $10,000,000 - $25,000,000.

Field investigations and conceptual planning would be required in order to more accurately assess the projects feasibility and develop cost estimates.

Concept Drawings
Saquatucket Harbor Landside

Typical passenger vehicle/parking loop

Pick-up/drop-off passenger vehicle loop

Vehicles with trailers, trucks and pick-up and drop-off route

Trailer backing pattern

Truck backing pattern

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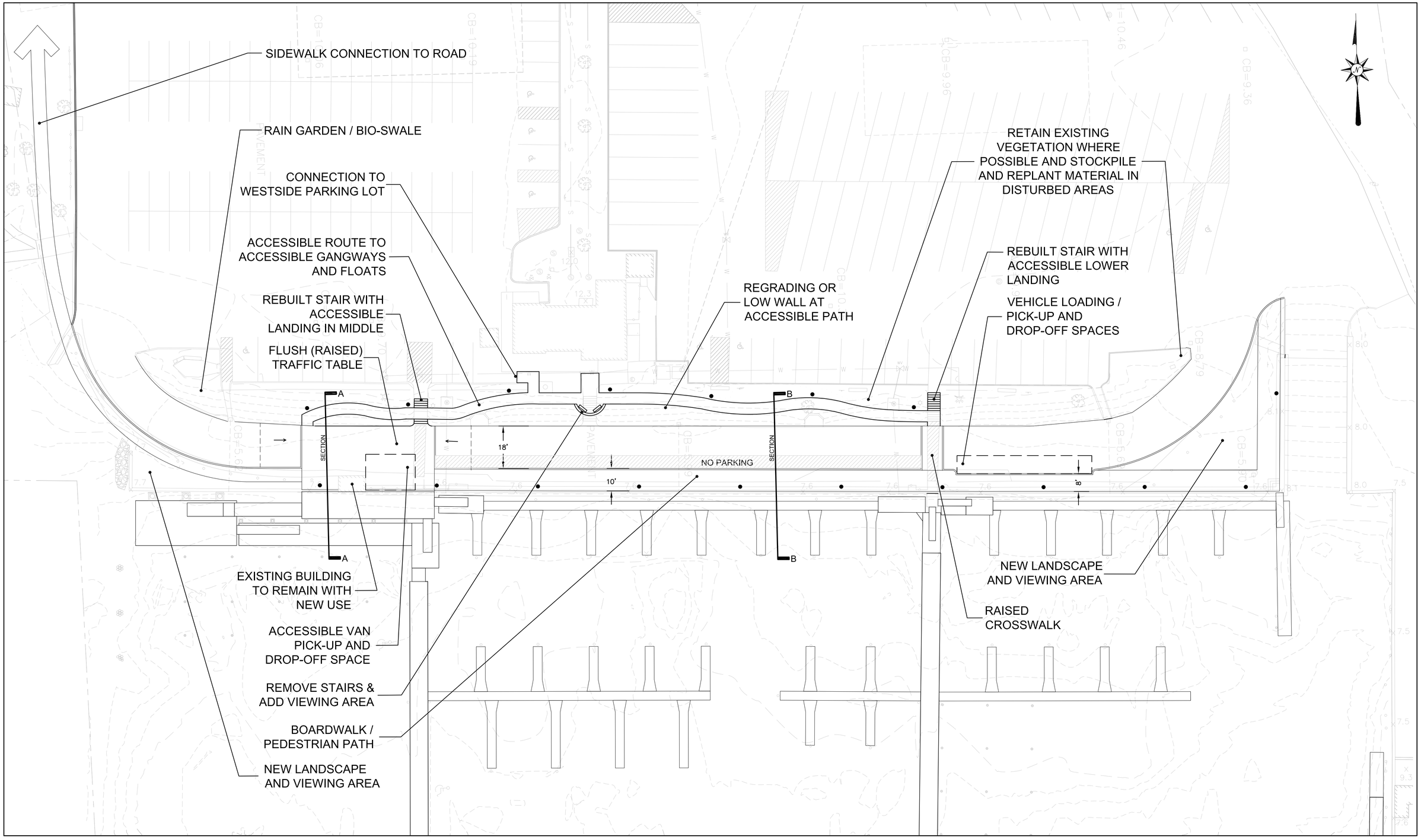
Figure 1

Proposed Vehicle Circulation Patterns
Saquatucket Harbor



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0 20 40 80
SCALE IN FEET

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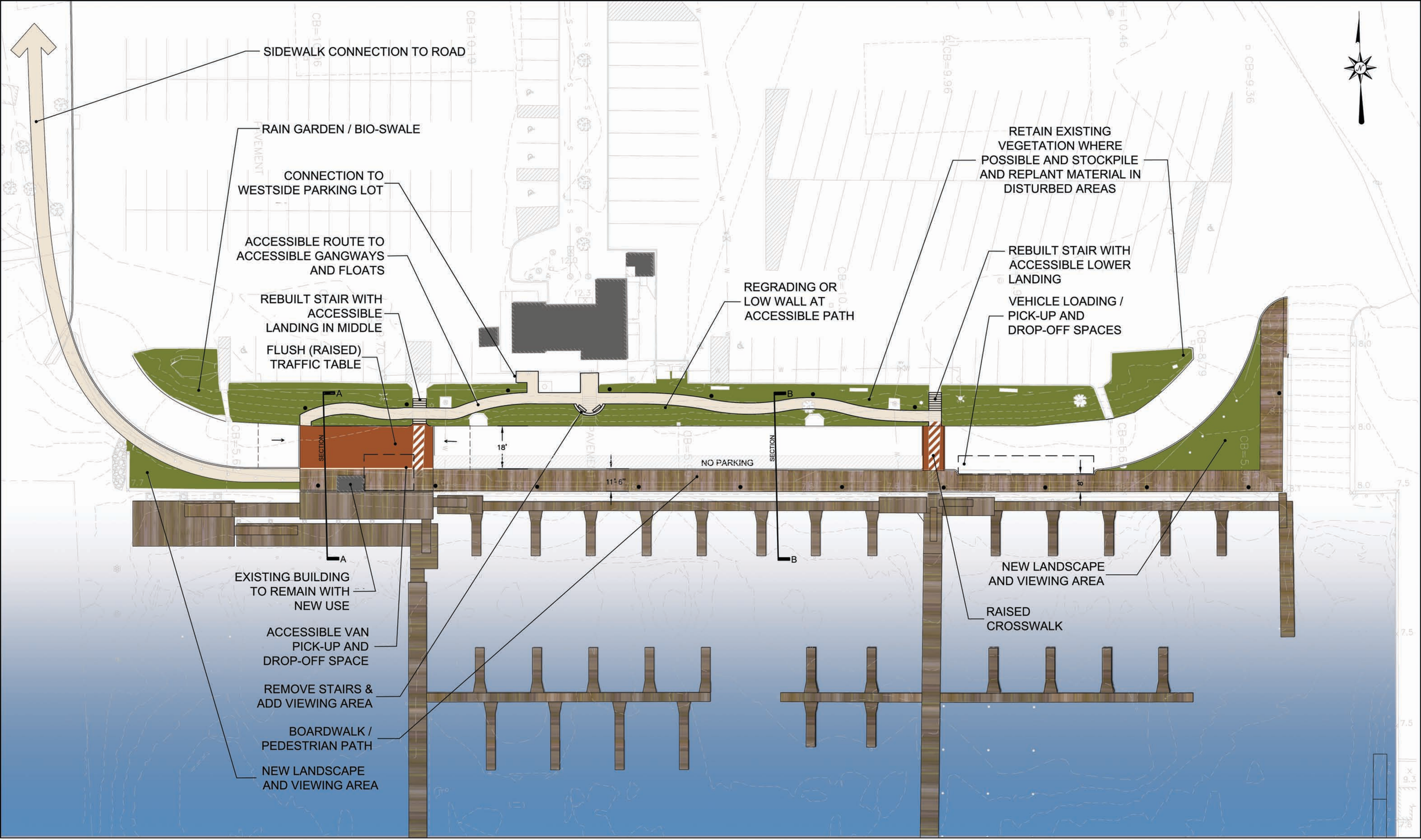
SAQUATUCKET HARBOR
LANDSIDE APPROACH-OPTION 1

Figure 2



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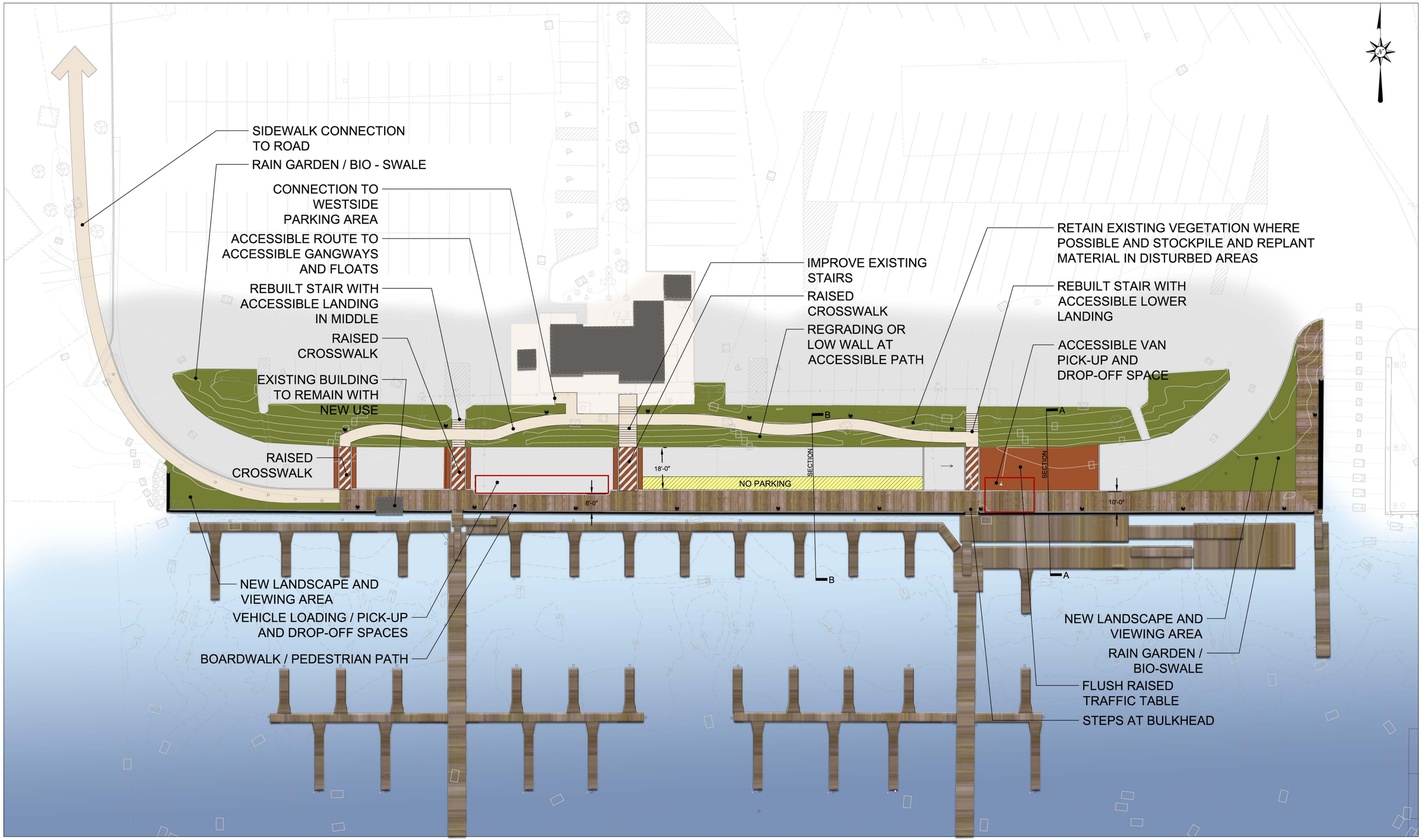
SAQUATUCKET HARBOR
LANDSIDE APPROACH-OPTION 1

Figure 3



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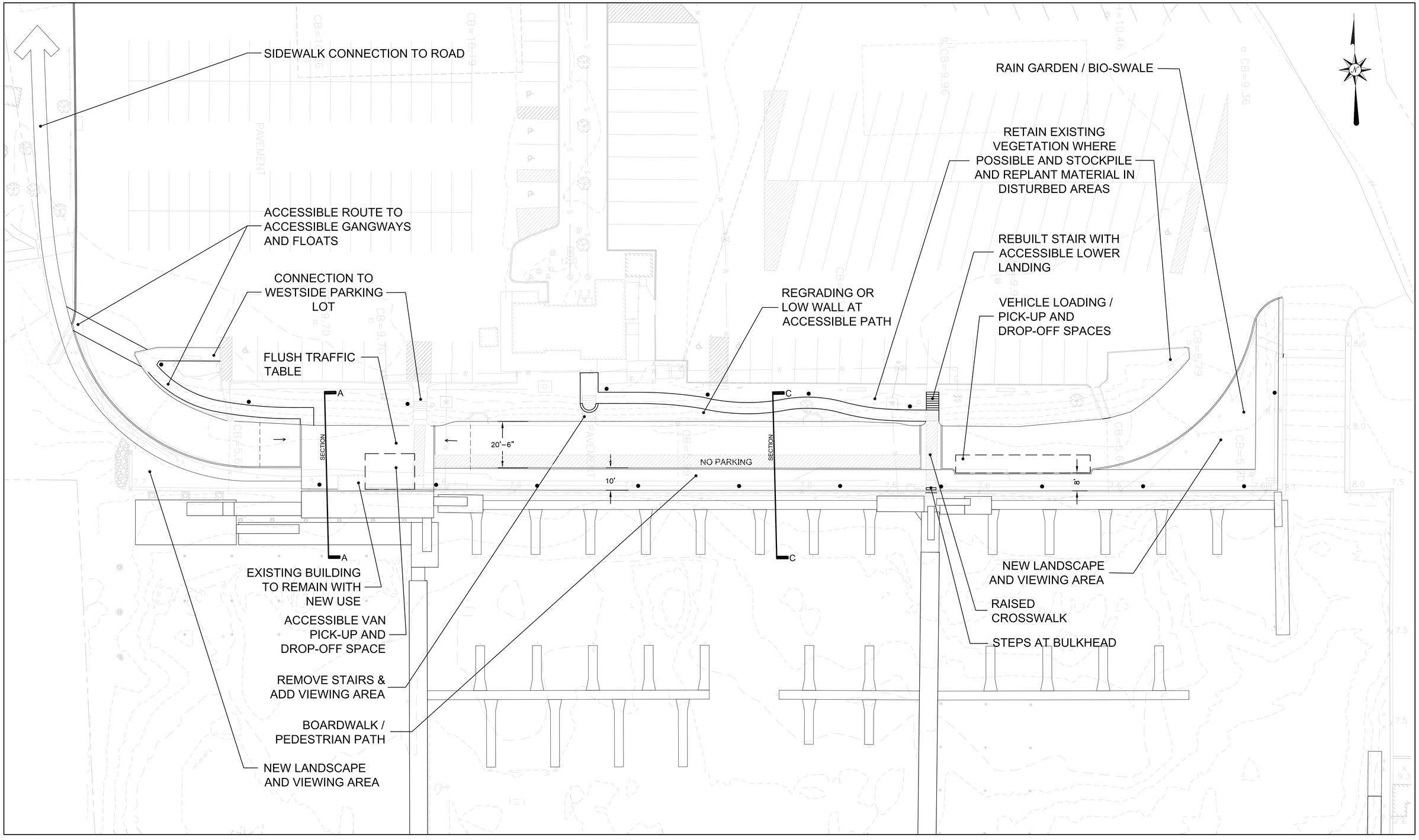
SAQUATUCKET HARBOR
LANDSIDE APPROACH-OPTION 1

Figure 4



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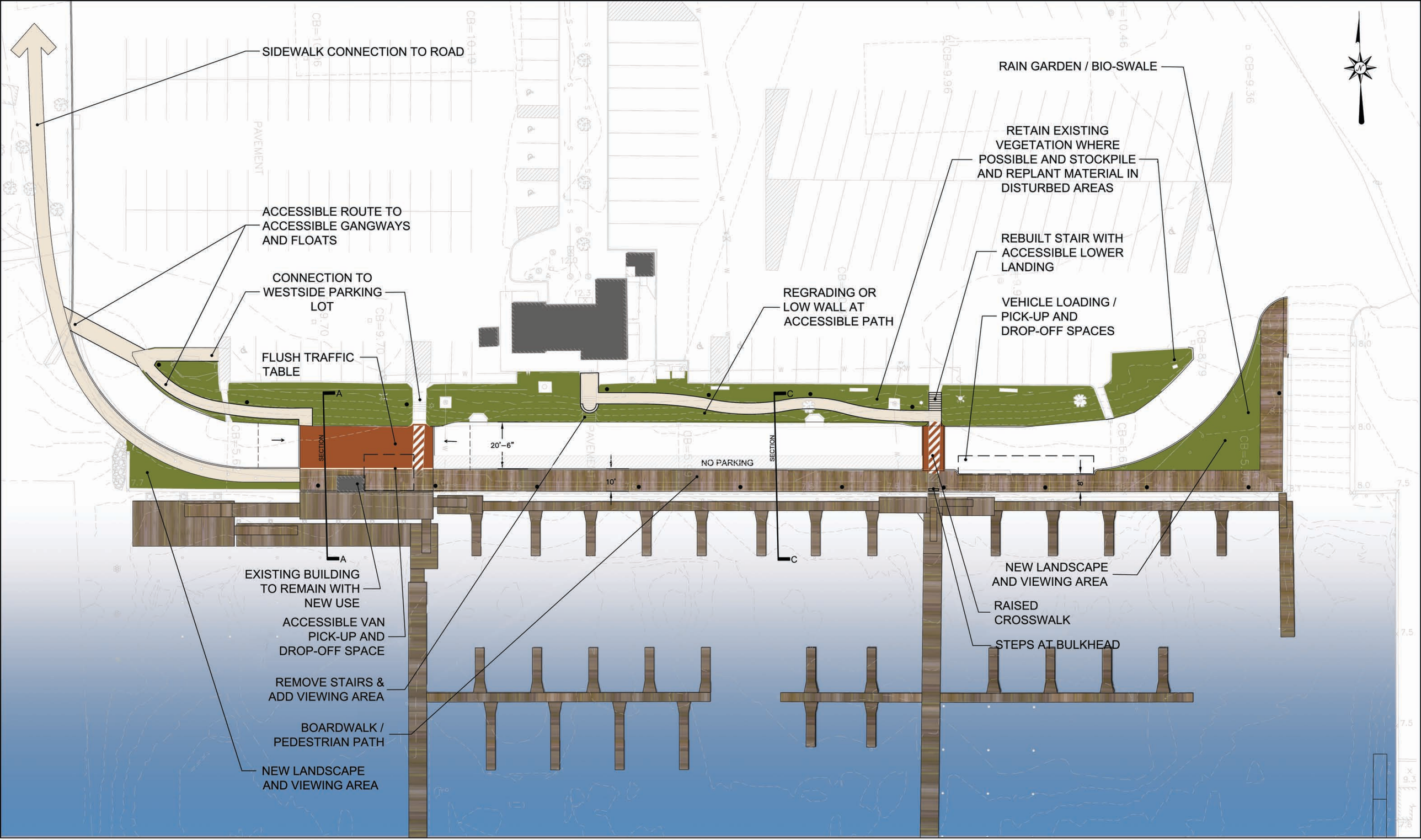
SAQUATUCKET HARBOR
LANDSIDE APPROACH-OPTION 2

Figure 5



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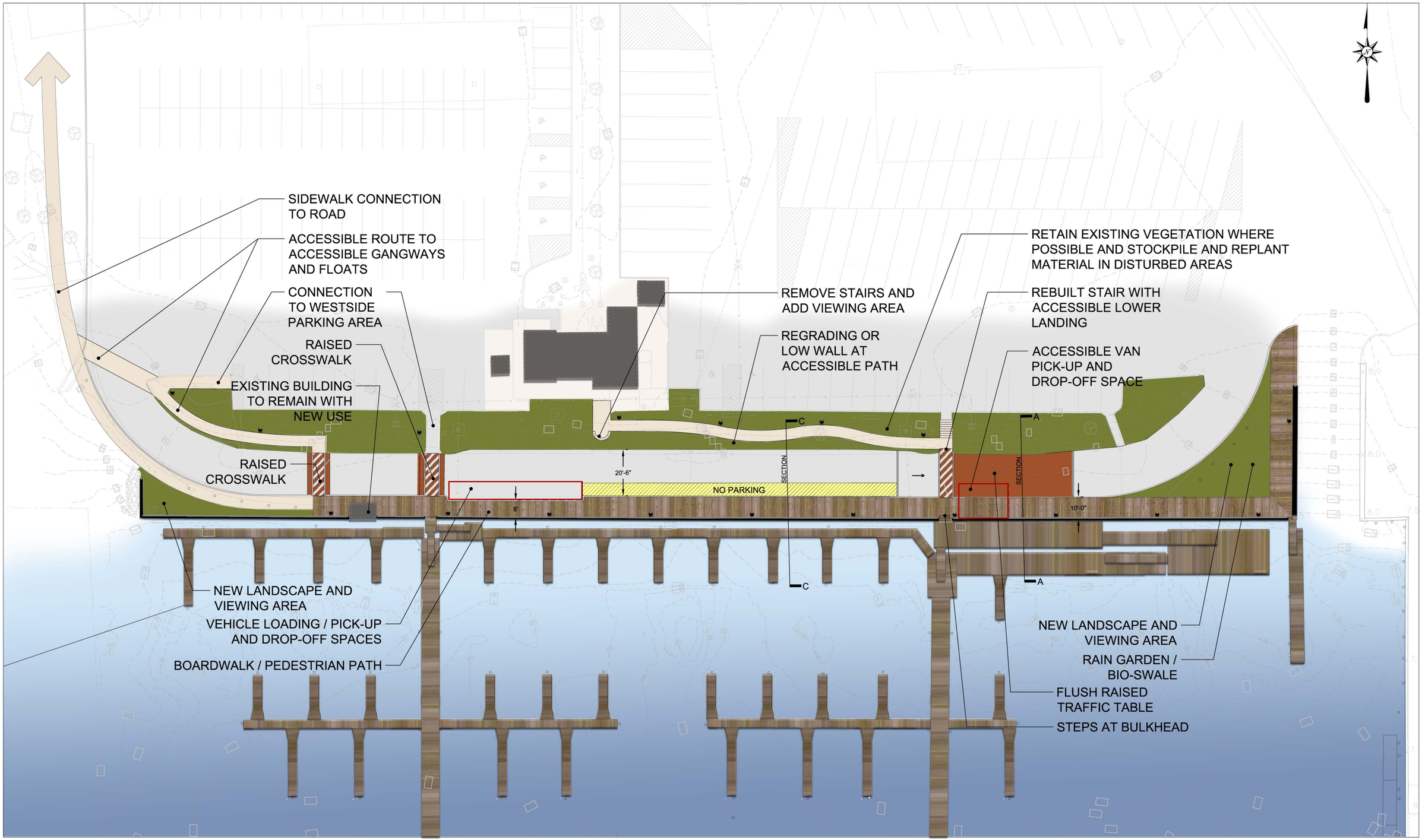
SAQUATUCKET HARBOR
LANDSIDE APPROACH-OPTION 2

Figure 6



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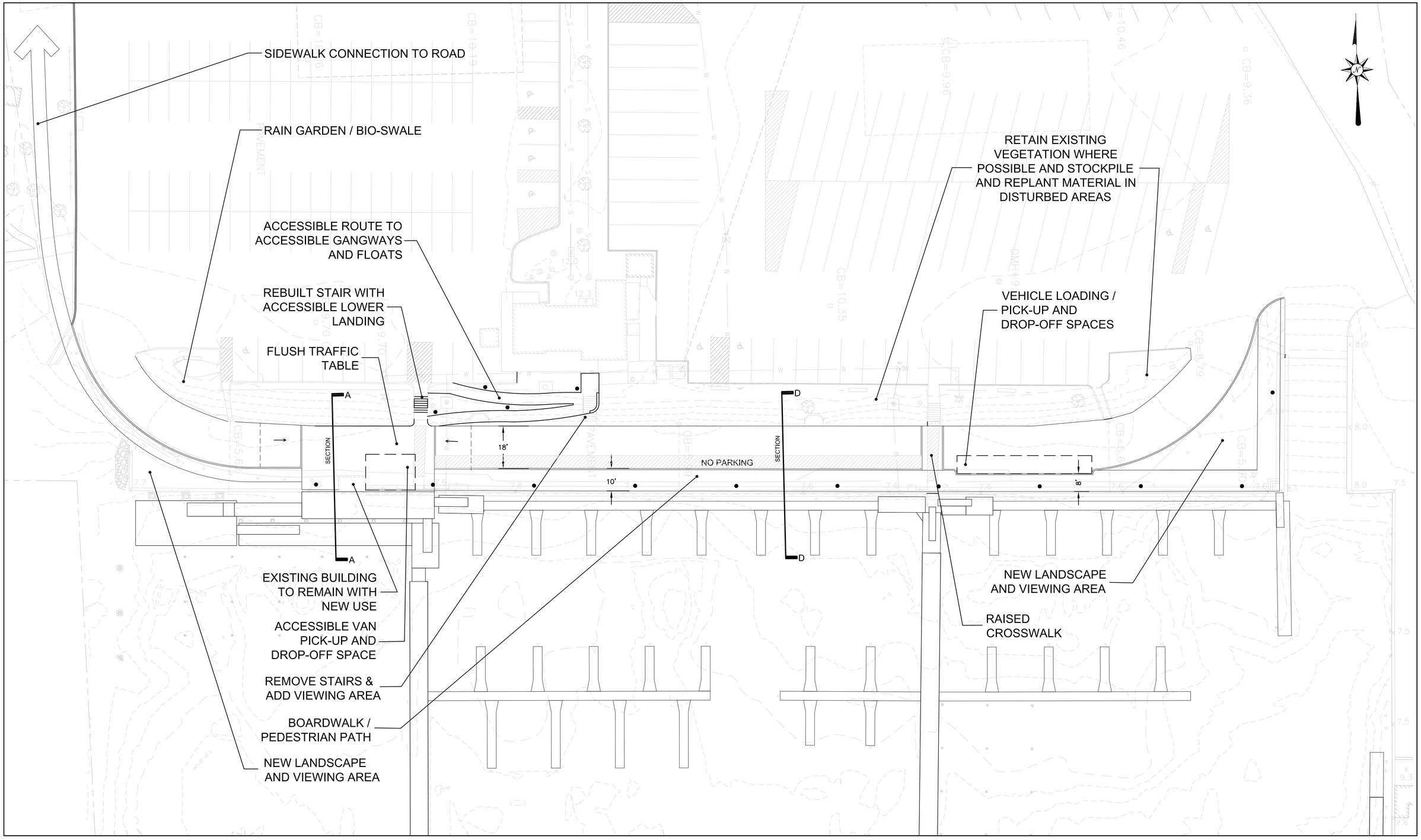
SAQUATUCKET HARBOR
LANDSIDE APPROACH-OPTION 2

Figure 7



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SAQUATUCKET HARBOR
LANDSIDE APPROACH-OPTION 3

Figure 8

SIDEWALK CONNECTION TO ROAD

RAIN GARDEN / BIO-SWALE

ACCESSIBLE ROUTE TO ACCESSIBLE GANGWAYS AND FLOATS

REBUILT STAIR WITH ACCESSIBLE LOWER LANDING

FLUSH TRAFFIC TABLE

RETAIN EXISTING VEGETATION WHERE POSSIBLE AND STOCKPILE AND REPLANT MATERIAL IN DISTURBED AREAS

VEHICLE LOADING / PICK-UP AND DROP-OFF SPACES

A

SECTION

18'

NO PARKING

10'

8'

D

SECTION

A

D

EXISTING BUILDING TO REMAIN WITH NEW USE

ACCESSIBLE VAN PICK-UP AND DROP-OFF SPACE

REMOVE STAIRS & ADD VIEWING AREA

BOARDWALK / PEDESTRIAN PATH

NEW LANDSCAPE AND VIEWING AREA

NEW LANDSCAPE AND VIEWING AREA

RAISED CROSSWALK

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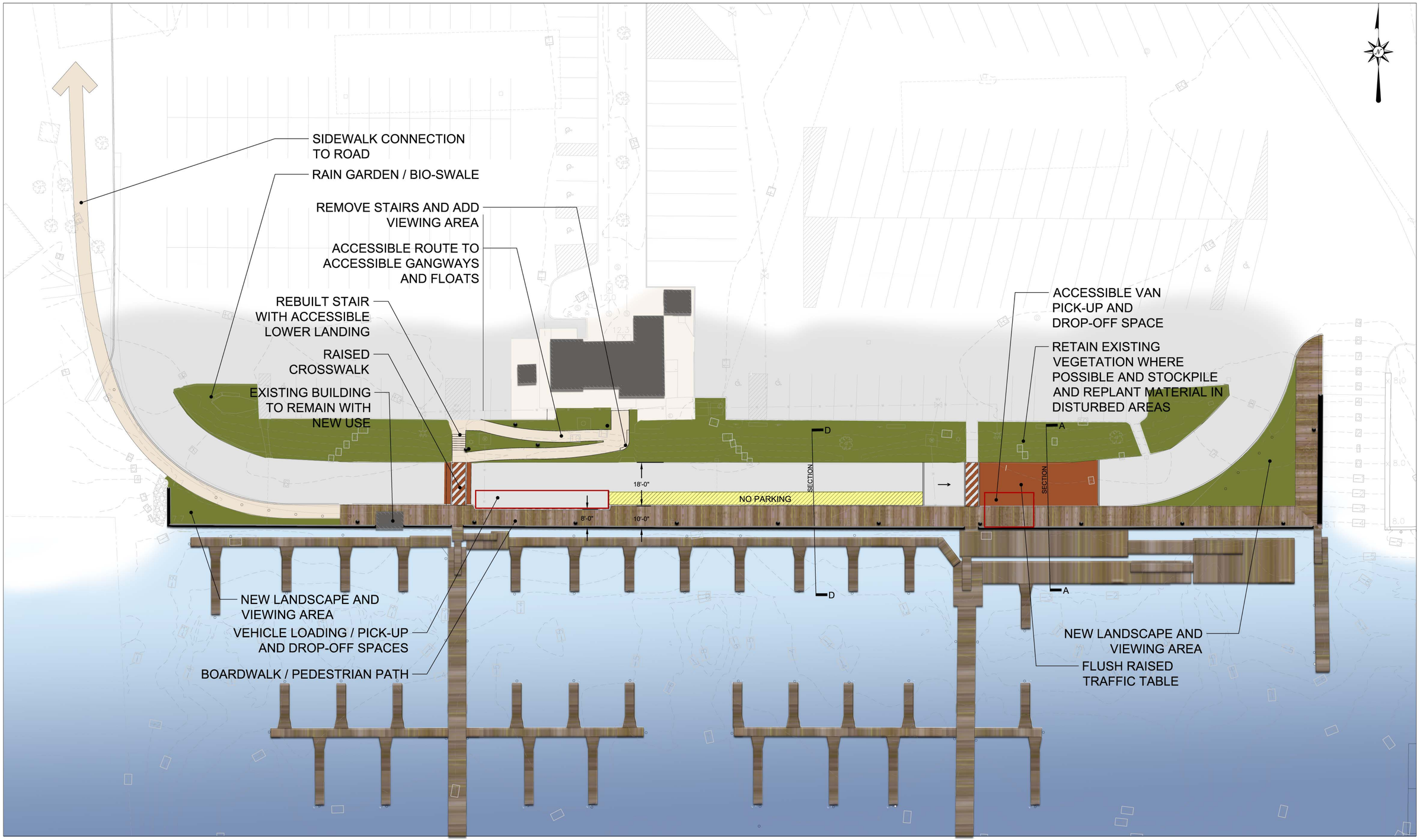
SAQUATUCKET HARBOR
LANDSIDE APPROACH-OPTION 3

Figure 9



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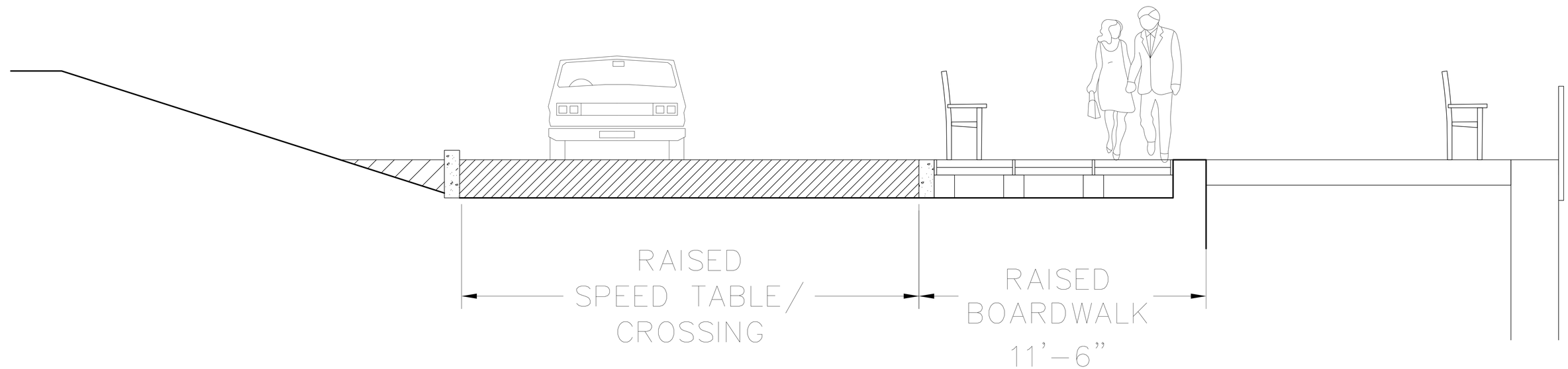
SAQUATUCKET HARBOR
LANDSIDE APPROACH-OPTION 3

Figure 10



RAISED BOARDWALK FLUSH WITH BULKHEAD

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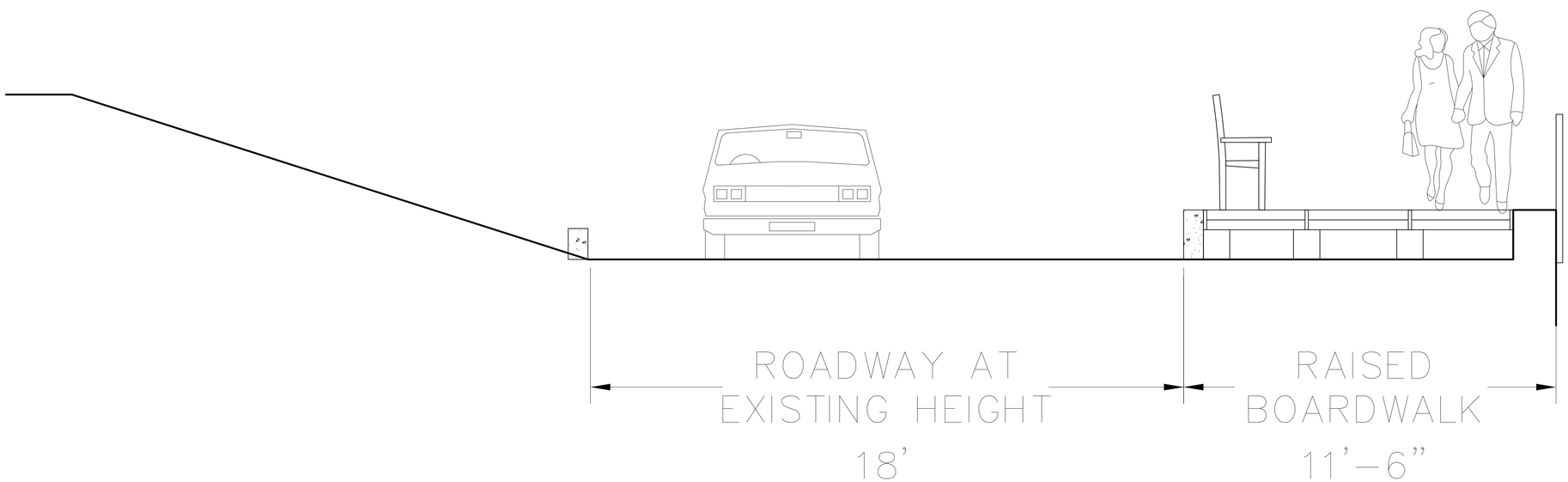
SAQUATUCKET HARBOR
LANDSIDE BULKHEAD SECTION A

Figure 11



RAISED BOARDWALK FLUSH WITH BULKHEAD

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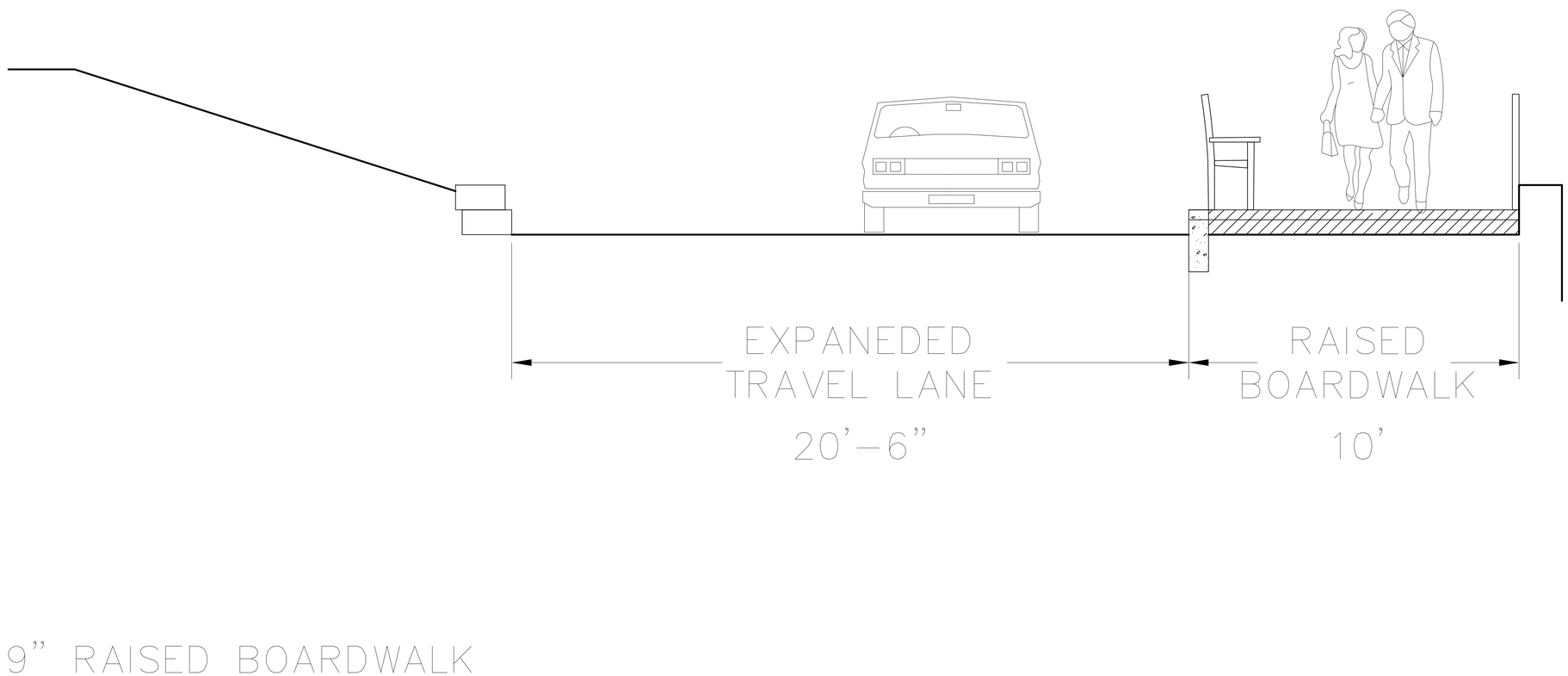
SAQUATUCKET HARBOR
LANDSIDE BULKHEAD SECTION B

Figure 12



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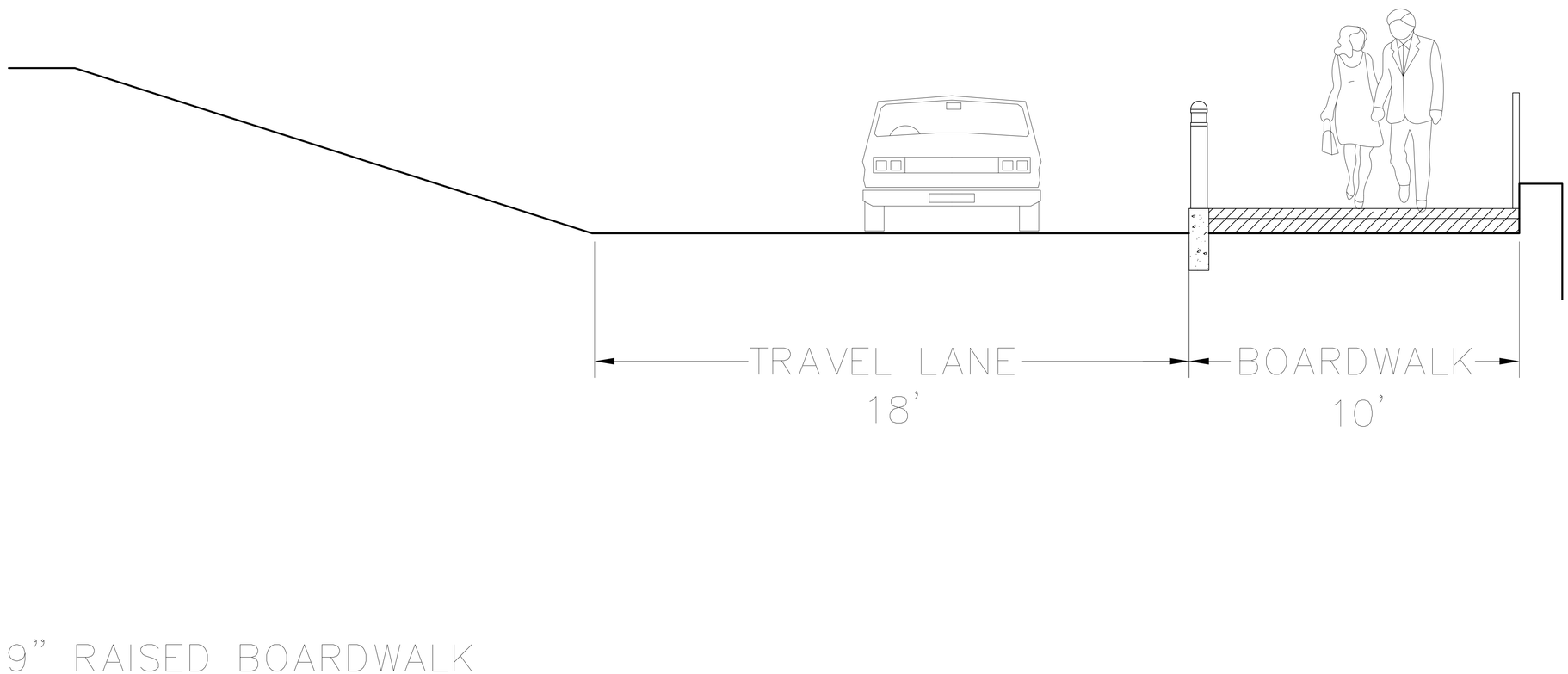
SAQUATUCKET HARBOR
LANDSIDE BULKHEAD SECTION C

Figure 13



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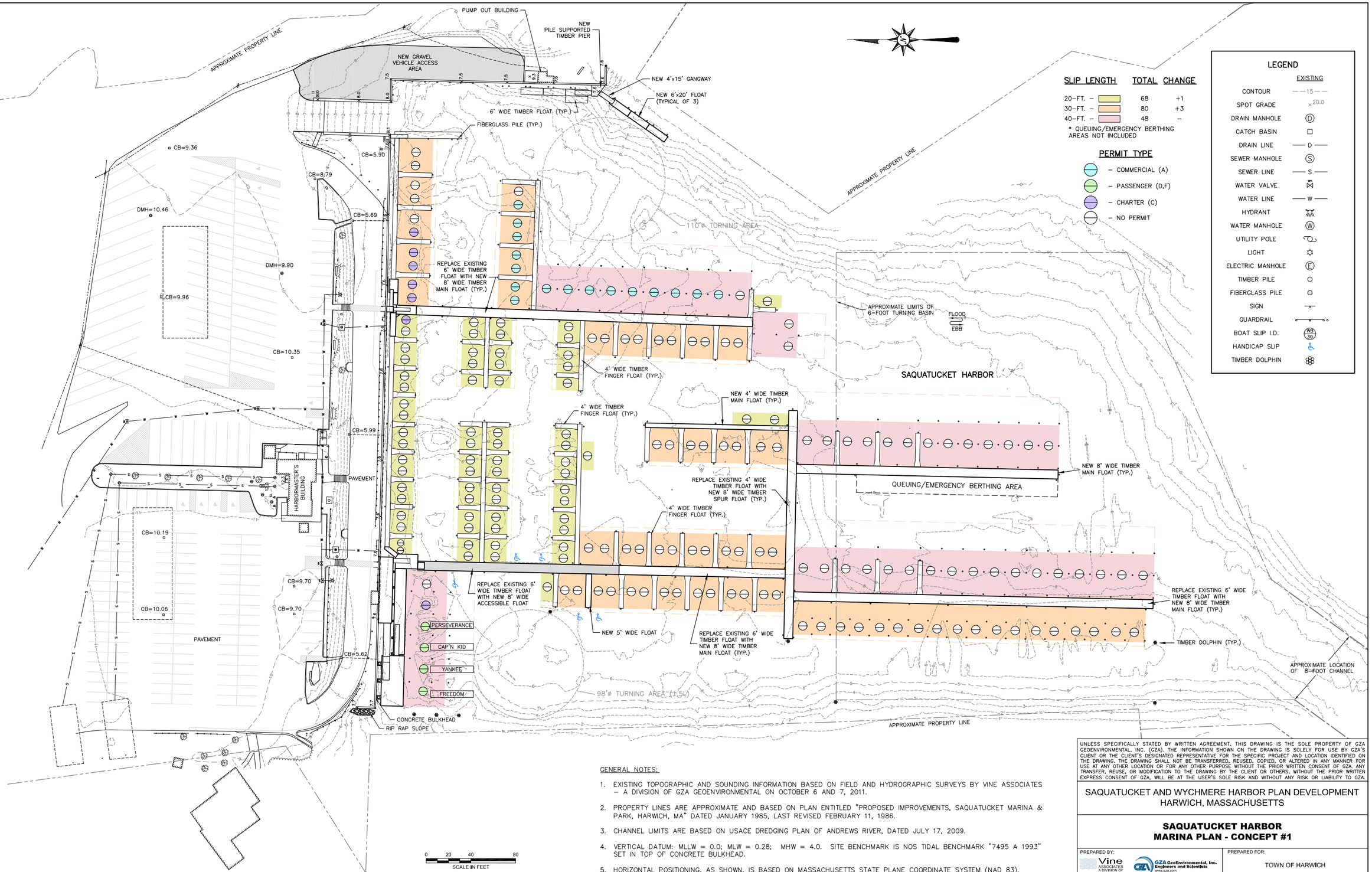
SAQUATUCKET HARBOR
LANDSIDE BULKHEAD SECTION D

Figure 14

Concept Drawings
Saquatucket Harbor Watersheet



SLIP LENGTH / TOTAL / CHANGE

SLIP LENGTH	TOTAL	CHANGE
20-FT. –	68	+1
30-FT. –	80	+3
40-FT. –	48	–

* QUEUING/EMERGENCY BERTHING AREAS NOT INCLUDED

PERMIT TYPE

- COMMERCIAL (A)
- PASSENGER (D,F)
- CHARTER (C)
- NO PERMIT

LEGEND

	EXISTING
CONTOUR	15
SPOT GRADE	20.0
DRAIN MANHOLE	D
CATCH BASIN	
DRAIN LINE	D
SEWER MANHOLE	S
SEWER LINE	S
WATER VALVE	W
WATER LINE	W
HYDRANT	
WATER MANHOLE	W
UTILITY POLE	
LIGHT	
ELECTRIC MANHOLE	E
TIMBER PILE	
FIBERGLASS PILE	
SIGN	
GUARDRAIL	
BOAT SLIP I.D.	WB 30
HANDICAP SLIP	
TIMBER DOLPHIN	

GENERAL NOTES:

1. EXISTING TOPOGRAPHIC AND SOUNDING INFORMATION BASED ON FIELD AND HYDROGRAPHIC SURVEYS BY VINE ASSOCIATES – A DIVISION OF GZA GEOENVIRONMENTAL ON OCTOBER 6 AND 7, 2011.
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3. CHANNEL LIMITS ARE BASED ON USACE DREDGING PLAN OF ANDREWS RIVER, DATED JULY 17, 2009.
4. VERTICAL DATUM: MLLW = 0.0; MLW = 0.28; MHW = 4.0. SITE BENCHMARK IS NOS TIDAL BENCHMARK "7495 A 1993" SET IN TOP OF CONCRETE BULKHEAD.
5. HORIZONTAL POSITIONING, AS SHOWN, IS BASED ON MASSACHUSETTS STATE PLANE COORDINATE SYSTEM (NAD 83).
6. UTILITY INFORMATION SHOWN IS BASED ON BOTH FIELD SURVEY AND THE LATEST PLANS OF RECORD. THE LOCATIONS OF ALL STRUCTURES AND UTILITIES IS APPROXIMATE AND SHALL BE VERIFIED BY CONTRACTOR PRIOR TO CONSTRUCTION. THE ENGINEER SHALL BE NOTIFIED OF ANY DISCREPANCIES WHICH WILL EFFECT SITE DESIGN. NO CHANGES IN THE FIELD SHALL BE MADE WITHOUT PRIOR NOTIFICATION OF THE DESIGN ENGINEER.

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SAQUATUCKET AND WYCHMERE HARBOR PLAN DEVELOPMENT
HARWICH, MASSACHUSETTS

SAQUATUCKET HARBOR
MARINA PLAN - CONCEPT #1

PREPARED BY: Vine ASSOCIATES A DIVISION OF GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com

PREPARED FOR: TOWN OF HARWICH

PROJ MGR: GGR	REVIEWED BY: GGR	CHECKED BY: DBV	DRAWING 1
DESIGNED BY:	DRAWN BY: MAG	SCALE: AS SHOWN	
DATE: DECEMBER 2011	PROJECT NO. 18.0171075	REVISION NO. 2 - APRIL 2012	SHEET NO. 1 OF 11

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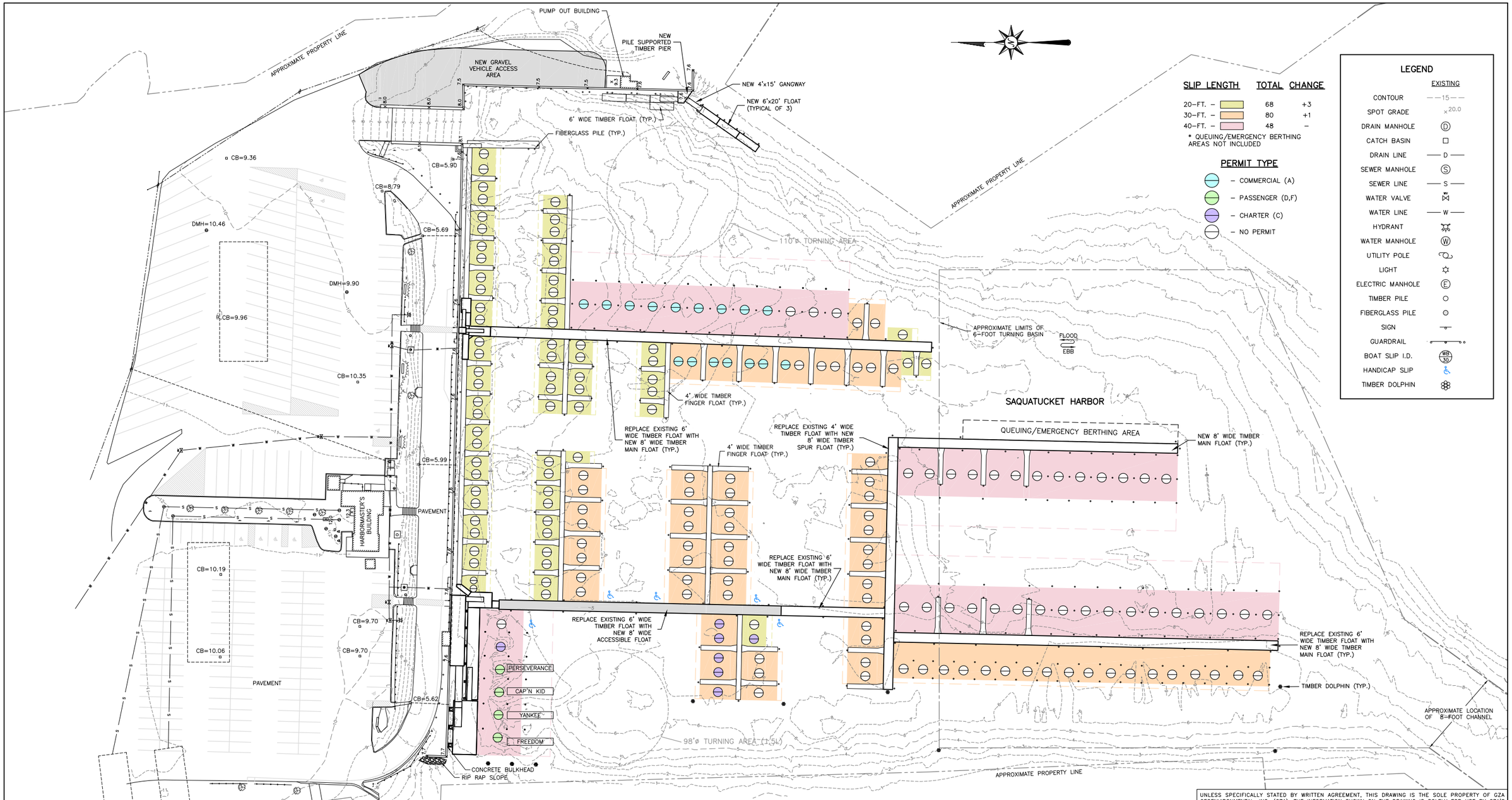

SLIP LENGTH	TOTAL	CHANGE
20-FT. –	68	+3
30-FT. –	80	+1
40-FT. –	48	–

* QUEUING/EMERGENCY BERTHING AREAS NOT INCLUDED

PERMIT TYPE

- COMMERCIAL (A)
- PASSENGER (D,F)
- CHARTER (C)
- NO PERMIT

LEGEND

	EXISTING
CONTOUR	15
SPOT GRADE	×20.0
DRAIN MANHOLE	D
CATCH BASIN	
DRAIN LINE	D
SEWER MANHOLE	S
SEWER LINE	S
WATER VALVE	W
WATER LINE	W
HYDRANT	
WATER MANHOLE	W
UTILITY POLE	
LIGHT	
ELECTRIC MANHOLE	E
TIMBER PILE	
FIBERGLASS PILE	
SIGN	
GUARDRAIL	
BOAT SLIP I.D.	WB 30
HANDICAP SLIP	
TIMBER DOLPHIN	

GENERAL NOTES:

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SAQUATUCKET AND WYCHMERE HARBOR PLAN DEVELOPMENT
HARWICH, MASSACHUSETTS

SAQUATUCKET HARBOR
MARINA PLAN - CONCEPT #2

PREPARED BY: Vine ASSOCIATES A DIVISION OF GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com

PREPARED FOR: TOWN OF HARWICH

PROJ MGR: GGR	REVIEWED BY: GGR	CHECKED BY: DBV	DRAWING 2
DESIGNED BY:	DRAWN BY: MAG	SCALE: AS SHOWN	
DATE: DECEMBER 2011	PROJECT NO. 18.0171075	REVISION NO. 1 - MARCH 2012	SHEET NO. 2 OF 11

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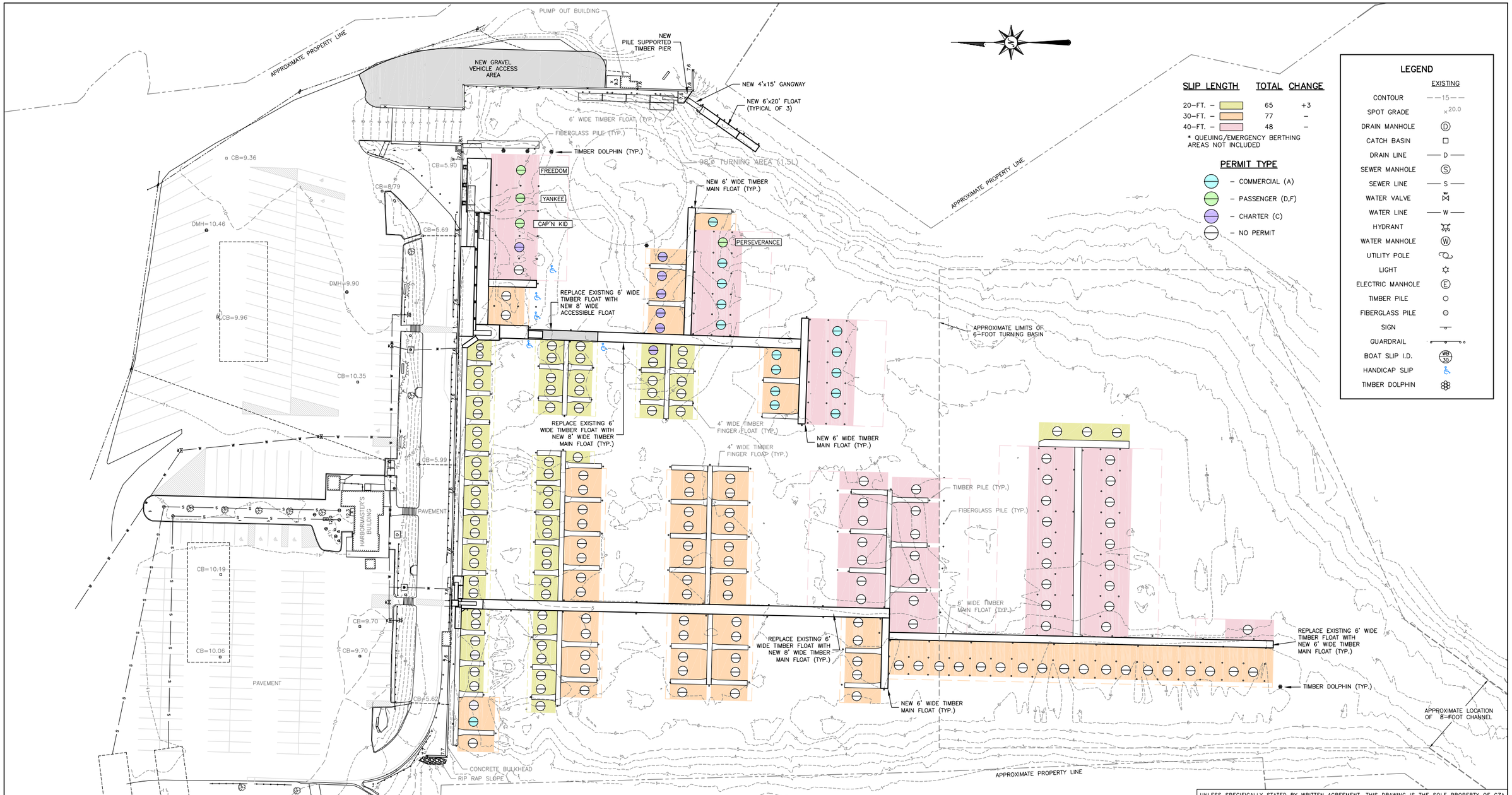

SLIP LENGTH	TOTAL	CHANGE
20-FT. –	65	+3
30-FT. –	77	–
40-FT. –	48	–

* QUEUING/EMERGENCY BERTHING AREAS NOT INCLUDED

PERMIT TYPE

- COMMERCIAL (A)
- PASSENGER (D,F)
- CHARTER (C)
- NO PERMIT

LEGEND

	EXISTING
CONTOUR	15
SPOT GRADE	20.0
DRAIN MANHOLE	D
CATCH BASIN	
DRAIN LINE	D
SEWER MANHOLE	S
SEWER LINE	S
WATER VALVE	W
WATER LINE	W
HYDRANT	
WATER MANHOLE	W
UTILITY POLE	
LIGHT	
ELECTRIC MANHOLE	E
TIMBER PILE	
FIBERGLASS PILE	
SIGN	
GUARDRAIL	
BOAT SLIP I.D.	WB 30
HANDICAP SLIP	
TIMBER DOLPHIN	

GENERAL NOTES:

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SAQUATUCKET AND WYCHMERE HARBOR PLAN DEVELOPMENT
HARWICH, MASSACHUSETTS

SAQUATUCKET HARBOR
MARINA PLAN - CONCEPT #3

PREPARED BY: Vine ASSOCIATES A DIVISION OF GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com

PREPARED FOR: TOWN OF HARWICH

PROJ MGR: GGR	REVIEWED BY: GGR	CHECKED BY: RJM	DRAWING 3
DESIGNED BY:	DRAWN BY: MAG	SCALE: AS SHOWN	
DATE: JANUARY 2013	PROJECT NO. 18.0171075	REVISION NO.	SHEET NO. 3 of 11

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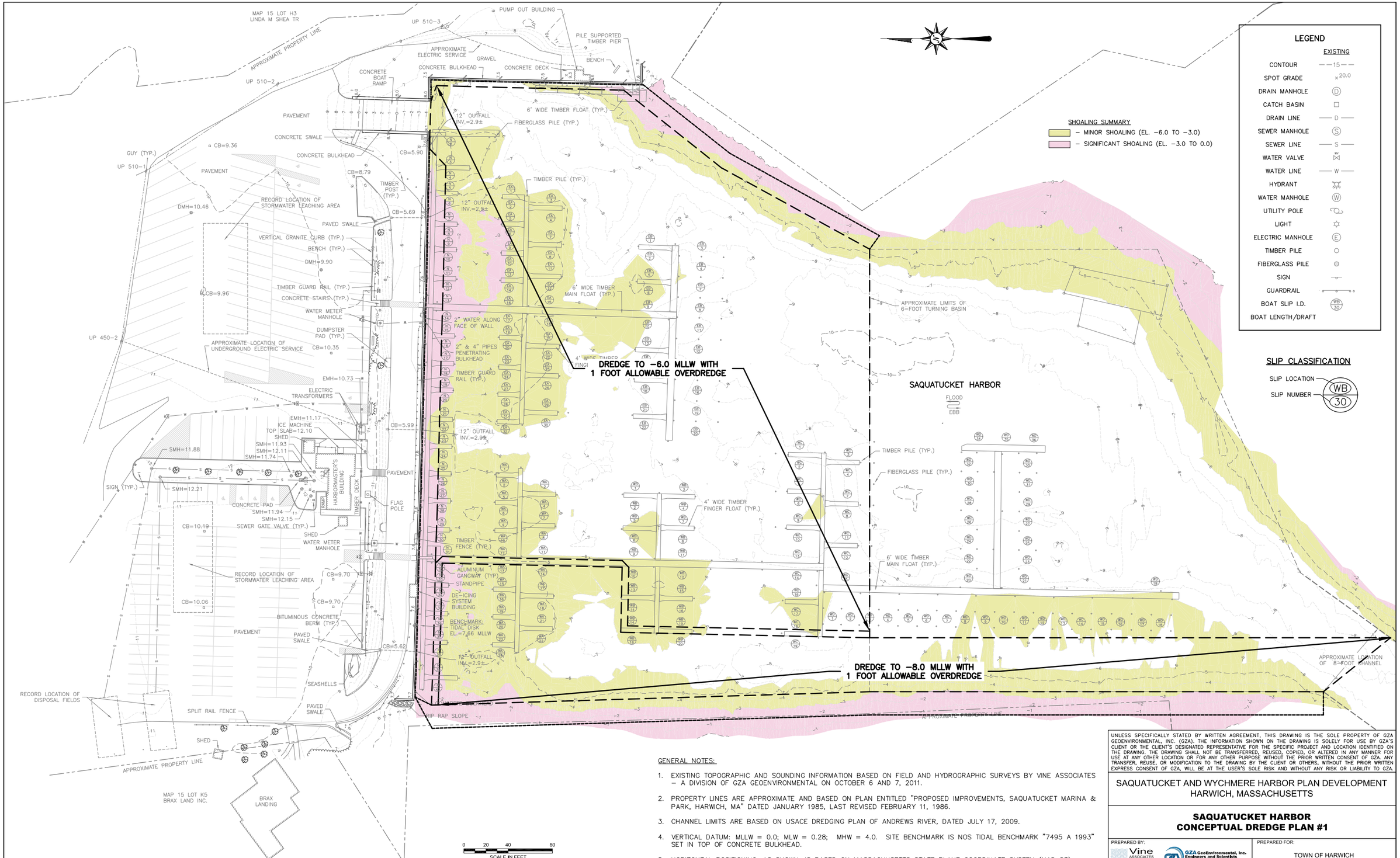

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SAQUATUCKET AND WYCHMERE HARBOR PLAN DEVELOPMENT
HARWICH, MASSACHUSETTS

SAQUATUCKET HARBOR
CONCEPTUAL DREDGE PLAN #1

PREPARED BY: Vine ASSOCIATES A DIVISION OF GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com

PREPARED FOR: TOWN OF HARWICH

PROJ MGR: GGR	REVIEWED BY: GGR	CHECKED BY: DBV	DRAWING 4
DESIGNED BY:	DRAWN BY: MAG	SCALE: AS NOTED	
DATE: MARCH 2012	PROJECT NO. 18.0171075	REVISION NO.	SHEET NO. 4 OF 11

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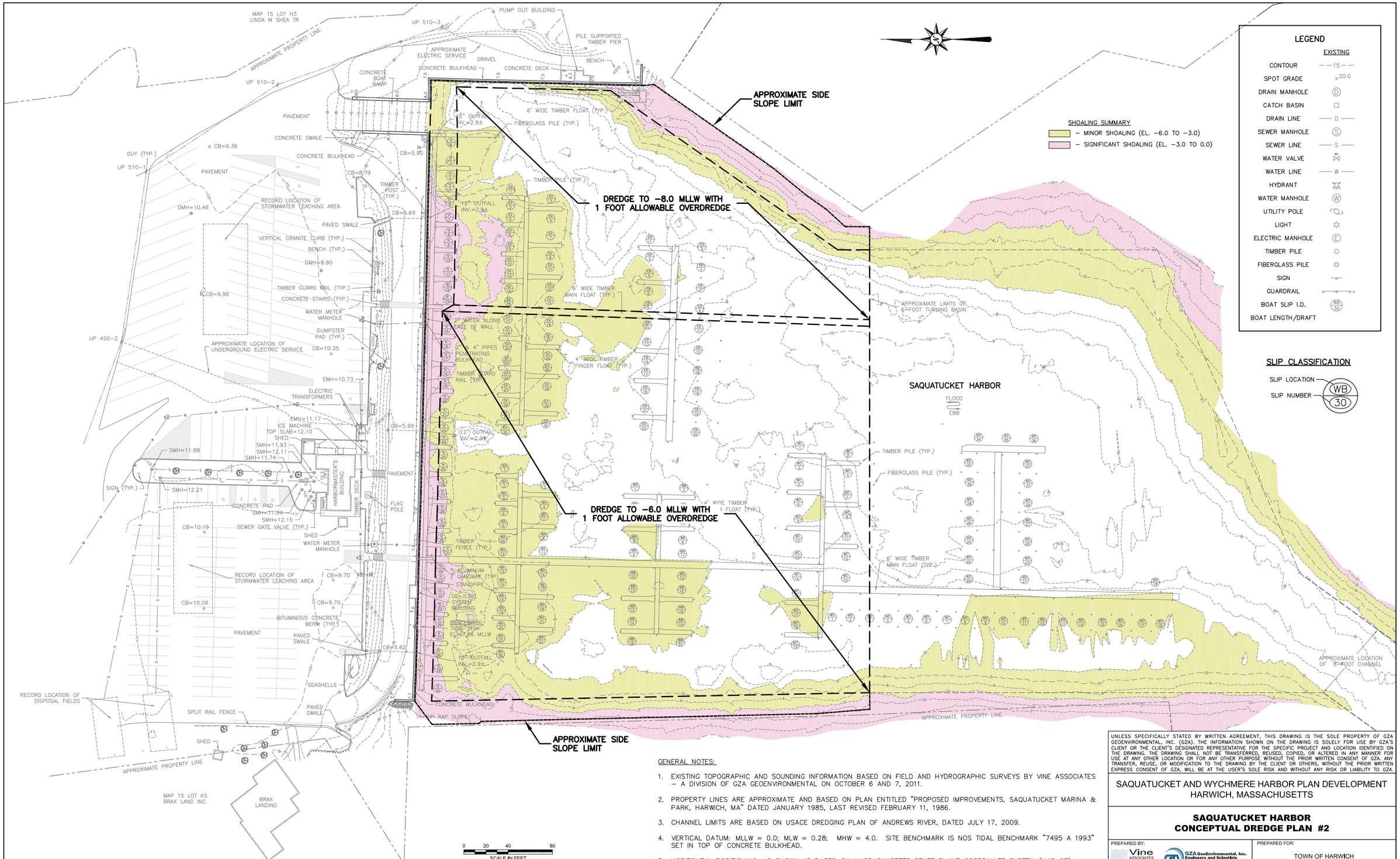

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SAQUATUCKET AND WYCHMERE HARBOR PLAN DEVELOPMENT
HARWICH, MASSACHUSETTS

SAQUATUCKET HARBOR
CONCEPTUAL DREDGE PLAN #2

PREPARED BY: Vine ASSOCIATES A DIVISION OF GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com

PREPARED FOR: TOWN OF HARWICH

PROJ MGR: GGR	REVIEWED BY: GGR	CHECKED BY: RJM	DRAWING 5
DESIGNED BY:	DRAWN BY: MAG	SCALE: AS NOTED	
DATE: JANUARY 2013	PROJECT NO. 18.0171075	REVISION NO.	SHEET NO. 5 OF 11

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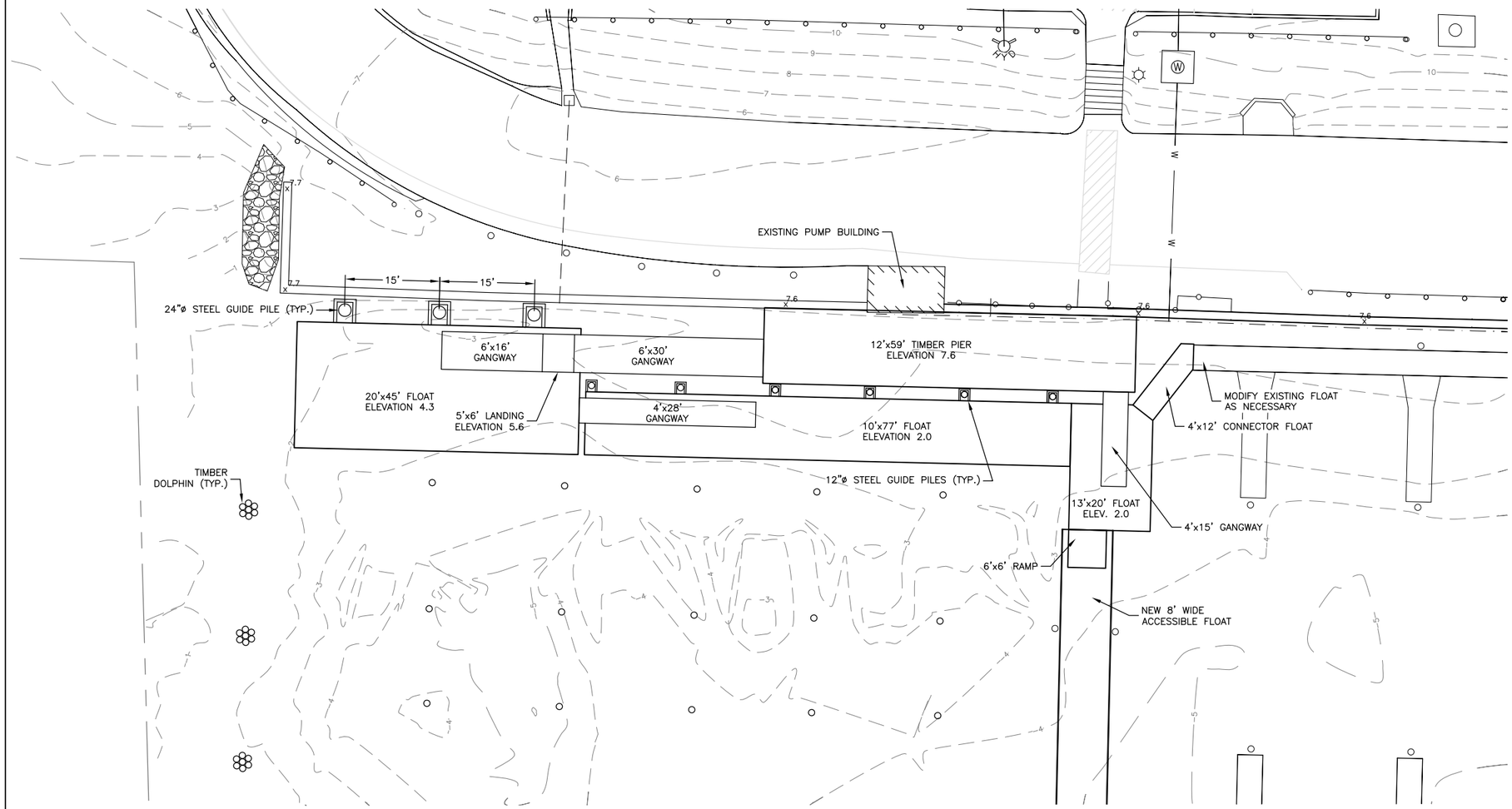

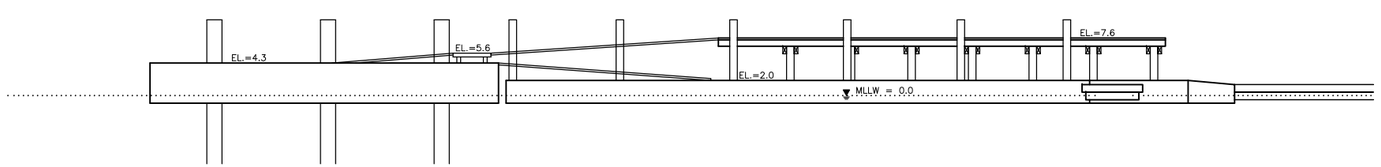

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SCALE IN FEET

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SAQUATUCKET AND WYCHMERE HARBOR PLAN DEVELOPMENT
HARWICH, MASSACHUSETTS

SAQUATUCKET HARBOR
PROPOSED ACCESSIBLE ROUTE IMPROVEMENTS
PLAN AND ELEVATION #1

PREPARED BY: Vine ASSOCIATES A DIVISION OF GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com

PREPARED FOR: TOWN OF HARWICH

PROJ MGR: GGR	REVIEWED BY: GGR	CHECKED BY: DBV	DRAWING 6
DESIGNED BY:	DRAWN BY: MAG	SCALE: AS NOTED	
DATE: MARCH 2012	PROJECT NO. 18.0171075	REVISION NO.	SHEET NO. 6 OF 11

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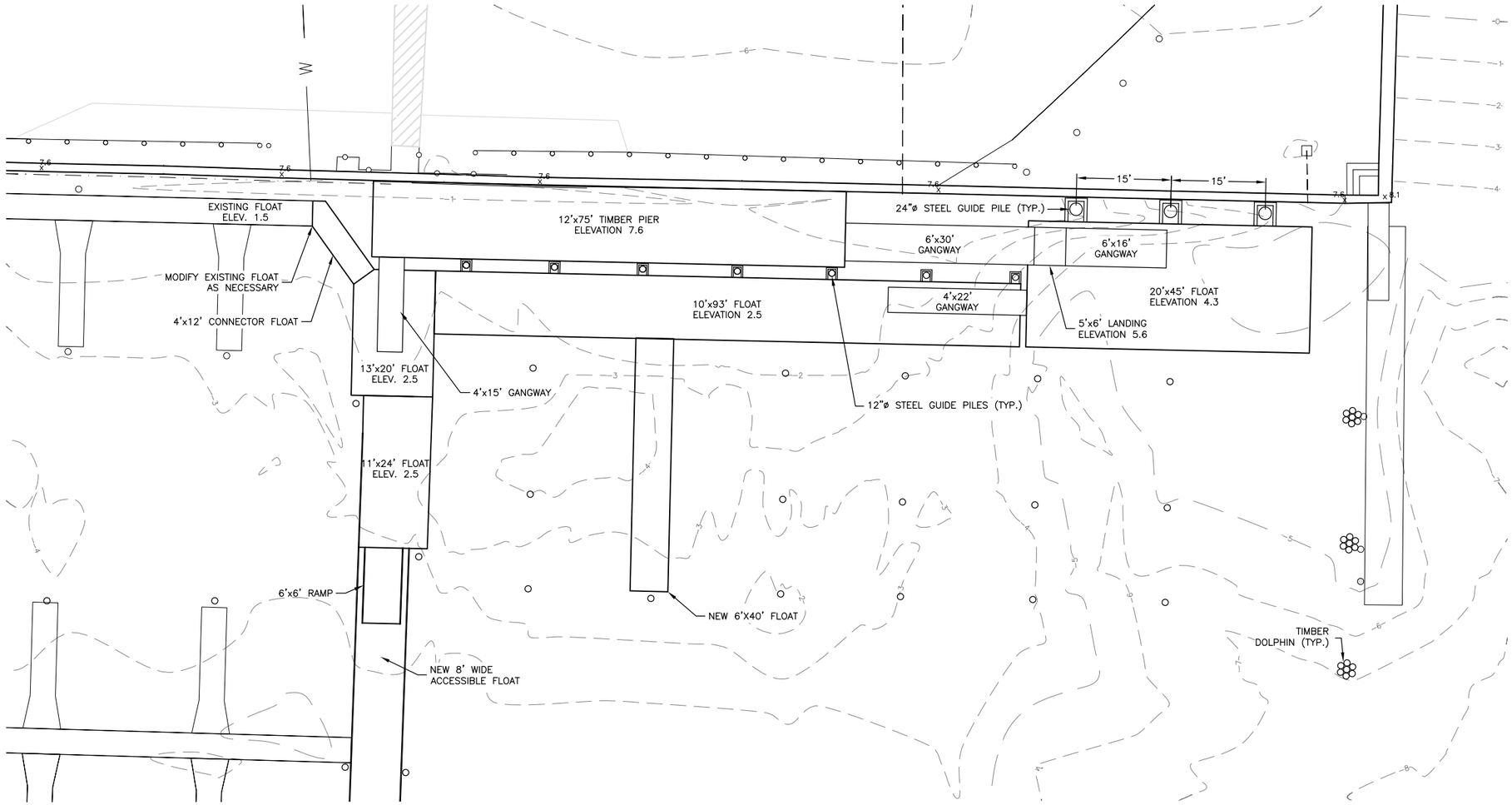

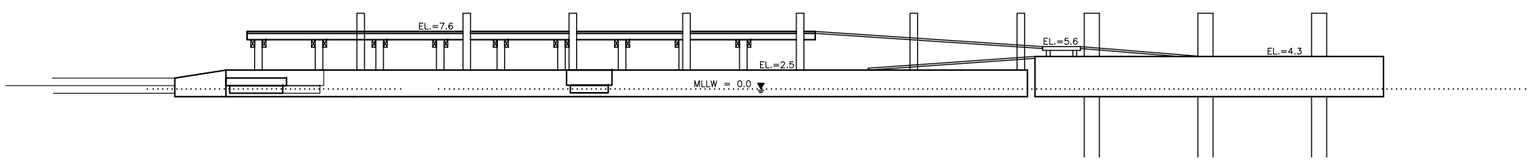

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SCALE IN FEET

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SAQUATUCKET AND WYCHMERE HARBOR PLAN DEVELOPMENT
HARWICH, MASSACHUSETTS

SAQUATUCKET HARBOR
PROPOSED ACCESSIBLE ROUTE IMPROVEMENTS
PLAN AND ELEVATION #2

PREPARED BY: Vine ASSOCIATES A DIVISION OF GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com

PREPARED FOR: TOWN OF HARWICH

PROJ MGR: GGR	REVIEWED BY: GGR	CHECKED BY: RJM	DRAWING 7
DESIGNED BY:	DRAWN BY: MAG	SCALE: AS NOTED	
DATE: JANUARY 2013	PROJECT NO. 18.0171075	REVISION NO.	SHEET NO. 7 OF 11

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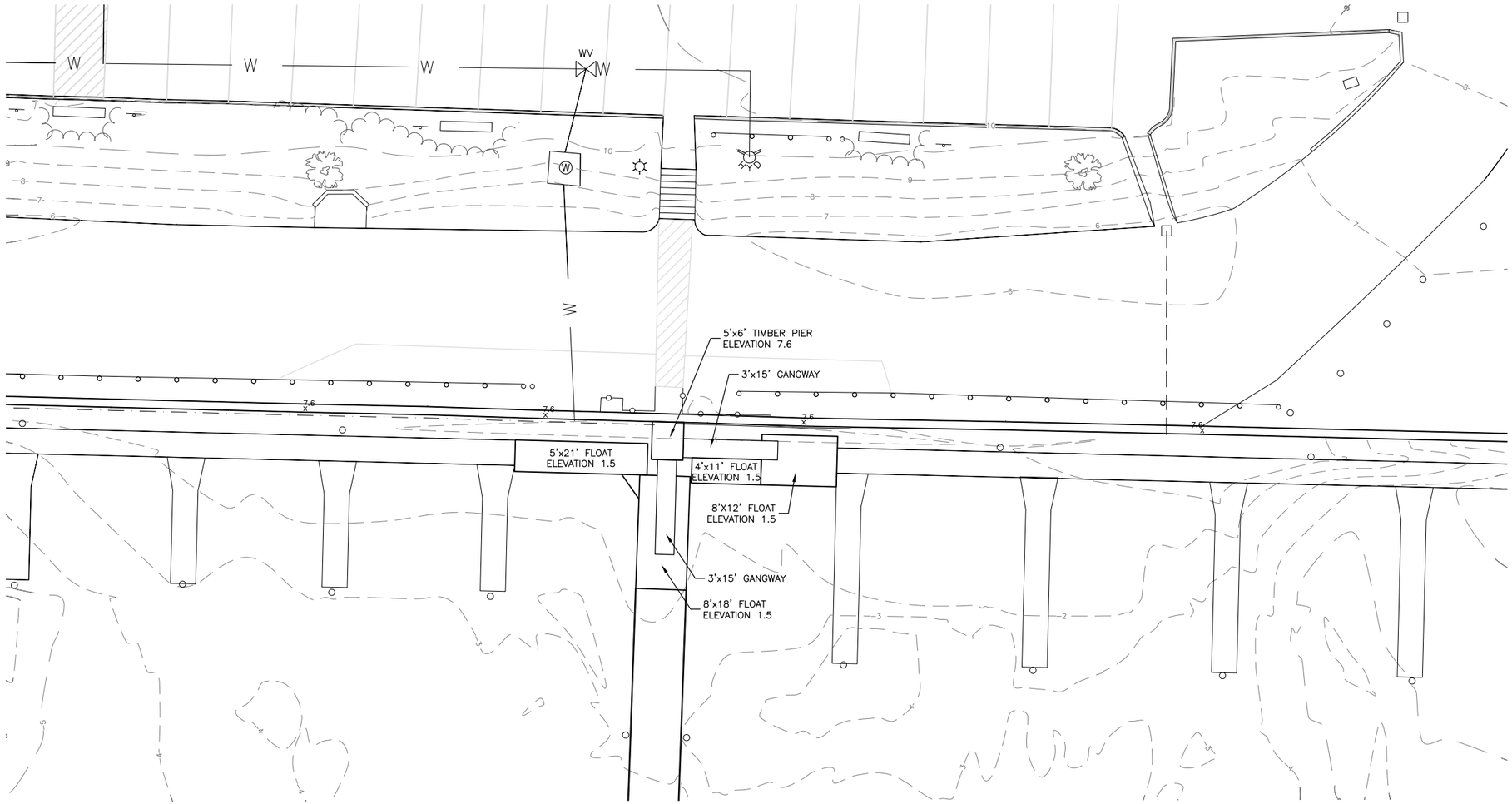

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SAQUATUCKET AND WYCHMERE HARBOR PLAN DEVELOPMENT
HARWICH, MASSACHUSETTS

SAQUATUCKET HARBOR
PROPOSED GANGWAY IMPROVEMENT PLAN #1

PREPARED BY:			PREPARED FOR:	
Vine ASSOCIATES A DIVISION OF GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com			TOWN OF HARWICH	
PROJ MGR: GGR	REVIEWED BY: GGR	CHECKED BY: DBV		DRAWING
DESIGNED BY:	DRAWN BY: MAG	SCALE: AS NOTED		8
DATE: MARCH 2012	PROJECT NO. 18.0171075	REVISION NO.		SHEET NO. 8 OF 11

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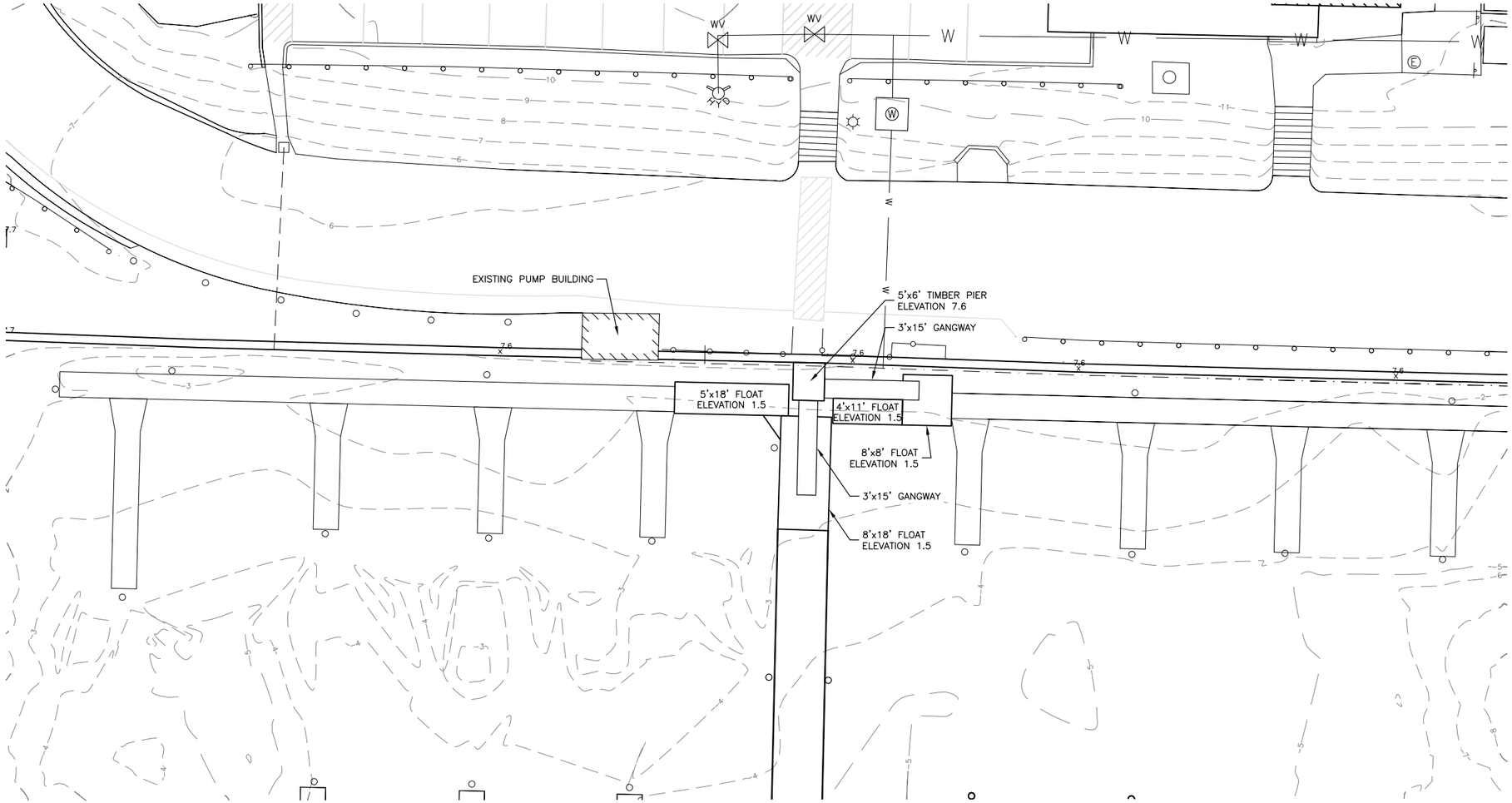

0 5 10 20
SCALE IN FEET

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SAQUATUCKET AND WYCHMERE HARBOR PLAN DEVELOPMENT
HARWICH, MASSACHUSETTS

SAQUATUCKET HARBOR
PROPOSED GANGWAY IMPROVEMENT PLAN #2

PREPARED BY: Vine ASSOCIATES A DIVISION OF GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com

PREPARED FOR: TOWN OF HARWICH

PROJ MGR: GGR	REVIEWED BY: GGR	CHECKED BY: RJM	DRAWING 9
DESIGNED BY:	DRAWN BY: MAG	SCALE: AS NOTED	
DATE: JANUARY 2013	PROJECT NO. 18.0171075	REVISION NO.	SHEET NO. 9 OF 11

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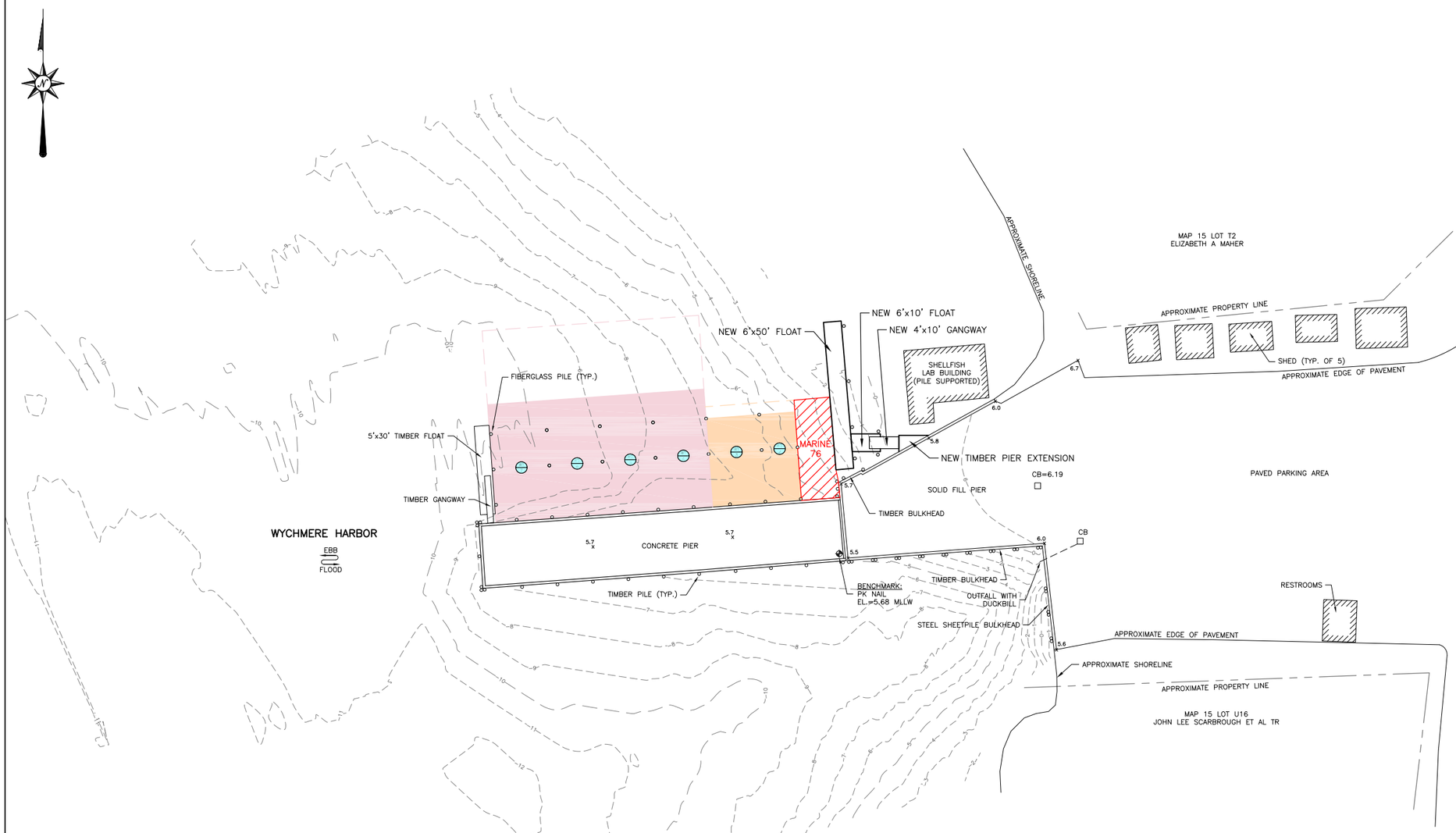
Concept Drawings
Wychmere Pier Watersheet



SLIP LENGTH	TOTAL	CHANGE
20-FT. –	0	–
30-FT. –	3	–1
40-FT. –	4	–

PERMIT TYPE

- COMMERCIAL (A)
- PASSENGER (D,F)
- CHARTER (C)
- NO PERMIT

LEGEND

	EXISTING
CONTOUR	15
SPOT GRADE	20.0
DRAIN MANHOLE	D
CATCH BASIN	
DRAIN LINE	D
SEWER MANHOLE	S
SEWER LINE	S
WATER VALVE	
WATER LINE	W
HYDRANT	
WATER MANHOLE	W
UTILITY POLE	
LIGHT	
ELECTRIC MANHOLE	E
TIMBER PILE	
FIBERGLASS PILE	
SIGN	
GUARDRAIL	
BOAT SLIP I.D.	WB 30
HANDICAP SLIP	
TIMBER DOLPHIN	

GENERAL NOTES:

1. EXISTING TOPOGRAPHIC AND SOUNDING INFORMATION BASED ON FIELD AND HYDROGRAPHIC SURVEYS BY VINE ASSOCIATES – A DIVISION OF GZA GEOENVIRONMENTAL ON OCTOBER 7, 2011.
2. PROPERTY LINES ARE APPROXIMATE AND BASED ON PLAN ENTITLED "WYCHMERE HARBOR DRAINAGE IMPROVEMENTS" PREPARED BY THE TOWN OF HARWICH ENGINEERING DEPARTMENT DATED DECEMBER 2010, LAST REVISED MAY 2011.
3. VERTICAL DATUM: MLLW = 0.0; MLW = 0.28; MHW = 4.0. SITE BENCHMARK IS NGS TIDAL BENCHMARK "M 28 BA", A SURVEY DISK SET IN THE TOP OF A CONCRETE MONUMENT NEAR 621 STATE HIGHWAY 28, ELEVATION = 16.82 MLLW. LOCAL SITE BENCHMARK IS "PK NAIL" SET IN CONCRETE PIER, ELEVATION = 5.68 MLLW.
4. HORIZONTAL POSITIONING, AS SHOWN, IS BASED ON MASSACHUSETTS STATE PLANE COORDINATE SYSTEM (NAD 83).
5. UTILITY INFORMATION SHOWN IS BASED ON BOTH FIELD SURVEY AND THE LATEST PLANS OF RECORD. THE LOCATIONS OF ALL STRUCTURES AND UTILITIES IS APPROXIMATE AND SHALL BE VERIFIED BY CONTRACTOR PRIOR TO CONSTRUCTION. THE ENGINEER SHALL BE NOTIFIED OF ANY DISCREPANCIES WHICH WILL EFFECT SITE DESIGN. NO CHANGES IN THE FIELD SHALL BE MADE WITHOUT PRIOR NOTIFICATION OF THE DESIGN ENGINEER.

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SAQUATUCKET AND WYCHMERE HARBOR PLAN DEVELOPMENT
HARWICH, MASSACHUSETTS

WYCHMERE PIER
MARINA PLAN - CONCEPT #1

PREPARED BY: Vine ASSOCIATES A DIVISION OF GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com

PREPARED FOR: TOWN OF HARWICH

PROJ MGR: GGR	REVIEWED BY: GGR	CHECKED BY: DBV	DRAWING 10
DESIGNED BY: MAG	DRAWN BY: MAG	SCALE: AS SHOWN	
DATE: NOVEMBER 2011	PROJECT NO. 18.0171075	REVISION NO. 2 - MARCH 2012	SHEET NO. 10 of 11

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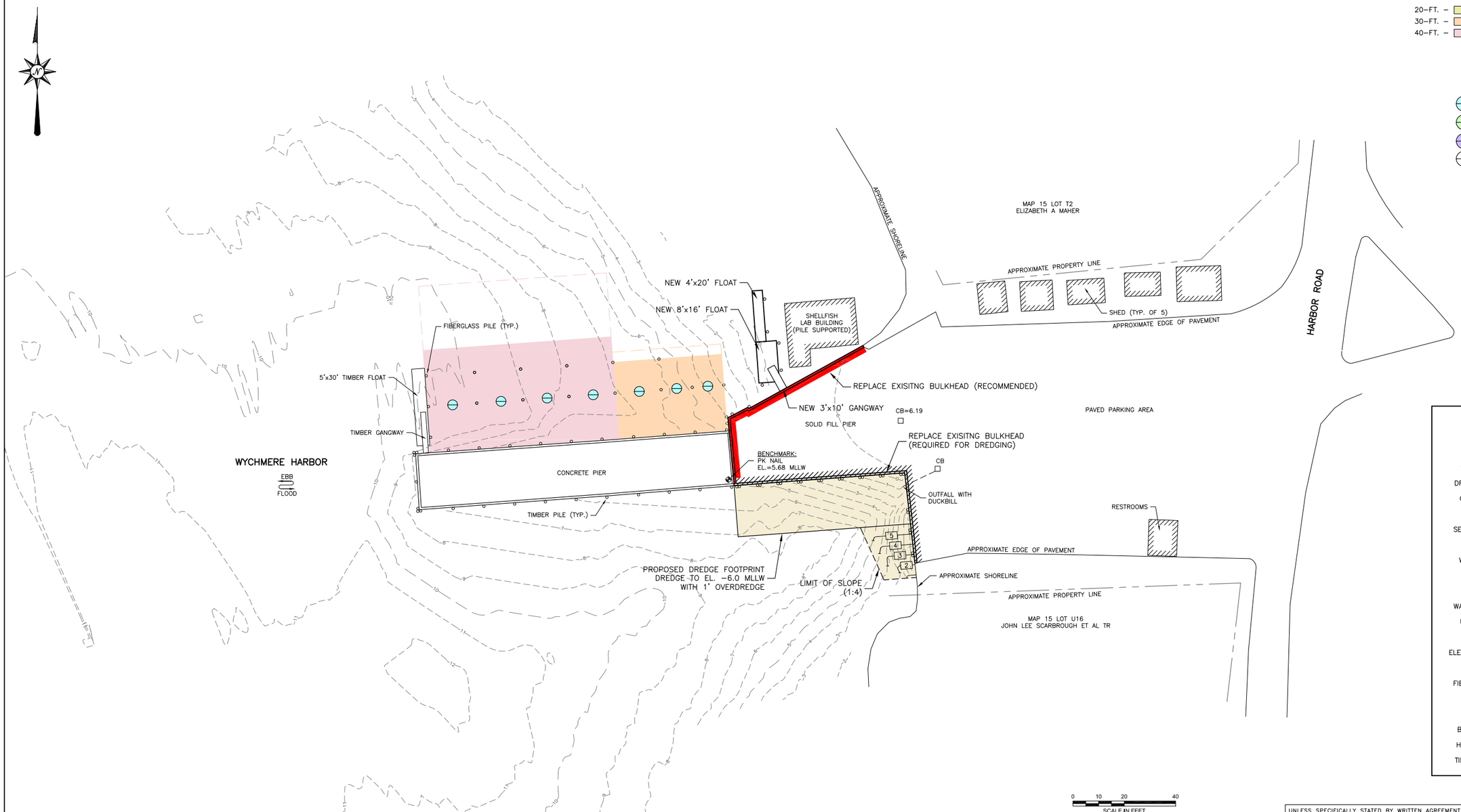
SLIP LENGTH	TOTAL	CHANGE
20–FT. –	0	–
30–FT. –	3	–
40–FT. –	4	–

PERMIT TYPE

- COMMERCIAL (A)
- PASSENGER (D,F)
- CHARTER (C)
- NO PERMIT



LEGEND

	EXISTING
CONTOUR	15
SPOT GRADE	×20.0
DRAIN MANHOLE	D
CATCH BASIN	□
DRAIN LINE	D
SEWER MANHOLE	S
SEWER LINE	S
WATER VALVE	
WATER LINE	W
HYDRANT	
WATER MANHOLE	W
UTILITY POLE	
LIGHT	
ELECTRIC MANHOLE	E
TIMBER PILE	○
FIBERGLASS PILE	○
SIGN	
GUARDRAIL	
BOAT SLIP I.D.	WB 30
HANDICAP SLIP	
TIMBER DOLPHIN	

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SAQUATUCKET AND WYCHMERE HARBOR PLAN DEVELOPMENT
HARWICH, MASSACHUSETTS

WYCHMERE PIER
MARINA PLAN - CONCEPT #2

PREPARED BY: Vine ASSOCIATES A DIVISION OF GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com

PREPARED FOR: TOWN OF HARWICH

PROJ MGR: GGR	REVIEWED BY: GGR	CHECKED BY: DBV	DRAWING 11
DESIGNED BY: MAG	DRAWN BY: MAG	SCALE: AS SHOWN	
DATE: NOVEMBER 2011	PROJECT NO. 18.0171075	REVISION NO. 2 - MARCH 2012	SHEET NO. 11 of 11

Structural Assessment of Wychmere Harbor Town Pier

Structural Assessment of Wychmere Harbor Town Pier

Project Description:

The town of Harwich, MA formed a Saquatucket and Wychmere Harbors Plan Steering Committee to assess improvements to the existing layout and services of the two harbors. Vine-GZA has been retained by the Town to provide engineering services in support of these efforts. As part of these services, calculations were performed to evaluate the existing condition of Wychmere Harbor Town Pier (Wychmere Pier) based on the following:

- *Summary Memorandum of Existing Conditions – Saquatucket and Wychmere Harbors Plan*, Vine Associates, a Division of GZA GeoEnvironmental, Inc., November 18, 2011
- *Field Observations*, Vine Associates, a Division of GZA GeoEnvironmental, Inc., November 18, 2011
- *Town of Harwich Harbors & Marine Facilities Analysis Report*, Coastal Engineering Co., Inc., August 19, 2009

Wychmere Pier Data:

Wychmere Pier is a timber pile-supported concrete structure believed to have been constructed during the 1970s. Other than replacing fender piles in 1996, it is unknown if repairs have been completed since its construction. The existing conditions of the major components are summarized below based on the references noted above.

A. Timber Support Piles:

- ¼" to ½" deep peeling of the outer surface
- Water retention in piles
- Deterioration of bracing near low water

Pile at Bent 2
(VA photo #86)

Typical Center Pile (Bent 4 shown)
(VA photo #112)

Wychmere Town Pier Data Cont'd:

B. Concrete Pile Caps:

- 7 of the 11 pile caps have major spalls and deterioration with exposed, corroded reinforcing steel
- 3 of 11 pile caps have cracks and minor spalls
- 7 of 11 piles caps have a vertical, hairline crack over the center pile
- 5 of the 11 grout pockets at the center piles have up to an 8" deep void on one side of the pile (either due to loss of grout or the pocket was not filled during construction)

Pile Cap 1, West Face
(VA photo #65)

Pile Cap 1, West Face – Exposed Reinforcing Steel
(VA photo #76)

Pile Cap 3, West Face – Void at Grout Pocket
(VA photo #102)

Wychmere Town Pier Data Cont'd:

B. Concrete Pile Caps Cont'd:

Precast Concrete Pile Cap Core Testing
Coastal Engineering Co, Inc. (August 2009)

Characteristic	Core	
	C-2	C-3
Core sample size	3-7/8" dia x 8-3/16" long	3-7/8" dia x 7-3/8" long
Test sample size	8-1/16" x 3-7/8" x 1-5/8"	7-1/4" x 3-7/8" x 1-3/4"
Reinforcing Steel Observation	½" dia 3-3/8" from surface ¾" dia 4-3/16" from surface	½" dia 3-1/2" from surface* ½" dia 4-9/16" from surface ¾" dia 4-9/16" from surface
Chloride-ion Content, 1" to 2" from surface	1645 ppm 6.4 lbs/cy	3140 ppm 12.2 lbs/cy
Chloride-ion Content, 3" to 4" from surface	825 ppm 3.2 lbs/cy	2760 ppm 10.7 lbs/cy
Concrete Quality	Poor	Poor
General Description of Concrete	Many microcracks throughout within outer 1-5/8" thickness, few microcracks throughout at various, deeper depths; Fair paste/aggregate bond; White ettringite observed; No evidence of active ASR observed; Estimated 3" to 5" slump; Estimated 0.43 to 0.48 w/c ratio; Air void system not consistent with current technology for freeze-thaw resistance	Numerous microcracks scattered throughout the paste at various depths; Fair paste/aggregate bond; White ettringite observed; No evidence of active ASR observed; Estimated 3" to 5" slump; Estimated 0.42 to 0.47 w/c ratio; Air void system not consistent with current technology for freeze-thaw resistance

* Only the impression of rebar observed

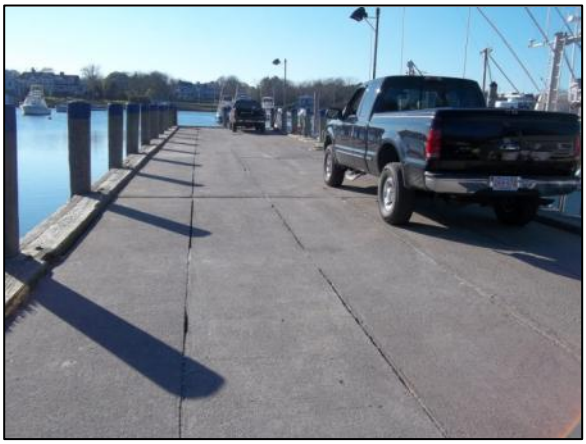
Wychmere Town Pier Data Cont'd:

C. Concrete Deck Planks

- Minor cracks, spalls, and deterioration
- Loss of joint grout and corroded connection pins (rust staining and cracks) between deck plank and pile cap

Precast Concrete Deck Plank Core Testing
Coastal Engineering Co, Inc. (August 2009)

Characteristic	Core	
	C-1	C-4
Core sample size	3-3/4" dia x 4-1/8" long	3-7/8" dia x 8-3/16" long
Test sample size	-	8-3/16" x 3-7/8" x 1-3/4"
Reinforcing Steel Observation	-	½" dia 3-3/8" from surface
Chloride-ion Content, 1" to 2"	370 ppm 1.4 lbs/cy	975 ppm 3.8 lbs/cy
Chloride-ion Content, 3" to 4"	105 ppm 0.4 lbs/cy	215 ppm 0.8 lbs/cy
Concrete Quality	-	Good
General Description of Concrete	-	Many microcracks scattered throughout the paste at various depths and orientations in a shrinkage pattern; Fair paste/aggregate bond; Evidence of active ASR observed Estimated 3" to 5" slump; Estimated 0.43 to 0.48 w/c ratio



Top of Deck Planks
(VA photo #214)

Deck Plank to Pile Cap Connection – Loss of Grout between Plank and Pile Cap (pin exposed)
(VA photo #129)

Calculations

By inspection, the existing condition of the concrete pile caps is expected to dictate the pier's live load capacity. Calculations to estimate the vertical live load capacity of the pile caps in their current condition were completed and are based on the following assumptions:

- Positive moment reinforcing steel (located near the bottom of the pile cap) consists of two #8 bars. One each side of the timber pile, based on limited field observations.
- Negative moment reinforcing steel (located near the top of the pile cap) is unknown. Calculations assume two #8 bars, similar to the positive moment reinforcing steel.
- Shear reinforcing steel is assumed to be #3 stirrups at 6" spacing, based on a photograph of a concrete spall at a pile.
- A 10% loss in cross-sectional area is assumed for corrosion of reinforcing steel.
- Pile cap width is reduced by 3" each side for capacity calculations to account for microcracking in the outer thickness and chloride ion content. The full pile cap width is used for dead load calculations.
- Pile cap depth is reduced by 3" along the bottom for capacity calculations to account for microcracking in the outer thickness, chloride ion content, and an average loss of concrete. The full pile cap depth is used for dead load calculations.
- Pile cap depth is reduced by an additional 8" at the center pile due to grout pocket deterioration. This reduced depth is used for punching shear checks.
- The size and condition of the piles and deck planks are assumed to be adequate for the estimated pile cap live load capacity. No observations of the piles below water were made.

Using the above assumptions, the pile cap allowable live loads, in pounds per square foot (psf), as an AASHTO HS truck (3-axle truck) and as an AASHTO H truck (2-axle truck)are summarized below with **controlling conditions** highlighted in bold face type:

Load Effect	**As-is Condition Uniform Live Load Capacity**	
	Calculated	**Functional**
Moment (live load across full pier width)	409 psf	400 psf
Moment (live load across one-half pier width)	299 psf	250 psf
Shear (concrete only)*	**111 psf**	**100 psf**
Shear (Concrete w/ assumed shear reinforcing steel)	290 psf	250 psf
Punching Shear	328 psf	300 psf

* Although vertical bars were observed at a concrete spall located at a pile, the shear capacity assumes no shear steel is included for an order of magnitude comparison with the other conditions listed.

Calculations Cont'd

Load Effect	**As-is Condition HS Truck Capacity***	
	Calculated	**Representative**
Moment	15.37 ton (P_{wheel} = 12.3 k) †	HS 15 (P_{wheel} = 12.0 k)
Shear (concrete only)‡	**4.73 ton (P_{wheel} = 3.78 k)**	**HS 4 (P_{wheel} = 3.2 k)**
Shear (Concrete w/assume shear reinforcing steel)	12.41 ton (P_{wheel} = 9.93 k)	HS 12 (P_{wheel} = 9.6 k)
Punching Shear	35.7 ton (P_{wheel} = 28.6 k)	HS 35 (P_{wheel} = 28.0 k)

* Truck designation used by AASHTO (American Association of State Highway and Transportation Officials), where H stands for highway, S for semi-trailer, and the number is the total weight of the first two axles in tons. HS trucks are 3-axle trucks.

† Maximum individual wheel load. 1 k = 1,000 lbs.

‡ Although vertical bars were observed at a concrete spall located at a pile, the shear capacity assumes no shear steel is included for an order of magnitude comparison with the other conditions listed.

Load Effect	**As-is Condition H Truck Capacity***	
	Calculated	**Representative**
Moment	19.66 ton (P_{wheel} = 15.73 k) †	H 19 (P_{wheel} = 15.2 k)
Shear (concrete only)‡	**6.05 ton (P_{wheel} = 4.84 k)**	**H 6 (P_{wheel} = 4.8 k)**
Shear (Concrete w/assume shear reinforcing steel)	15.87 ton (P_{wheel} = 12.70 k)	H 15 (P_{wheel} = 12.0 k)
Punching Shear	45.7 ton (P_{wheel} = 36.6 k)	HS 45 (P_{wheel} = 36 k)

* Truck designation used by AASHTO (American Association of State Highway and Transportation Officials), where H stands for highway and the number is the total weight of the truck in tons. H trucks are 2-axle trucks.

† Maximum individual wheel load. 1 k = 1,000 lbs.

‡ Although vertical bars were observed at a concrete spall located at a pile, the shear capacity assumes no shear steel is included for an order of magnitude comparison with the other conditions listed.

For comparison, the "as-constructed" (original) live load capacity of the pier based on the same concrete and reinforcing steel assumptions but with no section losses is estimated as follows:

Load Effect	**"As-constructed" Condition Uniform Live Load Capacity**	
	Calculated	**Functional**
Moment (live load across full pier width)	466 psf	450 psf
Moment (live load across one-half pier width)	341 psf	300 psf
Shear (concrete only)*	**170 psf**	**150 psf**
Shear (Concrete and shear steel)	370 psf	350 psf
Punching Shear	537 psf	500 psf

* Although vertical bars were observed at a concrete spall located at a pile, the shear capacity assumes no shear steel is included for an order of magnitude comparison with the other conditions listed.

Load Effect	**As-constructed Condition HS Truck Capacity***	
	Calculated	**Representative**
Moment	17.5 ton (P_{wheel} = 14.0 k)†	HS 17 (P_{wheel} = 13.6 k)
Shear (concrete only)‡	**7.28 ton (P_{wheel} = 5.82 k)**	**HS 7 (P_{wheel} = 5.6 k)**
Shear (Concrete and shear steel)	15.8 ton (P_{wheel} = 12.65 k)	HS 15 (P_{wheel} = 12 k)
Punching Shear	58.6 ton (P_{wheel} = 46.9 k)	HS 58 (P_{wheel} = 46.4 k)

* Truck designation used by AASHTO (American Association of State Highway and Transportation Officials), where H stands for highway, S for semi-trailer, and the number is the total weight of the first two axles in tons. HS trucks are 3-axle trucks.

† Maximum individual wheel load. 1 k = 1,000 lbs.

‡ Although vertical bars were observed at a concrete spall located at a pile, the shear capacity assumes no shear steel is included for an order of magnitude comparison with the other conditions listed.

Calculations Cont'd

Load Effect	**As-constructed Condition H Truck Capacity***	
	Calculated	**Representative**
Moment	22.4 ton (P_{wheel} = 17.94 k)†	H 22 (P_{wheel} = 17.6 k)
Shear (concrete only)‡	**9.31 ton (P_{wheel} = 7.45 k)**	**H 9 (P_{wheel} = 7.2 k)**
Shear (Concrete and shear steel)	20.2 ton (P_{wheel} = 16.18 k)	H 20 (P_{wheel} = 16 k)
Punching Shear	75.0 ton (P_{wheel} = 60.0 k)	H 75 (P_{wheel} = 60 k)

* Truck designation used by AASHTO (American Association of State Highway and Transportation Officials), where H stands for highway and the number is the total weight of the truck in tons. H trucks are 2-axle trucks.

† Maximum individual wheel load. 1 k = 1,000 lbs.

‡ Although vertical bars were observed at a concrete spall located at a pile, the shear capacity assumes no shear steel is included for an order of magnitude comparison with the other conditions listed.

Summary

Wychmere Pier is approximately 40 years old and has widespread minor to significant deterioration. The more significant deterioration is below deck and likely influenced by the limited clearance above high tide and the repeated submersion during the tide cycle. Although deterioration of the outer thickness of the timber piles was evident, the greatest deterioration was evident at the concrete pile caps.

The concrete pile caps have significant spalls with exposed, corroded reinforcing steel. Concrete core testing (2009) of samples from two pile cap members indicated a poor concrete quality with microcracking, elevated chloride ion concentrations, and evidence of ASR. Although significant deterioration of the deck planks was not observed, testing of core samples revealed elevated chloride ion concentrations within the upper 2 inches and evidence of active ASR.

Structural analysis calculations for the pile caps were completed to estimate the approximate vertical live load capacity of the as-is condition. No lateral load analysis was completed. The as-is condition assumed size and quantity of reinforcing steel based on that exposed at a concrete spall and an average concrete loss based on observation and results of core testing.

Based on this analysis current operational procedures limiting pier traffic to "heavy pick-up trucks" should remain in place until the pile cap reinforcing steel can be more definitively identified. We recommend that a "heavy pick-up truck" be defined as a 2-axle vehicle with a gross weight less than 6 tons (12,000 lbs) and a corresponding maximum wheel load of 4,800 lbs.

If the presence of adequate shear reinforcing steel in the pile caps is confirmed, increased operational restrictions on the existing pier of 250 psf of uniform live load, an AASHTO HS 12 truck loading (3-axle truck with maximum wheel load of 9,600 lbs), and an AASHTO H 15 truck (2-axle truck with maximum wheel load of 12,000 lbs) appear to be attainable.

Identification of the reinforcing steel present in the pile caps may be possible by using a non-destructive magnetic device, such as a Pachometer. If such additional field investigations can verify the moment and shear reinforcing steel assumptions used in the pile cap analysis performed above, truck weight limits of 15 tons for 2-axle trucks (maximum wheel load of 12,000 lbs) and 21 tons for 3-axle trucks (maximum wheel load of 9,600 lbs) may be possible. For budgeting purposes, the cost to perform the necessary field investigations and subsequent analysis is estimated to be less than $10,000 depending upon the scope of work.

Although the assumed “as-constructed” analysis yielded live load capacities for the pile caps that approximate the typical 250 psf and AASHTO HS 20 truck design live loads for light duty fishing piers, the current level of deterioration and assumptions regarding reinforcing steel are such that the pier does not currently meet these minimum design loadings. Considering the approximate age of the pier, the limited clearance of the framing members above the high tide, and the current level of deterioration, structural improvements to the pier are recommended.

Further studies would be required to evaluate if complete replacement is warranted or if replacement of specific pier elements, such as the pile caps, is feasible. However, based upon the information currently available it is estimated that repairs in the range of $10,000 - $50,000 could prove adequate for extending the usable life of the pier. For budgeting purposes, the cost to perform the necessary analysis and design of such repairs is estimated to be $5,000 - $15,000 depending upon the scope of work.