NAVIGATION STUDY REPORT

for

MiraBay
Apollo Beach, Florida

December 12, 2015

BUCHART HORN
ENGINEERS · ARCHITECTS · PLANNERS

1 Introduction

Mirabay as a community was designed with a bulkhead revetment management system as part of its master stormwater system. The existing bulkhead also serves as a retaining wall between the properties and canal system. The MiraBay community development is at the east side of Tampa Bay and immediately west of Tamiami Trail (U.S. Highway 41) in Apollo Beach, Florida. The site is nearly fully developed with most homes built along interior canals. There are approximately seven to eight miles of bulkhead along the back of the properties. The back of the properties adjacent to the bulkheads consist of uplands with amenity structures (i.e. pool and pool decks, screen houses and landscape walls). The canal system serves as a navigable waterway with access to Tampa Bay. It also serves as a stormwater conveyance system for the MiraBay community.

The aims of the present study are:

- Evaluate the dimensions of the MiraBay waterways including canal fairways and personal mooring berths.
- Compare the methodologies proposed by others for certain bulkhead modifications specifically as it relates to navigation in the waterways and berths.
- Develop suitable guidelines and procedures to be applied to navigate the MiraBay waterways smoothly and safely.

2 Reference Vessels

Vessel draft and height are the main parameters determining whether the network of canals is accessible for certain recreational craft. According to the MiraBay by-laws, a canal dock is allowed a vessel with a maximum length of one-half the size of the lot, as designated by the Harbor Bay Community Development District (CDD) plus 5 feet up to a maximum of 45 feet.

The following table shows a few vessel dimensions up to 45 feet in length and typical water depths for the allowable vessel classes per recognized published design data:

Location	Length (feet, maximum)	Beam (feet)*	Draft (feet)*	Typical Water Depth (feet, MLLW)*, **	Pleasure Boat Classification***
Canal Dock	17	7.5	2.5	5.5	II
Canal Dock	35	14	4.5	8	III
Canal Dock	45	16	5	8	III

Table 1: Standard Inventory Vessel Lengths, Beam and Draft Measurements
*ref: Marinas and Small Craft Harbors, 2nd ed., Tobiasson
**Water depths shown are about 3 feet greater than the draft of a representative deep draft vessel
***ref: Classification of Pleasure Boats as proposed by Permanent International Association of Navigation Congresses (PIANC) 1965. Class II-overall length 16ft < L < 26ft (5m < L < 8m), Class III overall length 26ft < L < 49ft (8m < L < 15m)

3 Hydraulic Parameters

Table 2 below lists the various water levels at MiraBay, Apollo Beach, Florida as provided by the National Oceanic and Atmospheric Administration (NOAA):

MIRA BAY, APOLLO BEACH, FLORIDA	
Latitude: 27°46'31.33"N	
Longitude: 82°25'38.45"W	
Water Level	**Elevation (Ft, NAVD88)**
Mean Higher High Water (MHHW)	0.8139
Mean High Water (MHW)	0.5319
Local Mean Sea Level (LMSL)	-0.3141
Mean Low Water (MLW)	-1.2119
Mean Lower Low Water (MLLW)	-1.6348

NGVD29	-0.8992
Datum Shift	
NAVD88 = NGVD29 – 0.899 ft.	
NGVD29 = NAVD88 + 0.899 ft.	

Table 2: Water Levels at MiraBay (ref: NOAA vDatum 3.2)

This navigation study considers MLLW to assess the full functionality of the waterways available to vessel navigation.

4 Wind Parameters

Wind problems must be prevented as far as possible on routes for recreational navigation. Problems are caused mainly by fluctuations in wind strength as a result of sudden lulls in the wind, abrupt transitions and wind effects around high buildings. It is unclear whether the canals that join the main waterways were designed with a view to possible wind problems.

5 Waterway Elements

The network of waterways at MiraBay includes an entrance channel, interior channels, fairways and personal berths, as well as a lagoon accessed by a boat lift structure. Table 3 lists various dimensions and water depths for the waterways at MiraBay with reference to MLLW.

Waterway Location	Width (avg., feet)	Depth at Center of Fairway	Depth at Waterward Edge of Dock	Depth at 12.5 ft. Waterward of Dock
Islebay Drive, North	90	4.90	3.66	4.49
Islebay Drive, South (E & W)	110	4.40	2.68	3.89
Islebay Drive, East	92	4.32	3.47	4.20
Islebay Drive, West	160	5.26	3.95	4.39
Sea Trout Place, East	115	4.16	3.43	4.19
Sea Trout Place, West	115	5.11	2.71	3.91
Sea Turtle Place, East	104	4.26	3.13	3.98
Sea Turtle Place, West	112	4.16	2.96	3.83
Skimmer Drive, East	92	4.08	3.14	3.82
Skimmer Drive, West	104	4.16	3.05	4.08
Seagrass Place, East	92	4.16	3.12	4.10
Mirabay Boulevard, North	92	4.39	3.04	4.46
Mirabay Boulevard, South	100	4.65	3.66	4.55

Table 3: Dimensions and Water Depths of Existing Waterways.
Note: Fairways that vary by more than several feet in width indicate critical widths. Waterway locations refer directionally to various roadways listed. Water depths are referenced to MLLW.

An entrance channel connects Tampa Bay with two interior channels along Islebay Drive, one located to the north and the other west. Channel width is defined as the clear width at the design depth, and specifically does not include the channel side slopes. According to UFC 4-152-07, minimum channel widths for 2-way traffic should be the greater of:

- 100 feet
- 5B, where B = Beam of the largest vessel expected to use the channel;

As can be seen in Table 3, the channel to the north of Islebay Drive at 90 feet wide is approximately 10 percent narrower than that preferred based on the above criteria; however, given the restricted wave climate it may be considered acceptable by some for 2-way traffic depending on user skill of each vessel.

A hydrographic survey for the MiraBay waterways has been prepared by GeoPoint Surveying, Inc. 7/7/2015 depicting the state of the waterway bottom at the MiraBay community (see Attachment 2). The vertical datum reference is MLLW as discussed in Section 3.

Fairways provide vessel access from interior channels to individual berths. The waterway canals having the marginal side-tie berths at MiraBay are considered fairways and not interior channels. Table 3 lists dimensions and water depths of existing fairways at this community. The fairways should have been designed to provide as much room as necessary to allow safe boat maneuvering under existing environmental parameters. In practice the actual sizing of a fairway is based on a certain rule of thumb according to which the fairway width is equal to the design boat length multiplied by a certain coefficient.

Per UFC 4-152-07, the minimum clear width of fairways should be based on the following where L_b is the length overall (LOA) of the design vessel:

- 1.5 L_b (finger slips) for power boats and 1.75 L_b for sailboats, where L_b is the length of the longest berth perpendicular to the fairway where vessel are not allowed to overhang the berth.

- 1.5 L_b (with side/end-ties) for power boats and 1.75 Lb for sailboats, where L_b is the length of the longest berth parallel to the fairway where the fairway width does not include the side-tie berth width. A side/end tie is a berth at the end of the main walkway adjacent to the interior channel (See Figure 2).

While the general rule of thumb most frequently used assumes a clear distance between boat extremities located on both sides of the fairway is equal to 1.5 times the longest boat length, in the past the coefficient used frequently was equal to 1.25. It is noted that certain fairways at the MiraBay community appear to have been designed closer to this 1.25 coefficient (see Table 3). With that said however, most fairways appear to meet the 1.5 coefficient as can be seen by comparing Tables 3 and 4.

The table below lists the minimum recommended fairways based on the above criteria for the vessels at MiraBay:

Location	Length (feet, maximum)	1.25 L_b	1.25 L_b + 2 Berths*	1.50 L_b	1.50 L_b + 2 Berths*
Canal Dock	17	21.25	46.25	25.5	50.5
Canal Dock	35	43.75	68.75	52.5	77.5
Canal Dock	45	56.25	81.25	67.5	92.5

Table 4: Minimum Clear Width of Fairways and Berths
* Berths assumed at 12.5ft each x 2 berths = 25ft.

Fairway depths are determined using the same considerations as interior channels.

Berth widths should be based on the particulars of the vessels to be berthed or recognized sources such as UFC 4-152-07 Design: Small Craft Berthing Facilities, or Marinas and Small Craft Harbors, 2 ed., Tobiasson may be referenced for typical vessel dimensions. The minimum width of a berth according to UFC 4-152-07 shall be:

- Double berth: 2 x Beam of the wider vessels served + clearance for environmental conditions, boater experience, and fendering system
- Single Berth: Beam of the widest vessel served + clearance for environmental conditions, user experience, and fendering system

Berth depths should be the same as the fairway depth. Depending on vessel characteristics, site and environmental conditions, and user skill, the bottom clearance for safe navigation will vary. Site conditions include rip rap, mangroves or other shoreline protection elements. It is recognized based on generally accepted navigation standards that the minimum water depth extending to a hard bottom should be no less than 3 feet below the keel of the deepest draft boat at the design low water level taken as the Mean Lower Low Water (MLLW) tidal datum. This distance is also recommended by Tsinker (Marine Structures Engineering, 1995, Tsinker).

6 Construction

6.1 Existing Sheet Pile Bulkhead

The existing bulkheads were designed and constructed between approximately 2000 and 2003. The existing anchored bulkheads were designed using vinyl sheet piles with a reinforced concrete cap. Hot dipped galvanized anchor rods extend from the back of the bulkhead cap to below-grade deadmen approximately 15 feet inland. Based on previous understanding of the original design and our discussions with Ingenium and HBCDD, the deadmen were constructed under pool structures at many locations. The top of the bulkhead cap was designed and constructed at elevation +6 MSL.

The permitted design showed the waterside berm at elevation +1 adjacent to the bulkhead. The design width of the waterside berm was about 5 feet. The most recent bathymetric survey performed by GeoPoint Survey, Inc. in July 2015 indicates that the waterside berm significantly eroded away on the eastside of the development with sounding elevations ranging between approximate elevation 0 and elevation -1.5. Where mangrove trees were planted and thriving, predominately at the west side of the development, the waterside berm has remained intact between approximate elevation +1 and elevation +2 MSL. Where the waterside berm has eroded, the bulkhead has excessive vinyl sheet deflection and cap rotation. In extreme instances at the eastside of the development, sheet pile deflection had become significant and caused localized rupture of the existing vinyl sheet piles. Hence, the existing bulkheads in those areas are undergoing emergency repairs that are described below as an Option 3 bulkhead rehabilitation alternative. The rehabilitation alternatives came about through on site pilot testing of the design alternatives performed by Ingenium, Inc. in 2014. The pilot study alternatives have since been peer reviewed and redesigned by Langan Engineering and Environmental Services, Inc., the project bulkhead engineers. The bulkhead rehabilitation alternative design Options 1, 2 and 3 are briefly described below.

6.2 Bulkhead Rehabilitation Alternatives

6.2.1 Option 1: Rip Rap Alternative

The Option 1 Rip-Rap Alternative consists stabilizing the existing vinyl sheet pile wall with rip-rap placed immediately waterside of the bulkhead. The rip-rap would extend a horizontal distance of approximately 8 feet from the bulkhead to the back edge of timber dock piers. The top of the rip rap would be at elevation +4 and is sloped at 2 horizontal to 1 vertical (2H:1V) downward into the canal.

6.2.2 Option 2: Rip Rap with Secondary Vinyl Sheetpile Wall Alternative

Option 2 was part of the pilot test study in 2014 and was constructed similar to Option 1, except the toe of the rip rap slope was shortened to about 4.5 feet by installing a secondary vinyl sheet pile wall 4.5 feet in front of the existing bulkhead. The pilot study Option 1 and Option 2 alternatives also had a waler with helical anchors as tie back support. This Option 2 alternative was peer reviewed by Langan who deemed it undesirable. The Option 2 alternative was therefore discarded.

6.2.3 Option 3: New Bulkhead using Fiberglass Reinforced Polymer Sheet Pile

The Option 3 bulkhead rehabilitation alternative consists of constructing a new bulkhead using significantly stiffer fiberglass reinforced polymer (FRP) sheet piles installed deeper than the previous vinyl sheet piles were driven and immediately in front of the existing PVC sheet pile wall. A new larger reinforced concrete cap envelopes the old bulkhead cap to act in conjunction with the new bulkhead. The new sheet pile wall is currently being installed as emergency repairs at several areas throughout the eastern half of the development. The FRP sheet piles are being installed with tip elevations at approximately elevation -10 feet in lieu of placing back the waterside berm to elevation +2 feet at the emergency repair areas. Additional tie-rod anchors are also being installed about every 13 ft on centers. These tie-rods are being incorporated into the new heavily reinforced concrete bulkhead cap.

A number of cross section profiles have been prepared as follows that depict representative design vessels of varying size and draft. The vessel geometry shown in these profiles is used only for assessment purposes and is not intended to match that of any particular craft. As can be seen in these profiles, clearance distances exist beneath the vessels to the soft mudline less than the recommended 3 feet. However, the recommended minimum 3 foot clearance to the hard rip rap is satisfied since it would be placed no further than the back edge of the docks which measure roughly 4 feet wide.

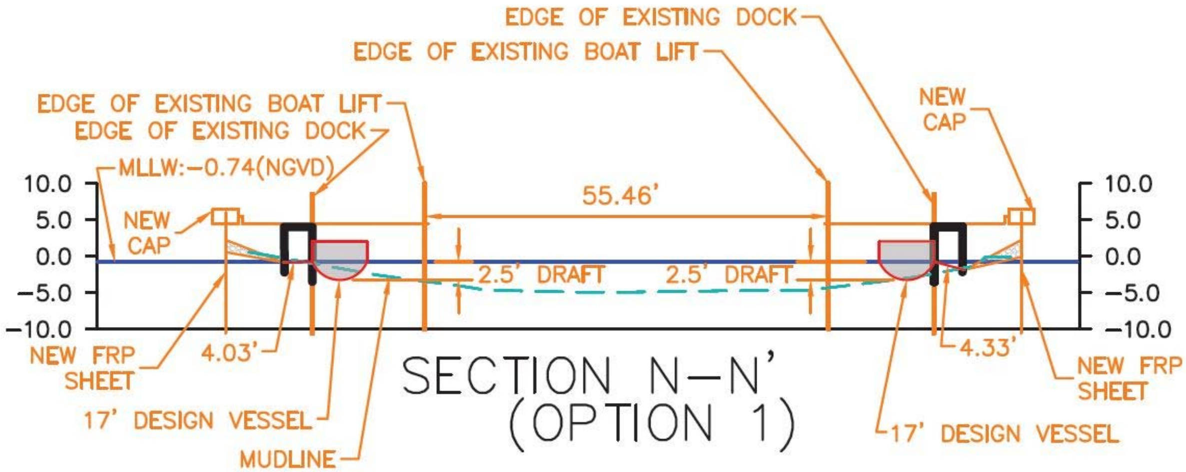

Figure 1: Waterway Profile (ref: vDatum MLLW)

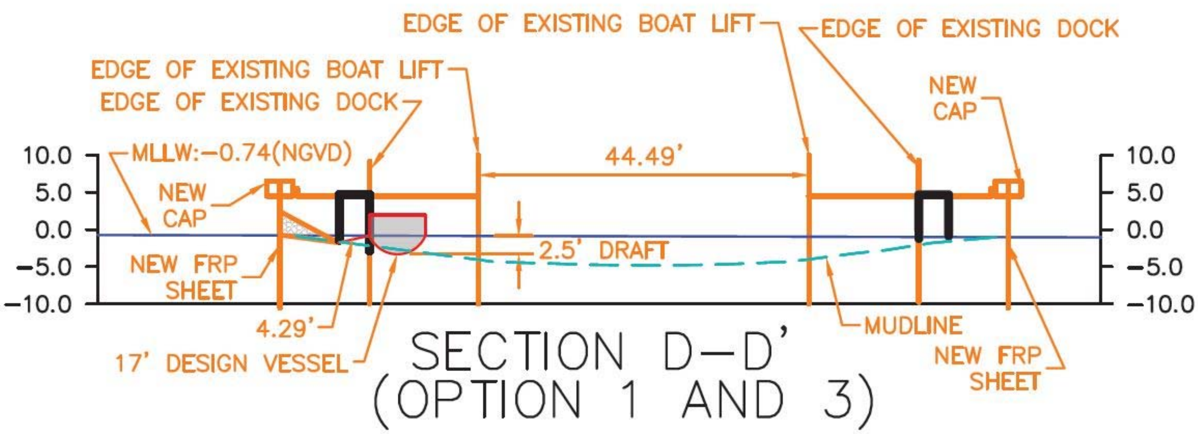

Figure 2: Waterway Profile (ref: vDatum MLLW)

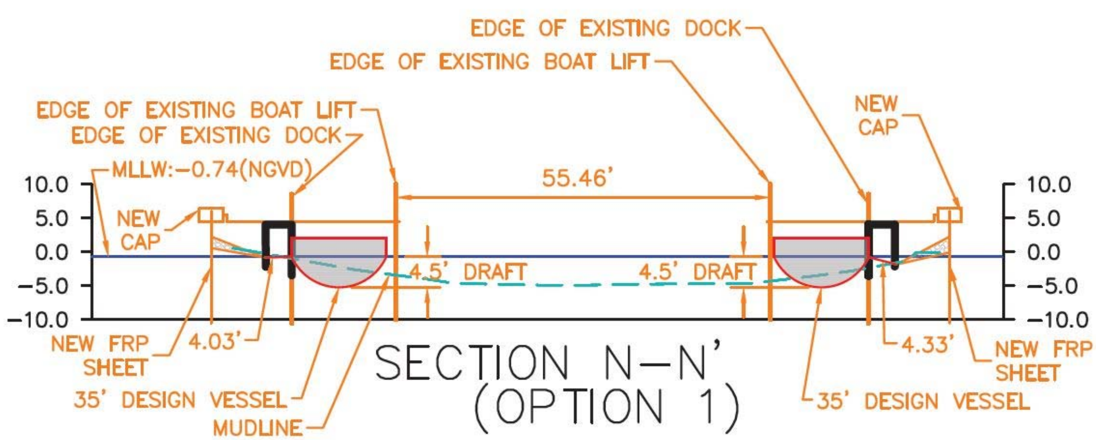

Figure 3: Waterway Profile (ref: vDatum MLLW)

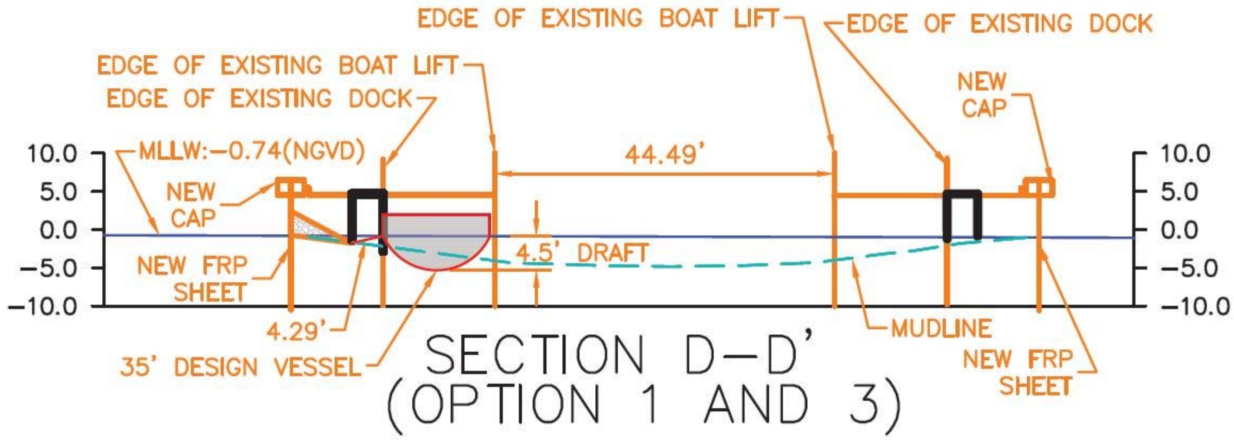

Figure 4: Waterway Profile (ref: vDatum MLLW)

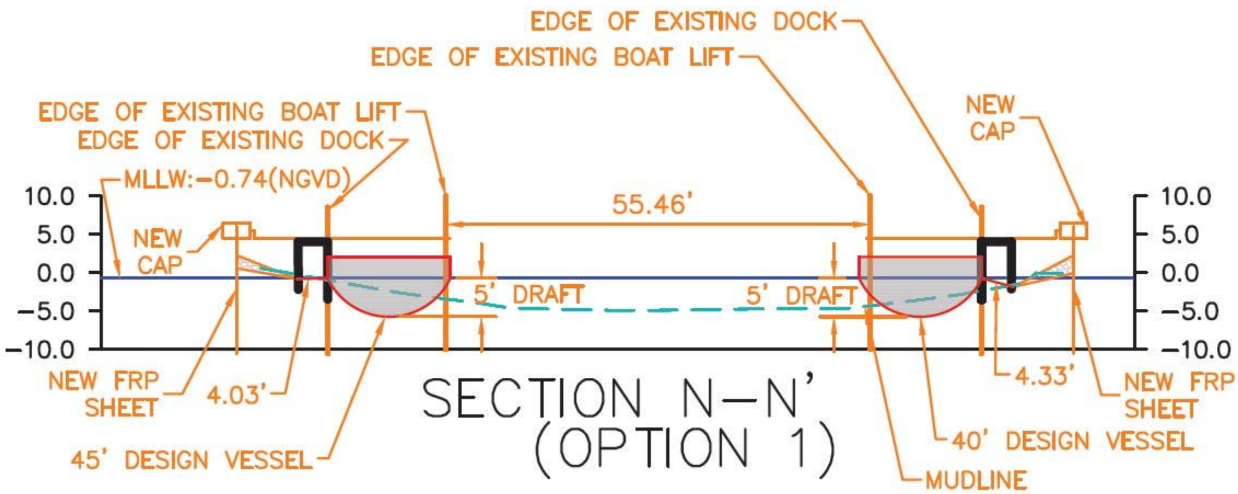

Figure 5: Waterway Profile (ref: vDatum MLLW)

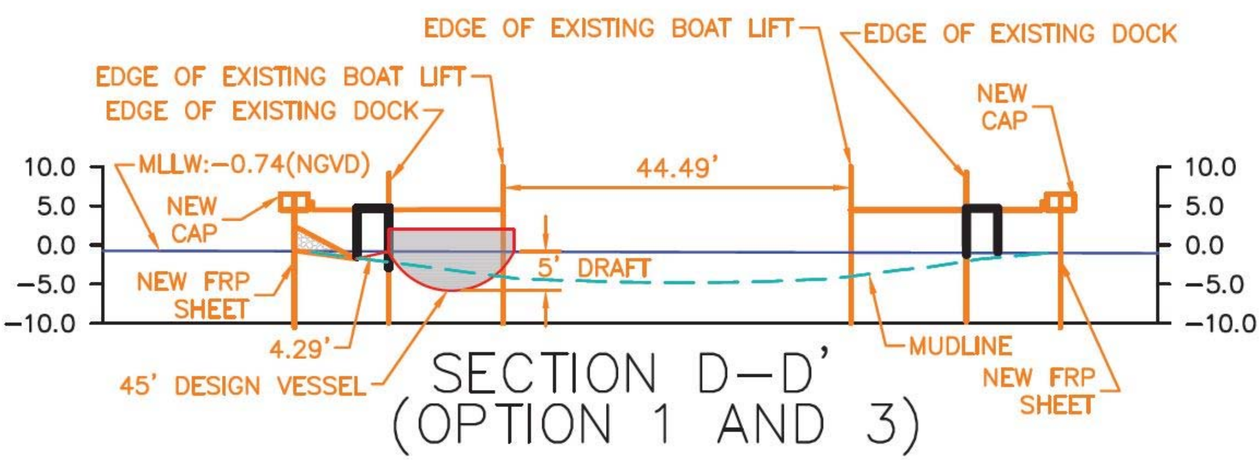

Figure 6: Waterway Profile (ref: vDatum MLLW)

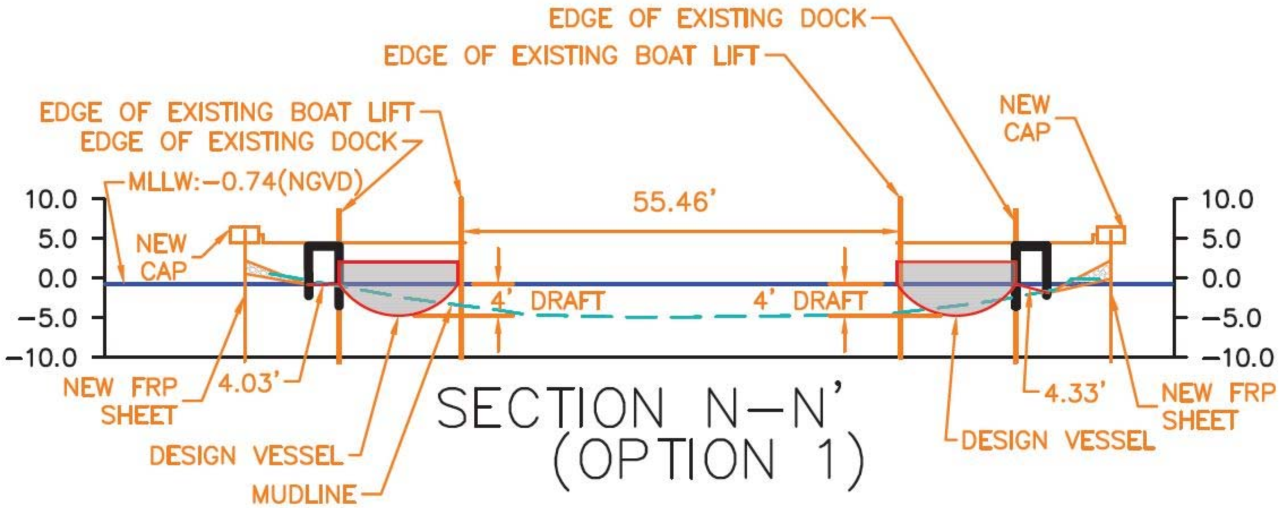

Figure 7: Waterway Profile (ref: vDatum MLLW)

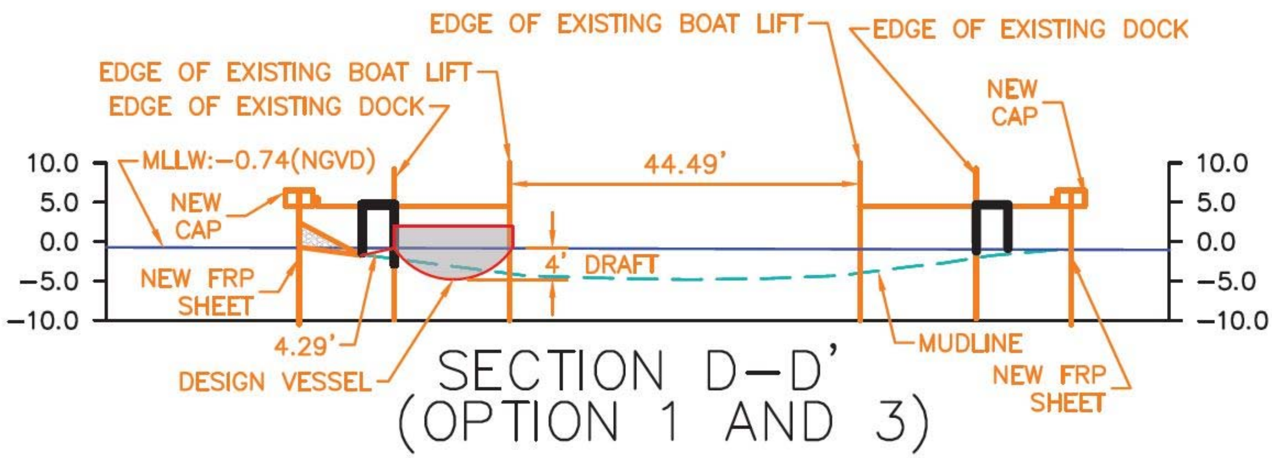

Figure 8: Waterway Profile (ref: vDatum MLLW)

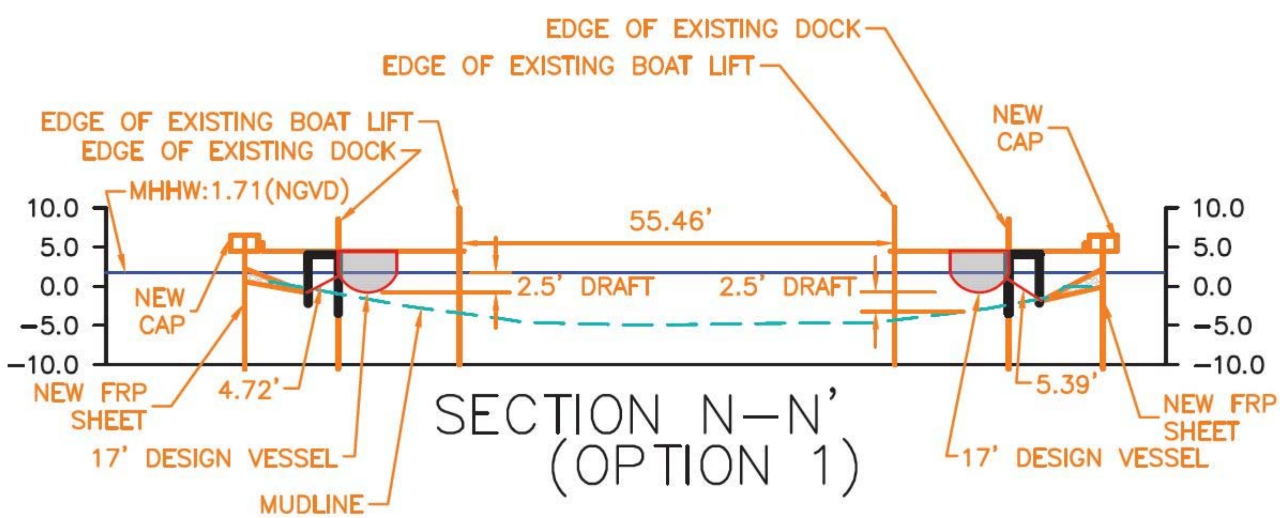

Figure 9: Waterway Profile (ref: vDatum MHHW)

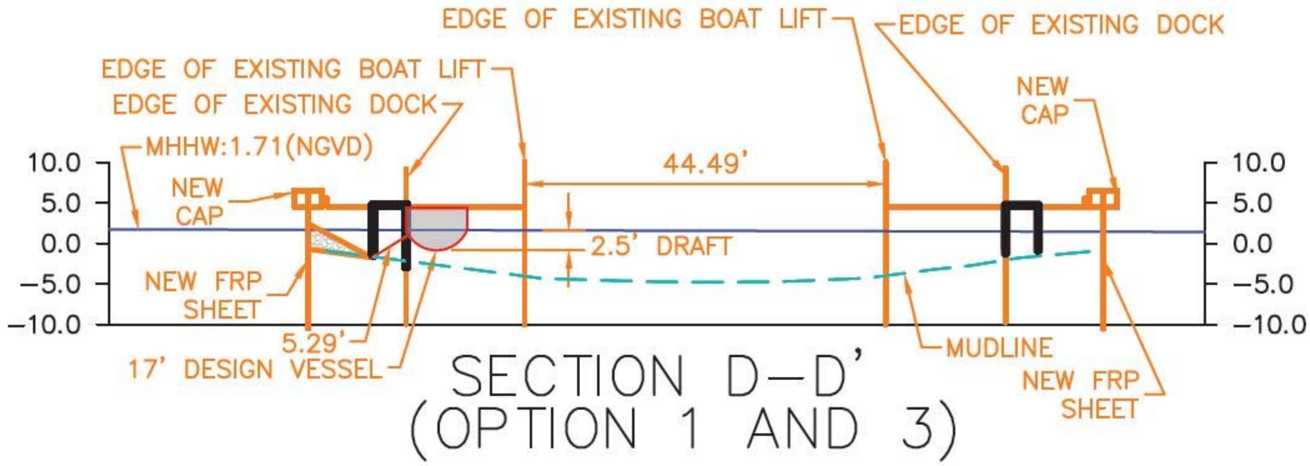

Figure 10: Waterway Profile (ref: vDatum MHHW)

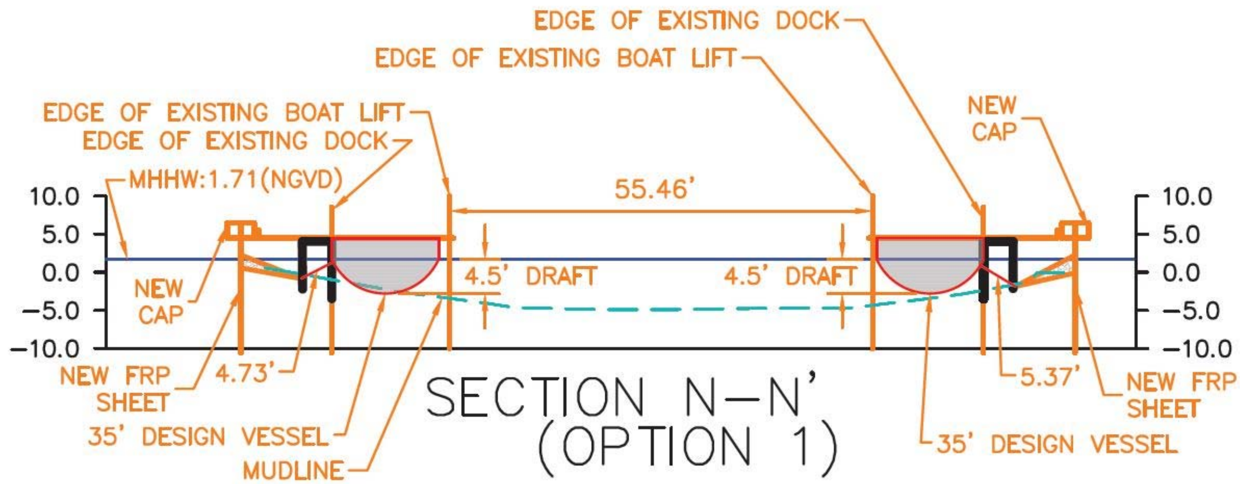

Figure 11: Waterway Profile (ref: vDatum MHHW)

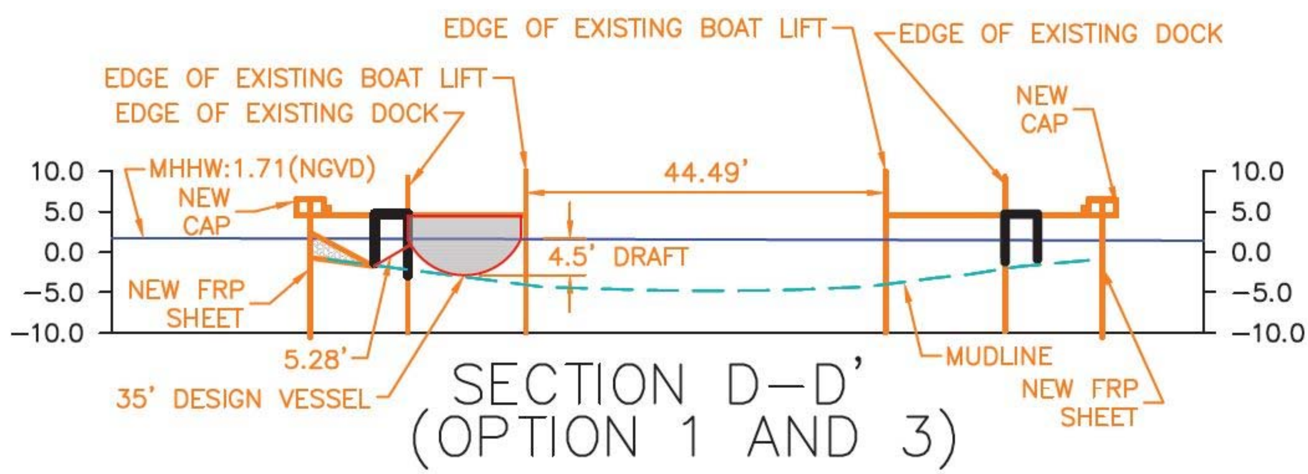

Figure 12: Waterway Profile (ref: vDatum MHHW)

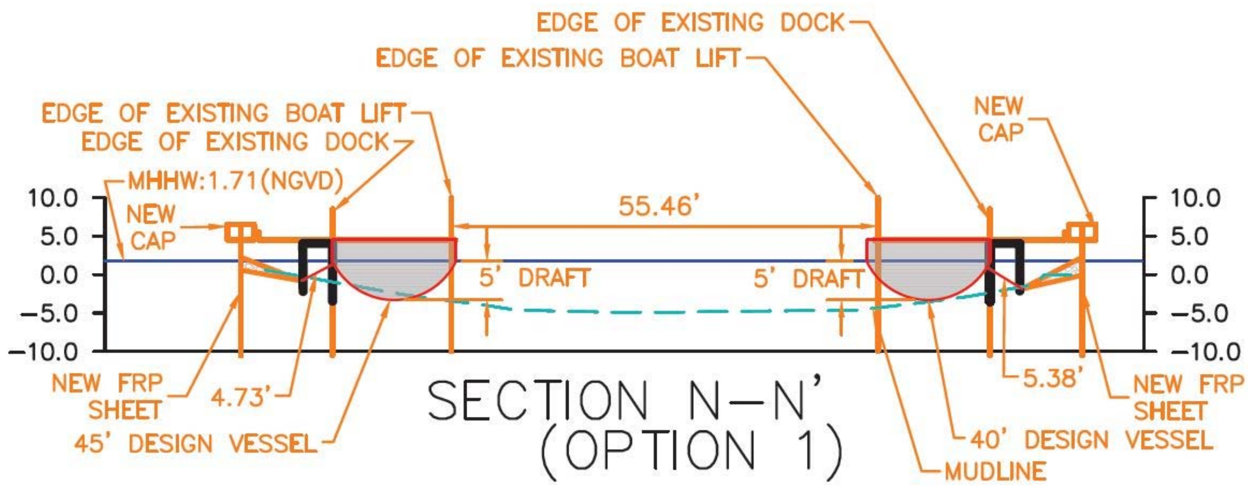

Figure 13: Waterway Profile (ref: vDatum MHHW)

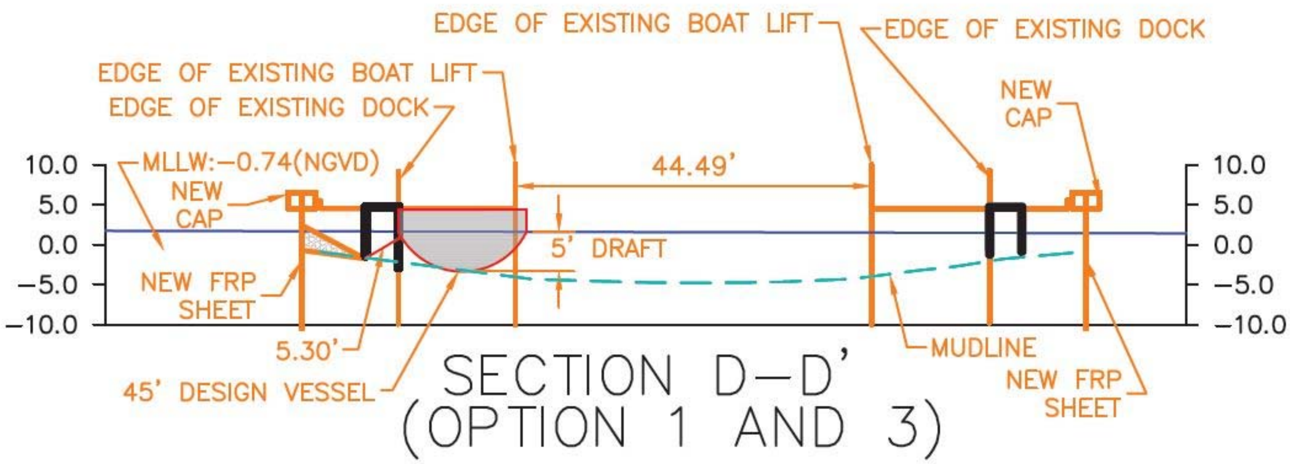

Figure 14: Waterway Profile (ref: vDatum MHHW)

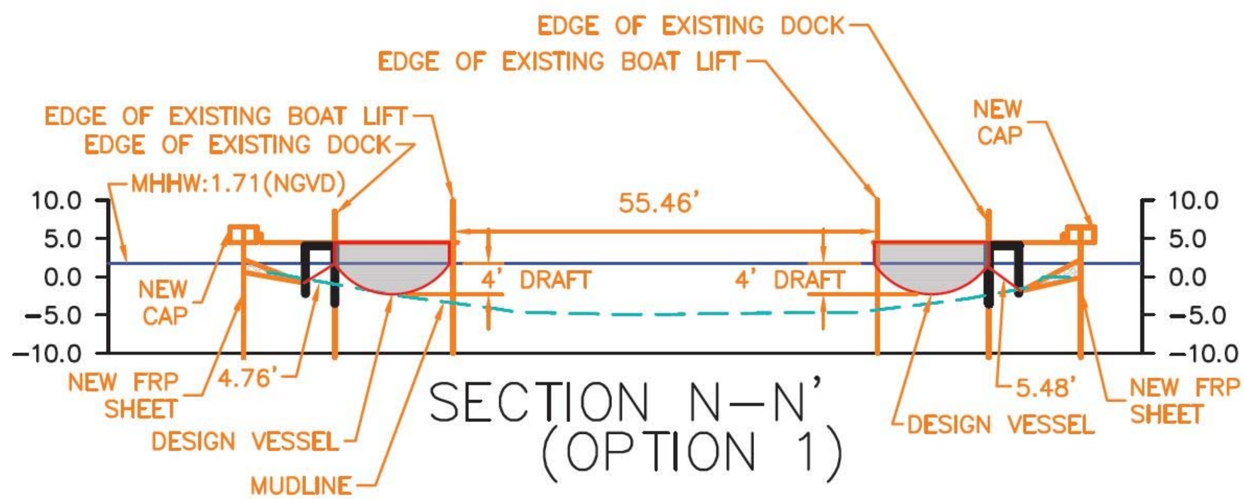

Figure 15: Waterway Profile (ref: vDatum MHHW)

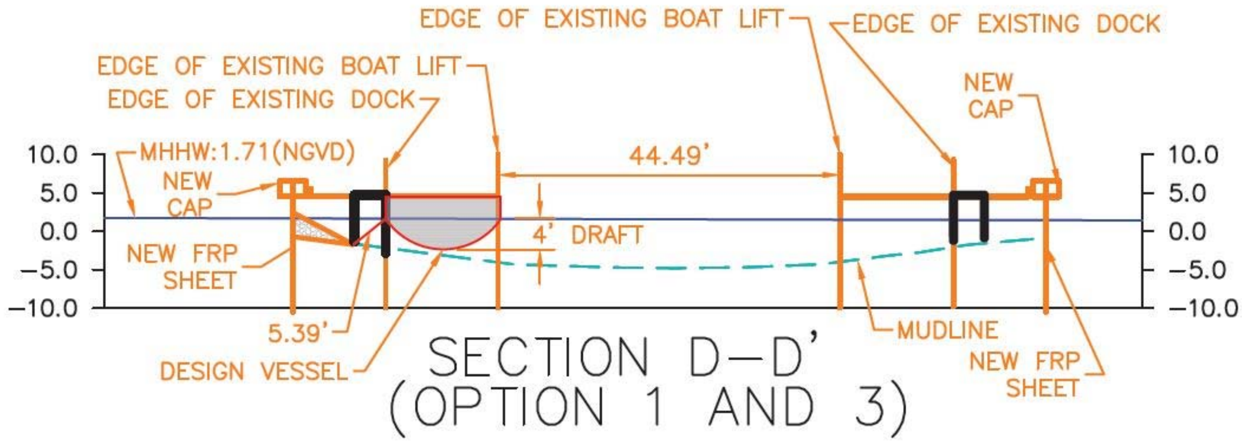

Figure 16: Waterway Profile (ref: vDatum MHHW)

6.2.4 Modified Option 1: Rip Rap, Mangroves and New Cap

Mangroves can help prevent erosion by stabilizing shorelines along the network of bulkheads with their specialized root systems. This has been evidenced by site surveys made throughout MiraBay indicating mudlines along the bulkheads at or close to their original elevations where mangroves are growing. Mangrove roots act not only as physical traps for sediments but provide attachment surfaces for various marine organisms. Mangroves also filter water and maintain water quality and clarity.

Naturally recruiting mangroves would protect sediments in front of the bulkhead from erosion as part of a long-term maintenance solution to the bulkhead system and provide improved water quality and attractive healthy ecosystems.

7 Conclusions

Table 3 lists dimensions and water depths of existing fairways at this community. The fairways should have been designed to provide as much room as necessary to allow safe boat maneuvering under existing environmental parameters. While the general rule of thumb most frequently used assumes a clear distance between boat extremities located on both sides of the fairway is equal to 1.5 times the longest boat length, in the past the coefficient used frequently was equal to 1.25. It is noted that certain fairways at the MiraBay community appear to have been designed closer to this 1.25 coefficient (see Table 3), however most fairways appear to meet the 1.5 coefficient as can be seen by comparing Tables 3 and 4.

The right of a vessel to have the navigable waters free of obstructions is paramount. It is recognized based on generally accepted navigation standards that the minimum water depth and clearance below the keel or prop of the deepest draft boat extending to a hard bottom should be no less than 3 feet and for a soft bottom no less than 2 feet below the Mean Lower Low Water (MLLW) tidal datum subject to environmental regulatory criteria. These clearance distances are recommended for safe navigation and berthing for the varying size vessels allowed at the MiraBay community, the existing and proposed site conditions, environmental conditions, and expected user skill. The cross sections through the canals contained in Section 6.2.3 show a sloped mudline profile that may result in restricted water depths at the berths at lower tide levels such as MLLW. In fact, it has been reported that various boats bottom out in the mud during lower tide levels

As discussed above, Option 1 includes placement of rip rap alongside the bulkhead extending out approximately to the back, landside edge of the parallel canal docks. Clearance distances would be greater than 3 feet from vessels to the toe of the proposed rip rap since the rip rap would not extend beneath the docks which measure approximately 4 feet in width. Nonetheless, taking a vessel towards the bulkhead area landward of the berths where rip rap placement is proposed under Option 1 may result in undesirable effects.

When transiting an area where there is a submerged obstruction to navigation such as the proposed rip rap in Option 1, a mariner is entitled to rely on the accuracy of soundings indicated on a navigation chart and signage on the shore unless he/she has notice they may be inaccurate. As such, if Option 1 is constructed, a post construction bathymetric survey should be performed and made available to the MiraBay community. Additionally, any underwater obstacles should be marked with beacons or another notification device. More specifically, safety navigation signage is strongly recommended to be affixed at regular intervals along the bulkhead warning boaters of the underwater obstructions. Fender piles may also be driven in alignment with the waterside edge of the docks at regular intervals providing both a visual marker and periodic fendering for vessels nearing the underwater obstructions. If mangroves were successfully planted or naturally recruited as part of the remediation program, these would act as natural markers indicating the location of the rip rap.

When navigating a vessel throughout the MiraBay environment, precise navigation is required for safety, efficiency, repeatability, accountability and to be systematic. However, the class of recreational craft at MiraBay is most likely depending mostly on visual information and perhaps depth finders. This precise navigation becomes more important during higher water levels such as MHHW which may suggest to an inexperienced boater that adequate water depths exist for navigating landward of the outside edge of the docks, thereby placing the vessel in proximity of the proposed rip rap considered in Option 1 and possibly striking it causing damage to the vessel.

Regardless of the type of navigation being used, there may be no practical action that can be taken to overcome inexperienced user skill so even safety signage and precise navigation instrumentation is not a guarantee that vessel damage does not occur for certain users if the Option 1 bulkhead rehabilitation alternative that involves placement of rip rap along the bulkhead wall is constructed. It is likened to driving a car in proximity to a guardrail; if you keep driving towards the guardrail the car will eventually strike the rail causing damage to the car. Boater skill is paramount to safe navigation in all water bodies and should be taken seriously, albeit it may not be possible to mandate this in the MiraBay community.

Consideration of future dredging operations is warranted in this study. The bulkhead design is sensitive to increase in the height of the exposed face. Election of Option 1 must be carefully considered in connection with any possible future dredging requirements that may jeopardize the structural integrity of the bulkhead in the form of further lateral deformation or failure of global or toe stability.

All bulkheads must have sufficient strength to resist the lateral soil pressure exerted on the structure by the soil on the upland side. A bulkhead is pushed towards a waterway by lateral soil pressure. The bulkhead structure has to transfer that force back into the surrounding earth to prevent lateral displacement and failure. At the bottom of the bulkhead, this resistance against "toe kickout" is provided by the soil in which the bottom of the bulkhead is embedded. Dredging near the existing bulkhead may remove sediment that is working to prevent this toe kickout for the structure. If sediment is removed from the waterway side of the bulkhead (or front side), then the resistance capacity at the bottom of the wall would be weakened. Dredging may also increase the vertical distance between the top of the bulkhead and the mudline, which is the same effect as making the bulkhead taller. This could lead to increased lateral deformation. These conditions could lead to failure of global or toe stability.

The MiraBay docks are also susceptible to any over dredging that may occur. Dredging near the existing docks may remove sediment that is working to prevent lateral and vertical stability of the docks. If sediment is removed adjacent to the piles, then their overall structural capacity would be weakened. This may cause increased lateral bending movement during berthing maneuvers and high wind events, or perhaps even a permanent deformation of the dock structures.

It may seem an obvious conclusion at this point, but election to construct a new bulkhead as described for Option 3 would eliminate the potential navigation hazards for inexperienced boaters associated with the rip rap proposed under Option 1. More specifically, Option 3 does not involve any rip rap as part of its rehabilitation solution.