FINAL REPORT

Bay Mooring Marina

Shoreline Natural Hazards and Condition Assessment

prepared by

Shoreplan
Engineering Limited

SHOREPLAN

Shoreline Natural Hazards and Condition Assessment
November 2018

Prepared for

Bay Mooring Marina

by

SHOREPLAN ENGINEERING LIMITED

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1 Introduction

Shoreplan Engineering Limited (Shoreplan) completed a site review of the Bay Mooring Marina property on September 24, 2018. The photographs presented in this report were taken at this time. The water level during the site visit was approximately 176.70 metres, IGLD85, as determined from the Canadian Hydrographic Service gauge at Midland.

A review of the condition of the existing shoreline structures is presented in the first section of this report. It is further used to determine appropriate action in relation to the proposed development of the property and mitigating the effects of the natural hazards. The structures included in the condition review incorporated only shoreline structures, steel sheet pile walls and revetments, and did not include the timber docks that extend into the water. It is our understanding that these docks will be removed.

Development along the shoreline is subject to erosion, flooding and dynamic beach hazards associated with Georgian Bay. The second section of this report presents our assessment of the natural hazards at the above noted property and provides comments on how the hazard limits will affect development setbacks. It addresses the dynamic beach hazard, the erosion hazard and the flood hazard as defined in the Natural Hazards Policies (3.1) of the Provincial Policy Statement (PPS). Our assessment is consistent with the general methods prescribed in the MNR (2001) technical guidelines published in support of the provincial policy statement.

2 Existing Site Conditions

The subject property is located north of the intersection of Fox Street and Beck Blvd. along the east shore of Penetang Harbour. The location is shown on Figure 1. The shoreline faces either south or west and changes directions often. Each change of direction is considered a new shoreline segment or reach. The shoreline segments have been numbered 1 to 7 starting on the south-east end as shown in Figure 2.

Approximately 400m of sheet pile wall was reviewed at the property. Additionally, approximately 100m of boulder revetment shoreline at the east end and an approximately 120m long segment of a wall within a boat slip at the north end were reviewed less formally. The conditions of these two segments are also noted below.

2.1 Boulder Revetment

The boulder revetment extends from the east end of Segment 1 on the south side of the marina, reaches to the east approximately 25m and then bends towards the south for approximately 75m. At the end of the revetment segment is another steel sheet pile wall that continues south. It was not inspected. The stones that make up this revetment are approximately 0.7m to 1.0m in diameter. The backshore is vegetated and slopes gently up away from the revetment crest at approximately 10h:1v slope that steepens on the east side as it approaches the adjacent roadway (Photo 1 and Photo 2). The top of the revetment is at an elevation of approximately 178.0m, IGLD85 while the roadway is at approximately 181.0m. No signs of instability or erosion in the backshore were noted. However the south end of the revetment before it joins the steel sheet pile wall does have some areas of thin stone cover or missing stones.

The size of the stone in this revetment is appropriate for the wave conditions in this area. However, the crest of the revetment is too low. The design high water level for this area is 178.0m GSC. During a design storm waves will overtop the revetment and there is a risk of erosion in the backshore. Areas of thin stone cover are also susceptible to damage and potentially erosion.

2.2 Segment 1

This segment of the shoreline is at the far southeast end of the site and runs north-south and east-west on the east side of a concrete ramp. The segment is approximately 48 m long. The shoreline includes a timber walkway constructed parallel along the water's edge with finger docks extending perpendicular to the shoreline. The backshore behind the walkway consists of a grassy area a few metres wide parallel to shore, with a paved parking lot further inshore.

There is a deteriorating concrete slab visible under the timber walkway that runs east-west on this segment as can be seen in Photo 3. It is sitting on top of timber posts and beams that appear to retain the shoreline. Both the concrete and the timber substructure are in severe disrepair; the concrete is cracked while the timber is rotten. The deck level for the walkway is approximately 1m above water level putting it at an elevation of 177.7m IGLD85. The deck itself appears to be supported on steel I-beam sections that sit on top of the concrete slab. Despite

the deterioration of the substructure the timber deck appears mostly level suggesting it was placed after the deterioration of the substructure became an issue.

The north-south portion of this shoreline also has timber docks running parallel to shore with finger docks extending into the water perpendicular to the shore (Photo 4). There is a gap between the docks and the grassy shoreline that makes access difficult. Looking under the docks, there appears to be a timber lagging wall between steel posts that retains the shoreline. It is also in severe disrepair. No concrete cap is visible under the walkway. The area behind this wall is missing a significant amount of fill material causing the shoreline to gently slope towards the water.

Both the north-south and east-west portions of this shoreline segment includes structures that have been repaired and/or modified and are at their end of life and will require replacement. The north-south segment does not retain the shoreline effectively and has failed completely along most of its length. Although no signs were seen to suggest loss of fill material in the east-west portion of the backshore, the substructure has failed and its function as a retaining wall is limited.

At the west end of this segment and before the start of segment 2 there is a concrete ramp. The concrete has signs of deterioration including some cracking and spawling. The concrete starts close to the water line and extends into the water at a gentle slope. The backshore consists of a paved area that continues to slope up to the grade of the surrounding segments. This ramp will need to be removed and replaced with the preferred shoreline protection structure in order to provide continuous protection against flooding and erosion.

2.3 Segment 2

Along this segment of wall, running east to west, timber docks extend out into the water at regular intervals (Photo 5 and Photo 6). The docks are connected to the shore wall and supported on piles. The segment is approximately 78 m long. The wall consists of 460mm wide, 4mm thick steel sheet piles. 5/8” bolts are located approximately 300mm down from the top of the wall presumably connected to a wale on the back of the piles. Occasionally these bolts were slightly larger with a ¾” diameter. The spacing of these bolts along the length of the wall is irregular, ranging from under 1.0m to 2.75m. The top of the wall was approximately 1.35 to 1.4m above the water level on the day of the inspection. This puts the top of wall at approximately 178m IGLD85. The walkway adjacent to the wall consists of timbers that sit perpendicular to the wall. The timbers extend over the top of the wall and approximately 2m inshore.

It was noted that the steel sheet pile wall had a slight lean to it. The top of the wall leans towards shore at a varying angle of 1 to 7 degrees along its length. Typically, a 0.5 degree lean is an acceptable installation tolerance. There were parts of the wall that did not extend up to the underside of the timber deck that sat above it. There were also small sections of patchwork repairs noted along the face of the wall. Near slip 128 (the 6th finger in from the east), a hole was created at the top of the wall by a pile cut shorter than the top of the wall. This made it possible to see the stone fill, wailer and tie rods behind the wall and under the deck (Photo 7). The section of wailer that could be seen is severely corroded. Although tie rods were seen it

could not be determined where they were anchored. No tie rods were visible on the outside of the wall.

A bow out of approximately 300mm was noted in the wall at the west end. This extended for approximately 3m at the west end of this segment of shoreline. This is considered a failure of the wall (Photo 8 and Photo 9).

The backshore along this segment is similar to segment 1. There is a grass area between the parking lot and the timber walkway edge that is at a noticeably lower elevation. It is unknown if this is due to loss of material due to erosion or if this is a condition that existed at time construction. The backshore parking lot is in good condition with no noted sink holes.

A number of observations lead us to conclude that the steel sheet pile wall does not provide suitable shore protection. These observations include a portion of wall that bows out indicating failure, poor condition of the wale, low elevation of the crest and the significant lean along some areas of this sheet pile wall. The wall in considered to be at its end of life and in need of replacement.

2.4 Segment 3

This segment of steel sheet pile wall runs more or less south to north. The segment is approximately 24 m long. The top of the wall is at approximately 1.4m above water level. This corresponds to an elevation of approximately 178.1m IGLD85. The face of the wall is covered in 2x6” horizontal timbers from the top of the wall to 1m down (Photo 10). It was not possible to measure the angle of lean, if any, or see the condition of the steel sheet piles due to the timbers. The timber face was near vertical with no consistent lean in or out. Looking between the timbers and wale bolts could be seen. The bolts along this wall were irregularly spaced, as with the previous segment. The spacing ranging from approximately 1m to almost 5m. No tie rods were visible on the outside of the wall.

The backshore at this location has a timber walkway along the length of the wall and a concrete pad near the south end inshore from the walkway. There is a paved parking lot on the north end and inshore from the concrete pad (Photo 11). This is the only segment of wall that does not have a grass area adjacent to the walkway. The edges along the concrete pad are broken and the west side is sunken into the ground approximately 50 to 100mm. The timber walkway along the edge of the wall slopes towards the water at up to a 10degree angle near the north end. This angle is only 5 degrees around the concrete pad and 3 degrees at the south end of the wall.

The condition of the pathway and concrete pad adjacent to the wall indicates there is movement in the backshore of this segment. It could not be confirmed that this is due to wall movement but it is reasonable to assume it might be. Due to the timbers facing the wall the condition of the steel sheet pile wall could not be entirely assessed. Based on the backshore condition, this segment of wall is most likely suffering the same deficiencies as the segment 2 wall.

2.5 Segment 4

The steel sheet pile wall along this segment runs more or less east to west. The segment is approximately 24 m long. It has a steel cap along its length which is galvanized on the top but not on the sides (Photo 12). The wale bolts along the face of the wall in this segment are ¾" diameter and again are spaced irregularly, anywhere from approximately 1.0m to 6.5m. No tie rods were visible on the outside of the wall. The timber facing the wall in the previous section is present on the east end, but does not cover the entire top portion of the wall and does not continue more than 10 to 15m from the east end.

The wall was measured to lean in at the top 1 to 4 degrees at the south end where the top of wall is at 1.4m from the water line (178.1m IGLD85). At the west end of this segment the top of the wall is lower. It extends only 1.1m from the water line (177.7m IGLD85), as seen in Photo 13. At this location the top of the wall also leans out one degree.

The backshore has a timber path along this segment of wall that slopes inshore 2 to 4 degrees at the top of the wall. The path follows the elevation change from east to west sloping to accommodate the elevation change. Inshore from walkway is a strip of grass with a paved parking area further inshore similar to what is typical on other sections.

There is no evidence of failure in this segment of wall however the lean to the wall suggests movement. The lower elevation of the west end is substantially below the design high water level for this area which is 178.0m GSC. This low elevation means it does not protect against flooding and the backshore would sustain damage during a design storm event. The remainder of the wall extends up to the design high water level but will be overtopped during design storms. Although the wall in this segment shows no structural deficiencies other than excessive lean, it cannot be established that the wall can be readily upgraded to provide the required flood protection.

2.6 Segment 5

This segment of wall turns north and is similar to the previous segment. The segment is approximately 22 m long. The top of deck is approximately 1.1m above water level (177.8m IGLD85). The ¾" diameter wale bolts are spaced either 1.2m or 1.8m apart except for the first two that are approximately 2.4m apart. No tie rods were visible on the outside of the wall. The top of wall has a 1 to 2 degree lean in toward the backshore along its entire length while the backshore path is mostly flat (Photo 14). Approximately a third of the way down the wall from the south end there is a 90mm diameter pipe coming through the wall approximately 240mm down from the top of the wall. Docks extend perpendicular to the wall.

There is no sign of failure and the lean at the top of the wall is minor in this segment. As with the previous segment this wall is below the design high water level and would be overtopped during a high water event which could cause damage to the backshore. In this condition the wall is considered under designed for the area's coastal conditions. Although the wall in this segment shows no structural deficiencies, it cannot be established that the wall can be readily upgraded to provide the required flood protection.

2.7 Segment 6

This segment of wall turns west and runs for approximately 71 m long. Access to this segment of wall was restricted due to the pile supported deck in front of the wall. The edge of the pile supported deck is then faced with timber which obstructed a clear view under the piled deck towards the wall. The inspection was completed using a high definition video camera taking continuous video of the wall between the horizontal timbers of the outer timber fenders. A review of the video indicates that the construction of this steel sheet pile wall is similar to that in reach 5 with a couple of exceptions. We observed no wailer bolts on the sheet piles. If present they would have to be very close to the top and obstructed by the deck structure or very low and be below water. Both conditions would be different than construction details in other part of the site. There were, what are likely anchor rods protruding through the wall at irregular intervals. The rods has a random piece of steel, typically a channel or plate, secured on the rod at the wall which appeared to be acting as a bearing plate. The rods extended a random length beyond the wall, in most cases 0.5m to 1.5m. No holes in the steel sheet piles or improper joints between the piles were noted.

The verticality of the wall could not be measured, but not obvious misalignment was noted. The top elevation of the wall remains the same as the previous segment. As noted in the other segments this puts the top of wall below the design high water level and as such the wall is considered under designed for the area's coastal conditions.

2.8 Segment 7

This is the furthest north segment of the wall. The segment is approximately 109 m long. It extends in an approximately south to north direction. The top elevation of the wall is 1.1 to 1.2m above water level which provides crest elevation of 177.6 to 177.7m IGLD85. The south part of the segment is the typical steel sheet pile wall seen on the other segments. However, there is no timber walkway adjacent to this wall. The backshore consists of a grass area a few meters wide with the paved parking area further in shore.

The first 10m at the south end of the wall has a lean out at the top of the wall of approximately 2 degrees. After this point there is a failure of the wall that extends over approximately 5m of length (Photo 17). At the centre line of the failure the wall leans 6 degrees out at the top. Approximately 0.25m deep depression has formed behind the failed wall. The wall is plumb on the north side of the failure.

Past the section of failure there are docks that extend into the water. At the second set of docks there is a depression behind the wall approximately 0.3m deep. Along this segment of wall the wale bolts are smaller than other areas with only ½" diameter instead of the typical ¾" seen elsewhere. They are located 400mm from the top of the wall. No tie rods were visible on the outside of the wall.

At the north end of the wall the construction changes from steel sheet piles to a 6mm thick by 1.2m wide plate held in place by vertically driven steel z-sections placed at the ends of the plate (Photo 18 and Photo 19). There is one tie at the centre of each plate approximately 300mm above water level. There is also a steel cap on south end of the wall. It is not connected to the wall for approximately 10m at the north end of this section. A depression behind the wall is

located at the connection between the steel plate structure and the sheet pile wall to the south. The sheets are not tight with the vertical z-section at the north end of this segment

This segment of wall has failed on the south end of the segment. In our opinion, the Z pile and plate segment is also unsuitable protection and will require replacement. The top elevation of the wall is also below design high water level along its entire length meaning it is unsuitable for the design coastal conditions. The backshore is susceptible to flooding.

2.9 Haul Out and Boat Slip

The marina area has two slips at the north end of the site (Photo 20). The two slips are separated by a pile supported "deck" which serves as the south travel ways. We assume that this pile supported structure will be removed and it was not reviewed.

The south wall of this area was difficult to review as it has a cantilevered, pile supported deck in front of it with a timber facing on the west end. The wall however appears to be a continuation of the "z" piles with steel sheets from the previous segment. The wall may also include some steel sheet piles, as one is visible at the corner. The visible steel sheet pile is not connected with the adjacent steel pile. There is a timber walkway for approximately 5m at the west end but a concrete deck supported by steel piles continues east along the shoreline towards the ends of the slips. The walkway and deck are at an elevation of approximately 177.7m IGLD85.

The east wall forms the ends of the slips (Photo 21). It appears to be constructed of newer steel sheet piles. The profile at this location is the same as the previous sheet piles. The backshore behind these sheet piles is poured concrete with a drainage grate (Photo 22).

The north wall is a continuation of this sheet pile wall for approximately 50m to the west. After this point the wall turns north toward the shore where it ends. This wall forms the north end of the study area.

The shoreline that continues west is a stone revetment with a timber walkway along the length of the shore and docks extending into the water from the walkway as seen in Photo 22.

The south wall in this section is unsuitable for shoreline protection for the same reasons as were noted in Segment 7. The newer east and north walls are in good condition with no signs of failure or extensive deterioration.

2.10 Summary of Condition & Remaining Service Life

The Bay Mooring Marina walls are in poor condition with the exception of the newer segments along the Boat Slip east and north walls. There are signs of failure along multiple segments of the wall, signaling that these segments were overstressed and/or are at or nearing their end of life. It is probable that the steel sheet piles walls were never properly design for a specific design life or design conditions. The backshore is showing sink holes and voids associated with the noted wall failures. Some segments of the wall have a crest elevation below what is now accepted as the design high water level leaving the backshore exposed to wave penetration, flooding and potentially damage.

The existing sheet pile sections were analyzed based on known section and layout parameters and reasonable assumptions on soil characteristic, strength of steel, rust rates and embedment. A pedestrian load was placed on the backshore and the wall was analyzed for various heights above the lakebed. It was found that the induced bending moment exceeds the capacity of the piles when the top of wall is more than 3.0m above the lakebed. The lakebed and thus high of wall varies across the site however this condition exists currently in segments 2, 3, 6 and 7.

Each segment of the wall has been classified as defined in Table 1. This classification can be found in Table 2.

The remaining service life has also been estimated for each segment. Remaining service life is a best estimate based on known age of a structure, expected material durability and condition determined during inspection. Unless an item is in need an immediate repair it was given a minimum 5 -10 year life expectancy. Service life also depends on regular maintenance, otherwise estimated life may be less. A summary of the remaining service life for each segment is also found in Table 2.

Table 1 - Overall Condition Classifications

Overall Condition Rating	
Poor	At end of life, may have signification structural or functional deterioration
Fair	Nearing end of life/ Functional but showing concerning signs of deterioration
Good	Structurally sound but showing minor signs of deterioration
Excellent	New or as-new condition

Table 2 - Condition and Service Life by Segment

Segment	**Condition Rating**	**Remaining Service Life**
Revetment	Good	15+
1	Poor	0
2	Poor	0
3	Fair	5-10
4	Fair	5-10
5	Fair	5-10
6	Fair	5-10
7	Poor	0
Boat Slip	Poor (south wall) Good (east and north wall)	0 (south wall) 15+ (east and north wall)

3 Natural Hazards

The Provincial Policy Statement identifies three natural hazards that must be considered along the shores of the Great Lakes including Georgian Bay. These hazards include the dynamic beach hazard, the erosion hazard and the flood hazard. Each of these hazards is discussed below.

3.1 Dynamic Beach Hazard

The definition of a dynamic beach is described in the Technical Guidelines to the Provincial Policy Statement. As there is no beach at the site the dynamic beach hazard is not applicable.

3.2 Erosion Hazard

The erosion hazard limit is a combination of the erosion hazard, which is the erosion rate applied over 100 years, and the stable slope allowance. The “default” erosion value suggested by the Technical Guidelines is 0.3m/yr. for the Great Lakes and 0.15 m/yr. for small inland lakes for areas where no site specific erosion values are available. There is no long-term measured erosion data along this part of the shoreline. The nearest erosion station on the open Georgian Bay shoreline is station H-6 (Coastal Zone Atlas, MNR/EC 1975) which shows historical recession of less than 0.07 m/yr.

The technical guide also makes special provisions for artificial shorelines. The intent of the artificial shoreline is to acknowledge that large areas of infill can exist where typical erosion processes associated with natural shoreline are not applicable. Artificial shorelines must be protected with shore protection structures that are maintained indefinitely. The provincial guidelines set out criteria for identifying artificial shores. Among the criteria are aspects of length of shoreline and ownership. The criteria set out to define an artificial shoreline do not fully apply to the Bay Mooring Marina site.

The other consideration for the erosion hazard limit is the stable slope allowance for the site. The stable slope is established using the toe of the existing sheet pile wall as the toe of the structure. Considering the soundings taken during the inspection the toe can be set at 174.5m while the backshore is at 178.0m. The stable slope ratio of 3h:1v is the standard applied when there isn’t any site specific geotechnical investigation. Applying this ratio results in a stable slope setback of 10.5m ((178-174.5) x 3).

We are of the opinion however that the Bay Mooring Marina site is an infill location and protecting the site indefinitely would follow the intent of the provisions for artificial shoreline. The solutions that we present for protecting the site will have a minimum design life of 50years but with proper maintenance could last much longer. This approach would allow for an erosion rate of zero. However, the provision must allow for full maintenance access to all components of the protection works. In our preliminary assessment and based on the preliminary design of protection works presented in chapter 4 of this report, the limit of development is approximately 10 meter behind (landward) of the existing shore protection works in segments 1 to 7.

Without the provision of new continuous shore protection works it is our opinion that the erosion hazard limit should be established by using 0.1 m/yr erosion rate over 100 years plus the stable slope allowance. This produces an erosion hazard of approximately 20.5 m behind the existing protection works in reaches 1 to 7. This limit is depicted in Figure 3. This limit does not assign any value to the existing protection works but also does not allow for potentially higher erosion rate of fill material that may be placed at the site.

3.3 Flood Hazard

The flood hazard limit is defined as the 100-year flood level (which is the instantaneous water level with a 1% probability of occurrence) plus an allowance for wave uprush and other water related hazards. MNR (1989) calculated 100-year flood levels along the Great Lakes shorelines using a combined probability analysis of the 100-year mean lake level and the 100-year wind setup (storm surge). The Bay Moorings property is located in Sector H-14 of that study, which has a 100-year flood level of 178.0m GSC.

MNR (2001) defines the flood hazard wave uprush elevation as that caused by a 20-year return period wave occurring at the 100-year flood level. The 20-year return period wave condition was estimated by modeling wave generation caused by a 20-year return wind using the SWAN spectral wave model developed by Delft Hydraulics. A total of nine wind directions were considered, ranging from south through to north at 22.5 degree intervals (therefore south, south-southwest, southwest, west-southwest, etc.). Figure 4 is a wave height contour and vector plot showing an example of the wave model results. Significant wave heights along the perimeter of the site ranged from 0.3m to 0.8m.

Wave conditions around the site were input to a profile-based wave uprush program. Uprush was calculated for a number of representative profiles, and the wave uprush limit was interpolated between profiles giving regard to the site contours. Wave uprush beyond the 178.0m contour was minimal because that contour was some distance in from the existing shore protection walls, and those walls break the incoming waves. Water depths between the walls and the 178m contour were in the order of 0.3m or less, so only small broken wave bores reach the 178m contour. The calculated wave uprush limit, which defines the flood hazard limit, is shown on Figure 3.

4 Development Discussion

Development can take place landward of the most landward shoreline hazard without provision of any new shore protection works. This is to say development outside the identified hazard areas for erosion or flooding does not require any improvements to the shoreline. Development can encroach into the shoreline hazard zone as long as the hazards are addressed. The shoreline hazards can be addressed with the provision of a new shore protection works and site grading designed according to accepted design and scientific principles.

Replacing the current shore protection with a properly designed and installed protection structure with a design life of approximately 50 years and crest elevation to reduce wave overtopping to an acceptable level will allow this encroachment into the shoreline hazard zone. The 50 year design life is based on the longest design life contemplated in the provincial Technical Guides for Great Lakes St. Lawrence River System and Large Inland Lakes. A maintenance access to the shore protection works of not less than 5 meters must be also included as a permanent feature of the site.

4.1 Shore Protection Options

Assuming the development is not placed outside the hazard zone there is one rehabilitation option for the existing wall and two options for new shoreline protection designed to overcome erosion and flooding. For sections of the wall that have not yet failed there is the option of improvements that would provide adequate protection against erosion and flooding. This option would include a concrete cap along the top of the existing steel sheet piles to raise the elevation to 178.3m. A rock berm would also be placed in front of the wall to strengthen the sheet piles, providing stability to the wall while allowing waves to break against the berm and energy to dissipate. A depiction of this option can be seen in Figure 5. It should be noted that the sections of wall that have failed, which includes segments 1, 2 and 7, will need to be replaced with one of the new options described below.

The two new shoreline protection options that we would propose are a stone revetment or a new sheet pile wall. One or any combination of the two can be used to overcome the hazards. A depiction of each preliminary option can be found in Figure 6. To protect against flooding and reduce the wave overtopping rate to acceptable levels, the top of all these structures should be at a minimum elevation of 178.3m.

Wave overtopping rates for the proposed new shoreline structures were calculated for the design wave conditions determined during the flood hazard assessment. With a wall or a revetment crest elevation of 178.3m, mean overtopping rates varied from approximately 20 to 50 l/s/m along the site. A mean overtopping rate of 50 l/s/m associated with a significant wave height less than 1m is a tolerable overtopping rate that can be accommodated with a hardened surface landward of the wall. The hardened surface can be reduced or possibly eliminated if the elevation of the structure crest elevation is increased. This area should be graded with positive drainage back towards the harbour.

The sheet pile wall option can be installed either landward of the existing structure, or directly in front of the existing structure. Installing the wall offshore, then removing or cutting down the old structure to install tie backs, is typically how repairs of steel sheet piles wall are completed. However, extending into the water and reclaiming land may require habitat compensation measures by MNRF or DFO and any infill should be kept to a minimum. For the revetment, areas under the fish habitat water elevation can be balanced so that fish habitat destroyed balances the area created. This is a typical method used to avoid having to install additional compensation measures. This is depicted in cross sections shown on Figure 6. For the rehabilitation option the revetment will occupy the lakebed and destroy fish habitat. Habitat compensation measures would be decided once the extent of destruction is known and evaluated by the regulatory officials.

Maintenance access will need to be provided for the full design life of the chosen structure to be considered. The minimum access should include a 5m wide path from the roadway to the shore and a 5m allowance along the length of the protection. The path from the roadway to shore can be provided by way of a 5m allowance between buildings shared by the two properties and maintained as a right of way. Maintenance is not expected to be necessary for decades once the shore protection structure is in place. Due to the sheltered nature of the bay it is possible this maintenance could be completed from the water eliminating and disturbance to landscaping features placed in the 5m between properties or along the length of the wall. Based on the configuration of the preliminary design of a revetment and a steel sheet pile wall, the proposed limit of development is approximately 10 meters behind the existing steel sheet pile wall in reaches 1 to 7 and is shown in Figure 3 as the development setback. The 10 m limit is proposed as the distance anticipated as the distance required for a standard anchor behind an anchored steel sheet pile wall.

5 Conclusions

A portion of the property you are looking to develop is within a shoreline hazard, as defined by the Provincial Policy and supporting technical guide. The current shoreline structures do not provide the necessary protection against erosion and/or flooding, as many segments of the protection works are at the end of their design life or are not properly designed for the coastal conditions at the site. The extent of the shoreline hazard under existing conditions is dictated by the flood hazard and/or erosion hazard and is depicted on Figure 3.

New shoreline protection structures can overcome the flood and the erosion hazard and allow development within the existing shoreline hazard. The minimum development setback with the provision of new shore protection works with a design life of 50 years is proposed to be 10 m. The protection structures will need to be maintained indefinitely to overcome the erosion and flood hazards.

The properly designed shore protection options presented for future development include rehabilitating the existing wall or replacing it using either a revetment or sheet pile wall or combination of the two. It is our professional opinion that a new residential development can be constructed at the desired location if the appropriate shore protection is put in place and maintenance access provided. If the new residential development is placed behind the existing flood and erosion hazard limits identified, no remediation of the shoreline is required to overcome the hazard.

6 APPENDIX A – FIGURES

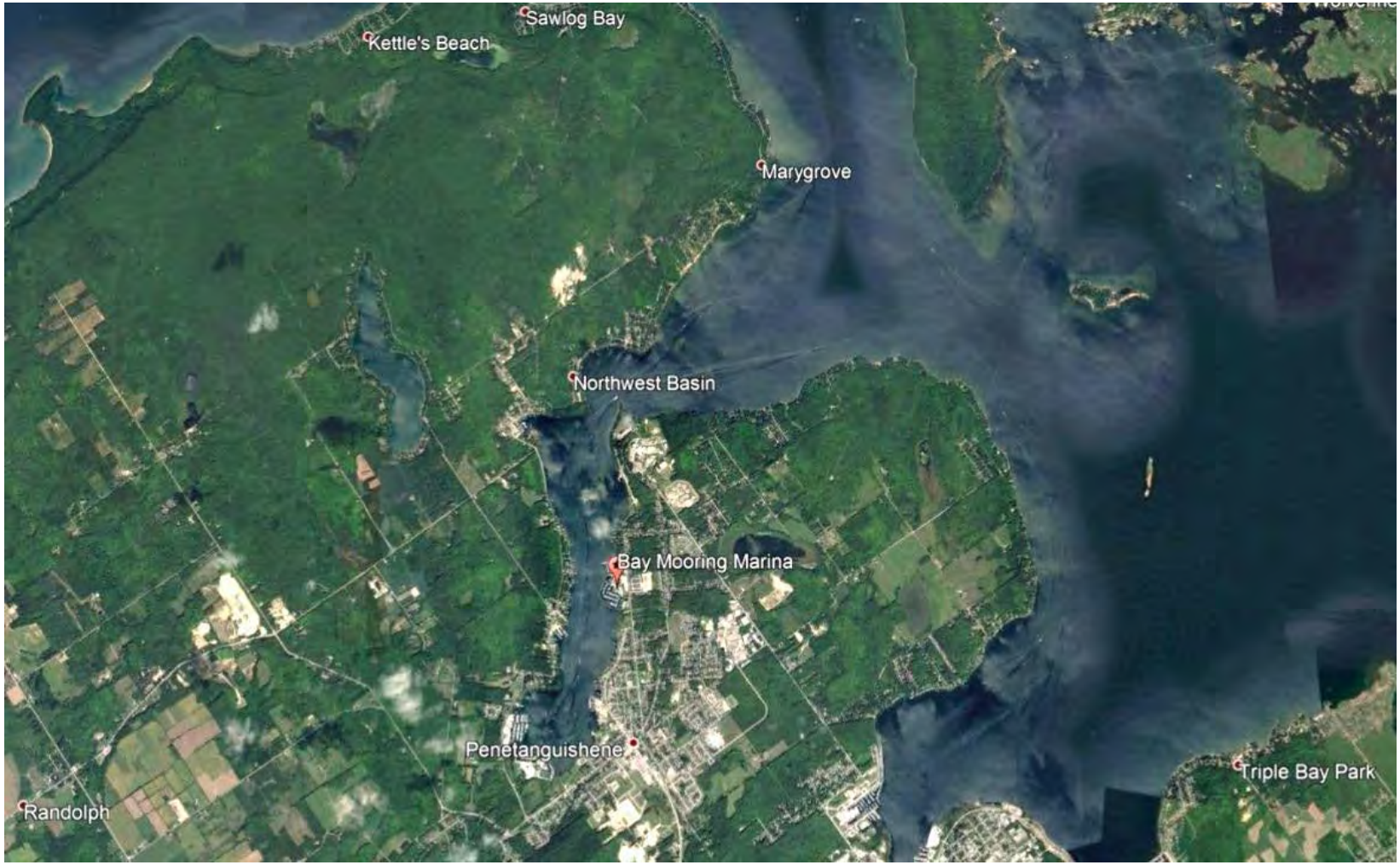
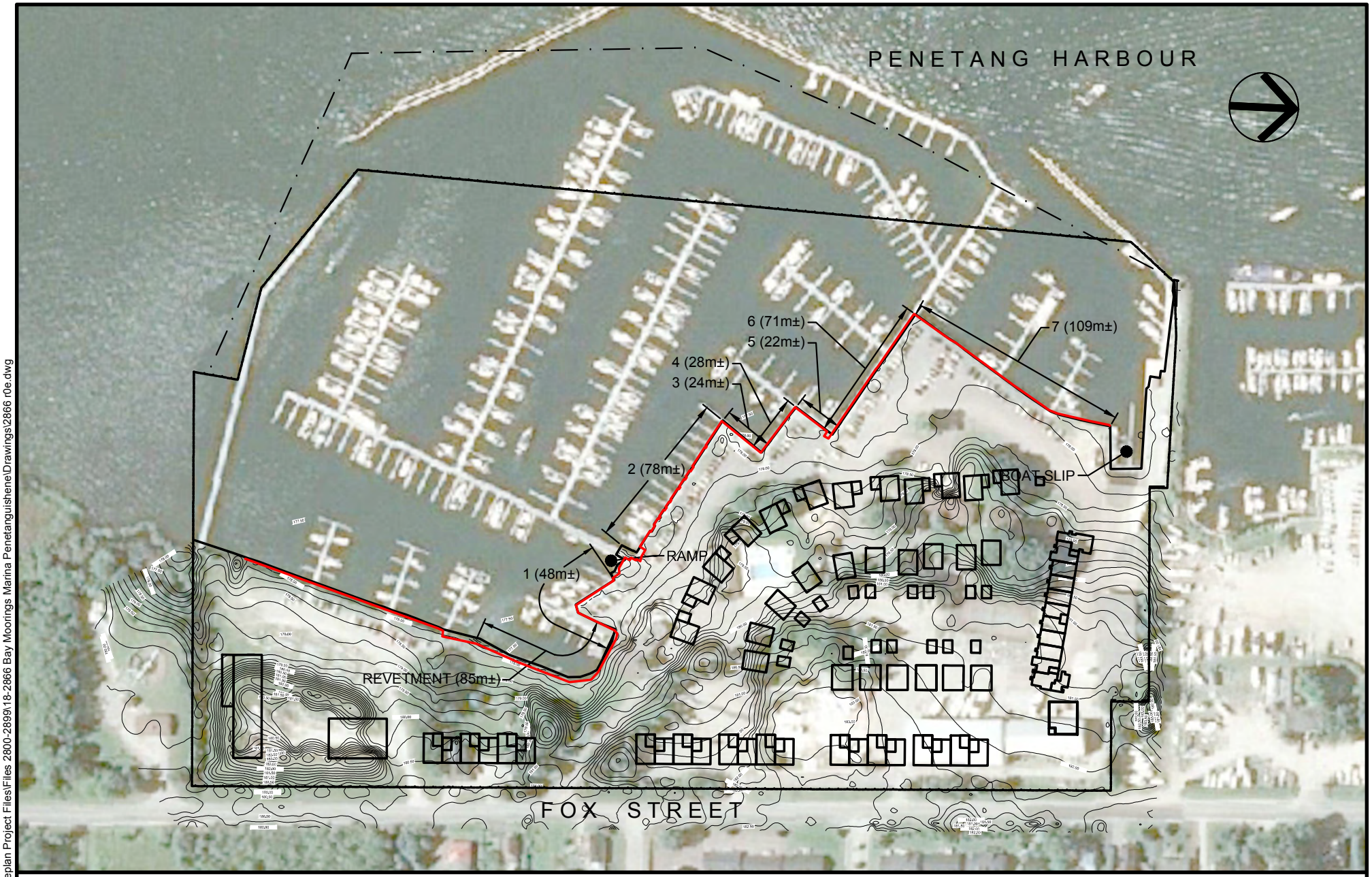


Figure 1 – Site Location



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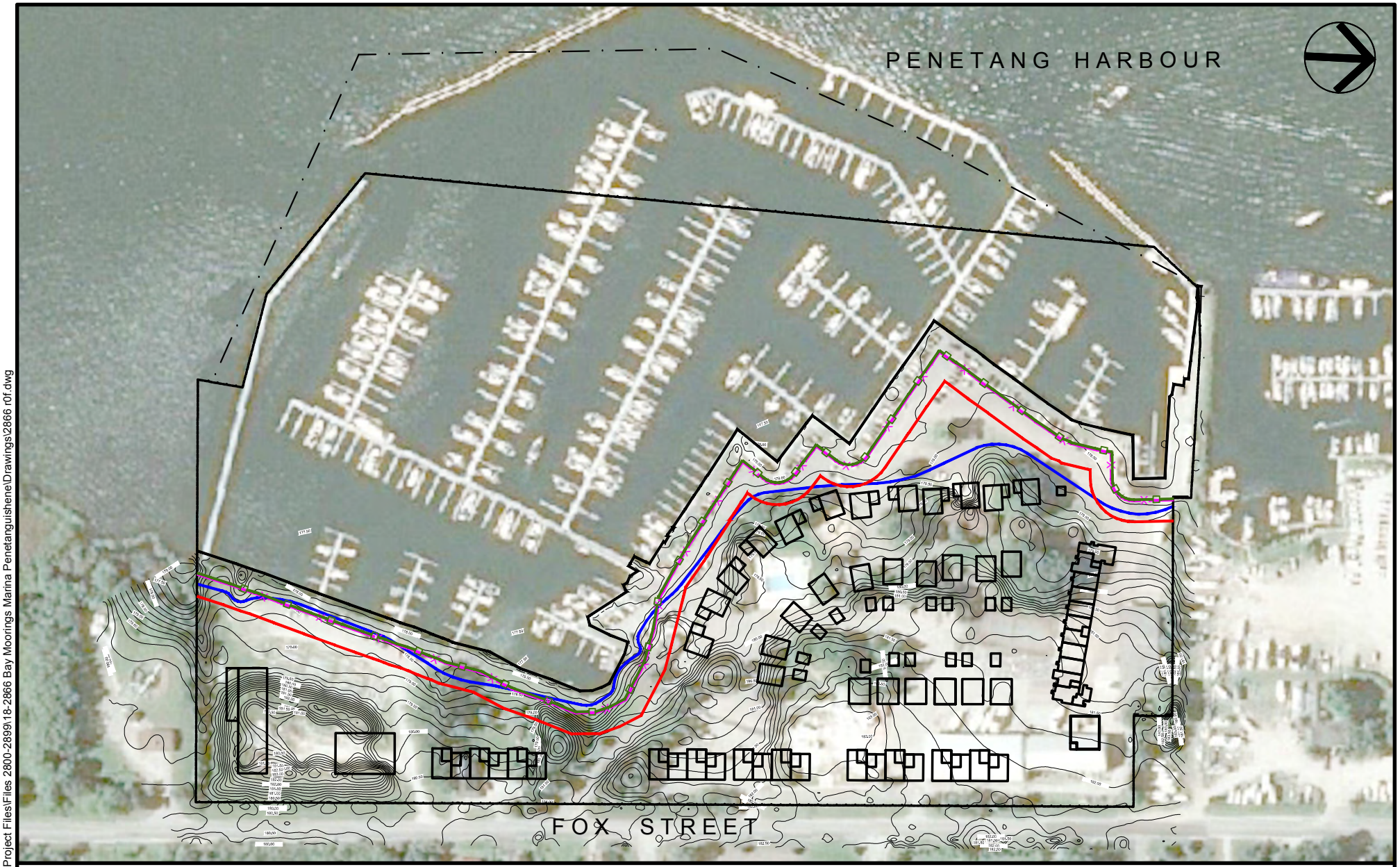
Scale 1:2500

SHOREPLAN

Project 18-2866, Figure 2
Bay Moorings Marina, Penetanguishene
Site Plan

Drawing Location: S:\Shoreplan Project Files\Files 2800-2899\18-2866 Bay Moorings Marina Penetanguishene\Drawings\2866 r0e.dwg



50 0m 50 100

LEGEND

- STABLE SLOPE ALLOWANCE 10.5m
- FLOOD HAZARD
- EROSION HAZARD
- DEVELOPMENT SETBACK WITH NEW PROTECTION WORK (see SHOREPLAN 2019)

Project 18-2866
Scale 1:2500
SHOREPLAN

Figure 3
Bay Moorings Marina, Penetanguishene
Development Hazard Limits

Drawing Location: S:\Shoreplan Project Files\Files 2800-2899\18-2866 Bay Moorings Marina Penetanguishene\Drawings\2866 r0f.dwg

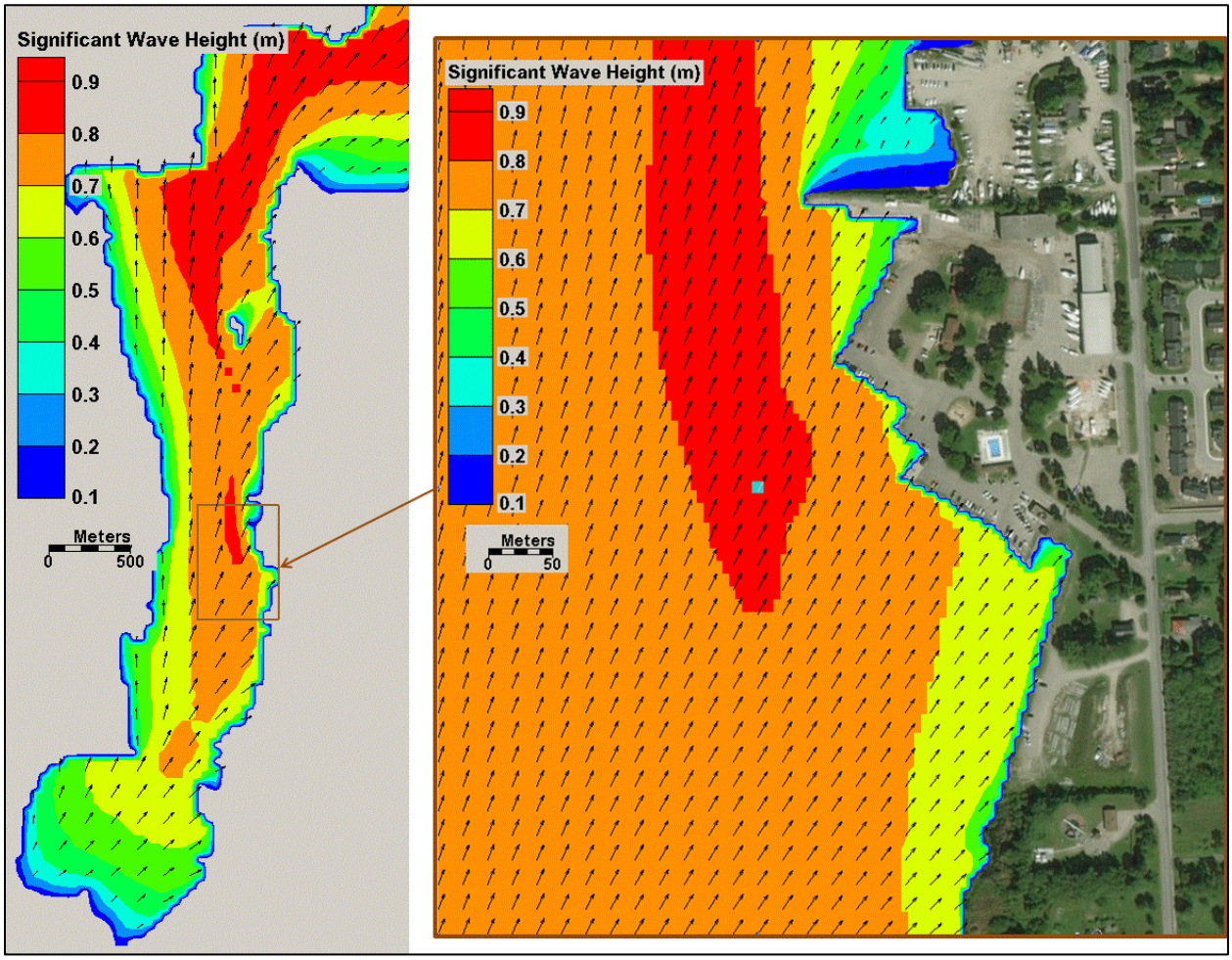
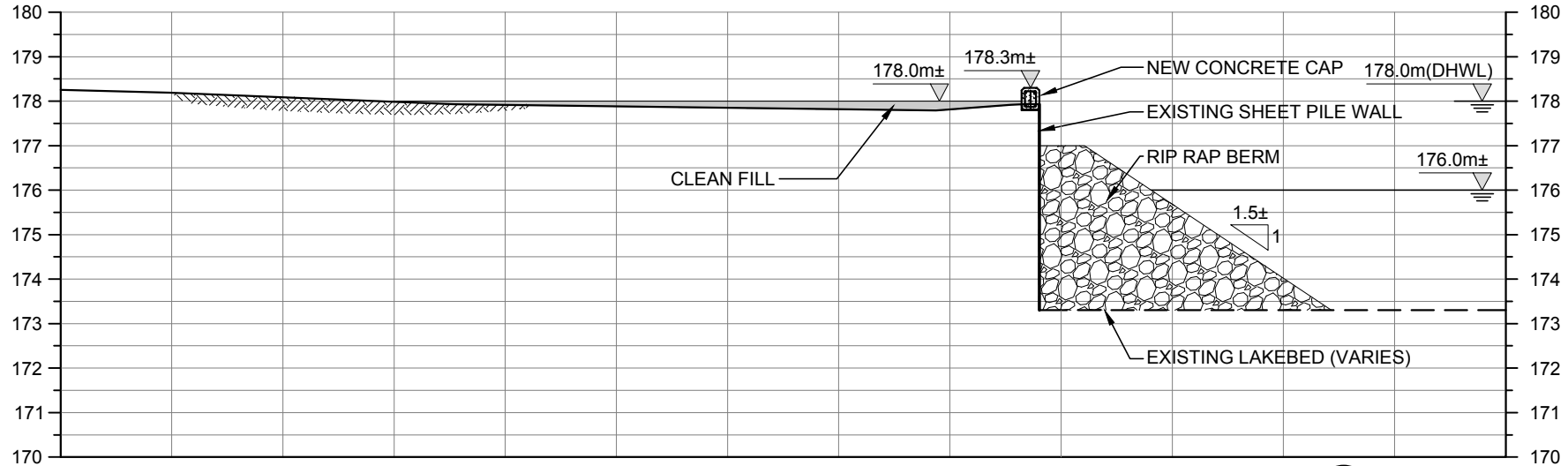


Figure 4 – Wave Model Results for Southwest Winds

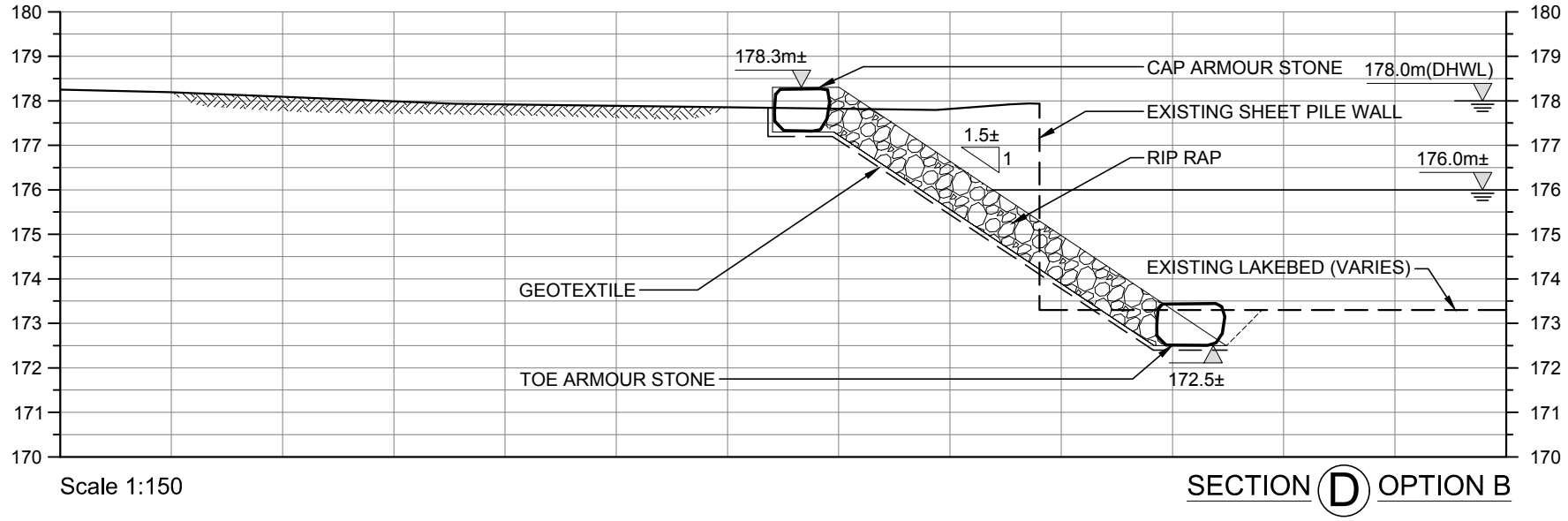


Scale 1:150

SECTION D OPTION A

Project: 18-2866
Scale 1:150
SHOREPLAN

Figure 5
Bay Moorings Marina, Penetanguishene
Rehabilitation Typical Sections



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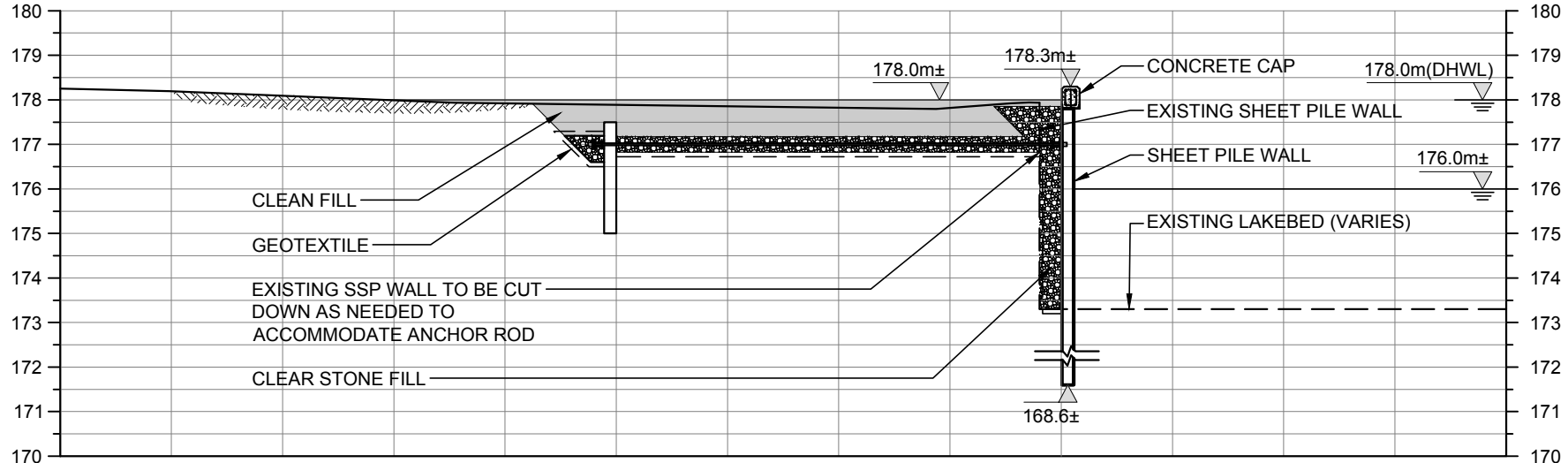
SECTION D OPTION B



Scale 1:150

SECTION D OPTION C

Project: 18-2866
Scale 1:150
SHOREPLAN

Figure 6
Bay Moorings Marina, Penetanguishene
New Typical Sections

Drawing Location: S:\Shoreplan Project Files\Files 2800-2899\18-2866 Bay Moorings Marina Penetanguishene\Drawings\2866 r0e.dwg

7 APPENDIX B – PHOTOS

Photo 1 – Revetment

Photo 2 – Revetment

Photo 3 – Segment 1 – Concrete Cap on Timber

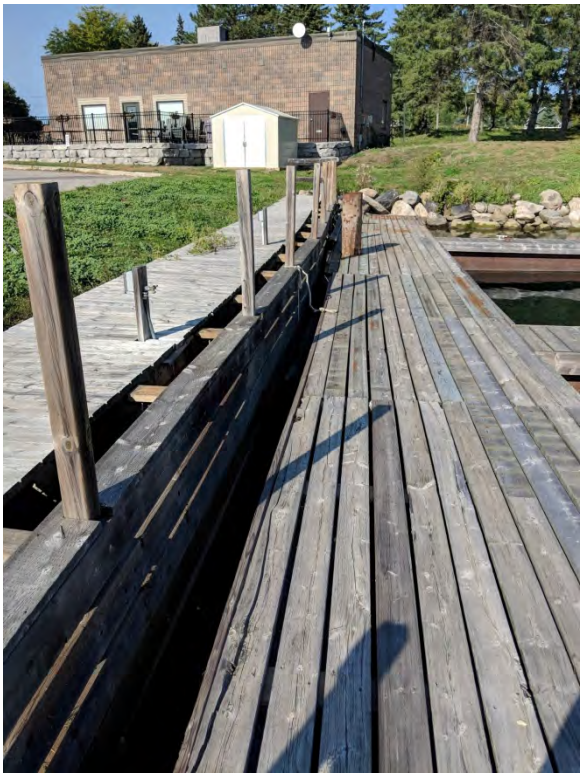


Photo 4 – Segment 1 – Timber Docks Running North South

Photo 5 – Segment 2 – Sheet pile wall

Photo 6 – Segment 2 – Dock Extending from Sheet Pile Wall

Photo 7 – Segment 2 - Fill Material Behind Wall

Photo 8 – Segment 2 – Failed Area

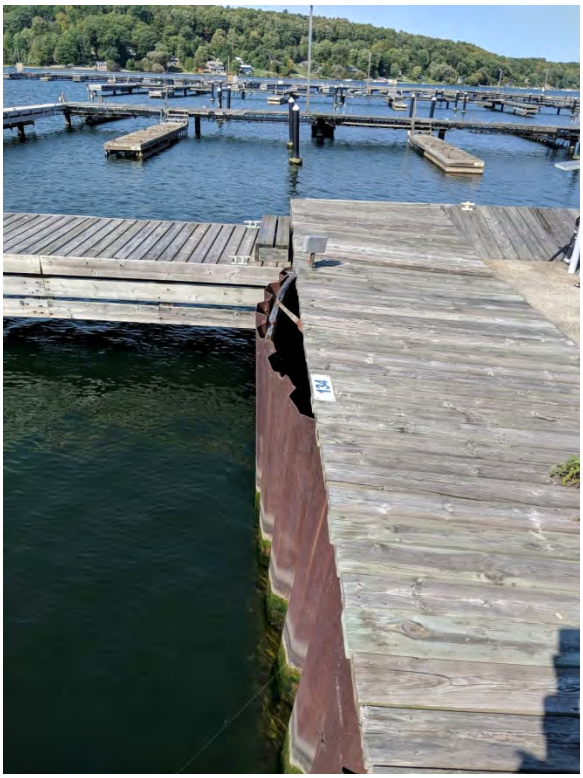


Photo 9 – Segment 2 – Close up Failed Area

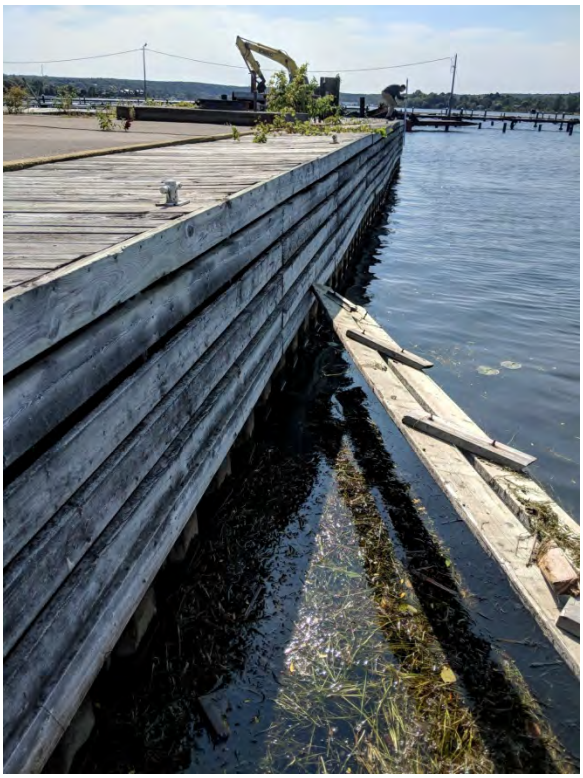


Photo 10 – Segment 3 – Timber Faced Wall

Photo 11 – Segment 3 – Concrete Pad

Photo 12 – Segment 4 – Steel Sheet Pile Wall

Photo 13 – Segment 4 – Lower End of Wall

Photo 14 – Segment 5 – Steel Sheet Pile Wall

Photo 15 – Segment 6 – Timber Faced Timber Deck In Front of Wall

Photo 16 – Segment 6 – Timber Deck In Front of Wall

Photo 17 – Segment 7 - Failed Area

Photo 18 – Segment 7 – Transition to Steel Plate Wall

Photo 19 – Segment 7 – Steel Plate Wall

Photo 20 – Boat Slip Wall

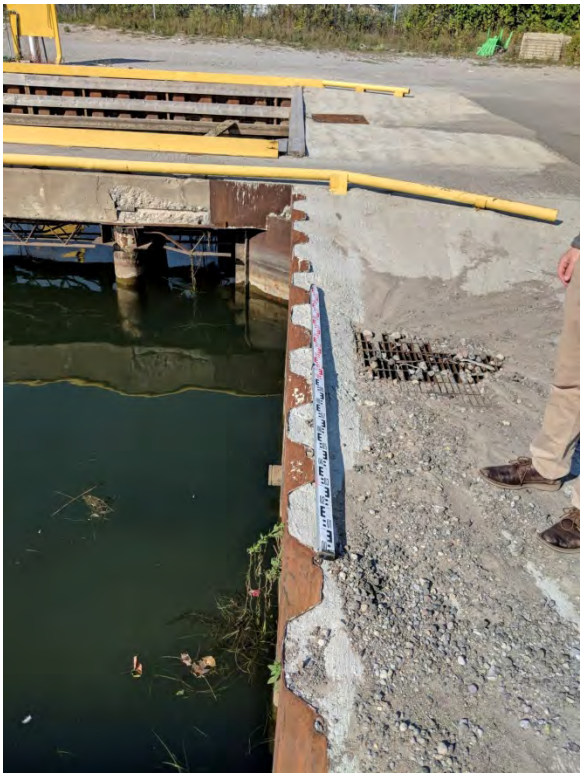


Photo 21 – Boat Slip Wall Close up

Photo 22 – Boat Slip Backshore