FINAL REPORT

Midland Bay Landing

Assessment of Shoreline Conditions and Treatments

prepared for

Town of Midland

prepared by

Shoreplan
Engineering Limited

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SHOREPLAN

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by

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01	2015-08-25	Draft	for review
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1 Introduction

Midland Bay Landing is located in the Town of Midland, Ontario, on the south shore of Midland Bay, Georgian Bay. Shoreplan Engineering Limited (Shoreplan) was initially retained by Consar Building Corporation (Consar) to complete a review of the existing shoreline and prepare preliminary shoreline treatment options. A draft report was submitted to Consar but was never finalized.

This final report is now being issued to the Town of Midland. This report presents the previous work with an updated construction budget plus additional information requested by the Town of Midland. Prices have been revised where noted to account for inflation and are marked as 2017. References to client beyond this point of the report, name the Town of Midland as the client with respect to this report.

1.1 Assignment

Shoreplan Engineering Limited (Shoreplan) was retained by the Town of Midland to undertake a condition inspection of the existing shoreline and prepare concept level shoreline treatments. The following work items are included within the scope of the assignment:

- site review, diving inspection and sounding survey
- wave hindcast and nearshore wave transformation for the site,
- preliminary coastal assessment of the existing shoreline based on the results of the site review, diving inspection and wave assessment,
- development of preliminary shoreline improvement concepts,
- preferred concept refinement,
- preparation of a coastal brief, and
- description of the approval process for waterfront construction

Shoreplan and General Diving Contractors Inc. (General Diving) carried out the diving inspection of the existing shoreline on June 22 and 23, 2015. The above water portion of the shoreline was also visually inspected from the diving boat and from land at that time and during other site visits. This report presents the remainder of the items within the scope of the work.

1.2 Site Location

The Midland Bay Landing shoreline is located on Georgian Bay within the Town of Midland. The location of the subject shoreline is shown on the location plan on Figure 1-1. The approximate extent of the shoreline within the study area is shown on Figure 1-2. The length of the property along the existing shoreline is approximately 1.1 kilometres.

The subject shoreline has been divided into three reaches for the purposes of describing the existing conditions and the preparation of concept level shoreline improvements. The three

reaches are the East Reach, the Centre Reach and the West Reach. They correspond to the three general alignments of the shoreline and are shown on the site plan on Figure 1-2. The East, Centre and West reaches are approximately 304 m, 388 m and 291 m long respectively.

1.3 Report Structure

The report is organized as follows. Chapter 2 provides a description of the existing coastal conditions on the site. Chapter 3 provides a summary of the existing physical conditions at the site observed during the diving inspection and above water inspection. Preliminary shoreline treatments are presented in Chapter 4 along with a cost estimate for each option. A natural hazards assessment of the site is provided in Chapter 5. A summary and recommendations are provided in Chapter 6. Figures are provided at end of each chapter. Tables are incorporated into the text where they are first referenced. Photos are provided in Appendix A.

Figure 1-1: Location Plan

Figure 1-2: Location Plan (Not to Scale)

2 Existing Coastal Conditions

2.1.1 Water Levels

Water levels on Lake Huron fluctuate on short-term, seasonal and long-term bases. Briefly, seasonal fluctuations reflect the annual hydrologic cycle which is characterized by higher net basin supplies during the spring and early part of summer with lower supplies during the remainder of the year. Figure 2-1 is a hydrograph for Lake Huron showing both recent and long-term mean monthly water levels with respect to chart datum. Chart datum for Lake Huron is 176.0 metres above the 1985 International Great Lakes Datum (IGLD85). To convert IGLD85 datum to Geodetic Datum using the Collingwood benchmark, 0.04 metres must be subtracted from the IGLD85 elevation.

The continuous black line in Figure 2-1 shows recently recorded monthly water levels and the continuous grey line shows the long-term mean monthly water levels. The red and blue horizontal lines show the maximum and minimum monthly mean over the period of record from 1918 to 2014. These are mean monthly water levels, not instantaneous levels and therefore do not represent the highest and lowest water levels on record.

It can be seen from Figure 2-1that water levels generally peak in the summer (July) with the lowest water levels generally occurring in the winter (February). The average annual water level fluctuation is approximately 0.3 metres. Although water levels below chart datum are rare, the lowest monthly mean on record is approximately 175.6 m (IGLD, 1985), or 0.4 metres below chart datum. The figure also shows a rapid rise in water level in the spring of 2014 after a prolonged period of low water levels. Present water level is slightly above seasonal average.

Short-term fluctuations last from less than an hour up to several days and are caused by local meteorological conditions. These fluctuations are most noticeable during storm events when barometric pressure differences and surface wind stresses cause temporary imbalances in water levels at different locations on the lake. These storm surges, or wind-setup, are most noticeable at the ends of the Lake, particularly when the wind blows down the length of the Lake.

MNR (1989) investigated storm surges throughout the Great Lakes as part of their analysis of extreme water levels for design conditions. They performed a joint probability analysis of static water levels (determined from monthly mean values) and storm-surges to estimate various return periods of instantaneous water levels. Storm surge values were determined from measured water levels at specific recording stations and through the use of a numerical circulation model for locations between the recording stations. Surges at Collingwood are based on recorded data. Table 2.1 shows the 1:100-year mean monthly water levels, storm surges and instantaneous water levels for the MNR sector containing both Collingwood and Midland Bay.

Table 2.1: Water Level and Wind Set-Up Summary for MNR's Lake Huron Section H-14

Return Period (years)	2	5	10	25	50	100
Instantaneous Water Level (metres, IGLD85)	177.23	177.53	177.69	177.85	177.95	178.04
Highest Annual Monthly Water Level (metres, IGLD85)	176.71	177.00	177.15	177.30	177.40	177.48
Wind Set Up, Wind Surges (metres)	0.50	0.61	0.68	0.78	0.85	0.93

Based on data from MNR(1989), converted from IGLD 1955 to IGLD 1985 using the Canadian Hydrographic Service benchmark at Collingwood

Long-term water level fluctuations on the Great Lakes are the result of persistently high or low net basin supplies. More than a century of water level records show that there is no consistent or predictable cycle to the long-term water level fluctuations. The intervals between periods of high and low water levels and the duration of those periods vary over the length of record and vary by lake. Figure 2-2 shows Lake Huron's mean monthly water levels from 1918 to 2014. Both long-term and seasonal fluctuations can be seen in Figure 2-2.

Some climate change studies that examine the impact of global warming have suggested that long term water levels on the Great Lakes will be lower than they are today. For the time being approving agencies require that the 100-year instantaneous water level be used for the design and assessment of shoreline protection structures and the assessment of flood hazard limits. The 100-year instantaneous water level determined by MNR (1989) is frequently used as the design high water level (DHWL). For this section of shoreline on Lake Huron, the DHWL is 178.0 m (Table 2.1). We have used this water level for the assessment of the existing structures and for the development of concept level shoreline treatments.

2.1.2 Wave Analysis

A wave analysis was carried out to provide design conditions for the different preliminary shoreline treatments described in the following section. Due to the shape of Midland Bay, the largest waves reaching the site are generated by north-northeast winds. Figure 2-3 shows the bathymetry of Midland Bay and includes the outline of the numerical grid used in the wave analysis. Wave conditions were calculated using the CMS-Wave numerical model (Lin et al, 2008). CMS-Wave, which was developed by the U.S. Army Corps of Engineers, is a two-dimensional spectral wave model with energy dissipation and diffraction terms. It simulates a steady-state spectral transformation of directional random waves co-existing with ambient currents in the coastal zone. It includes features such as wave generation, wave reflection, wave diffraction, and bottom frictional dissipation.

During the Great Lakes Hindcast Database project, Philpott (1988) determined that Gore Bay Ontario winds provided the best wind data for hindcasting on Lake Huron and Georgian Bay. A peak-over threshold extreme value analysis of NNE Gore Bay winds showed the 20-year return period wind speed to be 95 kph and the 100-year return period wind speed to be 105 kph, at the 90% upper confidence interval. Those wind speeds were modeled at the 100-year water level, which was determined by MNR (1989) to be 178.0 metres geodetic.

Figure 2-4 and Figure 2-5 are wave height contour and vector plots showing the calculated wave heights and directions generated by a 95 kph sustained NNE wind, occurring at the 100-year water level. Figure 2-4 shows the results over the entire numerical grid and Figure 2-5 shows conditions at the Midland Bay Landing site. The wave conditions shown in Figure 2-5 were used in uprush and overtopping calculations as part of the preliminary design of the different shoreline treatments described in the following section. MNR (2001) suggests that 20-year return period waves occurring at the 100-year return period instantaneous water level be used for the calculation of flood hazard limits.

We typically use the 100-year storm event occurring at the 100-year water level for the design of structural elements of shoreline treatments. As noted above, the 100-year return period NNE wind was estimated to be 105 kph. Figure 2-6 shows wave conditions are the Midland Bay Landing site for a 105 kph NNE wind. By comparing Figure 2-5 and Figure 2-6, it can be seen that there is not much difference between wave conditions associated with the 20-year and 100-year return period winds.

As described in the introduction, the shoreline of Midland Bay Landing was divided into 3 separate reaches; an east reach, a centre reach, and a west reach. Figure 1-2 shows the location of the three reaches. Figure 2-7 shows the alongshore variation in wave heights along the reaches for the two design storm events discussed above, as well as the water depth fronting the reaches. The water depth and wave heights are shown approximately 15 to 30 metres offshore to represent conditions not impacted by the shoreline structures. Reach averaged design significant wave heights were 2.0m, 1.7m, and 1.4m, respectively, for the East, Centre and West Reaches.

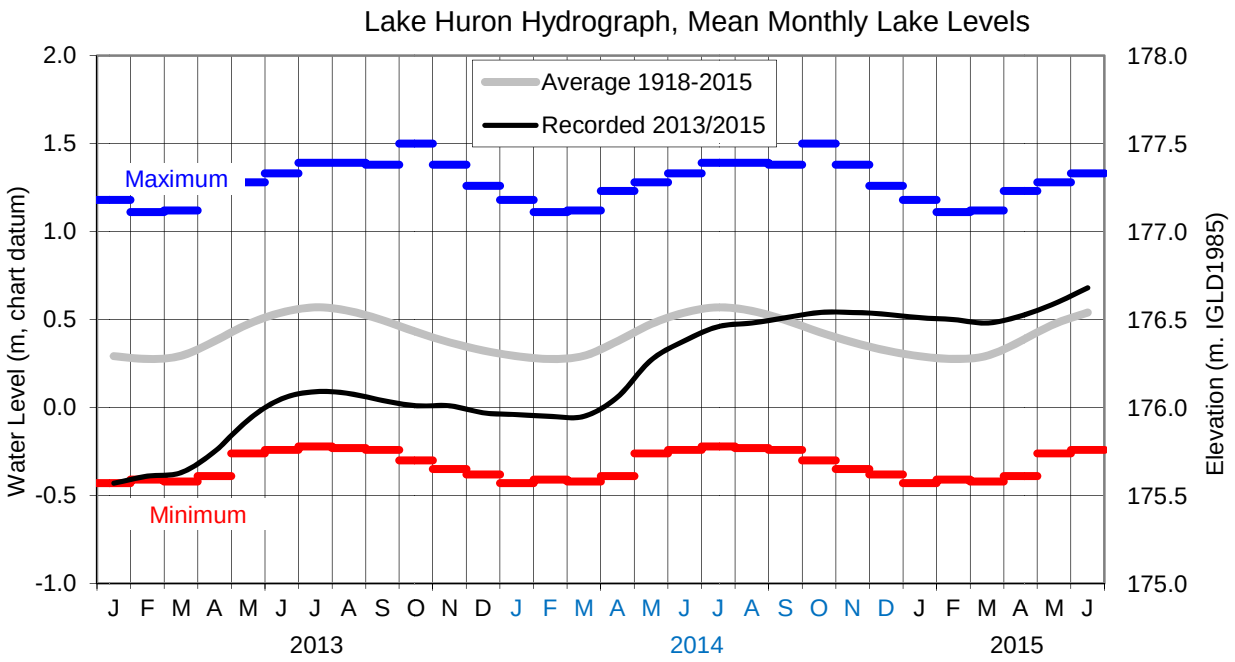


Figure 2-1: Lake Huron Hydrograph

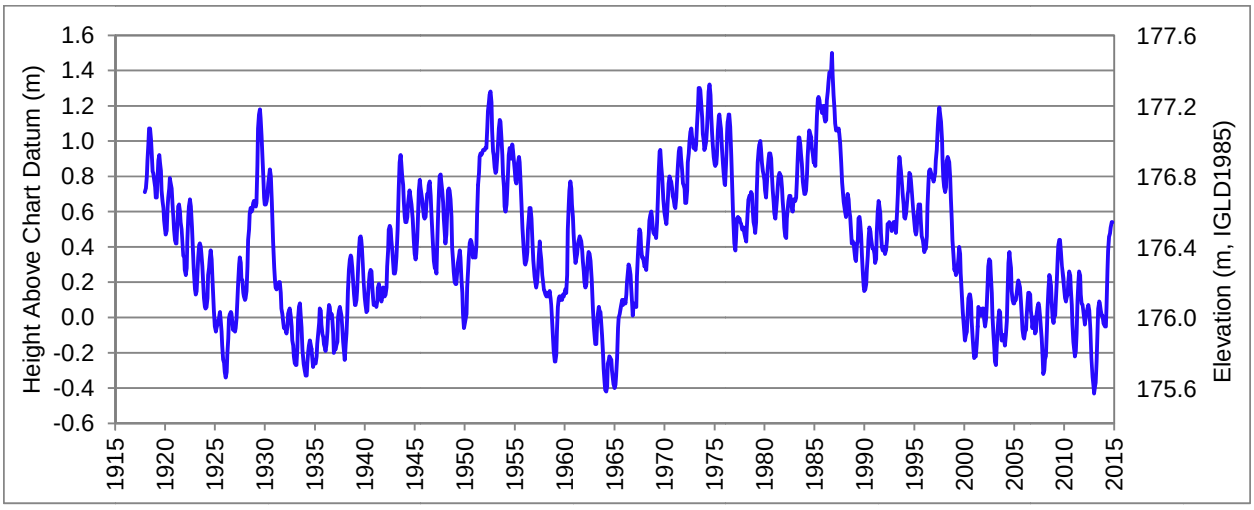


Figure 2-2: Lake Huron Monthly Mean Water Levels, 1918 – 2014

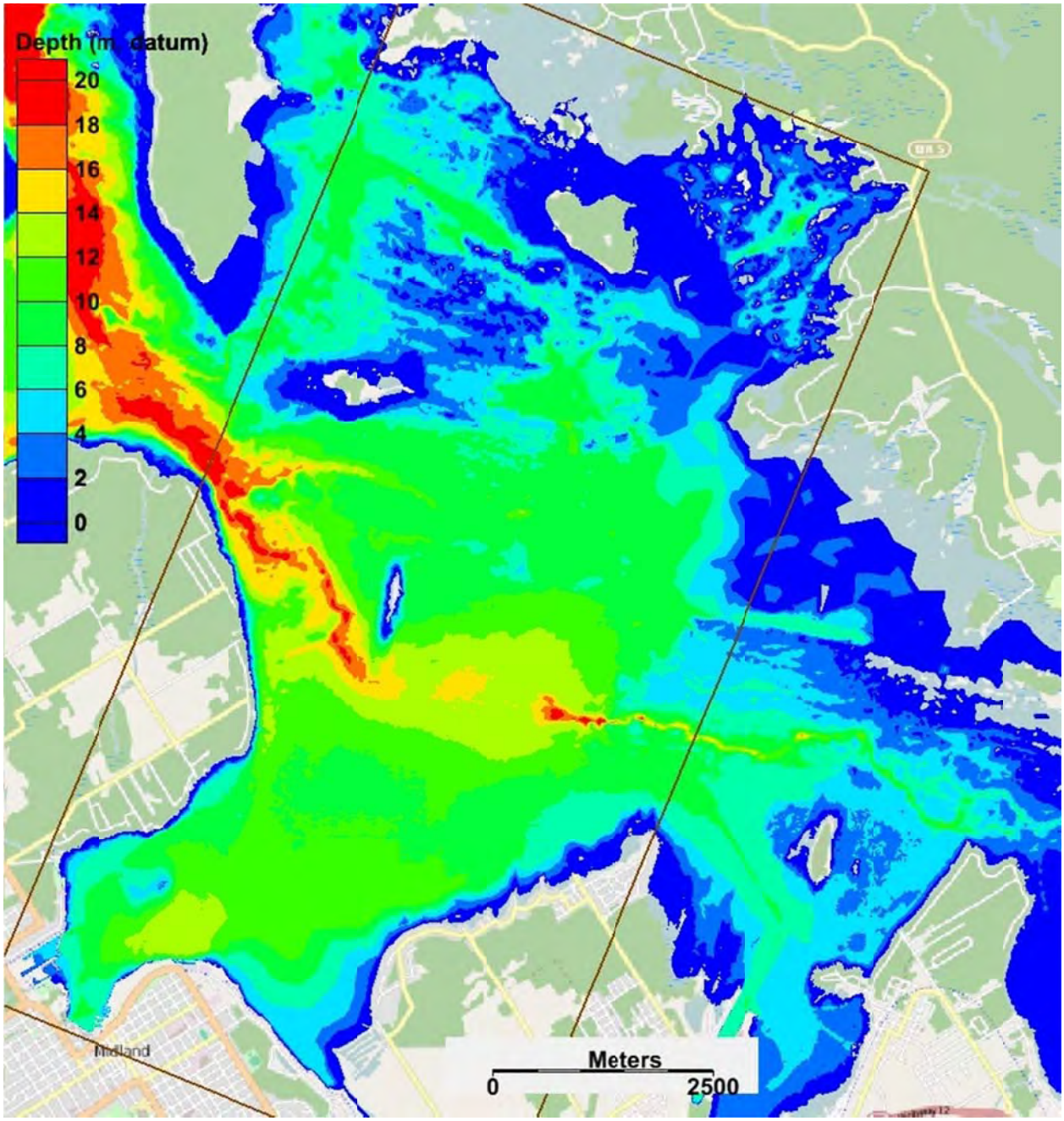


Figure 2-3: Midland Bay Bathymetry

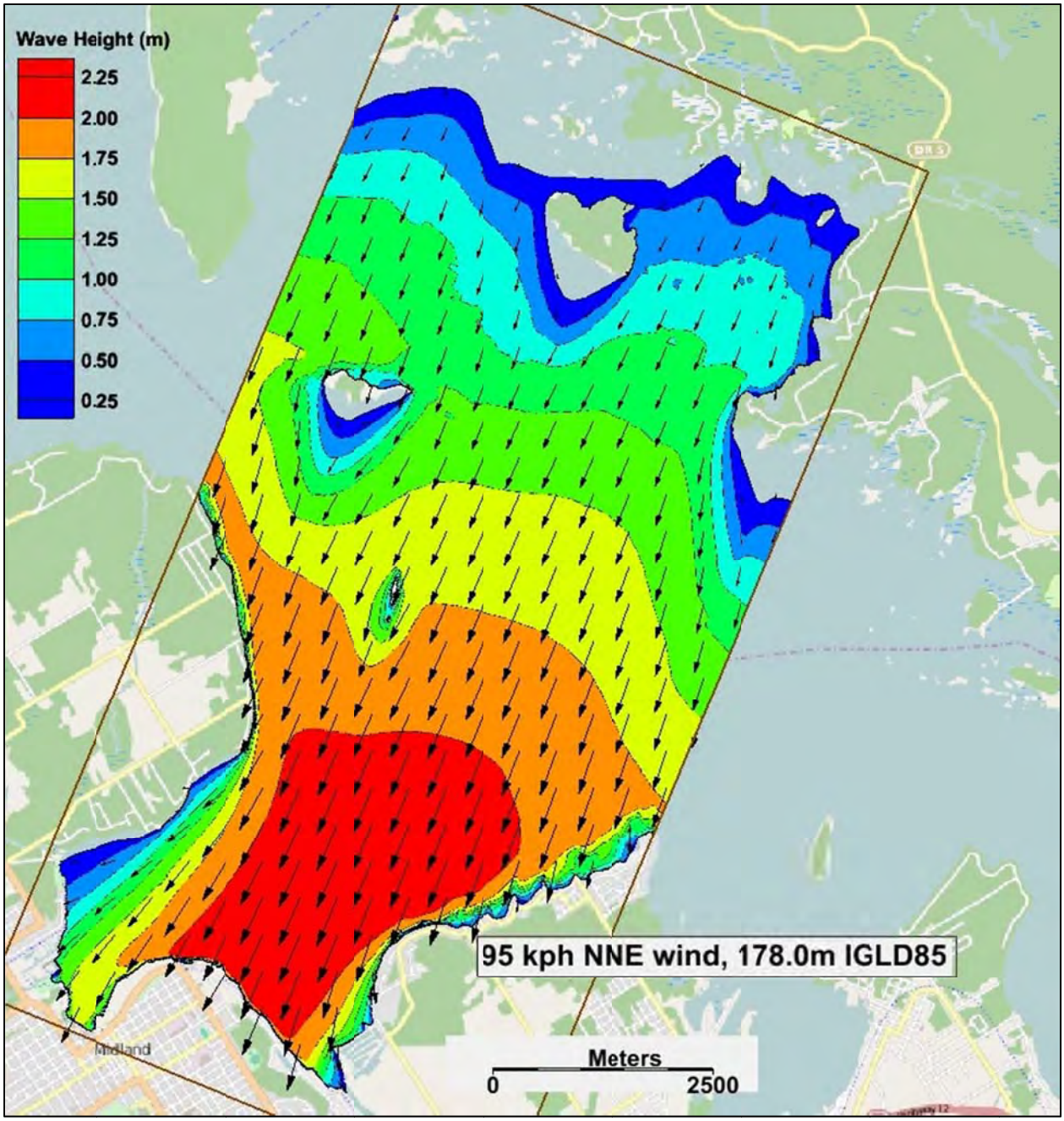


Figure 2-4: CMS-Wave Model Results for 95 kph NNE Winds

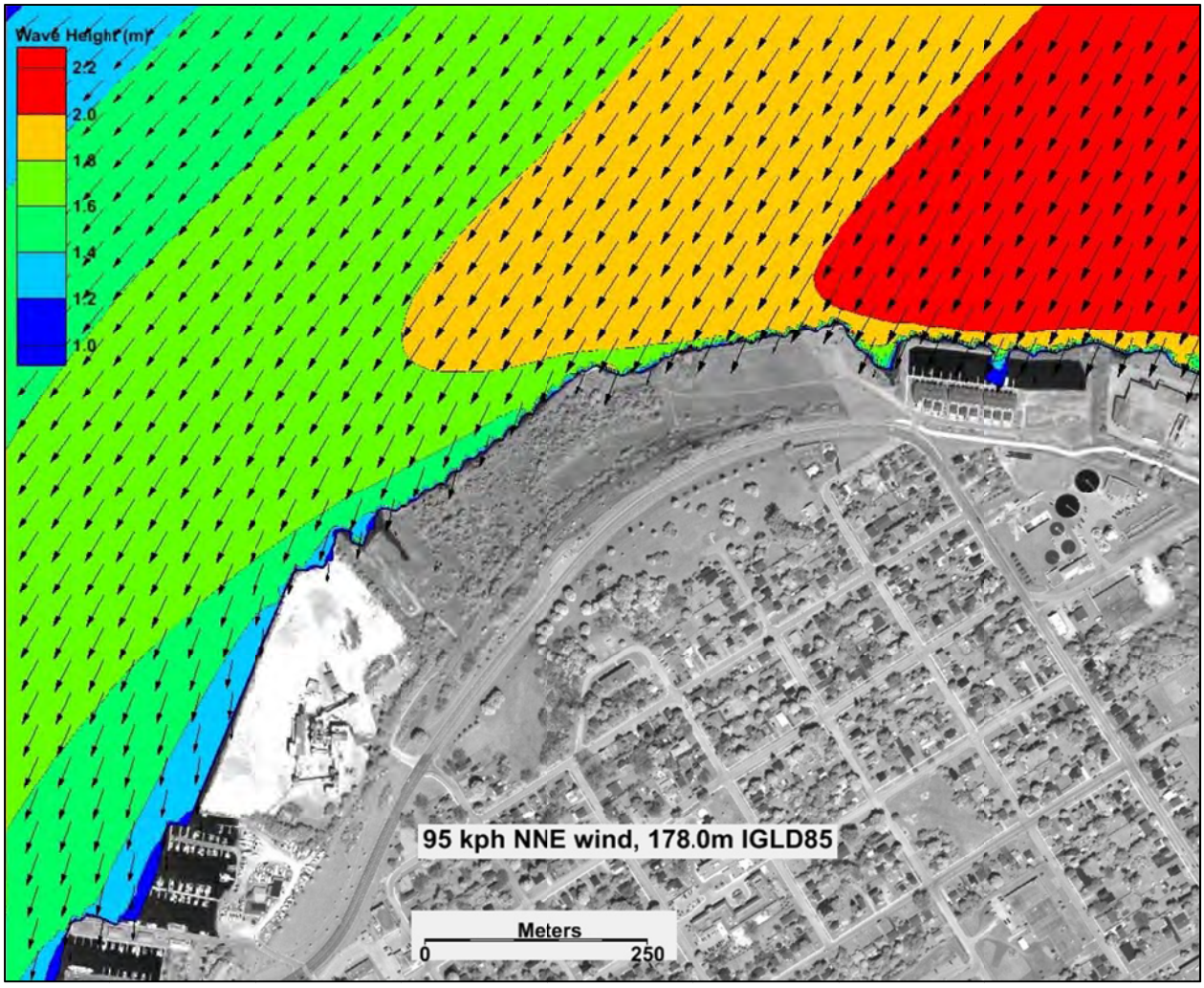


Figure 2-5: 20-Year Return Period Wave Conditions at the Site (95 kph NNE wind)

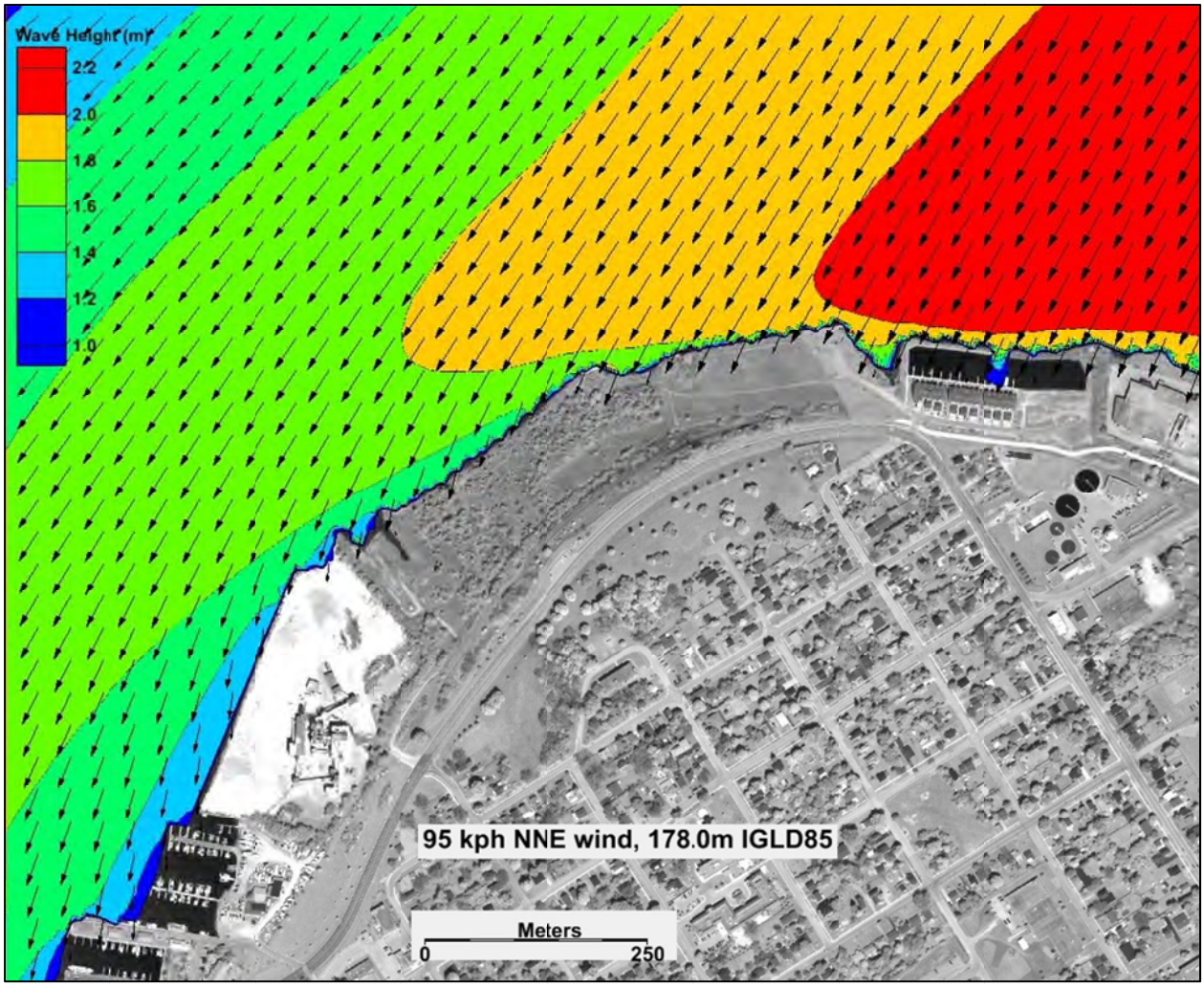


Figure 2-6: 100 - Year Return Period Wave Conditions at the Site (105 kph NNE wind)

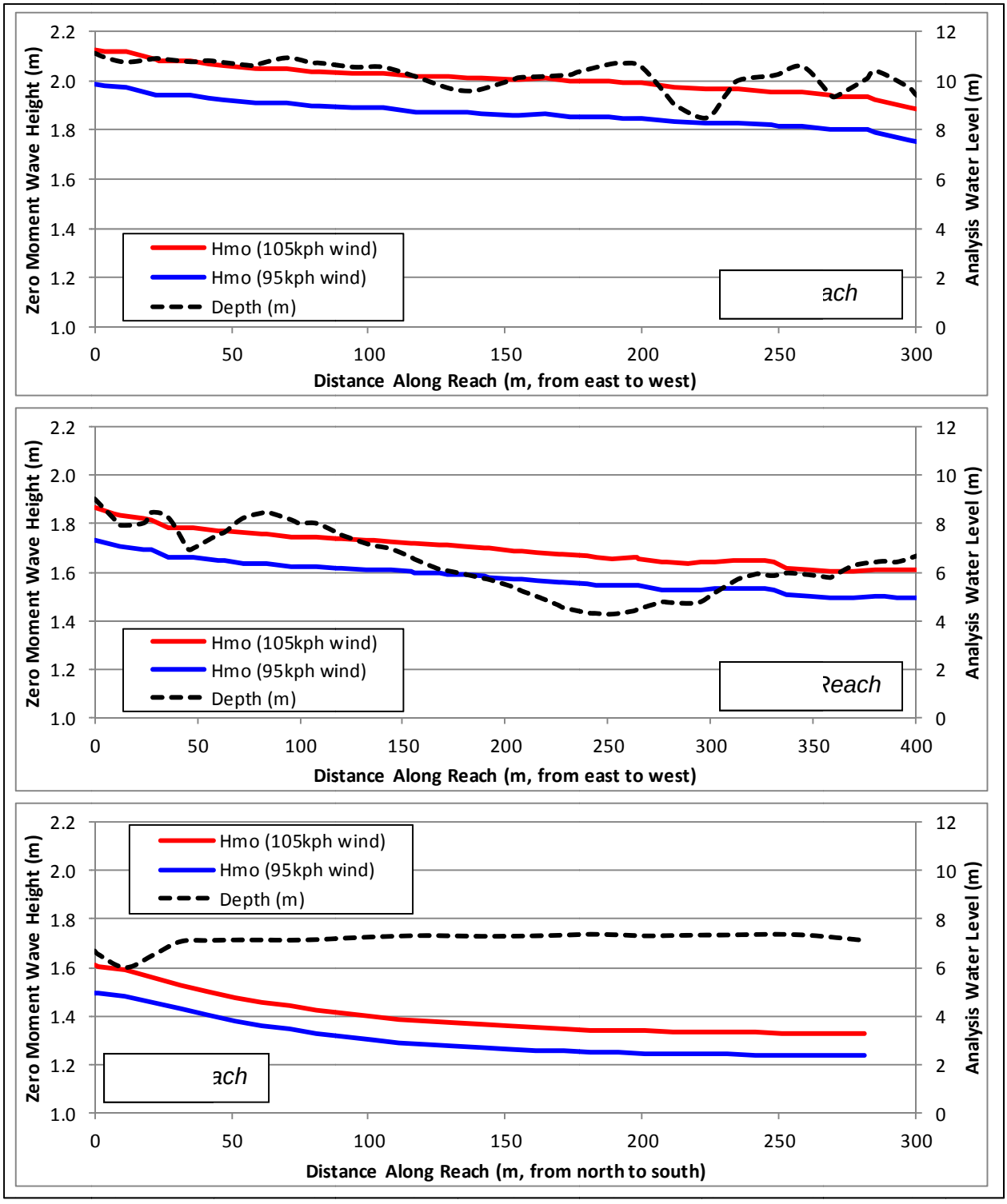


Figure 2-7: Alongshore Variation in Design Wave Heights

3 Existing Conditions

3.1 Existing Physical Conditions

Shoreplan carried out the inspection of the shoreline of the subject property on June 18, 22 and 23, 2015. Diving inspections were completed on the two latter days. Photographs taken during the inspection are included in Appendix A. During the inspection on June 22, 2015, the average water level recorded at the Midland gauge by the Canadian Hydrographic Service was approximately 176.63 m, IGLD 1985. The water level was approximately 176.78 m, IGLD 1985 during the inspection on June 23, 2015. The water levels are slightly above seasonal normal. All depths referred to in the text and inspection notes are below the water level on the day of the inspection.

For the underwater portion of the inspection, Shoreplan was assisted by General Diving Contractors Inc., a professional diving firm. The diving inspection was carried out from a General Diving work boat. Shoreplan personnel observed and monitored the diving inspection via a helmet mounted video camera and two-way audio communications.

For the purpose of the description of the shoreline provided herein, it is approximated that the shoreline faces north. On June 22, the diving inspection began at the east end of the site next to the outfall. The inspection progressed to the west along the east and centre reaches. A second inspection of the steel sheet pile wall in the west part of the west reach was carried out at the end of the day. On June 23, the diving inspection began at the west end of the site and progressed to the east along the west reach.

Shoreplan personnel also inspected the surface condition of the shoreline from the diving boat and from land. Observations were recorded relative to landmarks along the shoreline. A chainage system was established along the steel sheet pile (SSP) wall in the east part of the east reach. Detailed notes were taken during the diving and surface inspections and are provided in Appendix B. A DVD of the diving inspection is provided in Appendix D *(not included in draft report)*.

The descriptions of the existing conditions are organized into the three reaches described in the introduction (section 1.2). The east reach is the east portion of the site and includes the SSP wall and washed out section. It is approximately 304 m long. The east limit of this reach is the corner of the SSP wall the east end of the site. The west limit is the west end of the short remaining section of SSP wall west of the collapsed SSP wall. The centre reach extends from the west limit of the east reach to the bend in the shore approximately 60 m west of the marine railway. The centre reach is approximately 388 m long. The west reach is the remaining portion of the site. It extends from the west limit of the centre reach to the corner of the steel sheet pile wall before the marina. The east reach is approximately 291 m long. The approximate limits of the reaches are indicated on the site plan on Figure 3-1.

Elevations provided in the existing condition descriptions are based on the land survey by Dearton and Stanton Ltd (March 31, 2015) and lakebed soundings from field sheets 8050 and 8066 from the Canadian Hydrographic Service. They are also supplemented with

measurements made onsite during the site review and measurements taken during the diving inspection. Sections presented in this chapter use solid lines to represent elevations from the land survey and bathymetry from the field sheets. The area between the lakeward extent of the land survey and the bathymetry has been estimated based on observations and measurements made during the diving and site reviews. The assumed profile is shown on the sections as a dashed line.

The existing conditions for the east reach are summarized in section 3.1.1. Existing conditions for the centre and west reaches are summarized in sections 3.1.2 and 3.1.3 respectively. Sections 3.1.4 and 3.1.5 summarize the existing conditions on the shorelines to the east and west of the property limit. Detailed descriptions and inspection notes are provided in Appendix B.

A follow up overview of the above water conditions was undertaken in August 2017 for the report update. This was a visual review of the above water component of the site only. No notable changes to the shoreline conditions were observed during this site review.

3.1.1 East Reach

The East reach is approximately 304 m long. The entire shoreline along this reach was protected by a steel sheet pile wall. A steel sheet pile wall is made up of thin sheets of profiled steel driven into the ground. Individual sheets interlock to form a continuous wall along the shoreline. An anchoring system is located some distance back from the wall. Tie-backs, typically high tensile steel rods, are located at regular intervals along the length of the SSP wall, and tie the SSP to the anchor. The anchor is buried behind the wall and was not visible during the inspection. Details of its construction are not available to us. Excavation would be required to determine the type of anchor used for this wall. The tie-back and anchoring system provide support to the sheet pile wall to help it resist the load from the soil it is containing.

The steel sheet pile wall is still protecting the east end of the reach. The wall collapsed or is in disrepair at the west part of the reach. Currently, 193 m of the wall is still standing in the east part of the reach and approximately 33 m at the west end of the reach. The wall between these parts has collapsed and the area behind the wall has been washed out. A detailed site plan of the existing shoreline in the east reach is shown on Figure 3-2.

Observations on the remaining SSP wall in the east part of the reach were referenced to a chainage system along the wall. Chainage 0+00 was located at the east corner of the SSP and increases along the wall to the west. The existing fence is located at approximately chainage 1+49 m. The chainage system is shown on the site plan on Figure 3-2.

Along the toe of the SSP wall, the lakebed consists of a layer of zebra mussel shells and soft silts overlaying hard material. The depth of the soft material on top varied along the length of the wall. Soundings were recorded along the length of the wall. The lake bottom varied from approximately 169.9 m at the east corner to approximately 165.8 m at the west end of the collapsed section of SSP wall.

At chainage 0+00, the lakebed is sloped at the toe of the wall and flattens out to a gentle slope further offshore. The slope at the toe of the wall is a gentle slope offshore along most of the east part of the reach. The nearshore slope varies along the length of the wall. Throughout the section with the collapsed wall, the lakebed is relatively deep. Along the 33 m section of wall remaining at the west end of the reach, the lakebed slopes up to the west along the toe of the wall to form a very steep slope. At the west end of this portion of wall, the lakebed is sloping offshore at approximately 1 to 1.5h:1v.

The top of the existing steel sheet pile (see Photo 1 to Photo 3) wall is approximately 178.0 m. No construction drawings of the steel sheet pile wall were provided to us and the age of the wall is unknown. The SSP is an Algoma sheet pile. Based on measurements taken during the surface inspection, the steel sheet piling appears to be section A-9. The thickness of the steel sheet pile measured was 14 mm. Anchor rods are located, on average, ever 5 inpans. The anchor rods are 63.5 mm (2.5") diameter are located at approximately 176.7 m to 176.9 m. The wale is a steel rail with a railway track profile. It is placed on its side with the base of the rail up against the steel sheet pile.

Additional details regarding the construction of the wall we surmised from observations made at the collapsed part of the wall. We assume that the same section of the wall was constructed along the entire east reach. This is not confirmed, but is a reasonable assumption. The SSP wall is backed by a concrete relieving platform supported on timber bearing piles (see Photo 3 and Photo 5). A relieving platform transfers loads vertically to the soils below via the bearing piles and reduces the loading on the wall. The timber piles appeared to be irregularly spaced. The concrete platform is approximately 1.4 m deep by 2.1 m wide. A gap between the concrete and the SSP was observed at several locations (Photo 6).

At the east end of the collapsed SSP wall section, the fill material behind the SSP wall has been washed out. The anchor rods are exposed at this location (Photo 5). The rods run under the concrete relieving platform, across the washed out area and into the unprotected bank at the back of the washed out area. The bank is approximately 6 metres landward of the SSP wall. The remains of a timber structure were exposed on the side of the bank at one location (see Photo 7). The timber structure may be the anchor wall or anchoring system but this was not confirmed.

Within the east part of the reach, the SSP wall is still standing. A typical section through this part is shown as Section 1 on Figure 3-3. The SSP sheets appear to be leaning slightly towards the east. This likely originated from the construction of the wall and the original driving of the sheets. Broken and bent fender brackets remain attached to the wall along some sections. An example of this is visible in Photo 2.

The anchor rods and plates were inspected along the standing SSP wall and checked for tightness and deficiencies. Approximately 25 percent of the anchor rods were found to be missing, loose or damaged.

Verticality measurements were taken along the top of the existing steel sheet pile wall between chainage 0+00 and the existing fence at chainage 1+49. The measurements were taken just

below the pile cap and are presented in Table 3.1. The positive batter measurements indicate that the steel sheet pile wall is leaning toward land.

Table 3.1: Verticality measurements, existing steel sheet pile wall

Chainage	Batter (degrees)
0+10	0.0
0+20	1.6
0+30	4.8
0+40	3.2
0+50	3.2
0+60	0.0
0+70	1.6
0+80	0.8
0+90	4.0
1+00	4.8
1+10	3.2
1+20	6.4
1+30	6.4
1+40	6.4
1+49 (fence)	6.4

At the transition between the standing SSP wall and the collapsed SSP wall, a section of the SSP wall has detached from the concrete relieving platform and is leaning out into the lake (Photo 3). Fill from under and behind the concrete platform has been washed away (Photo 4). The concrete platform is unstable on the timber piles. To the west of this transition, the SSP wall has collapsed and the shoreline behind has washed out.

A typical section through the collapsed SSP portion is shown as Section 2 on Figure 3-3. Throughout the collapsed SSP section, the SSP wall was observed along the lake bottom. The toe of the SSP wall is still embedded in the lakebed. The SSP is vertical at the lakebed and has been bent over above the lakebed. The sheets are leaning out into the lake at an average angle of approximately 45 degrees (Photo 8). Remains of the concrete relieving platform were observed sitting on the back of the collapsed SSP (Photo 9 and Photo 10). The SSP is continuous across the washed out area. Timber piles which would have supported the concrete platform were not found behind the SSP wall underwater.

The collapsed SSP wall is still acting to retain some fill material. The diver noted that the lake bottom was 10 m below water on the lakeside of the SSP wall and 6 m on the landside of the collapsed wall. The lakebed behind the collapsed SSP wall gently slopes up to the shoreline. The shoreline behind the collapsed SSP wall section is shown in Photo 11. The shoreline is naturally vegetated with scattered concrete rubble and stone. Several timber piles were observed close to the shoreline. The top of the piles were close to the water level. The piles were not in line with the original installation of the SSP wall and therefore they do not appear to

have been bearing piles for the concrete relieving platform. They may have been part of the anchoring system or part of another structure.

To the west of the collapsed SSP wall is a short section of SSP wall that is still standing (Photo 12 and Photo 13). This part of the wall structure is approximately 33 m long. A typical section through this area is shown as Section 3 on Figure 3-3. The wall appears to be of the same construction as at the east end of the collapsed section. The concrete relieving platform and timber bearing piles are visible at the transition. Waves appear to have penetrated over the collapsed part of the wall and undermined the structure and eroded land behind the standing SSP wall at the west end. The concrete platform at this location is unstable and undermined (Photo 12). The configuration of the structure at the west end suggests there may have been a SSP return wall that is now missing (Photo 13). There are anchor rods and grooves in the remaining concrete platform that stands behind the SSP wall. The fill under the concrete relieving platform has been washed out even at the west end of the wall.

Closely spaced timber piles were observed at the west end of this section of standing wall (Photo 14). The timber piles are in line with the timber bearing piles supporting the concrete platform. They extend a few metres to the west of the end of the concrete relieving platform and SSP wall. The piles terminated just below the water level on the day of the inspection.

3.1.2 Centre Reach

The centre reach is approximately 388 metres long. The east limit of the reach is the west end of the standing SSP wall in the east reach. The west limit of the centre reach is the bend in the shoreline approximately 80 metres west of the existing marine railway. The limits of the centre reach and the position of the existing shoreline and property line are shown on Figure 3-4. The conditions of the existing shoreline vary along the length of the shoreline and are described below. There are three distinct parts or sub-reaches.

The east sub-reach is protected by informal randomly placed stone and concrete rubble (Photo 15). The length of shoreline with the informal protection is approximately 267 m. A typical profile through this section of shoreline is shown as Section 4 on Figure 3-5. Near the waterline, the existing slope is relatively steep, varying from 1h:1v to 1h:2v. The slope protection consists of randomly placed concrete rubble and stone. The protection extends approximately 0.2 to 0.5 m above the water level and 0.6 to 0.9 m below the water level. There is significant vegetation growth amongst the concrete rubble and stone above the waterline (see Photo 15). Moving offshore the concrete rubble and stone ends, and the lakebed consists of relatively soft silt material with some stones. The nearshore slope varies along the sub-reach. The slope was estimated to lie between 1h:1v and 1.5h:1v at the east end of the sub-reach. In the centre of this sub-reach of shoreline, the slope is closer to 2h:1v. The nearshore slope continues to flatten slightly moving towards the west to the west end of the sub-reach.

Timber piles were observed in the lakebed at two locations along this section of shoreline. The approximate locations of the timber piles are indicated on the site plan Figure 3-4. The west

group of piles consisted of four piles leaning towards land at approximately 45 degrees (Photo 16). This group of piles was approximately 50 metres west of the east limit of the centre reach. The second group of piles was approximately 240 m from the east limit of the centre reach. The piles appeared to have been cut off and only protrude from the lakebed about 5 to 10 cm (Photo 17).

The central sub-reach begins approximately 270 m west of the east limit of the Centre reach. A headland consisting of randomly placed stone and concrete rubble defines the start of this sub-reach. It includes an embayment with a marine railway and dock and it terminates at another headland (Photo 18). The small embayment is located west of the concrete rubble headland (Photo 19 and Photo 20). The embayment extends approximately 35 metres in from the end of the concrete rubble headland. The embayment is approximately 7 metres wide and relatively shallow. A profile through the embayment is shown as Section 5 on Figure 3-5. A collapsed deck and light standard are located to the west side of the small embayment (Photo 19 and Photo 20).

A marine railway lies to the west of the collapsed deck and light standard. The railway construction was observed to be a double rail with timber sleepers. The railway extends to a shed located in the backshore. The end of the marine railway was observed approximately 5 metres landward of the end of the remains of the pier to the west. The water depth at the end of the railway was approximately 3 metres. Based on these measurements, the slope of the railway underwater is estimated to be in the order of 10 %.

The remains of a pier are located to the west of the marine railway (Photo 22 and Photo 23). The pier appears to have been constructed of vertical rail driven into the lake bottom and horizontal timbers placed behind them. The timbers are only visible above water on the east side and stop just below the waterline. Large stones are visible behind the pier wall below the level of the timbers on the east side. Voids, up to approximately 1.2 m deep, were observed in the structure. The remains of an approximately 0.3 m high diamond pattern grating were visible along the toe of the wall. Most of the horizontal timbers on the end and west side are no longer visible above water. A few timbers were observed underwater. Below the water level on the end and west side, the sides of the pier are sloping and consist of randomly placed stones. The lakebed here consists of silts, zebra mussel shells and rock. Some stone was observed at the toe of the pier wall.

The west sub-reach extends west of the pier. It consists of approximately 56 m of unprotected shoreline (Photo 24). A typical section through this stretch of shoreline is shown as Section 6 on Figure 3-5. Two rows of timber piles, running parallel to the shoreline, were observed along this section of shoreline. The two rows were approximately 1.5 m apart, with the landward piles having a smaller diameter. The spacing between the piles was estimated to be approximately 1.2 metres. The timber piles terminated just below the water line. The lake bottom in this section consisted mainly of sand and gravel.

3.1.3 West Reach

The west reach of the site is approximately 291 metres long. The remains of a timber structure were observed along most of this reach. Approximately 11 metres of steel sheet pile wall were observed at the west end of this reach. The limits of the west reach and position of the existing shoreline and property line are shown on Figure 3-6.

A timber wall structure was observed below the water along most of the west reach. The following provides a general description of the timber structure based on observations. No information on the original construction of the structure is available to us. The structure appears to consist of a row of closely spaced round timber vertical piles on the lakeward side. The front row of timber piles were estimated to be approximately 0.3 m in diameter and terminated, on average, approximately 0.3 m to 0.6 m below the water level. The piles acted like a vertical wall to contain stone material on the landward side. The timber piles have deteriorated and loss of stone material through the gaps between the piles was observed. The row of vertical timber piles appear to have been restrained at the top by a horizontal timber wale consisting of two horizontal timbers; one on each side of the vertical timber piles at the same elevation. The remains of steel rods and plates were observed at several locations. These appeared to have held the horizontal timber and vertical timber piles together. Anchor rods were observed running into the backshore at several locations. The rods were located between the vertical timbers and likely extended through the horizontal timbers. The rods were approximately 0.6 m below the water level. The original spacing of the anchor rods is unknown since most of the rods are missing. The location of the anchor wall was not determined. A row of smaller (approximately 0.15 m in diameter) and more intermittent timber piles was observed behind the larger piles in some locations.

The water depth in front of the vertical timber piles varied between approximately 1 and 2 metres along the length of the reach. The lakebed in front of the timber piles consists mainly of stone fill material. The material slopes down to the natural lakebed at an average angle of approximately 1h:1v to 1.5h:1v. The natural lakebed has a gentle offshore slope.

Starting at the east end of the west reach, a timber structure, similar to that described above was observed. The vertical piles were more intermittent in this location than in the west part of the reach and the second row of piles was not observed. Evidence of loss of stone fill through the piles was observed. From the front row of piles, the profile slopes up to the backshore. Large pieces of concrete slab were observed on the slope just above the water level (Photo 25). A typical profile through this section of the shoreline is shown on Section 7, Figure 3-7.

The remains of a concrete foundation were observed approximately 50 m from the east end of the west reach (Photo 26). The approximate location is identified on Figure 3-6. In the west part of the reach, the stone fill slopes up from the front row of timber piles. West of the concrete foundation, a plateau was observed underwater on the landside of the timber piles. The plateau consists of stone fill and concrete rubble between the timber piles and the existing shoreline and is approximately 2 to 3 metres wide. The stone fill is approximately level with the top of the timber piles in some sections and slightly lower in other locations. An approximately 0.6 m wide concrete curb was observed at the landside of the plateau. Other than a few missing sections,

the concrete curb is continuous to the SSP wall at the west end (see Photo 26 to Photo 28). The average elevation of the top of the curb is approximately 177.0 m. A typical section is illustrated as Section 8 on Figure 3-7. This profile was more or less consistent along the main part of the west reach, west of the remains of the concrete foundation.

The concrete curb has shifted and exposed the underside of a concrete deck behind it in an area approximately 100 m to 115 m west of the east end of the reach (Photo 27). Along this part of the shore the deck was observed to be supported by concrete beams running the width of the deck and perpendicular to the shore. The concrete beams were sitting on timber piles. In other locations, the concrete deck appeared to be sitting directly on timber piles. The presence of the same concrete deck design along the entire reach was not confirmed.

A 300 mm diameter corrugated steel pipe (CSP) was observed approximately 120 m from the east start of this reach (Photo 29). Its approximate location is indicated on the site plan, Figure 3-6. The CSP has been cast into the concrete curb. The invert elevation of the pipe is approximately 176.8 m.

An approximately 11 metre long section of SSP wall is located at the west end of the reach (Photo 30). The top of the SSP wall varies between approximately 177.2 and 177.3 m. In the centre of the SSP wall section, the wall was leaning in towards land at an angle of approximately 2 degrees. The water depth in front of the SSP wall was approximately 6 metres on the day of the inspection. The lakebed in front of the wall consisted of a soft layer of silt and zebra mussel shells overlaying harder material. A typical section through the SSP wall is shown as Section 9 on Figure 3-7.

The SSP wall is composed of two sections. The east section is an Algoma sheet pile, and appears to have the same sheet section as that in the East Reach (see section 3.1.1). This section was approximately 8 sheets long. The east part was constructed of a U-series section. The sheets had a width of approximately 500 mm and a thickness of approximately 6 mm. Along the U-series wall, anchor rods were observed on every inpan. The anchor rods are at approximately 177.0 m and approximately 30 mm in diameter.

The U-series wall appears to be more recent than the Algoma wall. At the interface between the two wall types, the ball of the Algoma sheet has been wedged into the knuckle of the first U-series sheet (see Photo 31). The two sheets are welded together at the top. A welded connection below the waterline was not confirmed. No loss of material at the interface was observed underwater. The U-series SSP wall turns the corner into the adjacent marina. The wale, which is two back to back channels, was observed 0.4 m below the top of the wall. It runs parallel along both sections of the wall and at the corner an additional section of wale runs on a diagonal between the two sections of wall. This diagonal wale likely accommodates an anchor rod. The location of the anchors was not observed. Excavation behind the wall is required to determine the anchor location.

3.1.4 Shoreline East of Property Limit

The shoreline east of the property limit faces approximately the north-east direction and is, for the most part, located outside the property line (see site plan, Figure 3-2). A brief description is provided for any future work that may be considered that may need to connect to works within the study area. At the northern end of this reach, there is an approximately 4 metre long section of SSP wall (see Photo 32). This is the return wall for the SSP wall in the East Reach. A storm sewer outfall is located at the end of shoreline (Photo 33) and is shown on the site plan on Figure 3-2. The shoreline between the end of the SSP wall and outfall is approximately 84 metres long and is protected by informal shoreline protection. Above the water line, the shoreline is vegetated with some informal concrete rubble and stone protection visible (Photo 33). There is an informal launch ramp in approximately the middle of this section of shoreline.

Below the waterline, the remains of a timber structure were observed for approximately 10 metres from the end of the SSP wall. The timber piles terminated at approximately the water line. Some loss of stone from behind the timber was observed. The water depth at the toe of the timber crib was approximately 0.6 m. The shoreline protection consists of randomly placed armour stone and concrete rubble south of the end of the timber crib structure, similar to that observed above the water. The water depth at the toe of the shore protection was approximately 0.6-0.9 m. The water depth was too shallow to conduct the diving review along the south third of the shoreline.

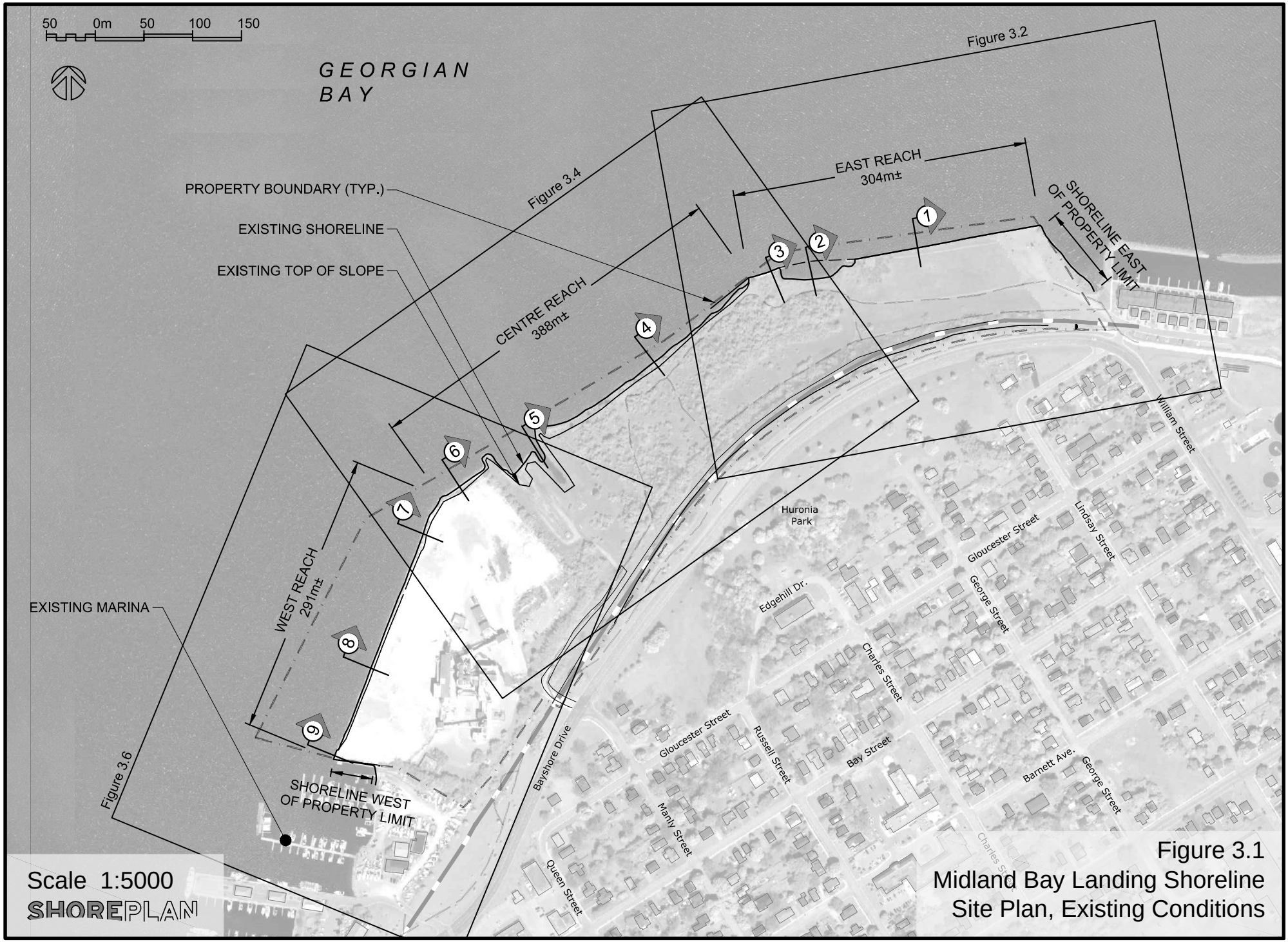
3.1.5 Shoreline West of Property Limit

The shoreline west of the property limit runs along and appears to be just west of the west property line of the property. A brief description is provided here for the same reason as described for the east shore in section 3.1.4.

The north part of the reach is protected with a SSP wall. The SSP wall is the same U-series SSP wall observed at the west end of the west reach and described in section 3.1.3. The top of the steel sheet pile wall varies from approximately 177.3 m at the corner to 177.1 m at the end of the south end of the SSP wall. A chain-link fence runs along the top of the SSP wall and is attached to the SSP wall with brackets. A timber deck runs along the SSP wall and is supported by brackets attached to the SSP wall at the water level. The location of the anchor wall for the SSP wall was not determined.

To the south of the end of the SSP wall, the shoreline consists of an unprotected gravel slope (see Photo 35). At the south end of this section of shoreline, there is a boat launch ramp within the marina (Photo 37).

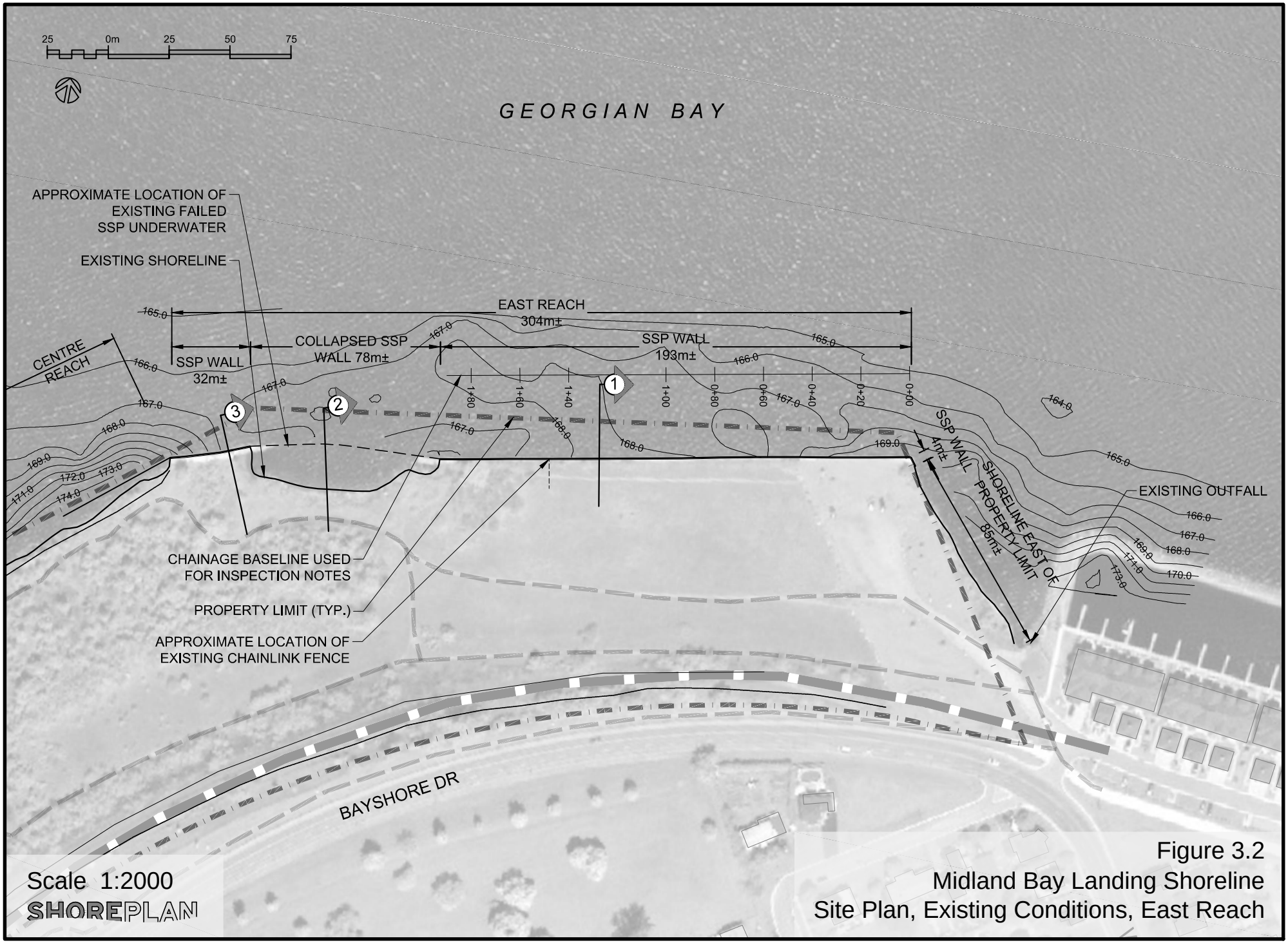
For the purpose of this study, we have assumed that the west shoreline is outside of the property line. We have not considered shoreline protection concepts for this portion of shoreline.



Scale 1:5000

SHOREPLAN

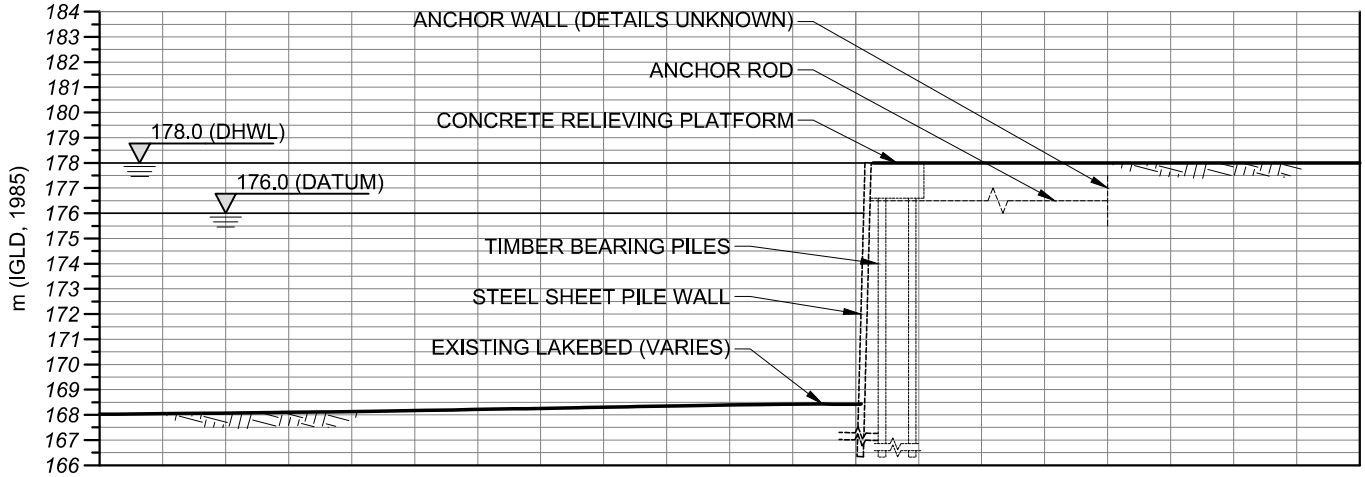
Figure 3.1
Midland Bay Landing Shoreline
Site Plan, Existing Conditions



Scale 1:2000

SHOREPLAN

Figure 3.2
Midland Bay Landing Shoreline
Site Plan, Existing Conditions, East Reach



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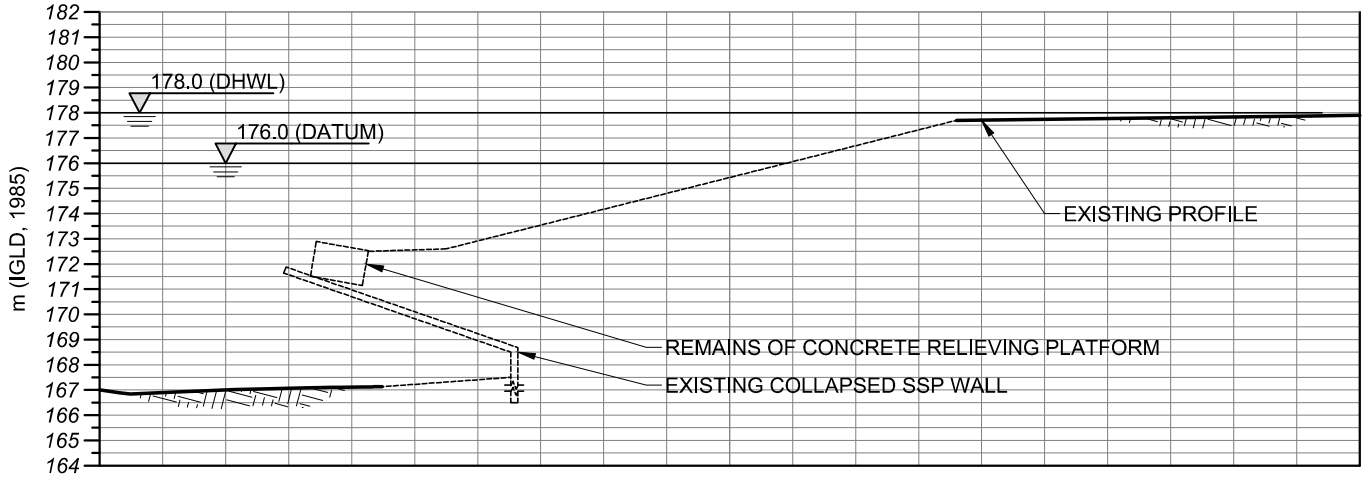
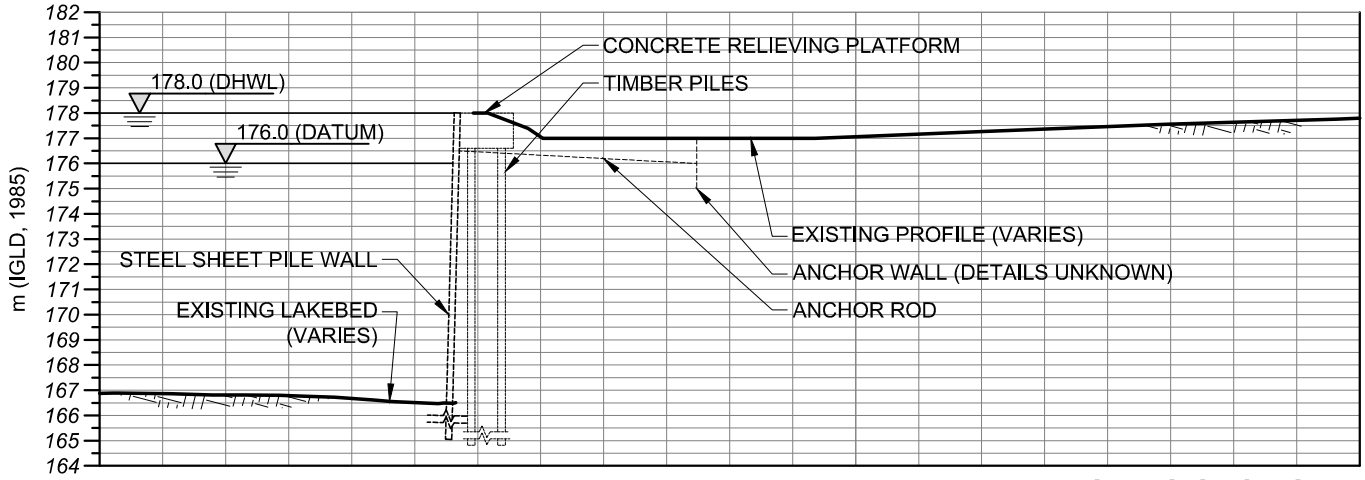
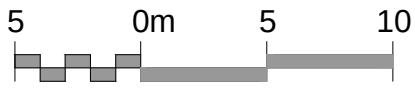


EXISTING SECTION 2



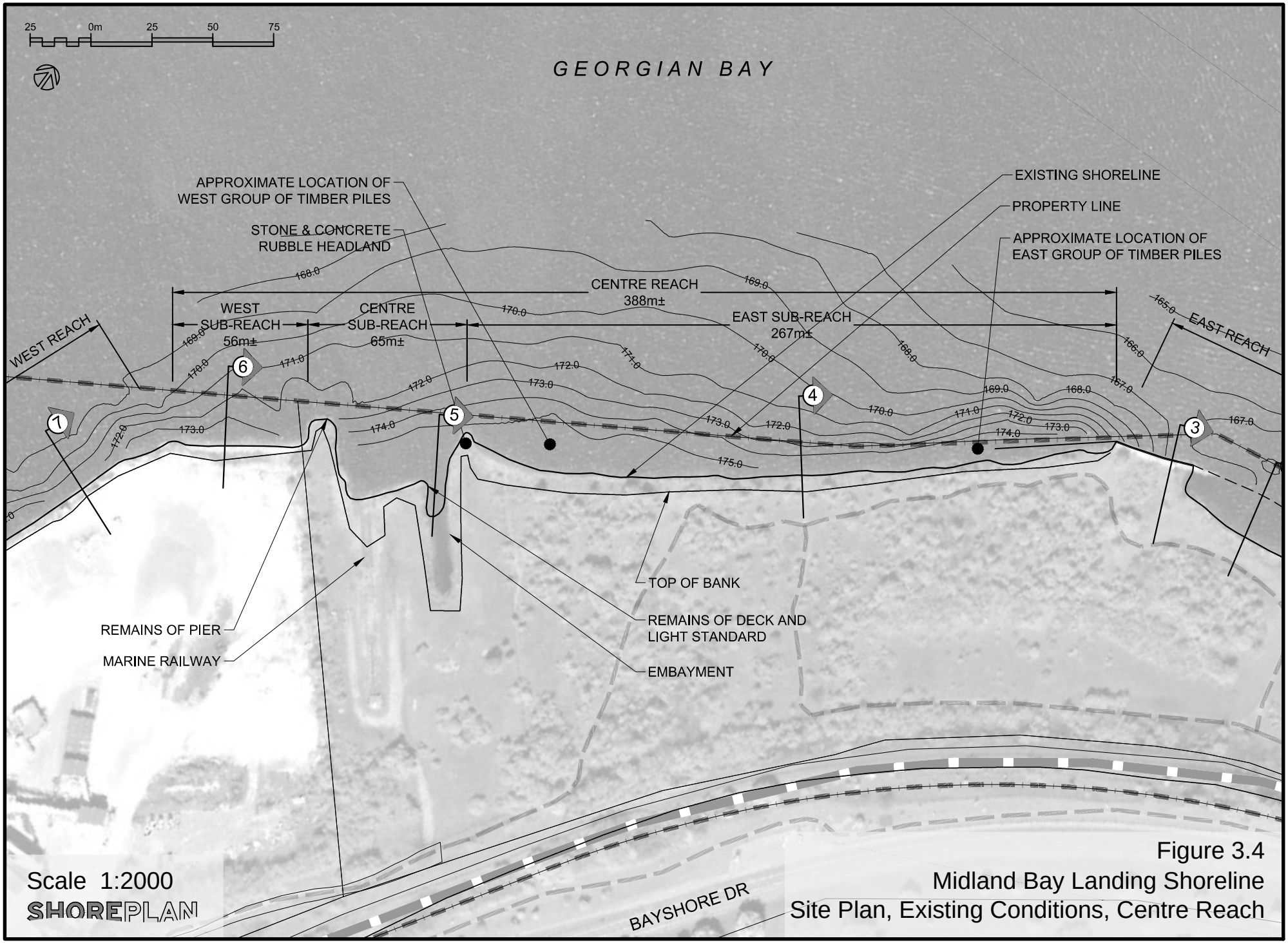
EXISTING SECTION 3

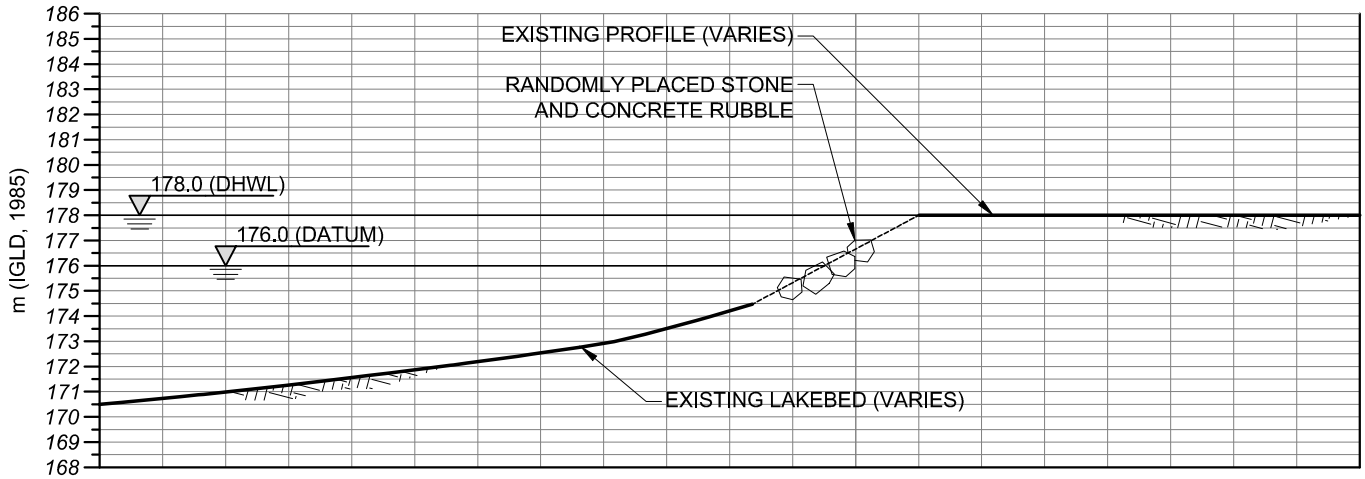


Scale 1:300

SHOREPLAN

Figure 3.3
Midland Bay Landing Shoreline
Existing Sections, East Reach


25 0m 25 50 75
GEORGIAN BAY
APPROXIMATE LOCATION OF WEST GROUP OF TIMBER PILES
STONE & CONCRETE RUBBLE HEADLAND
EXISTING SHORELINE
PROPERTY LINE
APPROXIMATE LOCATION OF EAST GROUP OF TIMBER PILES
CENTRE REACH 388m±
WEST SUB-REACH 56m±
CENTRE SUB-REACH 65m±
EAST SUB-REACH 267m±
WEST REACH
EAST REACH
168.0
169.0
170.0
171.0
172.0
173.0
174.0
175.0
165.0
166.0
167.0
1
3
4
5
6
TOP OF BANK
REMAINS OF DECK AND LIGHT STANDARD
EMBAYMENT
REMAINS OF PIER
MARINE RAILWAY
BAYSHORE DR
Scale 1:2000
SHOREPLAN
Figure 3.4
Midland Bay Landing Shoreline
Site Plan, Existing Conditions, Centre Reach



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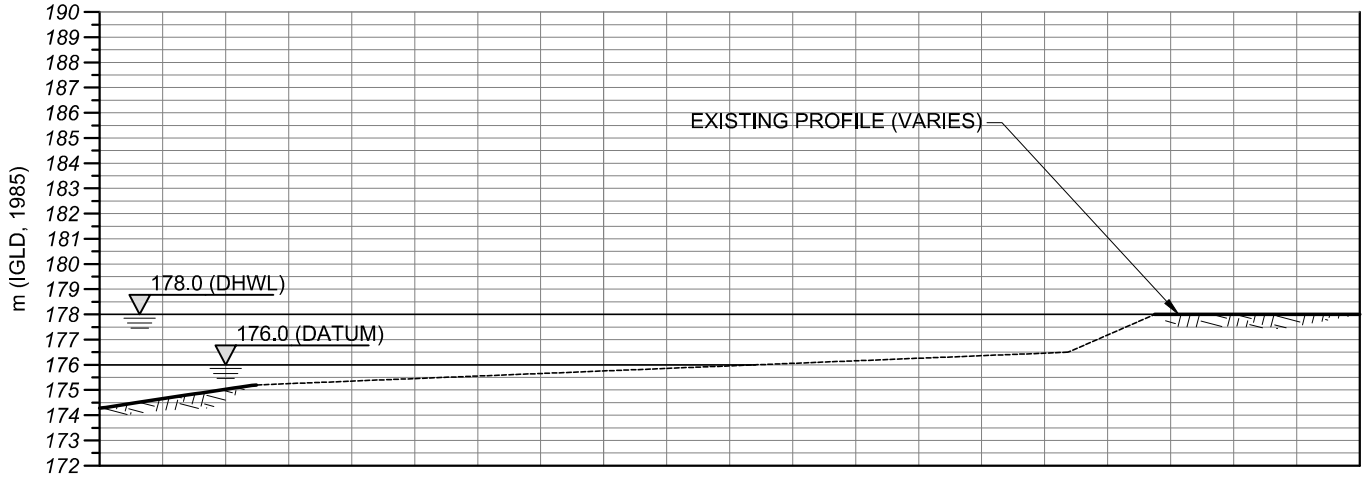

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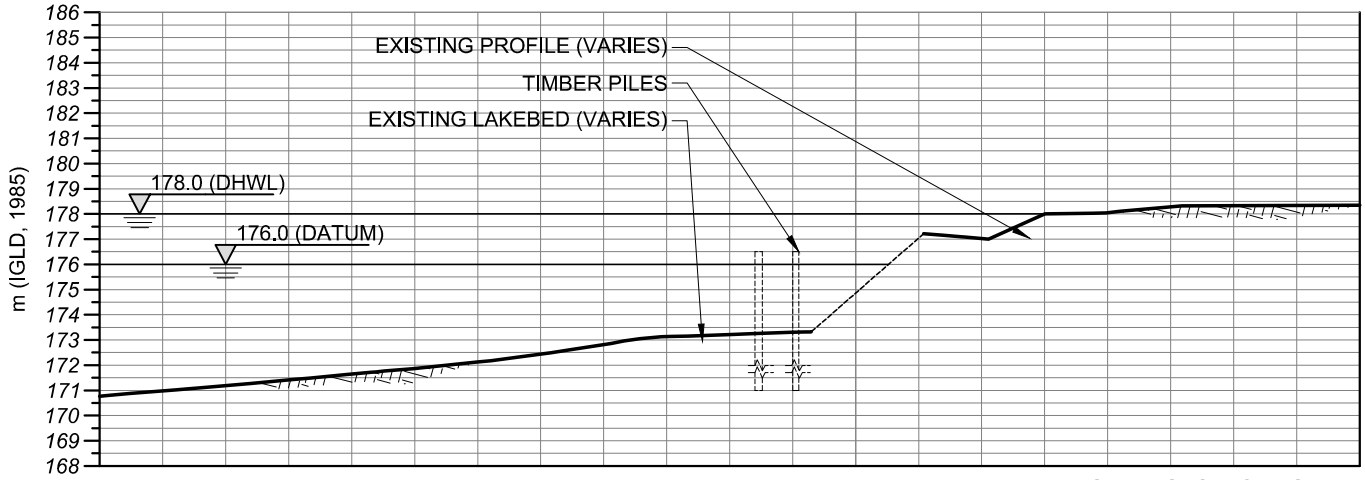

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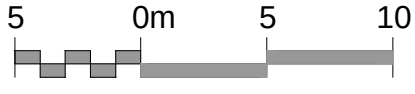
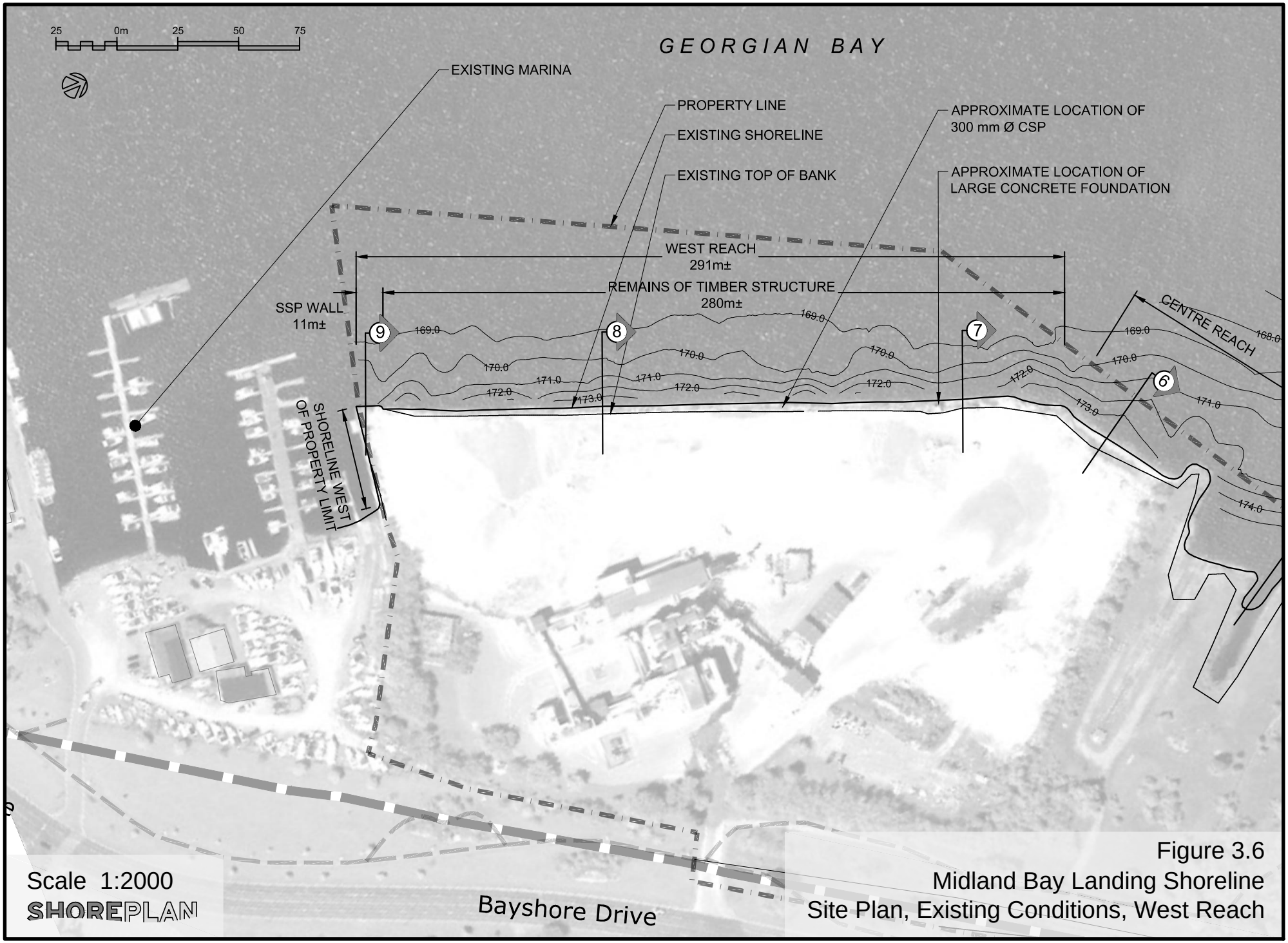


Scale 1:300

SHOREPLAN

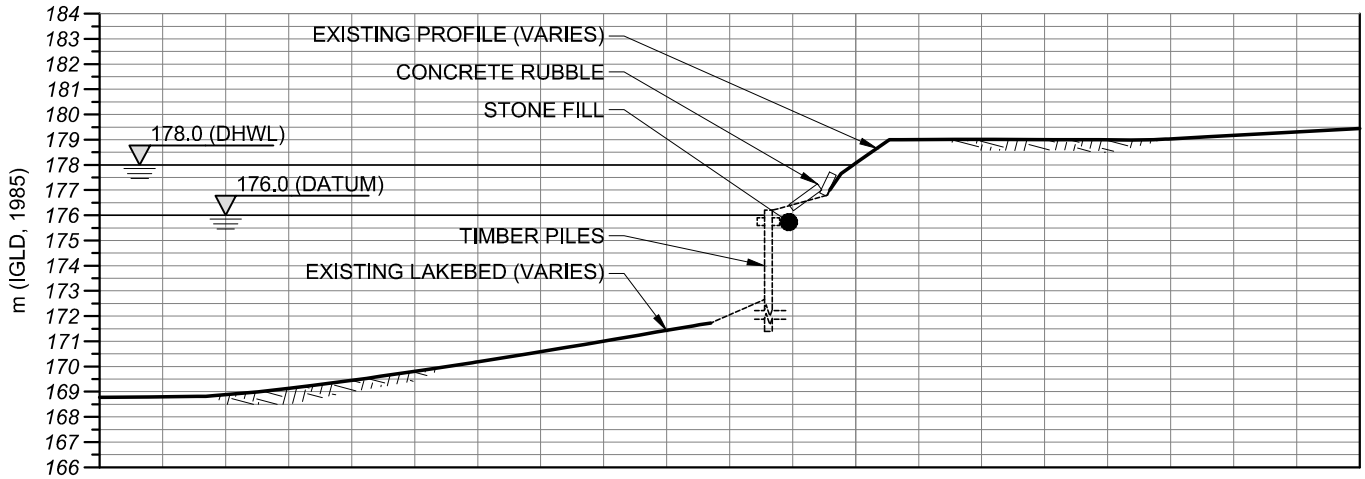
Figure 3.5
Midland Bay Landing Shoreline
Existing Sections, Centre Reach



Scale 1:2000

SHOREPLAN

Figure 3.6
Midland Bay Landing Shoreline
Site Plan, Existing Conditions, West Reach



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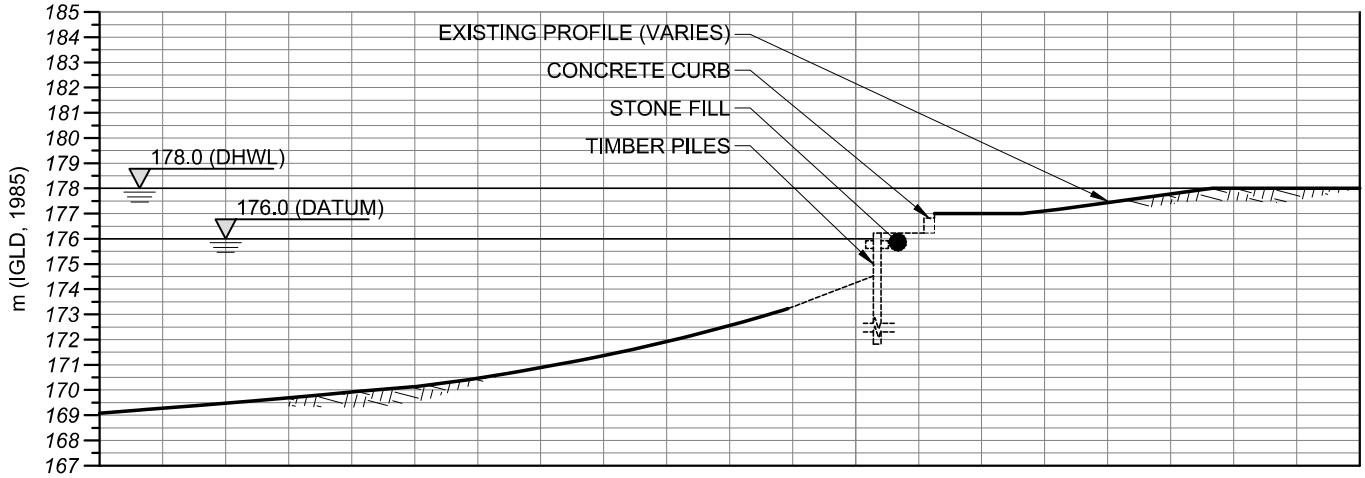

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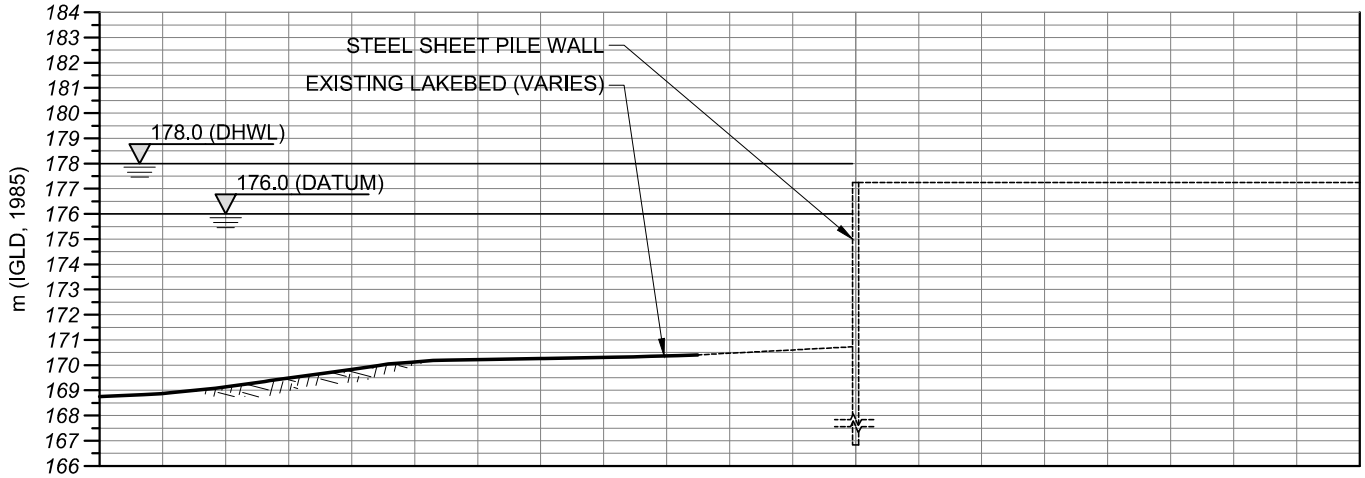

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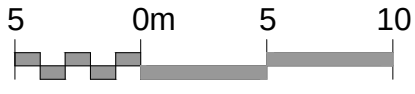

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SHOREPLAN

Figure 3.7
Midland Bay Landing Shoreline
Existing Sections, West Reach

4 Concept Shoreline Treatments

This section presents concept level shoreline treatments for the Midland Bay Landing shoreline. Options have been developed for the three reaches described Chapter 3, Existing Conditions; the east, centre and west reaches. The limits of the three reaches are shown on the site plan on Figure 4-1.

The demonstration plan presented in the master plan (Town of Midland, 2013) shows the proposed shoreline position. For the development and cost estimates of preliminary shoreline treatments, where possible, we have used this line to position the shoreline protection crest. The shoreline position shown in the demonstration is shown the site plan, Figure 4-1.

All structures presented allow for some wave overtopping. That is, during the design storm at the DHWL, water will pass over the crest of the structure and spill into the backshore. This has been done to reduce the crest elevation and provide better connections between the water and the public amenity space. The crest elevations of the structures have been determined by permitting an acceptable level of wave overtopping under the design wave and water level conditions described in Section 2.1.2. The lower crest will also reduce the construction cost.

The wave overtopping methods described in TAW (2002) and Pullen et al. (2007) were used to calculate overtopping rates. This method allows the influence of the angle of incidence of wave attack to be taken into account. The generation of a wave perpendicular to the shoreline was also considered using a fetch-limited wave generated across the bay in the centre and west reaches. The EurOtop guidelines give overtopping thresholds. Damage to grasses or lightly protected promenades or reclamation cover behind a revetment or seawall may occur at overtopping rates of 50 l/s/m or greater (Pullen et al. 2007). In the development of concept level shoreline treatments, the crest elevations were adjusted so as to limit the overtopping to 50 l/s/m. Other backshore uses may require lower overtopping rates.

Options for the East Reach are presented in section 4.1. The East Reach was divided into two sub-reaches. Six options are presented for the East Reach; three for the east sub-reach (Options E(a)1 to E(a)3) and three for the west sub-reach (Options E(b)1 to E(b)3). Three options are presented for the Centre Reach (C1 to C3) in section 4.2. Five options were developed for the West Reach (Options W1 to W5) and are presented in section 4.3. An option for the shoreline east of the property limit is presented in section 4.4.

Construction cost estimates were prepared for the options. The preliminary costs presented in this section do not include any allowances for tree removal, landscaping, or walkways along the shoreline. The costs do not include design costs, construction contingencies, mobilization, demobilization or HST. Mobilization and demobilization costs depend on the phasing of the project. Typically, at the concept design stage, a contingency of not less than 30% of the capital cost estimate would be appropriate.

The cost estimates for the steel sheet pile wall options include an allowance for a standard CMRM pile cap on the SSP wall, unless otherwise indicated. The additional cost to substitute

the pile cap with a concrete cap (measuring approximately 0.6 m wide x 0.5 m high) is estimated to be approximately $350 per metre of shoreline ($367.50 – 2017).

The costs include rough grading of the backshore to the proposed elevations and distance behind the shoreline protection described, then grading at 2h:1v to the existing grade. A description of the back shore grading included in each option's cost estimate is provided below. This was done so that the shoreline options, which extend varying distances into the backshore, could be fairly compared.

The unit prices used to estimate the cost per metre of shoreline for each option are shown in Table 4.1 in 2015 prices and adjusted with 5% inflation for 2017 prices. A breakdown of costs for each alternative is provided in Appendix C.

Table 4.1: Unit Prices used in Cost Estimate

Item	Unit Price 2015	Unit Price 2017 (+5%)
Excavation	$ 25 /cu.m.	26.25 /cu.m.
Rip Rap	$ 50 /tonne	52.50 /tonne
Geotextile	$ 8 /sq.m.	8.40 /sq.m.
Steel (SSP associated work)	$ 4 /kg	4.20 /kg
Armour Stone (Special placement)	$ 100 /tonne	105 /tonne
Armour Stone (Stacked)	$ 150 /tonne	157.50 /tonne
Clean Fill	$ 30 /tonne	31.50 /tonne
Clear Stone	$ 40 /tonne	42.00 /tonne
Removals	$ 200 /cu.m.	210 /cu.m.
Reinforced Concrete (Pad)	$ 800 /cu.m.	840 /cu.m.
Reinforced Concrete (Cap)	$ 1500 /cu.m.	1575 /cu.m.

4.1 East Reach

The East Reach is approximately 304 m long. The reach-averaged significant wave height of 2.0 metres, at an angle of 45 degrees to the shoreline (see section 2.1.2), has been used for the preliminary design of the shoreline treatments.

The proposed shoreline essentially follows the existing SSP wall in the east part of the reach, and then turns about 10° at the start of the collapsed SSP wall segment. At the west end of the reach, the proposed shoreline is approximately 18 metres landward of the end of the existing standing SSP wall.

For the purposes of preparing concept level shoreline treatments for this reach, the reach was divided into two sub-reaches; sub-reach E(a) and sub-reach E(b). Sub-reach E(a) is approximately 170 m and is the east part of the East Reach where the existing SSP can be retained. In sub-reach E(b), the existing SSP wall is in disrepair and cannot be retained. This includes the 33 m of the standing SSP wall in the west part of the reach and the collapsed SSP underwater. Sub-reach E(b) is approximately 134 m long.

Three options have been prepared for sub-reach E(a). Option E(a)1 includes the installation of a new anchored SSP wall with rip rap berm in front of the existing SSP wall. For Option E(a)2, a concrete cap on top of the existing steel sheet pile wall and rip rap berm in front of the wall are proposed. Option E(a)3 involves adding a rip rap berm in front of the existing SSP wall and a concrete splash pad and amour stone retaining wall at the back of the wall.

Three options have been prepared for sub-reach E(b). Option E(b)1 proposes the installation of a new anchored SSP wall and rip rap berm. Option E(b)2 proposes the installation of a rip rap berm with armour stone protection on the upper slope. Option E(b)3 involves the installation of a new steel sheet pile wall, rip rap berm, concrete splash pad and armour stone retaining wall. It is intended to be similar to Option E(a)3.

A fourth option has been prepared for both the E(a) and E(b) reaches that includes a new anchored SSP wall without a rip rap berm. This option was developed as an alternative that will allow for cruise ships with drafts up to 8 metres to berth against the wall. It should be noted that the other three options will allow ships of up to 2.5 metre draft to berth along the wall. It is expected that local ships will not exceed the 2.5 metre limit, however larger ships entering the area from the St. Lawrence Seaway may require up to 8 metres draft. Further studies should be conducted to explore this hypothesis and determine if the added cost of Option 4 is warranted.

4.1.1 Option E(a)1 – Anchored Steel Sheet Pile Wall with Rip Rap berm

Option E(a)1 consists of a new anchored steel sheet pile wall with a rip rap berm. This option is illustrated on Figure 4-2.

A steel sheet pile wall is made up of thin sheets of steel driven into the ground. Individual sheets interlock to form a continuous wall. For an anchored steel sheet pile wall, an anchor is installed some distance back from the wall. Tie-backs or anchor rods, typically high tensile steel rods, are

located at regular intervals along the length of the SSP wall and tie the SSP to the anchor. The tie-back and anchor provide additional support to the sheet pile wall.

For option E(a)1, the top of the proposed SSP wall is 180.0 m. The SSP would need to be driven approximately up to 2 metres in front of the existing wall to account for the non-verticality of the existing wall observed during the diving inspection and measured from the shoreline (see Table 3.1). The cavity between the existing wall and new SSP wall would be filled with clear stone. The anchor rods for the new wall would be installed above the existing concrete platform. The SSP wall and concrete relieving platform would not be removed and would be buried under fill material.

The top of the new wall (180.0 m) is approximately 10 to 13 metres above the existing lakebed. A preliminary analysis indicated that standard anchored steel sheet pile wall design with a single anchor wall would not be sufficient for this wall height on this site. To reduce the load on the wall, a rip rap berm is added in front of the wall. A rip rap berm consists of stone material placed in a stable sloping mass. The rip rap berm has a crest elevation of 173.5 m and a crest width of approximately 2 metres. The berm slopes at 2h:1v to meet the existing lake bed. The water depth at the wall will be 2.5 metres at chart datum water level.

The construction cost estimate for this option includes rough grading of the backshore to an elevation of 180.0 m a distance of 20 m back from the lakeside edge of the SSP wall. The cost estimate includes an allowance for a standard CMRM SSP cap only. The estimated cost for this option is $22,000 ($23,100 – 2017) per linear metre of shoreline.

4.1.2 Option E(a)2 – Concrete Cap on Existing SSP Wall with Rip Rap Berm

For Option E(a)2, a concrete cap is proposed on the top of the existing SSP wall. A new anchor rod and anchor wall system is proposed to replace the existing system. A rip rap berm is also proposed in front of the wall. This option is illustrated on Figure 4-2.

The top of the existing steel sheet pile wall is at an elevation of approximately 178.0 m. At the DHWL, the water level will be at the top of the wall and the wall will be overtopped by any incoming wave. For Option E(a)2, a 2 metre high concrete cap has been added to the top of the existing SSP wall to raise its crest elevation. The top of the concrete cap is at 180.0 m. Fill material would be placed to an elevation of 179.5 m behind the wall.

The additional backfill material behind the wall will increase the loading on the existing steel sheet pile wall. To provide increase the stability of the wall, a rip rap berm has been added in front of the wall. The rip rap berm has a crest elevation of approximately 174.5 m and has a crest width of approximately 2 metres. The water depth against the wall at the datum water level (176.0 m) will be approximately 1.5 metres.

As noted previously, approximately 25% of the tie rods were observed to be missing, loose or damaged. In addition, the design or condition of the existing anchor wall is unknown. The capacity of the existing tie rod and anchor wall system cannot be ascertained. For Option E(a)2, the installation of a new anchor wall and anchor rods is proposed. The anchor rods are proposed at approximately the same location as the existing rods (approximately 176.8 m), at

the bottom of the existing concrete platform. The new tie rods would likely be installed via directional drilling under the existing concrete platform. The anchor wall would be driven into the backshore an appropriate distance from the wall. This installation could be completed only if water levels drop to close to chart datum level, as they did over the past twenty years or so. Alternatively, the rod would need to be installed above the existing SSP wall under the new concrete cap, and the cap should be connected with the SSP wall. If the anchor rods are installed at the top of the existing SSP wall, the crest of the rip rap berm may need to be raised during the detailed design phase.

As part of the new anchor wall and anchor rod system, a new wale would also need to be installed on the existing SSP wall. A wale is horizontal member to brace the vertical steel sheet pile wall at the location of the anchor rods. Typically, in the construction of a new SSP wall, the wale would be installed on the inside of the wall and buried. In this case, the wale would need to be installed on the outside of the wall since the inside of the wall cannot be accessed. This does not affect the structural integrity of the wall but can be a concern for damage to boats docked against the wall. To protect boats from the steel wale, a fender that protrudes further out from the wall than the wale can be installed along the length of the wall. The installation of a fender has not been included in the cost estimate for this option.

The existing steel sheet pile wall design includes a concrete relieving platform (see Section 3.1.1). No construction or design information was provided to us on the details of the wall or relieving platform and the condition of the timber piles could not be inspected. The timber piles that were exposed at the east end of the collapsed SSP wall section appeared to be irregularly spaced. The design and current capacity of the relieving platform is unknown. This option relies on the relieving platform being able to support additional load from the backfill material on top of the platform. Should this option proceed, we would need to undertake load testing during the detailed design process to verify the capacity of the concrete relieving platform. A testing allowance has not been included in the construction cost estimate.

The construction cost estimate for this option includes rough grading of the backshore to an elevation of 179.5m to 20 metres back from the existing SSP wall. The construction cost estimate for this option is $15,300 ($16,100 – 2017) per metre of shoreline.

4.1.3 Option E(a)3 – Existing SSP Wall with Retaining Wall and Rip Rap Berm

In Option E(a)3, the existing SSP wall is retained. A concrete cap is proposed on top of the existing SSP wall with a top elevation of 178.3 m. An armour stone retaining wall is proposed approximately 7 metres landward of the existing SSP wall. A concrete splash pad will be installed between the armour stone retaining wall and the SSP wall. The installation of a new anchor wall and new tie rods are proposed for the existing wall. A rip rap berm has been proposed in front of the existing SSP wall. A typical section for this option is illustrated on Figure 4-2.

Under the DHWL, the water level will be 0.3 m below the top of the concrete cap. The wall will be severely overtopped by waves during the design storm event. A reinforced concrete pad is proposed between the SSP wall and an armour stone retaining wall in the backshore. The pad

would be placed on top of the existing concrete platform, effectively raising the elevation by 0.2 to 0.3 m, and will prevent damage behind the wall during storm events. The new concrete pad would extend approximately 7 metres from the existing SSP wall to the armour stone retaining wall.

The purpose of the armour stone wall is to reduce overtopping into the backshore. The wall must be located a certain distance back from the existing SSP wall so as to not add any additional load relieving platform. The armour stone wall consists of stacked armour stones on a base of clear stone. The armour stone wall is also backed by a layer of clear stone for drainage purposes. Other types of secondary wall could be considered.

A rip rap berm in front of the existing SSP wall is also proposed as part of this option. The rip rap berm has a crest elevation of approximately 173.5 m and has a crest width of approximately 2 metres. The water depth against the wall will be approximately 2.5 metres at the datum water level. The crest elevation of the rip rap berm is slightly lower for this option than for Option E(a)2. In Option E(a)2, the backfill directly behind the SSP wall creates additional loading on the wall. The higher rip rap berm is required to provide support to the wall to resist the loading. The aim for this option was to not create any additional loading on the wall. The proposed rip rap berm provides a factor of safety on the stability of the wall and reduces scour at the toe of the SSP wall.

As with Option E(a)2, the installation of a new anchor wall, anchor rods and wale are proposed with as part of this option. The installation method would likely be similar to that described for Option E(a)2 (section 4.1.2). As with Option E(a)2, the wale would need to be installed on the lakeward side of the existing SSP wall.

This option relies on the continuing functioning of the concrete relieving platform. It does not result in additional loading on the relieving platform. The Owner may still wish to consider undertaking load testing to verify that the platform will continue to support the load since its existing condition cannot be assessed visually.

The construction cost estimate for this option includes rough grading of the backshore to 179.5m to 20 metres from the existing SSP wall. The cost estimate for this option is $14,100 ($14,800 – 2017) per metre of shoreline.

4.1.4 Option E(b)1 – Steel Sheet Pile Wall with Rip Rap Berm

Option E(b)1 is a steel sheet pile wall with rip rap berm. This Option is similar to Option E(a)1, described in Section 4.1.1. A typical section of Option E(b)1 through the washed out section is shown on Figure 4-3.

This option consists of a new anchored SSP wall including tie rods and an anchor wall. The top of the proposed SSP wall is at an elevation of 180.0 m. The rip rap berm in front of the wall has a crest elevation of 173.5 m and a crest width of approximately 2 metres. The slope of the rip rap berm is 2h:1v to the existing lake bottom.

The steel sheet pile wall has been aligned to the proposed shoreline position shown in the demonstration plan in the west part of the sub-reach. In the east part of the sub-reach, the sheet pile wall would be driven in front of the existing SSP wall. Similar to the east section the new SSP wall would need to be driven an appropriate distance in front of the existing SSP wall. The existing steel sheet pile wall would remain. The cavity between the new and existing SSP wall would likely be filled with clear stone. The existing concrete platform would need to be removed in any locations where it is unstable.

The 33 m of standing SSP wall in the west part of the reach would require removal. The collapsed SSP wall underwater would also need to be removed. The material sitting on the back of the bent over wall would first need to be excavated to expose the landward side of the wall. Once exposed, the removal of the SSP wall would likely be carried out from a barge with the assistance of a diving team to cut the steel sheet piling.

In the west part of the sub-reach, a large amount of excavation will be required to bring the shoreline back to the proposed location. Along this section of shoreline, the land would be excavated to accommodate the proposed protection structure and its alignment.

The construction cost estimate for this option includes rough grading of the backshore to 180.0m to 20 metres back from the SSP wall. The cost estimate for this option is $22,200 ($23,300 – 2017) per metre of shoreline.

4.1.5 Option E(b)2 – Rip Rap Berm with Armour Stone Protection

Option E(b)2 proposes a rip rap berm with armour stone protection on the upper slope. A typical section of Option E(b)2 through the collapsed SSP wall section is shown on Figure 4-3.

Similar to Option E(b)1, the 33 m metres of standing SSP wall in the west part of the reach and the collapsed SSP underwater would need to be removed. Most of the SSP wall in the east part of sub-reach E(b)2 could likely be retained and buried in the rip rap berm. The wall would need to be removed where it is unstable.

The proposed structure consists of rip rap placed in a berm with a slope of 2h:1v. A geotextile would likely be used on excavated slopes and under the upper portion of the structure. Armour stones are keyed and set into the upper slope and crest. The armour stone would be specially placed, meaning that stones are individually placed and interlocked with adjacent stones. The stones will provide additional protection in the region of wave run-up and run-down and ice protection during the winter. The crest elevation of the structure at the preliminary design phase is 179.6 m. The lakeside edge of the crest stone has been aligned to the proposed shoreline position in the demonstration plan.

A disadvantage of this option is if the crest is positioned at the proposed shoreline then the toe of the structure is outside of the property limit in the west part of the sub-reach. This may then require additional approvals under the Public Lands Act which may include acquisition of Crown land depending on the area of encroachment.

The construction cost estimate for this option includes rough grading of the backshore to 179.6m to 20 metres back from the lakeside edge of the crest stone. The construction cost estimate for this option is $20,400 ($21,400 – 2017) per metre of shoreline.

4.1.6 Option E(b)3 – Steel Sheet Pile Wall with Concrete Pad and Retaining Wall

Option E(a)3 proposes a new steel sheet pile wall, concrete splash pad, armour stone retaining wall and rip rap berm. This option is intended to be comparable to Option E(a)3, described in section 4.1.3. A typical section showing Option E(b)3 through the washed out section is shown on Figure 4-3.

The design consists of an anchored steel sheet pile wall. The wall has a concrete cap with a top elevation of 178.3 m. Under the DHWL, the water level will be 0.3 m below the top of the concrete cap. The wall will be severely overtopped during the design storm event. Behind the top of the SSP wall is an approximately 7 metre wide concrete pad. The purpose of the concrete pad is to protect the backshore during overtopping events. At the back of the pad is a stacked armour stone retaining wall. The crest of the armour stone wall is 180.0 m. Its purpose is to reduce overtopping into the backshore to a manageable level. The armour stone wall is constructed on a base of clear stone and backfilled with clear stone.

A rip rap berm is proposed in front of the SSP wall. The rip rap berm has a crest width of approximately 2 metres and a crest elevation of 173.5 m. The water depth at the wall at the datum water level (176.0 m) will be approximately 2.5 m. The berm provides additional stability to the SSP wall.

In the west part of the sub-reach, the SSP wall has been aligned to the shoreline position shown in the demonstration plan. In the east part of the sub-reach, the SSP wall would be driven in front of the existing wall. The cavity between the existing and new SSP wall would be filled with clear stone. The anchor rods in this section would need to be installed by drilling through the existing SSP wall and directional drilling under the existing concrete relieving platform.

The construction cost estimate for this option includes rough grading of the area behind the wall to 179.5 m. The extent of the grading is 20 metres back from the SSP wall. The cost estimate for this option is $17,100 ($18,000 – 2017) per metre of shoreline.

4.1.7 Option E(a) & (b)4 – New Steel Sheet Pile Wall Without Rip Rap Berm

Option E4 proposes a new steel sheet pile wall similar to options E(a) &(b) 1, however to maintain water depth in front of the wall the rip rap berm has been removed.

As a result of removing the rip rap berm, larger sheet pile sections will be required and they will need to be driven to deeper depths to maintain stability of the wall. Two anchors are required with the second anchor wall installed below water. This option will maintain the top of wall at 180.0m in order to reduce overtopping into the backshore.

The construction cost estimate for this option includes rough grading of the backshore to an elevation of 180.0 m a distance of 20 m back from the lakeside edge of the SSP wall. The cost

estimate includes an allowance for a standard steel SSP cap only. The estimated cost for this option is $28,500 ($29,900 – 2017) per linear metre of shoreline.

4.2 Centre Reach

The Centre Reach is approximately 388 m long. The existing conditions in this reach are described in Section 3.1.2. The design wave used for the development of concept level treatments for this reach has a significant wave height of 1.7 metres and is at an angle of 30 degrees to the shoreline.

The proposed shoreline position in the Centre Reach follows the existing shoreline for the most part. At the east end of the reach, the proposed shoreline is approximately 15 metres landward of the existing shoreline. The proposed shoreline curves out to join the existing shoreline approximately 40 metres to the west. In the west part of the reach the proposed shoreline evens out the undulations in the existing shoreline. The proposed shoreline is landward of the concrete and armour stone headland and the remains of the pier. The proposed shoreline is landward of the existing shoreline through the shoreline with the small embayment and marine railway. The position of the proposed shoreline is shown on Figure 4-1.

Three options were considered for this reach. Option C1 is a rip rap berm with armour stone protection on the upper slope. Option C2 is a cantilever steel sheet pile wall and Option C3 is an anchored steel sheet pile wall.

4.2.1 Option C1 – Rip Rap Berm with Armour Stone Protection

Option C1 is a rip rap berm with armour stone protection on the upper slope. The crest of the structure for Option C1 is 179.2 m. This option is illustrated on Figure 4-5. The lakeside edge of the crest stone has been aligned to the proposed shoreline in the demonstration plan.

The structure consists of rip rap stone randomly placed in a stable berm. The berm has a slope of 2h:1v. The rip rap overlays a geotextile placed on the excavated, or existing, slope. Armour stone is keyed and set into the upper slope and crest of the rip rap berm to provide additional protection. The armour stone would have special placement, meaning that each stone is individually placed and interlocked with adjacent stones.

The armour stone protection extends to the limit of wave run-down calculated using the design wave at the datum water level (176.0 m). The wave run-down is the lower extreme water level reached by a wave on a sloping structure. The limit of wave run-down has been calculated using the method described in CIRIA (2007).

The proposed shoreline is approximately 8 metres landward of the property limit at the closest point. The closest point is approximately 80 metres from the east limit of the reach. The toe of the structure will be outside of the property at this location and for a distance either side of it. As described for Option E(b)2, section 4.1.5, approvals under the Public Lands Act may be required which may require acquisition of Crown land.

The cost estimate includes rough grading of the backshore to 179.2 m to 12 metres back from the lakeside edges of the cap stone. The estimated cost for this option is $5,800 ($6,100 – 2017) per linear metre of shoreline.

4.2.2 Option C2 – Cantilever Steel Sheet Pile Wall with Rip Rap Berm

Option C2 is a cantilever steel sheet pile wall with a rip rap berm in front. The lakeside edge of the SSP wall has been aligned to the proposed shoreline alignment in the demonstration plan. This option is illustrated on Figure 4-5.

A cantilever steel sheet pile wall is a steel sheet pile wall without an anchor wall and tie-back system. The crest of the steel sheet pile wall is 179.4 m. The crest of the wall is slightly higher than the berm in Option C1 since overtopping is higher for a vertical wall than for a porous sloping structure, such as a sloping armour stone structure or rip rap berm.

The rip rap berm has a crest elevation of 177.0 m and a crest width of approximately 1 metre. The crest of the berm will be visible above water at most water levels. The berm slopes at 2h:1v to meet the existing lakebed. Where the nearshore is shallow, we have allowed for excavation to allow for placement of a nominal thickness of rip rap to 174.0 m, then horizontal excavation to meet the existing profile.

The construction cost estimate includes grading to 179.4 m to 12 m landward of the shoreline. The estimated cost for this option is $11,100 ($11,700 – 2017) per linear metre of shoreline.

4.2.3 Option C3 – Anchored Steel Sheet Pile Wall with Rip Rap Berm

Option C3 is an anchored steel sheet pile wall with a rip rap berm. The lakeside edge of the SSP wall has been aligned to the proposed shoreline alignment in the demonstration plan. This option is illustrated on Figure 4-5.

The crest elevation of the steel sheet pile for Option C3 is 179.4 m. The rip rap berm in front of the wall has a crest elevation of 176.0m and a crest width of approximately 1 metre. The crest of the rip rap berm will only be visible at low water levels. The berm slopes at 2h:1v to meet the existing grade. Where the nearshore is shallow, we have allowed for excavation to 174.0 m to accommodate the placement of a minimum thickness of rip rap and then horizontal excavation to meet the existing profile.

The construction cost estimate for this option includes grading of the backshore to 179.4 m between the shoreline and 12 m landward of the shoreline. The estimated cost for this option is $7,200 ($7,600 – 2017) per linear metre of shoreline.

4.3 West Reach

The West Reach is approximately 291 metres long. The existing conditions for this reach are presented in Section 3.1.3. The design wave used for this reach has a wave height of 1.4 metres at an angle of 20 degrees to the shoreline (see section 2.1.2). The position of the

proposed shoreline in this reach is shown on Figure 4-1. It essentially follows the existing shoreline.

Five options were considered for the west reach. Option W1 is a rip rap berm with a cap armour stone. Option W2 is a rip rap berm with armour stone on the upper slope and crest. Option W3 is a rip rap berm with a stacked armour stone wall above water. Option W4 is a cantilever steel sheet pile wall and Option W5 is an anchored steel sheet pile wall.

All options presented for this reach raise the elevation of the backshore. At the west end of the reach, the fill will result in increased loading on the existing SSP wall along the west shoreline in the adjacent marina (see section 3.1.5). The stability of the existing SSP wall, which we believe is outside the property limits, has not been checked. It will need to be checked as part of the detailed design and may require modification to support the additional load. No allowance to undertake modifications or reconstruct the wall has been included in the construction cost estimates presented.

4.3.1 Option W1 – Rip Rap Berm with Cap Armour Stone

Option W1 is a rip rap berm with a cap armour stone. This option is illustrated on Figure 4-6.

The option consists of a rip rap placed in a berm at a slope of 2h:1v to meet the existing lakebed. The crest of the rip rap is approximately 1 metre wide and has a crest elevation of 178.3 m. A single cap armour stone with a crest elevation of 178.8 m is proposed along the back of the crest of the rip rap. The lakeside edge of the cap armour stone is in line with the shoreline location shown in the demonstration plan. The rip rap extends under and behind the crest armour stone.

Along the shoreline with the submerged timber structure, the rip rap would be placed directly on top of the structure. The rip rap would be placed on a geotextile at the back of the structure and at the upper part of the structure. The intention is that the rip rap berm essentially buries the timber structure such that its removal is not required. At the west end of the reach, the SSP would be cut and removed at an elevation above the waterline to facilitate the installation of the berm.

The construction cost estimate for this option includes grading of the backshore to 178.8 m to14 metres behind the crest of the cap armour stone. This construction cost of this option is $6,600 ($6,900 – 2017) per metre of shoreline.

4.3.2 Option W2 – Rip Rap Berm with Armour Stone Protection

Option W2 is a rip rap berm with armour stone protection on the upper slope. A typical section of this option through the portion of the shoreline with the submerged timber structure is shown on Figure 4-6.

The structure consists of rip rap stone placed in a stable berm. The rip rap is placed on a geotextile on the upper portion and directly on the timber structure in the lower portion. Armour stone is keyed and set into the upper slope and crest of the rip rap berm. The armour stone

would be specially placed. The armour stone will provide additional protection against wave attack and ice forces at the water line. The crest elevation is 178.8 m. The lakeside edge of the crest stone has been aligned to the proposed shoreline in the demonstration plan.

Similar to Option W1, the intention with this option is to essentially bury the timber structure. Along the section of the shoreline with the SSP wall, the wall would be cut off at an elevation above the water level to accommodate the installation of the stone.

The cost estimate includes rough grading of the backshore to 178.8 m to 14 metres back from the lakeside edges of the cap stone. The estimated cost for this option is $7,600 ($8,000 – 2017) per linear metre of shoreline.

4.3.3 Option W3 – Rip Rap Berm with Armour Stone Wall

Option W3 is a rip rap berm with an armour stone wall at the water line. A typical section of this option through the portion of the shoreline with the submerged timber structure is shown on Figure 4-6.

The armour stone wall consists of three stacked armour stones. Each stone layer is set back from the one below to give the wall an overall batter. The crest of the armour stone wall is at elevation 178.8m. The lakeside edge of the top stone has been aligned to the proposed shoreline in the demonstration plan. The wall is founded on a base of rip rap. Some removal of the remains of the timber structure may be required to provide a stable base for the armour stone wall.

The rip rap extends up and behind the wall. A rip rap splash pad will be visible along the shoreline at the back of the wall. Rip rap will be placed in front of the wall in a berm. The berm has a crest elevation of approximately 177.7m and a crest width of approximately 1 metre. The bottom stone and the lower half of the middle stone will be buried in the rip rap berm. The rip rap berm slopes at 2h:1v to meet the existing grade.

The cost estimate for this option includes rough grading of the backshore to 178.8 m to 14 metres back from the lakeside edges of the cap stone. The estimated construction cost for this option is $7,300 ($7,700 – 2017) per linear metre of shoreline.

4.3.4 Option W4 – Cantilever Steel Sheet Pile Wall with Rip Rap Berm

Option W4 is a cantilever steel sheet pile wall with a rip rap berm in front. A typical section for this option is shown on Figure 4-6.

The top of the SSP wall is at 179.0 m. The top of the wall is slightly higher than the crest elevation for Options W1 to W3. This is because overtopping is higher for a vertical wall compared to a sloping porous structure (such as a rip rap berm or sloping armour stone structure).

The steel sheet pile would be driven on the lakeside of the existing vertical timbers. The timber structure would be buried under fill material placed behind the SSP wall. No allowance has been made for removal of the timber structure.

A rip rap berm is proposed in front of the cantilever steel sheet pile wall. The berm provides additional support to the cantilever wall. The crest of the rip rap berm is at an elevation of 177.0 m and approximately 1 metre wide. The crest of the berm will be visible above water at most water levels.

The cost estimate has been prepared assuming that the backshore will be rough graded to 179.0 m from the shoreline to 14 metres landward of the shoreline. The construction cost estimate for this alternative is $13,300 ($14,000 – 2017) per metre of shoreline.

4.3.5 Option W5 – Anchored Steel Sheet Pile Wall with Rip Rap Berm

Option W5 is an anchored steel sheet pile (SSP) wall with a rip rap berm in front. This option is illustrated on Figure 4-6.

The steel sheet pile wall essentially follows the existing shoreline. The sheet pile would be driven in front of the existing timber piles. Stone fill would be placed directly on top of the timber structure. An anchor wall is located a certain distance back from the wall. Anchor rods, installed at regular intervals along the length of the wall, tie the SSP wall to the anchor wall. The crest of the SSP wall is 179.0 m for this option.

A rip rap berm is proposed in front of the SSP wall and provides additional stability to the wall. The crest of the rip rap berm is approximately 1 metre wide with a crest elevation of 176.0 m. The crest of the berm will only be visible above water at low water levels.

The cost estimate has been prepared assuming that the backshore will be rough graded to 179.0 m from the shoreline to 14 metres landward of the shoreline. The estimated construction cost for this option is $9,300 ($9,800 – 2017) per metre of shoreline.

4.4 Shoreline East of Property Limit

The shoreline east of the property limit is approximately 85 metres long. The existing conditions for this shoreline were presented in Section 3.1.4. From Figure 2-6, the design wave along this section of shoreline is approximately 2.0 m in the north part of the shoreline. The significant wave height reduces to 1.6 m and lower along the south part of the shoreline, moving towards the existing outfall.

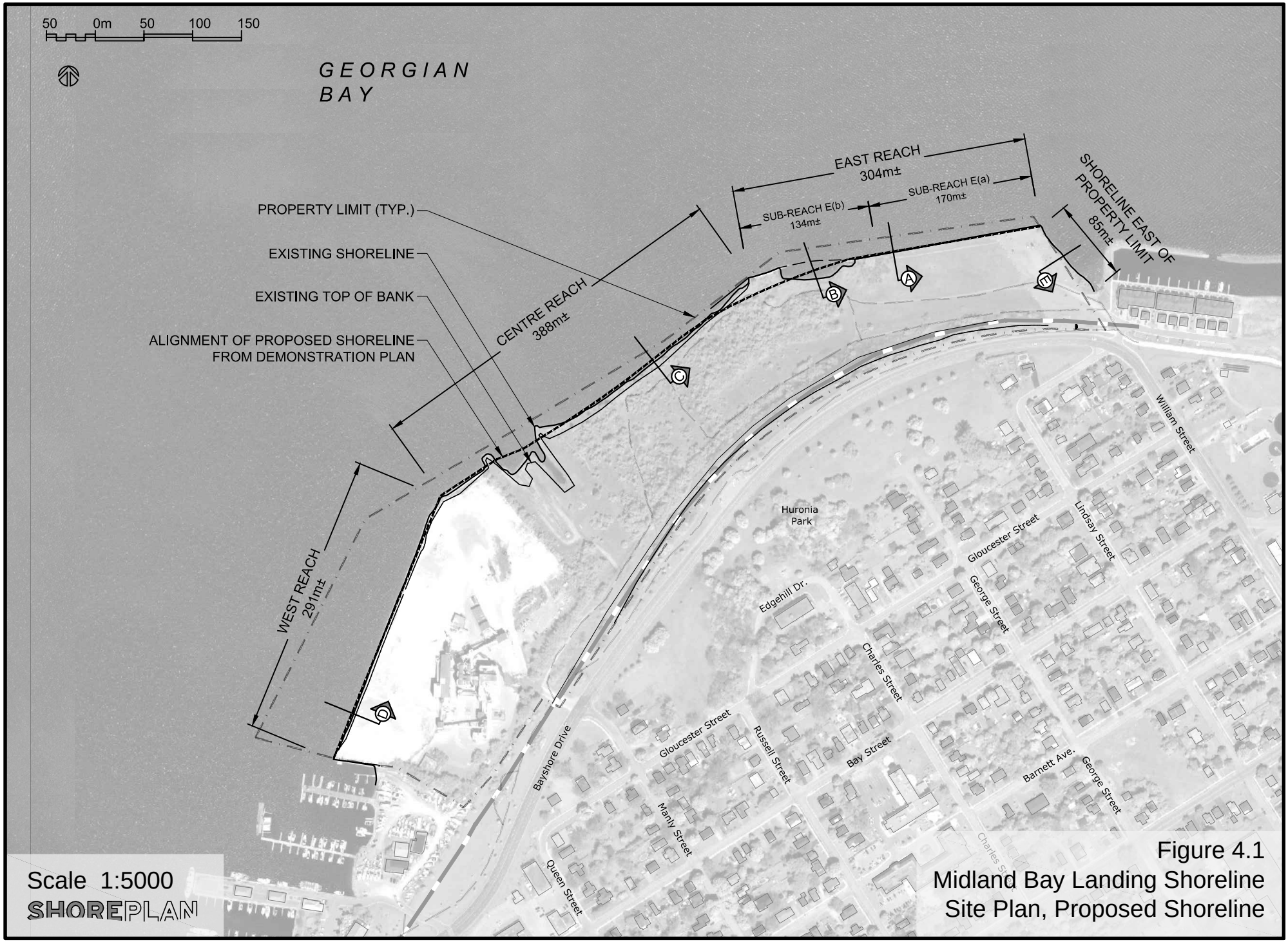
Although this section of shoreline is outside of the property line and study area, a flooding hazard exists on the subject property from this section of shoreline. We have considered one option for this reach; Option EPL. Option EPL is an armour stone revetment and is described below.

4.4.1 Option EPL

This option proposes an armour stone revetment along the east property limit shoreline. A revetment is a sloping stone structure. This option is illustrated on the section in Figure 4-8

The revetment for Option EPL is composed of a layer of primary armour stone overlaying a layer of rip rap. The layer of rip rap is separated from the excavated slope by a geotextile. The overall slope of the structure is 2h:1v. We have assumed special placement of the armour stone. A single toe stone is considered suitable at the preliminary design phase. The crest of the structure varies to match the elevation of the shore protection along East reach and reduces moving towards the outfall at the south end of this section of shoreline. This reduction in the crest elevation along the length of the structure corresponds to the reduction in design wave height along this length of shoreline.

For the cost estimate, we have assumed that the structure will follow the alignment of the existing shoreline. The construction cost estimate has been prepared to the back of the rip rap. No allowance for fill or rough grading of the backshore has been included. The construction cost estimate for this alternative is $6,100 ($6,400 – 2017) per metre of shoreline.



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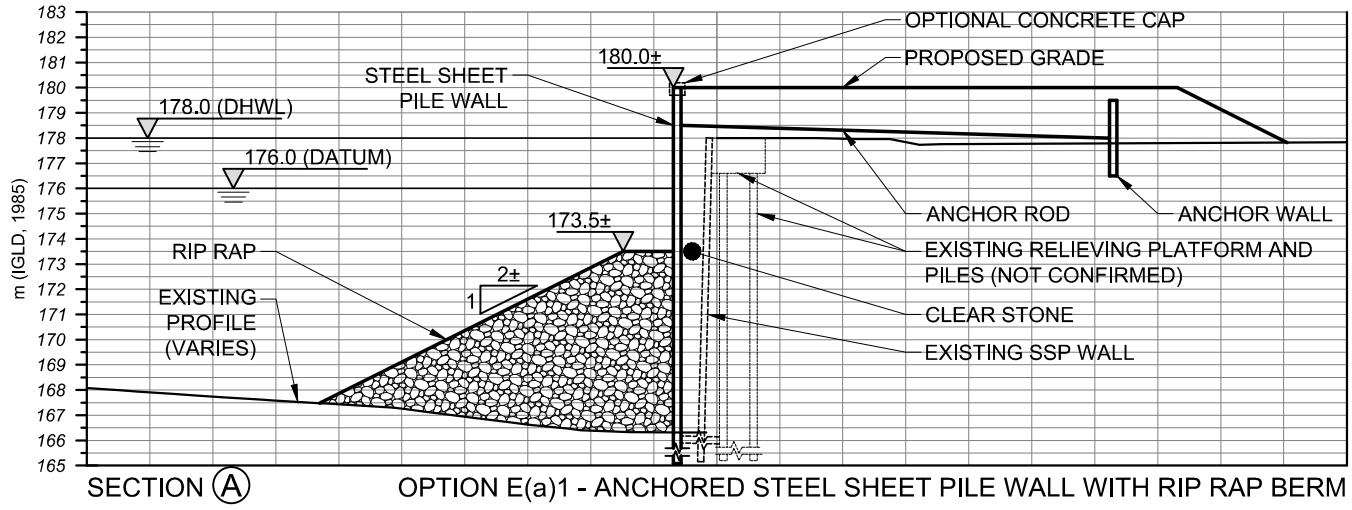
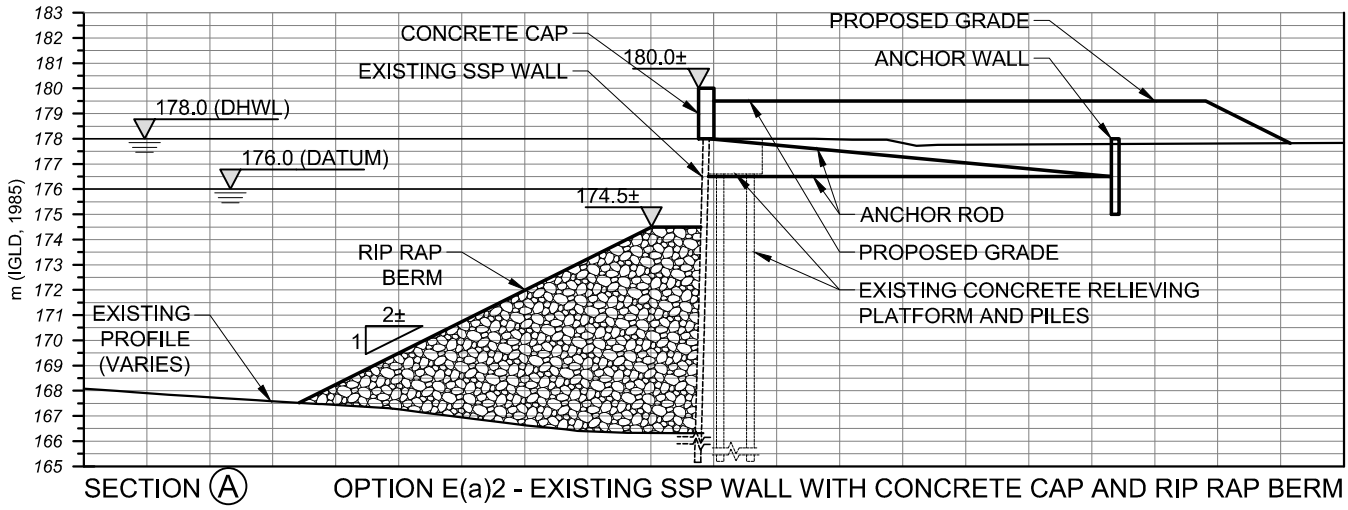
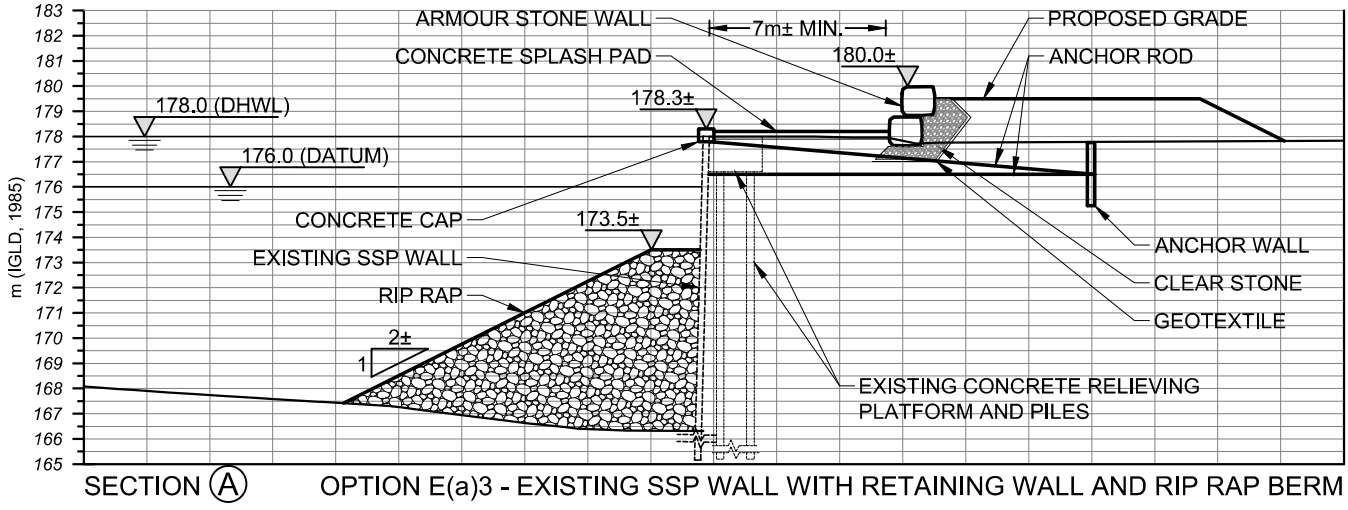
SHOREPLAN

Figure 4.1
Midland Bay Landing Shoreline
Site Plan, Proposed Shoreline







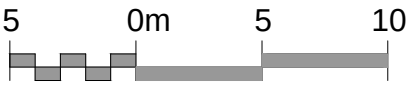


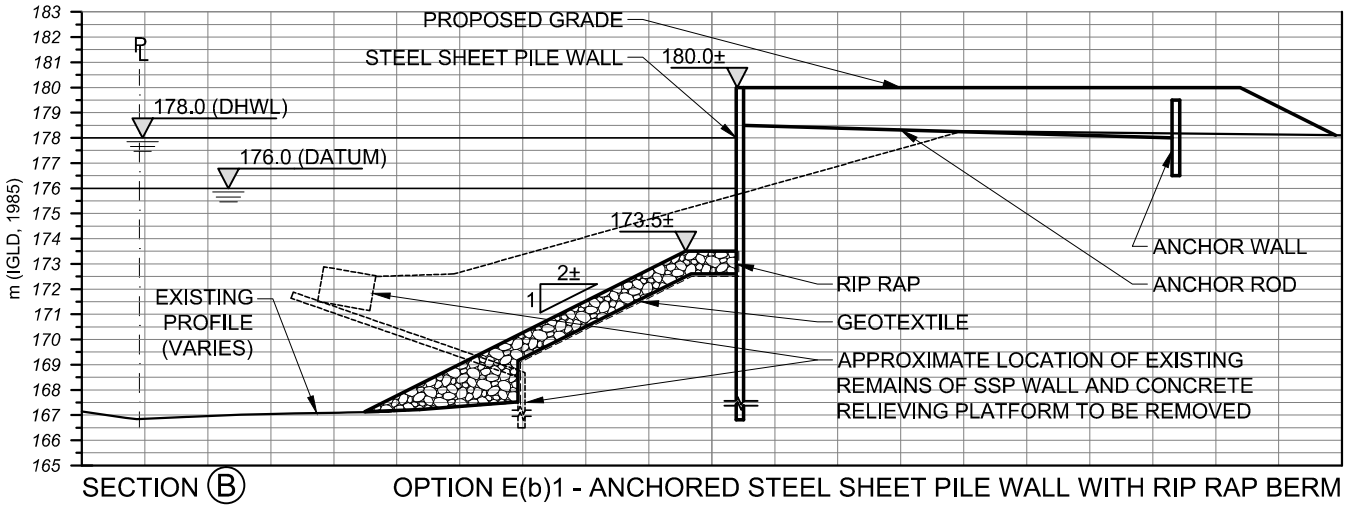
Figure 4.2

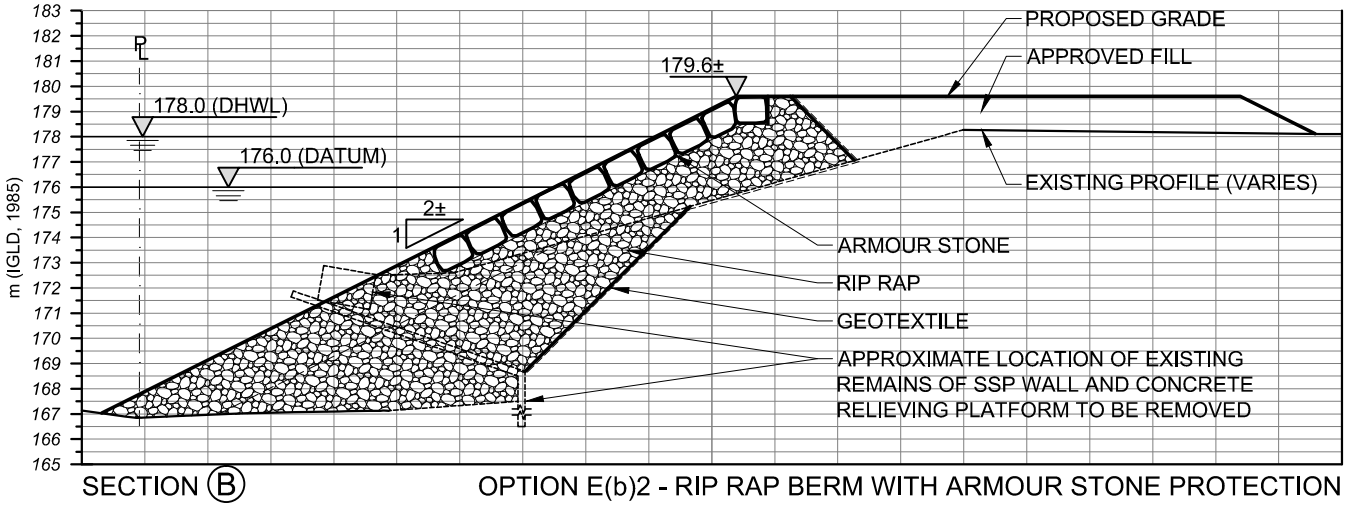
Scale 1:300

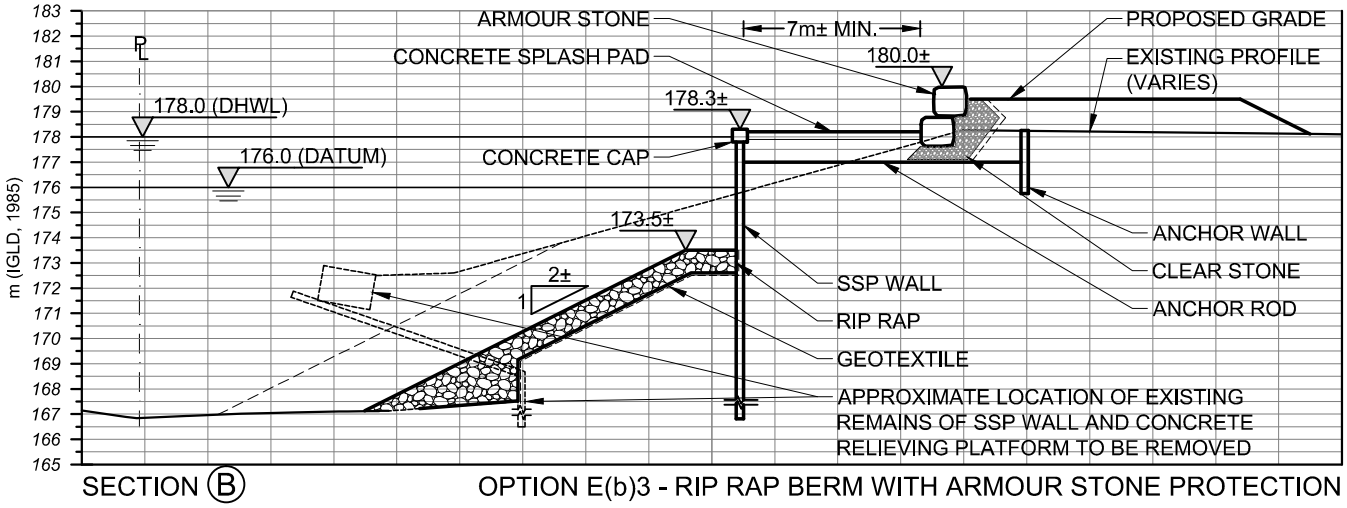
Midland Bay Landing Shoreline

SHOREPLAN

East Reach, Options E(a)1 to E(a)3, Typical Sections







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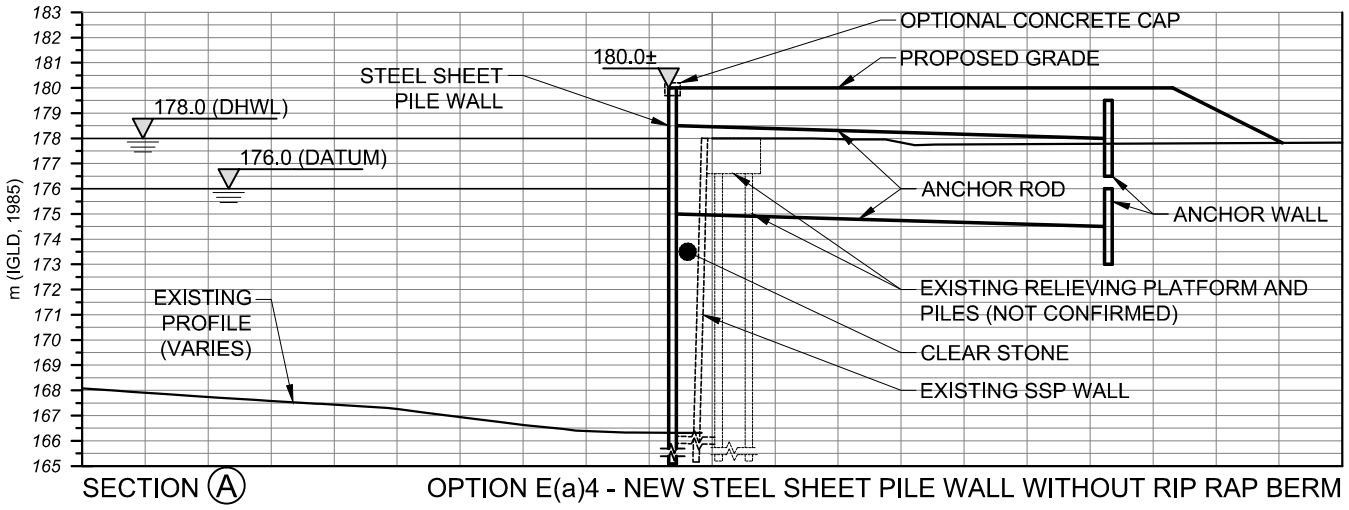
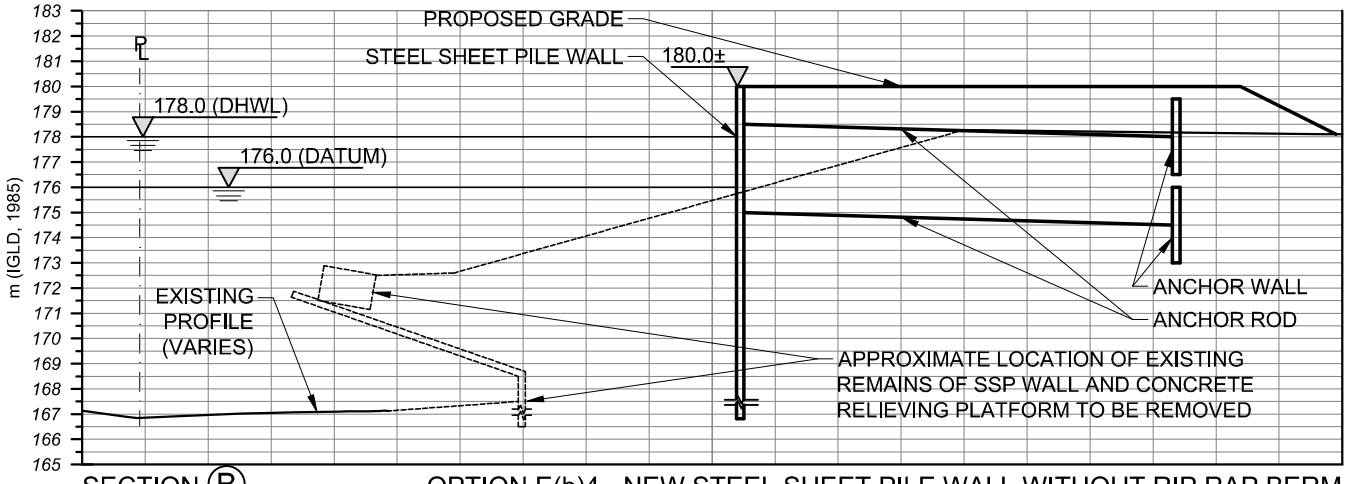
SHOREPLAN

Figure 4.3
Midland Bay Landing Shoreline
East Reach, Options E(b)1 to E(b)3, Typical Sections



SECTION Ⓐ OPTION E(a)4 - NEW STEEL SHEET PILE WALL WITHOUT RIP RAP BERM



SECTION Ⓑ OPTION E(b)4 - NEW STEEL SHEET PILE WALL WITHOUT RIP RAP BERM

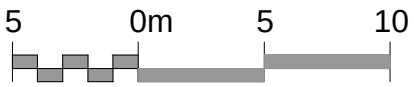
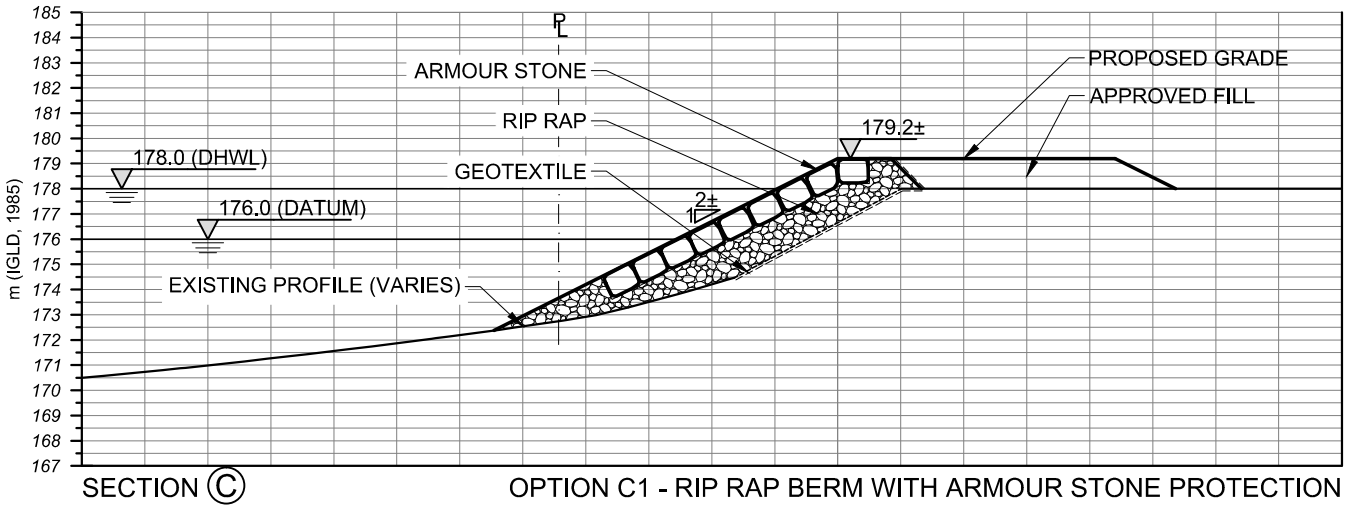


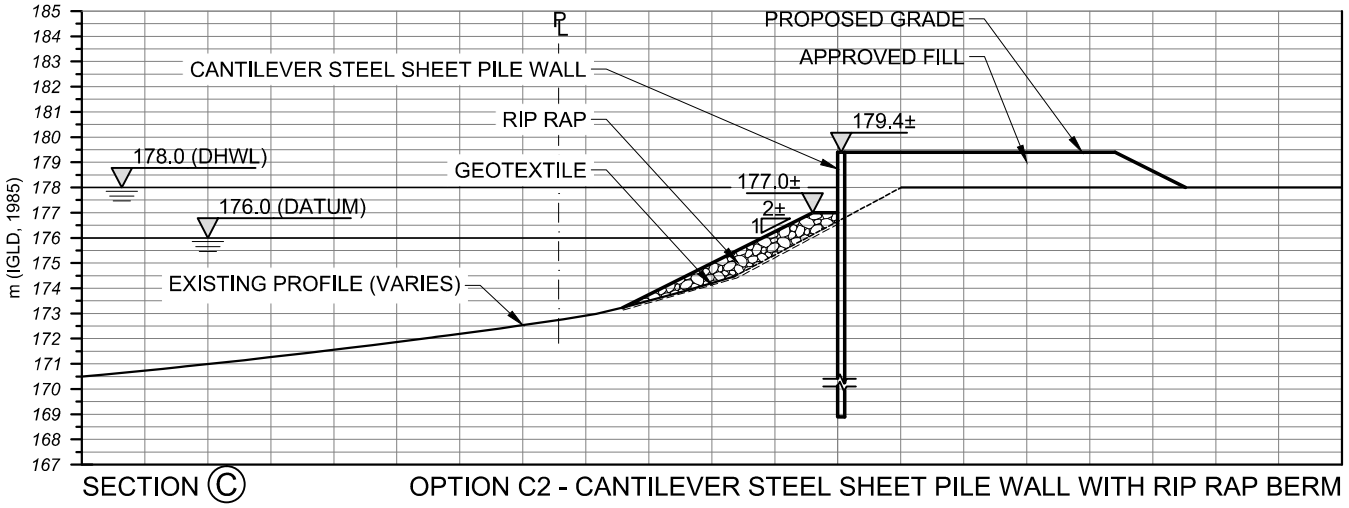
Figure 4.4
Midland Bay Landing Shoreline
East Reach, Options E(a)4 & E(b)4, Typical Sections

Scale 1:300

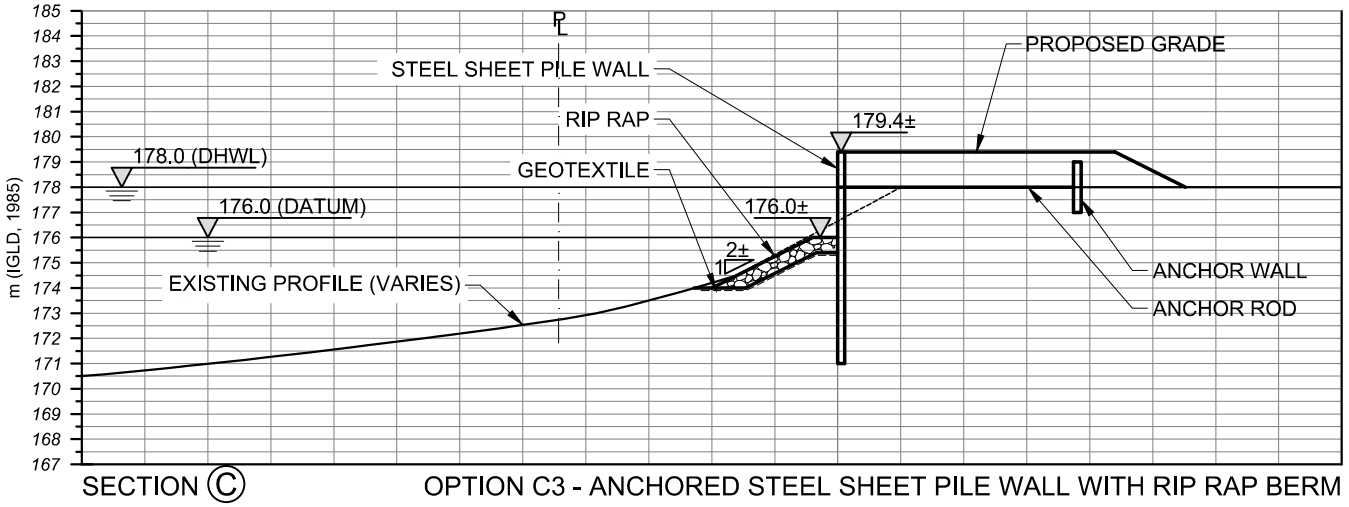
SHOREPLAN



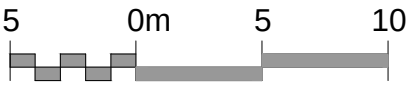
SECTION Ⓒ OPTION C1 - RIP RAP BERM WITH ARMOUR STONE PROTECTION



SECTION Ⓒ OPTION C2 - CANTILEVER STEEL SHEET PILE WALL WITH RIP RAP BERM



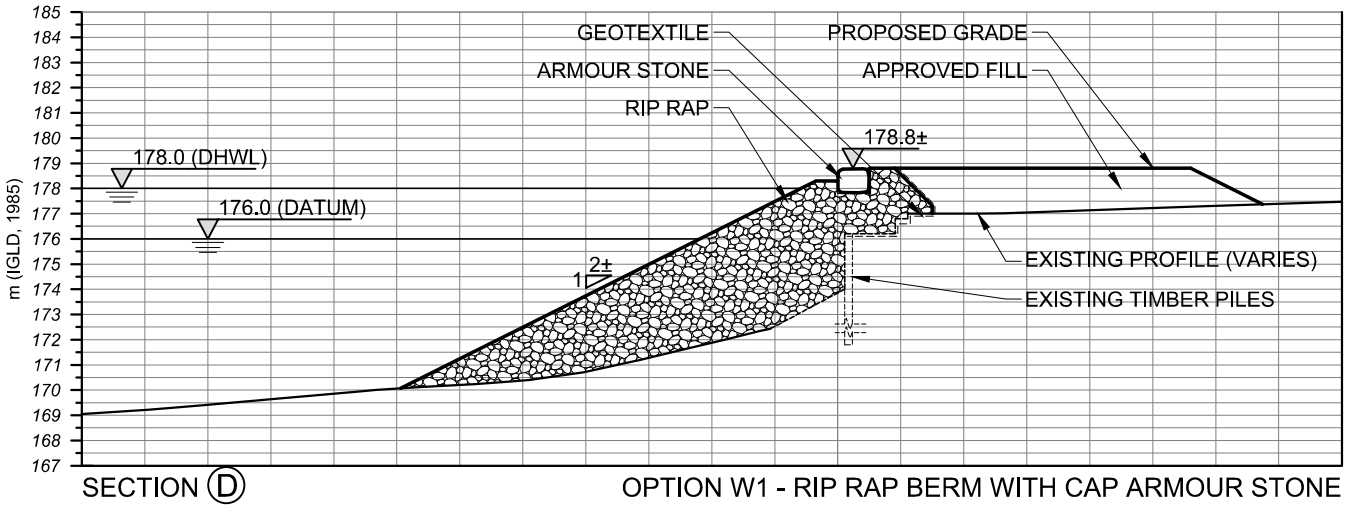
SECTION Ⓒ OPTION C3 - ANCHORED STEEL SHEET PILE WALL WITH RIP RAP BERM

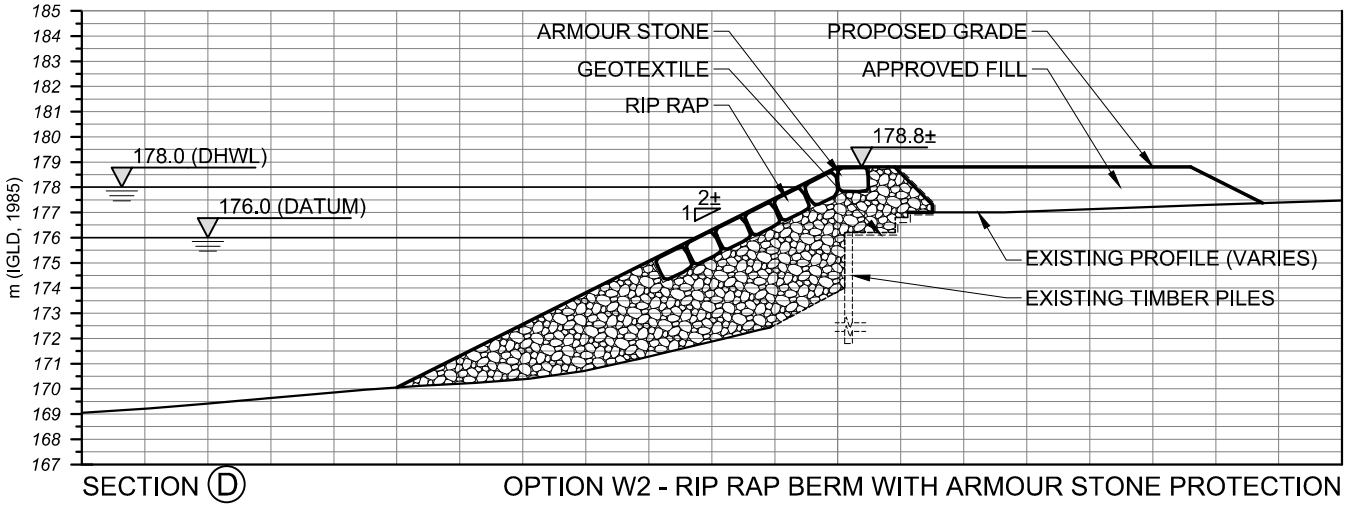


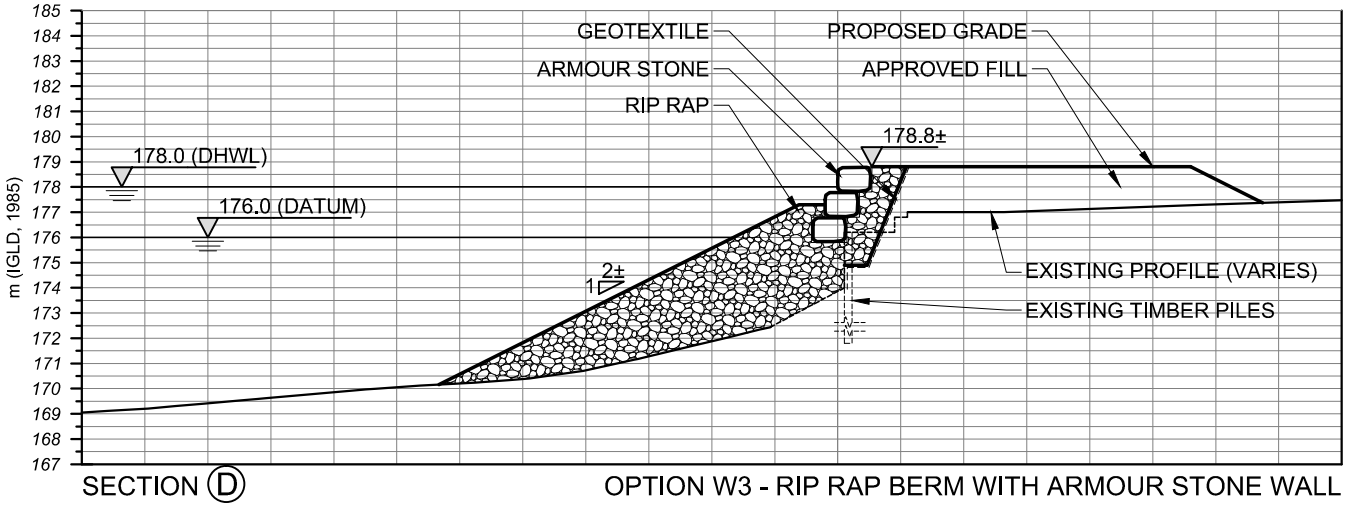
Scale 1:300

SHOREPLAN

Figure 4.5
Midland Bay Landing Shoreline
Centre Reach, Options C1 to C3, Typical Sections







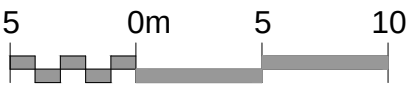
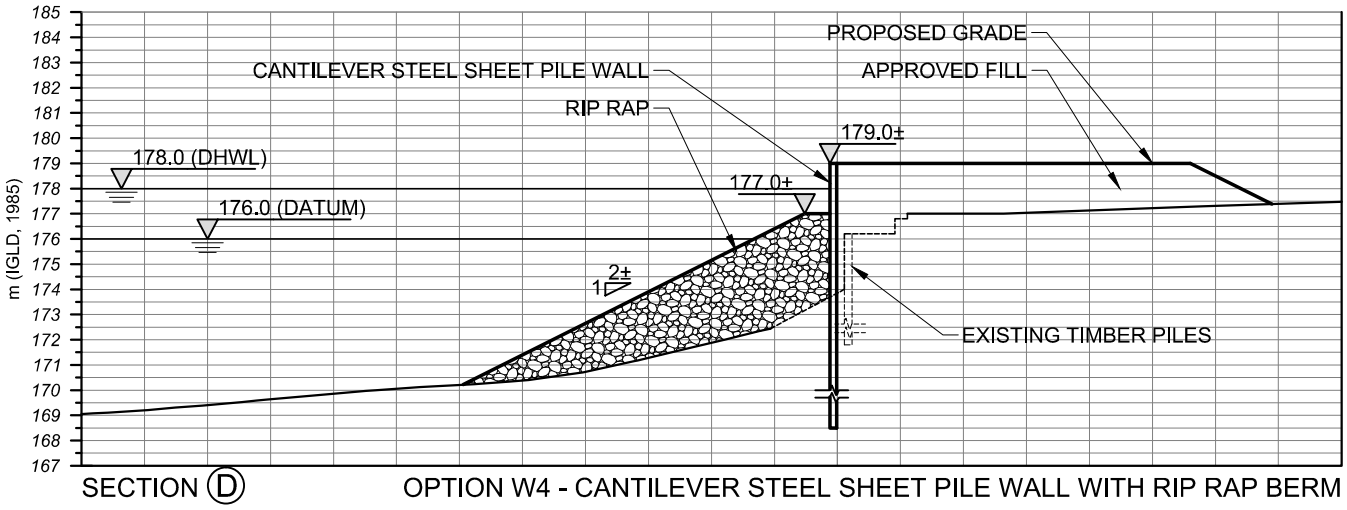


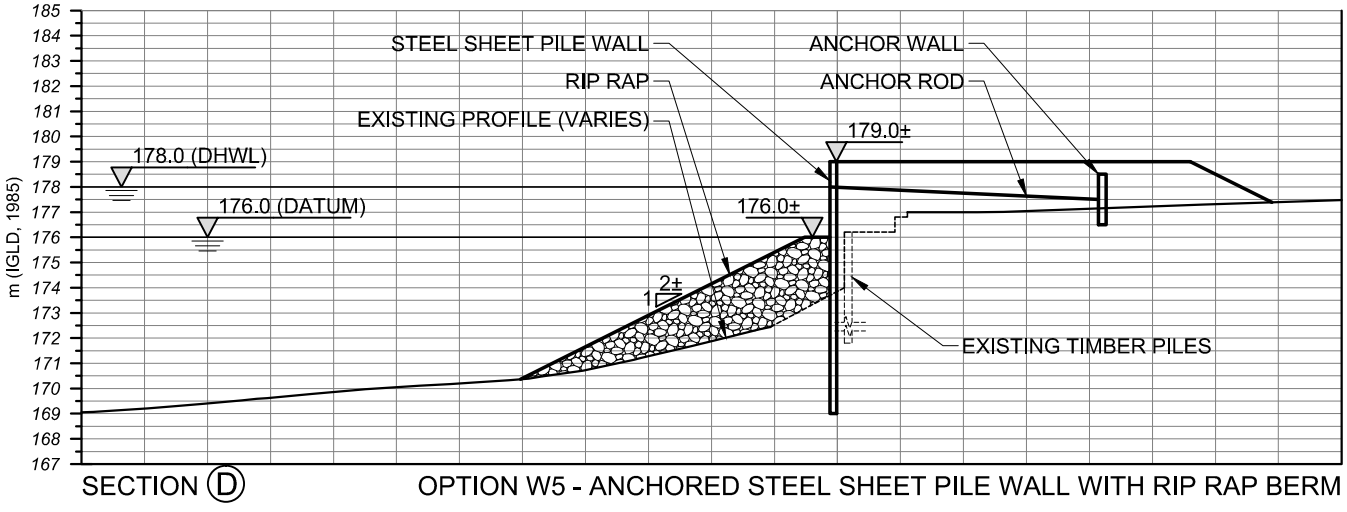
Figure 4.6
Midland Bay Landing Shoreline
West Reach, Options W1-W3, Typical Sections

Scale 1:300

SHOREPLAN



SECTION Ⓓ OPTION W4 - CANTILEVER STEEL SHEET PILE WALL WITH RIP RAP BERM



SECTION Ⓓ OPTION W5 - ANCHORED STEEL SHEET PILE WALL WITH RIP RAP BERM

Figure 4.7
Midland Bay Landing Shoreline
West Reach, Options W4 and W5, Typical Sections

Scale 1:300

SHOREPLAN

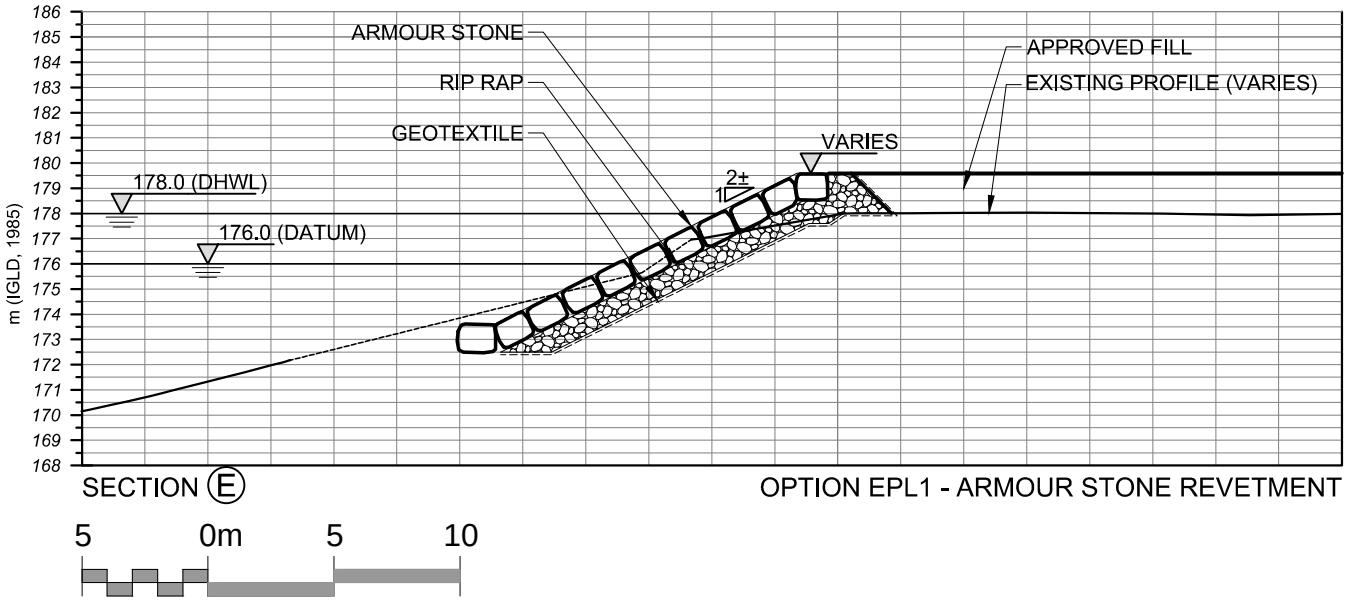


Figure 4.8

Scale 1:300

Midland Bay Landing Shoreline

SHOREPLAN

Shoreline East of Property Limit, Option EPL1, Typical Section

5 Natural Hazards Assessment

Following the MNR (2001) Technical Guides prepared to support the natural hazards policies of the PPS, the Midland Bay Landing shoreline is classified as artificial. The criteria used to define the artificial shore type include those shorelines that:

- cannot be classified on the basis of their physiographic characteristics due to human activities and/or alterations to the shoreline;
- involve structural changes that extend inland;
- involve protection works that exist above and below the waterline and extend alongshore for about 1 km;
- have the protection works under public ownership and/or are maintained by a public agency or a significant private concern; and
- have shoreline processes and flood, erosion and dynamic beach hazards which have been significantly altered by the protection work.

All of these conditions apply to the Midland Bay Landing shoreline.

When the shoreline is artificial the standard hazard assessment techniques do not apply and the Technical Guides note that site specific studies may be required to understand the local flood, erosion and dynamic beach hazards. This report constitutes such a study. For this site the appropriate action is to ensure that the artificial shore provides suitable erosion protection for any development that takes place behind that shoreline. Enhancement of the shoreline protection is discussed in Chapter 4 of the report. All of the options provide suitable erosion protection.

Each of the shoreline treatments described in Chapter 4 have been designed for the crest elevation required to control overtopping. The crest elevations of the structures ultimately selected for the site will be reviewed (and revised if necessary) during detailed design, to ensure overtopping rates are manageable. For the preliminary design, overtopping rates have limited to a mean rate of 50 l/s/m width of crest. The EurOtop guidelines give 50 l/s/m as the overtopping limit beyond which damage to grassed or lightly protected promenade or reclamation cover behind a revetment or seawall could occur (Pullen et al. 2007). Overtopping rates were calculated using the procedures described in the EurOtop manual (Pullen et al., 2007) and TAW (2002).

6 Approvals

Construction of shore protection will require agency acceptance or review. These reviews will be conducted by the Department of Fisheries and Oceans, Transport Canada and the Ministry of Natural Resources and Forestry. Details of these reviews are found in this section.

Fisheries Act: The Fisheries Act requires that projects avoid serious harm to fish unless authorized by the Minister of Fisheries and Oceans. This applies to work being conducted in or near waterbodies that support fish. DFO has developed list of pre-approved projects that do not require review by DFO. If the proposed work is not included in the pre-approved projects, the project will need to be reviewed under the Fisheries Act.

Shoreline protection projects generally require review by DFO if there is an increase in the footprint below the high water mark (HWM) in other words, occupation of the lake bottom or loss of fish habitat. DFO uses the 80th Percentile of the high water mark values as the water level that corresponds to the limit of aquatic habitat. HWM for Lake Huron is 176.96 m. (IGLD 1985). It is likely that the construction of shoreline protection will result in an increased footprint below the HWM. DFO looks at the difference between the existing and proposed HWM contours to assess the extent of fish habitat loss. The fish habitat loss will be larger the more lakeward that the structure is positioned. Authorization and an offsetting plan may be required if the loss of fish habitat is significant. Quality aspects of the habitat created and lost are also critical in the assessment.

An application for review to DFO is typically made after detailed design of the structures is complete. The submission typically includes fish habitat enhancements to offset the loss of fish habitat.

Navigation Protection Act: Transport Canada (TC) will review the project under the Navigation Protection Act. If TC determines that the work will not substantially interfere with navigation, the project may proceed without the Minister's approval. If the project is likely to substantially interfere with navigation, Minster's approval is required. TC will need to review this project to determine if it does substantially interfere with navigation. Detailed design drawings which include information regarding the navigational aids and dimensions of new structures will need to be provided with the application.

Public Lands Act: For the most part, lake and river bottoms in Ontario are Crown Land. Approval from the Ministry of Natural Resources and Forestry (MNRF) is required under the Public Lands Act if the any part of the works is constructed on Crown Land. Crown Land Acquisition may also be required based on the size of the area. If Crown Land acquisition is required, a work permit can typically be provided once the crown land acquisition process is underway.

Endangered Species Act: MNRF also reviews projects under the Endangered Species Act (ESA). If species-at-risk are known to be in area, an ESA authorization may be required.

Environmental Assessment Act: Depending on the implementation approach, the project may also be subject to the Environmental Assessment Act. The compliance with the requirements of the Act may be met with completion of an individual environmental assessment or a class environmental assessment under the Municipal Class Environmental Assessment. The work may not be subject to EAA if completed as part of a private undertaking.

Most of the alternatives we have suggested replace an existing structure with a new structure of same purpose, use and capacity at relatively the same location. It is possible that this project falls under schedule A or B of the Municipal Class Environmental Assessment.

7 Summary

The existing conditions along the Midland Bay Landing shoreline vary. The subject shoreline was divided into three main reaches; the East, Centre, and West reaches. The reaches are approximately 304 m, 388 m and 291 m respectively. The condition of the shoreline and protection structures was reviewed with the assistance of a diving crew.

The original shoreline protection in the East Reach consisted of a SSP wall. The SSP wall in the west part of the reach has collapsed or is in disrepair. The SSP wall in the east part of the reach is still standing. The shoreline protection along the Centre Reach consists mainly of informal protection. A marine railway is located within the Centre Reach. In the West Reach, the submerged remains of a timber structure were observed. There is a short section of SSP wall at the west end of the West Reach. The shoreline along the east property limit is protected by scattered armour stone and concrete rubble.

Sixteen options in total were considered for the rehabilitation of the various reaches of the shoreline; seven for the East Reach, three for the Centre Reach, five for the West Reach and one for the shoreline east of the property limit. Capital costs for each option were estimated and are presented in Table 7.1, Table 7.2, and Table 7.3 for the East, Centre and West reaches respectively.

The costs presented include only rough grading of the site in close proximity of the shoreline, to the limits and elevations described in the text and shown on the sections. No allowances for walkways or landscaping along the shoreline have been made. The costs do not include design costs, mobilization, demobilization, construction contingencies, acquisition of water lots, or HST. Mobilization and demobilization costs depend on the phasing of the project. Typically, at a concept design stage, a contingency of not less than 30% of the capital cost estimate would be appropriate.

A review or approvals by senior levels of government are required for the activities and that are expected to take place during the waterfront rehabilitation. These approvals include Fisheries Act, Navigation Protection Act, Public Lands Act and Endangered Species Act. The project may also require an assessment under the Environmental Assessment Act.

Table 7.1: Summary of Costs – East Reach

Option	2015 Construction Cost per metre *	2017 Construction Cost per metre *
Option E(a)1 – Anchored Steel Sheet Pile Wall with Rip Rap Berm	$22,000	$23,100
Option E(a)2 – Concrete Cap on Existing SSP wall and Rip Rap Berm	$15,300	$16,100
Option E(a)3 – Existing SSP wall with Armour Stone Retaining Wall and Rip Rap Berm	$14,100	$14,800
Option E(b)1 – Anchored Steel Sheet Pile Wall with Rip Rap Berm	$22,200	$23,300
Option E(b)2 – Rip Rap Berm with Armour Stone Protection	$20,400	$21,400
Option E(b)3 – Steel Sheet Pile Wall with Armour Stone Retaining Wall and Rip Rap Berm	$17,100	$18,000
Option E(a) & (b) – New Steel Sheet Pile Wall without Rip Rap Berm	$28,500	$29,900

Table 7.2: Summary of Costs – Centre Reach

Option	2015 Construction Cost per metre *	2017 Construction Cost per metre *
Option C1 – Rip Rap Berm with Armour Stone	$ 5,800	$6,100
Option C2 – Cantilever Steel Sheet Pile Wall with Rip Rap Berm	$11,100	$11,700
Option C3 – Anchored Steel Sheet Pile Wall with Rip Rap Berm	$ 7,200	$7,600

Table 7.3: Summary of Costs - West Reach

Option	2015 Construction Cost per metre *	2017 Construction Cost per metre *
Option W1 – Rip Rap Berm with Cap Armour Stone	$ 6,600	$6,900
Option W2 – Rip Rap Berm with Armour Stone	$ 7,600	$8,000
Option W3 – Rip Rap Berm with Armour Stone Wall	$ 7,300	$7,700
Option W4 – Cantilever Steel Sheet Pile Wall with Rip Rap Berm	$13,300	$14,000
Option W5 – Anchored Steel Sheet Pile Wall with Rip Rap Berm	$ 9,300	$9,800

* The preliminary costs do not include any allowances for tree removal, landscaping, or walkways along the shoreline. The costs do not include design costs, construction contingencies, mobilization, demobilization or HST.

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Town of Midland (2013) *the unimin waterfront lands master plan*, prepared by The Planning Partnership, Plan B Natural Heritage, TCI Management Consultants and Baird Associates Coastal Engineering, June 2013

Appendix A

Photo 1: East end of East Reach

Photo 2: SSP Wall, East Reach

Photo 3: SSP wall at east end of collapsed section, East Reach

Photo 4: East end of collapsed SSP wall section, East Reach

Photo 5: East end of collapsed SSP wall section, East Reach

Photo 6: SSP separated from concrete relieving platform, East Reach

Photo 7: Remains of timber structure exposed in bank at east end of collapsed SSP wall section, East Reach

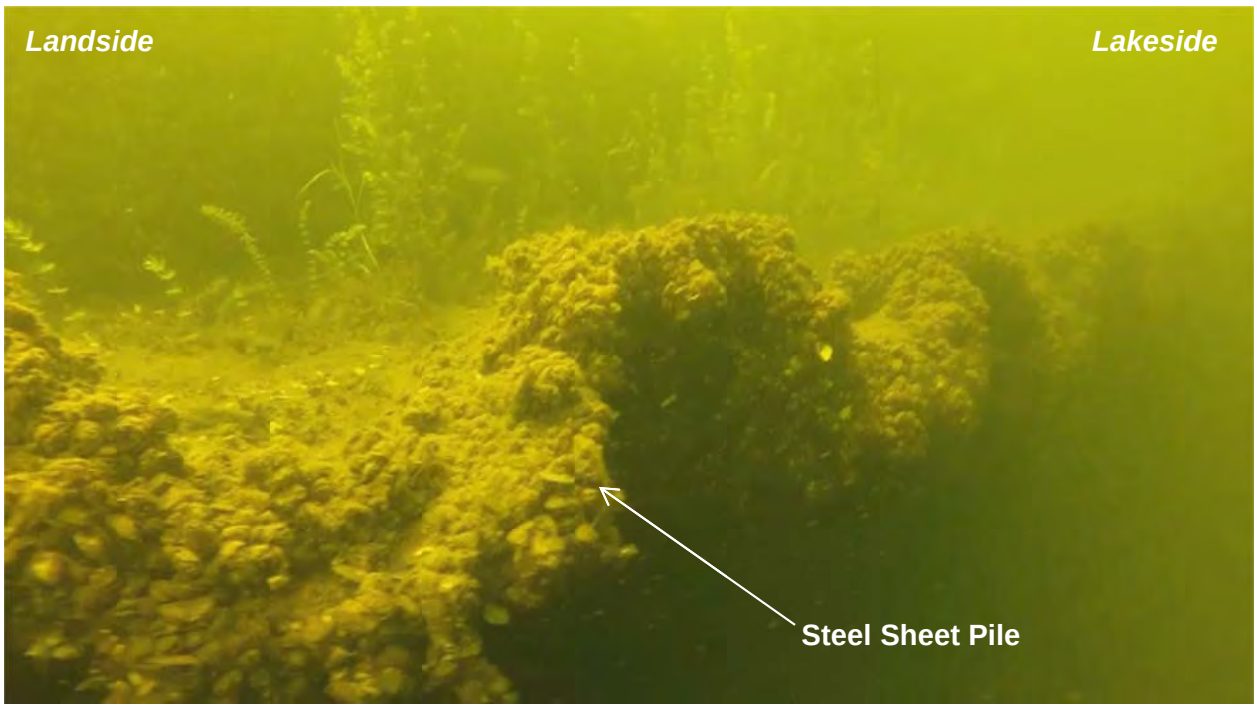

Photo 8: Collapsed SSP under water (Day 1 Dive 1, 1:12:39)

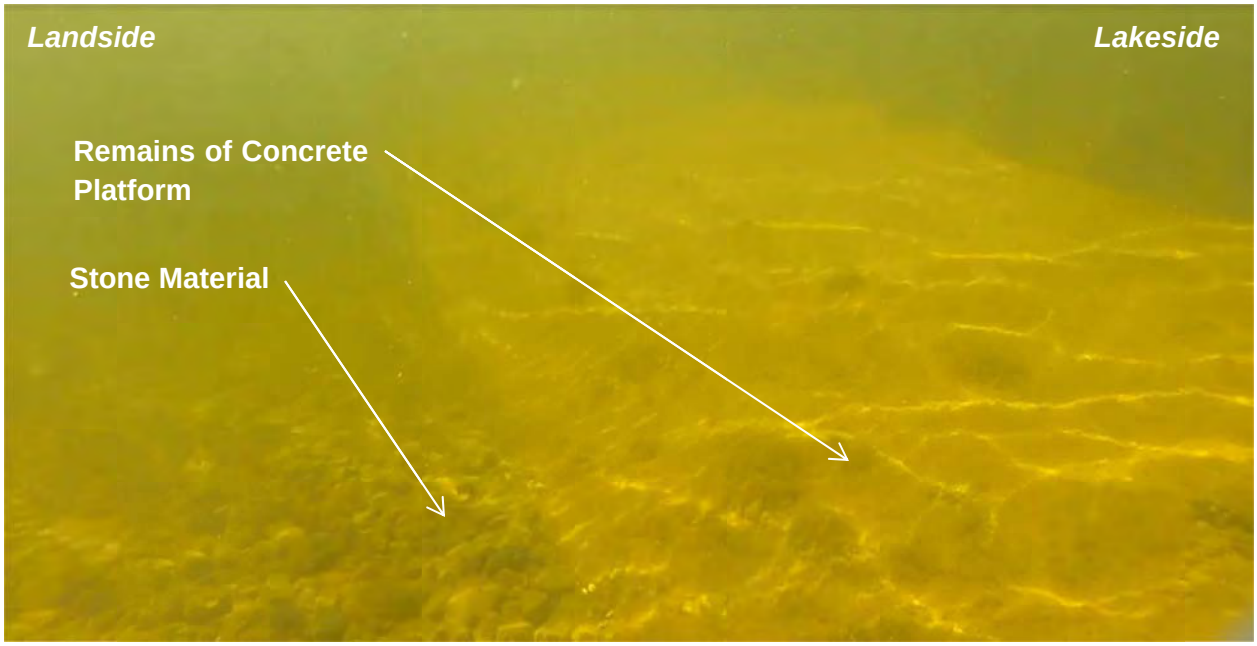

Photo 9: Remains of Collapsed Concrete Relieving Platform underwater (Day 1, Dive 1, 1:23:13)

Photo 10: Collapsed SSP and Concrete Relieving Platform underwater (Day 1, Dive 1, 1:23:53)

Photo 11: Shoreline behind collapsed SSP wall, East Reach

Photo 12: East SSP wall

Photo 13: End of west SSP, East Reach

Photo 14: Timber piles at west end of East Reach (Day 1, Dive 1, 1:33:37)

Photo 15: East end of Centre Reach

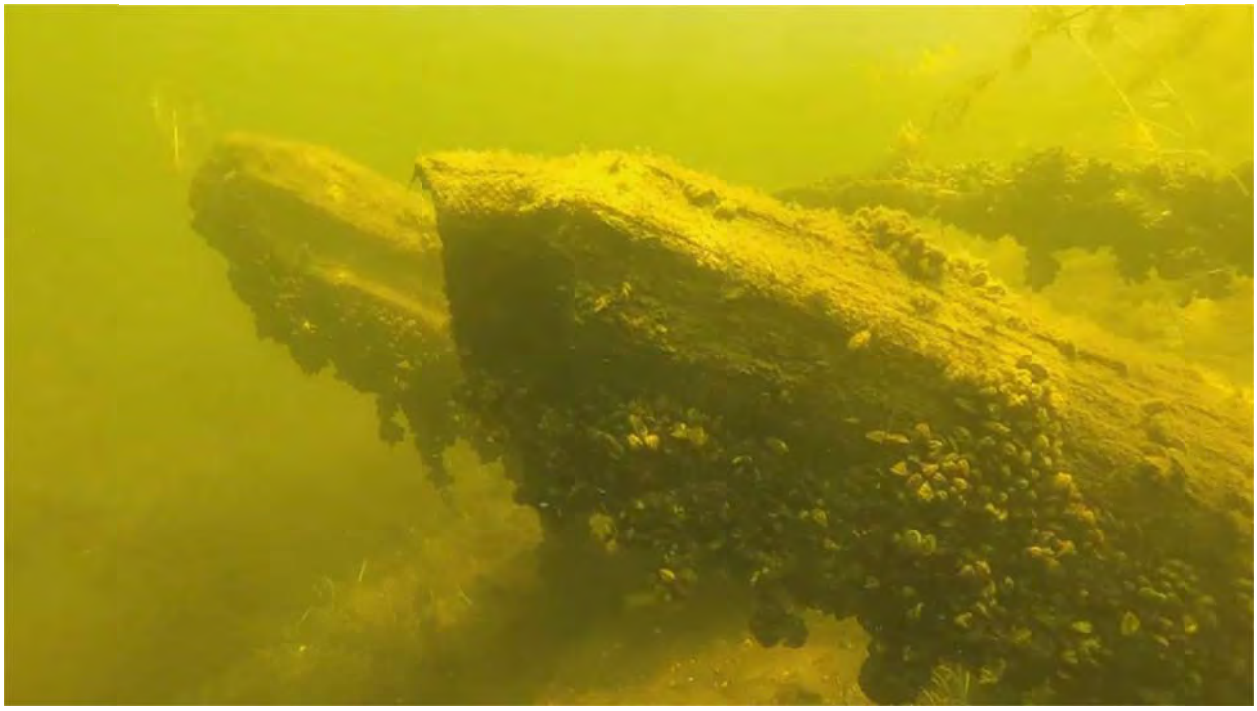

Photo 16: Timber Piles in Centre Reach (Day 1, Dive 1, 1:49:37)

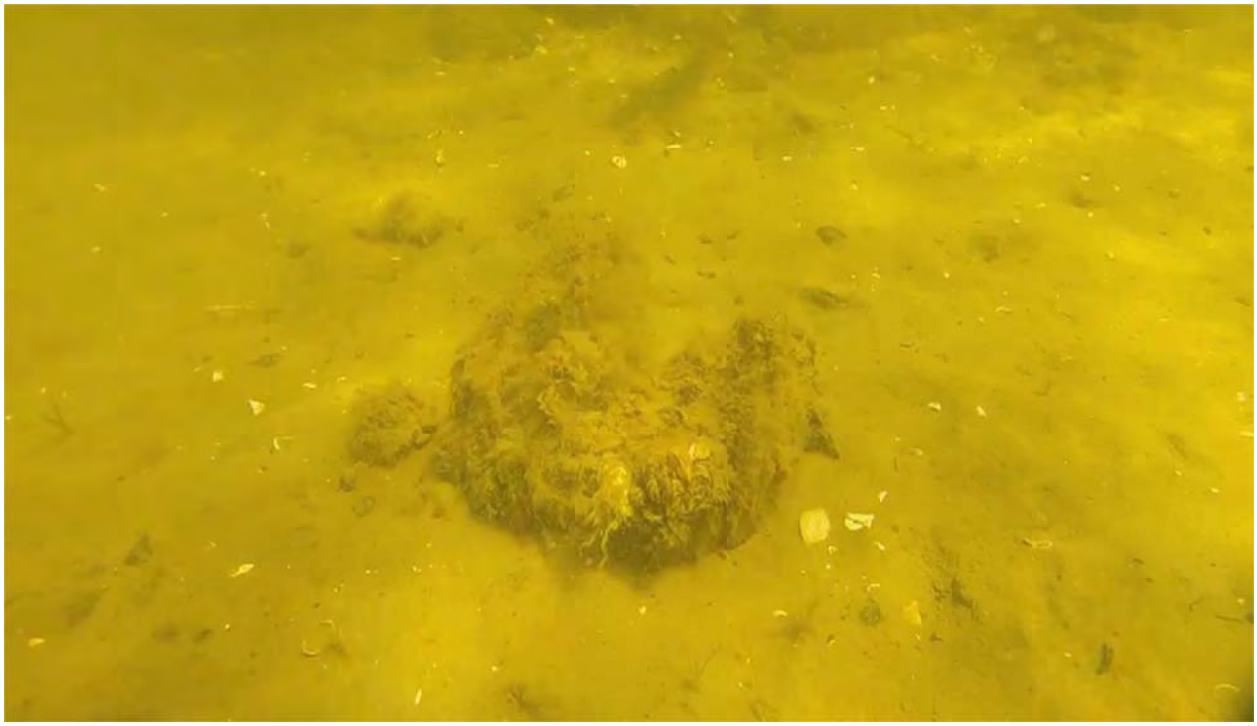

Photo 17: Timber pile in lakebed in Centre Reach (Day 1, Dive 1, 1:59:13)

Photo 18: Concrete rubble and armour stone headland in Centre Reach

Photo 19: Embayment and Collapsed deck and light standard, Centre Reach

Photo 20: Small embayment in Centre Reach

Photo 21: Marine Railway, Centre Reach

Photo 22: Remains of Pier, West side, Centre Reach

Photo 23: Remains of Pier, East side, Centre Reach

Photo 24: West end of Centre Reach

Photo 25: East end of West Reach

Photo 26: Large concrete foundation in east part of West Reach

Photo 27: Exposed underside of concrete deck, west reach

Photo 28: West Reach

Photo 29: Corrugated Steel Pipe in West Reach

Photo 30: SSP wall at west end of site, West Reach

Photo 31: Interface between U-series and Algoma SSP wall, West Reach

Photo 32: East end of SSP wall, East Reach

Photo 33: Shoreline east of property limit

Photo 34: Outfall at east end of property

Photo 35: Shoreline west of property limit

Photo 36: Shoreline west of property limit

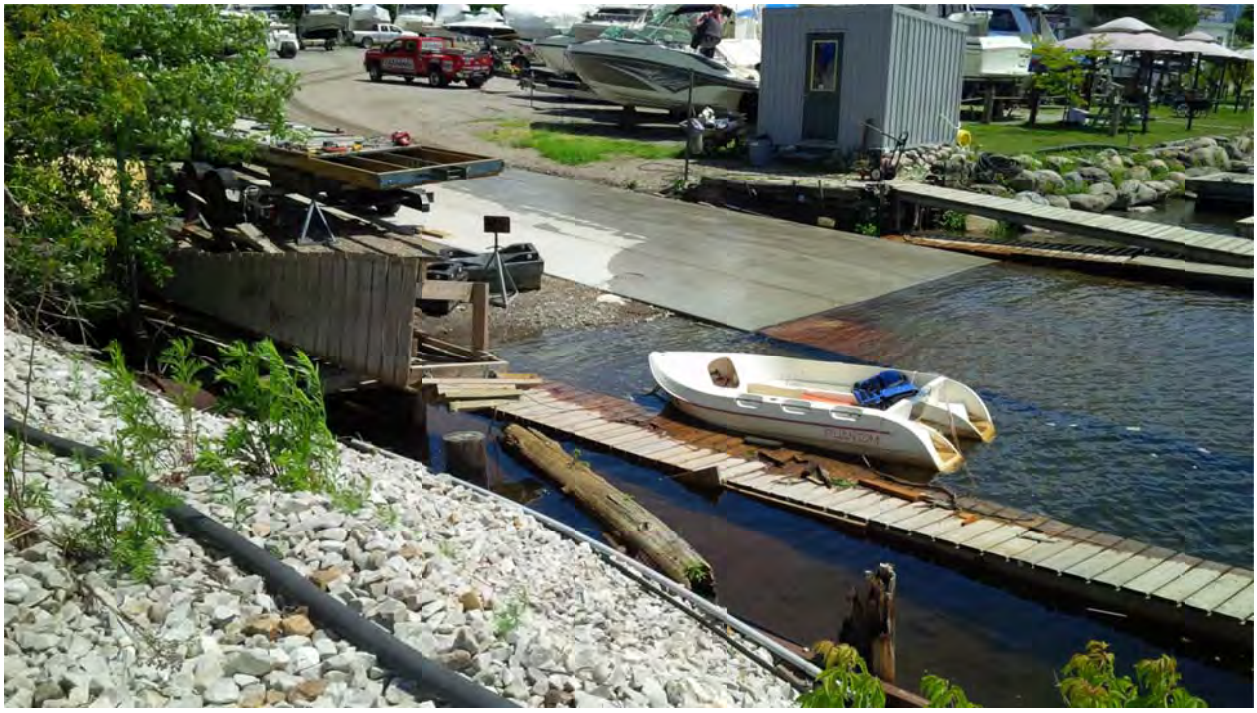

Photo 37: Boat launch ramp at end of shoreline west of property limit

Appendix B

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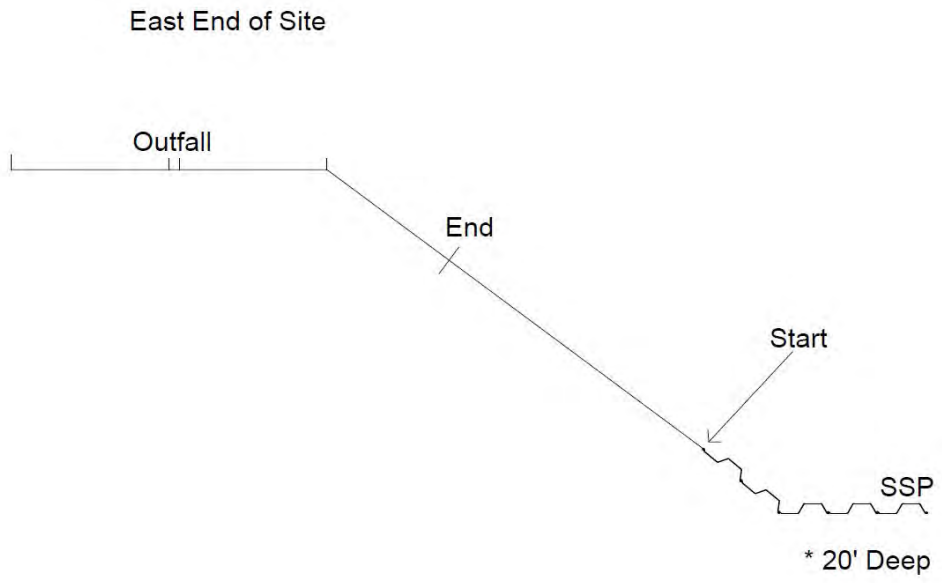
INSPECTION NOTES

Project:	Midland Bay Landing Shoreline
Client:	Salter Pilon Architecture
Our File:	15-2179
Review Date:	June 22 & 23, 2015
Reviewed By:	

General Diving
Andy
Joey
Dillon
Shoreplan
Jane Graham, P.Eng.
Claire Murray

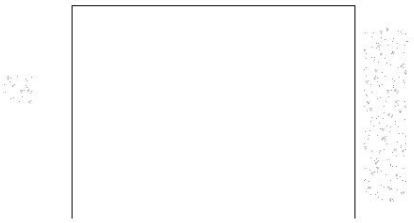
East End of Site



Starting at corner of SSP and swimming out into bay towards alignment of outfall:

- Vertical timbers with steel angle
- Was an old sheet pile
- Timbers coming out from bottom
- Driven into sandy material – stones placed offshore
- Drops quickly offshore
- Slope, steeper than 45°, 30° or so
- 7 m offshore
- Silty bottom
- Levelled out, 25’ of water
- Rock or concrete rubble on bottom. Quite a bit of concrete rubble covered in muscles

- Timber crib – boxes out

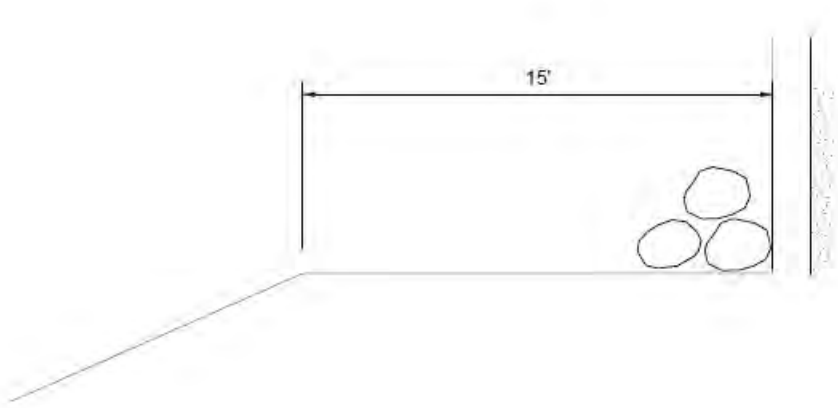


SHOREPLAN

    - Stones or concrete bags over top
    - Timber crib in line with outfall

Inspection starting at end of SSP and swimming in towards outfall:

- Timber piles vertical – 1 ½’
- Large rocks at the bottom – 4’ x 5’ and smaller stuff
- Flat area then starts to slope ~ 15’ from shore



- Behind timber crib, stone 1” dia. to 2’ x 3’
    - Some gaps where rock has come out
- → 10 m from end of steel sheet pile wall
- 2’ of water to bottom of timber piles
    - Starting to stop at ~10m
- Concrete rubble and stone similar as above water
- Under rocks, sand silt, rock and pebbles
- Slope about 45° - toe by wall
    - Only 2-3’ deep
    - Concrete 4’ long, 2’ diameter

- Stopped ~ 2/3 of the way along towards the outfall

Steel Sheet Pile Wall

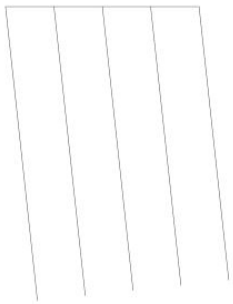
Chainage 0+00 located at east end of SSP, increases to west

SHOREPLAN

Surface Inspection

Landmark	*Chainage*
Corner	0+00
Bollard	0+23.25
Ladder	0+39.20
Bollard	0+49.95
Bollard	0+69.10
Ladder	0+72.10
Bollard (with tire)	0+92.40
Ladder	1+07.6
Bollard	1+12.25
Bollard	1+38.2
Fence	1+49.05

- Concrete behind SSP starts to become visible at approx.. 0+39
- Top of wall to WL = 1.4 m
- Anchor rods 0.35 m above WL
- SSP sheets
    - 0.245 m height
    - 0.4 m knuckle to knuckle
    - 0.265 m inpan
- Sheet piles are leaning slightly to the east



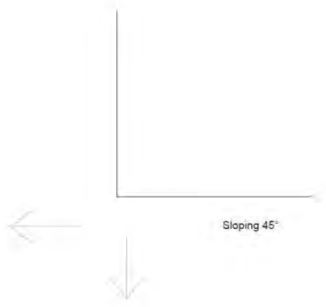
- 1 ½" dia. rods on inpans – every other inpan

Diving Inspection

Starting at east corner and swimming west along wall

Chainage 0 + 0

- Lake bottom sloping 45° offshore in both directions



- 22’ depth at corner
- Sloping 45°
- Mix of zebra mussels and silt
    - Can put hand in 6”
- Broken fender brackets start at 0+18
- Inpans 1” bolt
- SSP marked ALGOMA
- Anchor rods – 2 ½” rod (0.3 m above water line) (every 5th inpan)
- Concrete appears to be approx. 1.2 m deep below top of SSP wall

Chainage 0 + 0
- Starting at corner again
- Steel sheet pile covered in zebra mussels
- Wall looks vertical

Chainage 0 + 20
- Zebra mussels and silt on lake bottom
- Pretty flat, slopes down a little
- SSP driven in
- 1.5’ until solid bottom, soft material on top
- Relatively vertical, leaning inshore slightly

Chainage 0 + 040 [At Waterline]
- Wall bowed 60mm from concrete behind
- 27’ deep
- Ladder

Chainage 0 + 050 [At Waterline]
- Gap between SSP and concrete behind

Chainage 0 + 35
- Lake bottom slopes off at 45°
- Water depth ~20’ at wall
- Flat bottom - 30’ deep, 20’ from wall
- Single piece of wood

Chainage 0 + 60 [At Waterline]
- No fender brackets
- 32’ deep

Chainage 0 + 40
- Same..

Chainage 0 + 60
- No spill outs
- No loss of material

Chainage 0 + 70
- 2’ + deep of soft material on lake bottom
- Wall still vertical

Chainage 0 + 80 [At Waterline]
- 30’ deep
- Start of long bent anchor rods
- Top of wall flame cut

Chainage 0 + 90
- 2’ + deep of soft material

Chainage 1+10 [At Waterline]
- 58” to top of bolt from top of wall
- 3-4” bolt to water line
- Seems to be leaning more towards east

Chainage 1 + 10
- Leaning inshore
    - 2’ difference from top to bottom

Chainage 1 + 20
- 22’ deep at wall
- 10’ from wall, 26’ deep
- all silt

Chainage 1 + 40 [At Waterline]
- Wale bolts and anchors below waterline
- 57” below top of wall is fill

Chainage 1 + 40
- Leans in towards shore
- 2’ difference between top and bottom
- 2’ + deep soft material
- Lakebed slopes off shore at 45°
- More silty – feet sinking in very very soft

Chainage 1+50
- 10 m past fence – 33’ deep

Just before broken section
- 31’ deep

- Slopes at 45°, 5’ away from wall flat
- Everything looks pretty tight on SSP

At collapsed section (last portion of SSP visible above water)

- Material on bottom
- Portion of wall at 45 degrees to alignment of rest of wall
- Gap between rest of wall and ripped off section
    - Can see through
    - 2 large 2’ dia. piles in gap
- Concrete cap stops 1’ to 6” below the water level
- Railways running along front row of timber piles supporting concrete cap
    - Welded to SSP?
- Piles are 3’ apart, width of area with piles is 2-3 m
- Railway is 6” deep, 5” width bottom flange, 2.5” width upper flange

Starting at East End of Broken SSP Section

1:31 pm: Starting at end of long SSP

Walking out into cleared area

- SSP on 45° angle - leaning out from shore into lake
- No timber piles visible
- 20’ of water at top of SSP
- Bottom about 30’ deep
- Appears to have been same SSP wall with concrete relieving platform
- Concrete 3-4’ deep with no timbers
- About 5 m out from rest of alignment of SSP wall
- 3” →1” diameter stone on bottom
- Timbers scattered along the shoreline
- No timber piles visible
- About 1/3 of way across washed out area
- Some concrete rubble
- Stone material 1-3” and slag (stuff on railroad tracks)
- SSP is continuous all the way across the washed out area
- Can see inpans and outpans on concrete across

End of washed out section (east end of remaining short section of SSP visible above water)

- Water depth 34’
- Lakebed slopes up along wall to west

West end of SSP

- 28’ deep
- Bollard 1.5 m from west end of wall
- Vertical pile (timber)
    - Tight – could have been crib
    - Closely spaced at west end to support concrete
    - Goes back towards land

- Bottom slopes off at 45 degrees

West of SSP wall

- Concrete slab rubble protection
- 2 pipes coming out of bottom
- 2-3’ water at toe of protection
- Top of concrete rubble 0.2-0.5 m +/- above water line
- ~45° slope
- 24’ approximate 10 m from water line
- ~6” diameter stone material
- 50 m west of end of SSP
- Silt with rocks underneath – pretty soft material
- Timber piles sloping inshore at 45° 3’ apart
    - One line of piles along shoreline
- Halfway between SSP and remains of pier
    - 19’ deep, 10m offshore
- Timber piles – in line parallel to shore (x3) only sticking out of lake bottom a few inches. About 30m and in line with concrete rubble at end of point
- Silty sand with scattered rocks
- One more timber pile only a few inches above lakebed

Marine Railway

- Can see tracks
- At end can see timbers on railway (1 ½”)
- End of marine railway approx. 5 m landward of end of collapsed pier to west
- Can see end of pulley
- 10’ deep water

Collapsed Pier west of Marine Railway

- Wood - 1 log under water
- Material coming out
- Location with no material inside – all come out 4’ + deep void
- Vertical railways – run to surface
- Mesh at bottom
    - Diamond ½” mesh

- At end of pier
    - no wood above surface – evidence of wood- several timbers right at bottom
- Steel wire wrapped around steel
    - Appears to be holding vertical railways together
- Lakebottom - Silts, zebra mussels, and rock – mix of material

West of Collapsed Pier

- 2 x 1 ½' diameter timber piles

3:23 pm – Joey diving

- 1st row of timbers 1.2 m deep, slopes up to water line
- 1st row extends to approximately water line – just above/below
- Lakebed slopes at 15° at timbers
    - 30-45° slope approximately 15' away
    - More vegetation
    - Keeps going at 30° angle
    - 13' deep

- Black pipe in corner – open ended
- 2 ½" flexi-pipe
- 3" diameter steel pipe in corner, extends a couple of feet below

- Bottom of railways of collapsed pier in and amongst armour stone
- Timbers sitting within, running behind, just sitting behind
- 2 rows of piles (timber)
- Smaller row about 5' away, next to shoreline
- About 4' spacing
- Concrete extends about 2' below water
    - Aggregate at bottom
- Lake bottom – sand mixture

Steel Sheet Pile Wall

Starting at east corner of SSP/site, swimming west along SSP at waterline

Tie Rods

- 5th outpan from corner 0.3 m above water line

1. Missing
2. Missing
3. In place – hand tight – no plate
4. (5 + 2 out pans) large plate -tight
5. Tight, no plate. Good.
6. (6 outpans) position + plate good
7. (5 outpans) nut damaged but tight and plate
8. Plate and tight
9. (8 outplans) plate full tight
10. (7 outpans) good. Rod bent.
11. (4 outpan) nut tight. Good.
    Just past ladder
12. (5 outpan) tight – plate 0.3 m above water line
13. (5 outpan) tight. Plate good
14. (5 outpan) missing
15. 5 outpan-inpan in this location

16. (5 outpan) plate bowed in centre
17. (5 outpan) tight. No plate. Gap. Iffy.
18. (5 outpan) tight. Good.
19. (6 outpan) plate tight. Good.
20. (5 outpan) no tie rod, rod located on the inpan
    Ladder
21. (inpan) spacer plates tight
22. (5 outpan) tight plate
23. (5 outpan) missing – sheared off. Small diameter
24. (7 outpan) missing – concrete visible, rod cast into concrete
25. (5 outpan) tight. plate installed
26. (5 outpan) moved
27. (5 outpan) tight. plate good.
28. (5 outpan) missing. moved to 6th outpan at waterline nut is in contact with concrete
29. (5 outpan) tight. Ok.
30. (5 outpan) tight. Ok.
31. (3 outpan) slightly lower Tight
    ##31 (5 outpan) missing – no rod inside. Not filled with concrete. Fill material at the inpan.
32. (4 outpan) plate bowed pulling on rod, thread rod heat at 45°
33. (5 outpan) tight. plate good.
34. (5 outpan) tight. good plate
35. (5 outpan) tight. good plate
36. (5 outpan) tight. good plate
37. (5 outpan) tight. good plate
38. (5 outpan) tight. good plate
39. (5 outpan) tight. good plate below surface
40. (5 outpan) Tight. good plate
41. (3 outpan) good below water
42. (5 outpan) good
43. (5 outpan) good
44. (5 outpan) concave plate. nut pulled into plate, SSP bent
45. (3 outpan) damage/tight
46. (4 outpan) missing. vacant hole
47. (5 outpan) concave plate
48. (5 outpan) plate/nut tight
49. (5 outpan) ok. good.
50. (5 outpan) ok
51. (5 outpan) ok
52. (5 outpan) at waterline/ nut and plate tight
53. (5 outpan) no plate. 1” diameter rod as well, good
54. (4 outpan) tight ok.
55. (5 outpan) light subsurface. Good
56. (5 outpan) ok
57. (5 outpan) ok
58. (2 outpan) plate loose. rod bent. nut is tight. damage
59. (5 outpan) tight against outpan. nut plate
60. (1st outpan from end) stressed. tight

June 23rd 2015

Starting at west end of site (at corner of marina) and moving east along shoreline

SHOREPLAN

West End SSP

Dive 1

Moving west along SSP from corner

- SSP carries around corner
- Corner tight – no loss of material
- Vertical, tight knuckles
- Zebra mussels 100%
- Lake bottom silt and zebra mussels, 6" soft material on top
- Two sheets of SSP overlapping
    - no outpan – join between old and new SSPs
    - visible from surface
    - Looks tight – no loss of material
- End of SSP
- Timbers – square, round
    - Behind, rocks 1-2' diameter
    - Piles, horizontal

Swimming along east SSP on marina side starting at corner

- Bracket supporting timber docks
- Looks vertical
- 100% zebra mussel cover
- Arched section doesn't extend down
- At end of SSP
    - Vertical timbers, horizontal
    - More vertical under horizontal timber
    - Rock on top

At end of SSP along shoreline of property:

- Piles - Some square and some round
- 3-6" gap between adjacent piles in line along shoreline
- 1' diameter (round), 1 ½" (square)
- Horizontal timbers, sitting behind – not attached
- Looks fairly vertical (piles)
- Can't see timbers anymore
- In some locations rock, some completely washed out
- 75' from end SSP
- Stone on lake bed (silica – same white stone material as behind wall above wall)
- No concrete rubble
- Timber lying horizontally on bottom
- Consistent vertical piles, tightly spaced

- No horizontal timbers at bottom
- Marine growth on bottom
- Slope with rocks offshore 45°
- Silt covering sand/gravelly layer
- Lakebed sloping at approx. 1v:1h offshore

Turning back toward SSP/boat, swimming at waterline

- Timber stops ~1' below water line
- 2nd row of timbers behind – scattered
- ½' diameter timbers (back row)
- Just stone on top
- Horizontal timber at top in some locations
- Concrete slab, 1' thick, about 1' below vertical timbers supporting concrete deck

Dive 2: 10:45 am, starting at row of bushes

- Concrete cap appears to be sitting on stone not on timber piles
- Timbers still about 1' below surface
- Tie back or pipe (3" diameter) wedged in between
- Another one – runs back under concrete cap – another 1
- 6' deep water
- Steel rods about 10' apart
- Horizontal timber – behind vertical
- Rod goes through horizontal timber
- Stacked horizontal timbers
- Concrete curb 10' long x 3' wide
- Vertical timbers at back about 10' apart
- 2"x4" running horizontal across at bottom
- 10' deep water
- 2nd row spaced 10' apart
- 4' deep (about 2 m offshore)
- Appears to have been horizontal timber wales approx. 2' below waterline – both on front face and back of vertical timbers
    - Horizontal 2' x 2'
    - Vertical 1 ½' dia.
- Smaller rods 1" diameter to back of horizontal timber ("wale bolts")
- Lager rods 2-2 ½" diameter to under concrete cap
- Profile:
    - 3-4' water depth at timber piles
    - 2-3 ' flat area in front of piles
    - Slopes down at 1:1
- Concrete bollard not supported on timbers, just big concrete block
- Beams run behind concrete block
- 1' diameter pipe corrugated steel pipe (12:22 pm)
    - Cast into cap
- Can see through to under concrete deck on backshore
    - Supported by vertical piles 1 ½' diameter
    - Concrete beams running under and width of path

    - Supports deck and appear to have been poured separately
- Gap – no vertical piles (in location of concrete deck exposed)
- Another tie rod
- 4’ deep (7.5 m from boat, 21’ deep)
- Starts to get deeper towards end of concrete
- All the same approaching the large concrete block
- Concrete block back from front row of timber piles
- Rocks 2-3’ diameter – concrete cast on top of rocks

13:03

- Point at end of straight concrete deck section just past concrete block
- Tie back rod
- Piles with concrete rubble sitting on top
- 10’ deep, 45° - 50° drop off
    - Orange wooden triangle 5 m from concrete block
- White (silica) stone on bottom
- Horizontal timbers sitting off
- Pretty vertical piles
- More intermittent 6-10’ apart
- Missing vertical piles

Appendix C

Unit Prices	2015		2017	
Armour stone - special placement	$ 100.00	/ tonne	$ 105.00	/ tonne
Armour stone - stackable	$ 150.00	/ tonne	$ 157.50	/ tonne
Rip rap	$ 50.00	/ tonne	$ 52.50	/ tonne
Geotextile	$ 8.00	/sq.m.	$ 8.40	/sq.m.
Steel - supply and install	$ 4.00	/ kg	$ 4.20	/ kg
Excavation	$ 25.00	/ cu.m.	$ 26.25	/ cu.m.
Granular Fill	$ 30.00	/ tonne	$ 31.50	/ tonne
Removals	$ 200.00	/ cu.m.	$ 210.00	/ cu.m.
Concrete (pad)	$ 800.00	/cu.m.	$ 840.00	/cu.m.
Concrete (cap)	$ 1,500.00	/cu.m.	$ 1,575.00	/cu.m.
Concrete Cap (0.5x0.6m)	$ 350.00	/m	$ 367.50	/m
Clear Stone	$ 40.00	/ tonne	$ 42.00	/ tonne

2015 & 2017
Construction Cost Estimate of Options

Material	*Estimated Quantity*		*Unit Price*		*Estimated Cost*	2015 *Total Cost*	*Cost per metre*
East Reach							
Option E(a)1 - New SSP Wall with Rip Rap Berm						$ 3,740,000.00	$ 22,000.00 /m
Rip rap	18000	tonnes	$ 50.00	/ tonne	$ 900,000.00		
Geotextile	6300	sq.m.	$ 8.00	/sq.m.	$ 50,400.00		
Clear Stone	6500	tonnes	$ 40.00	/ tonne	$ 260,000.00		
Fill	15400	tonnes	$ 30.00	/ tonne	$ 462,000.00		
Steel - Supply and Install	515000	kg	$ 4.00	/ kg	$ 2,060,000.00		
Option E(a)2 - Concrete Cap on Existing SSP wall with Rip Rap Berm						$ 2,590,000.00	$ 15,300.00 /m
Rip rap	24000	tonnes	$ 50.00	/ tonne	$ 1,200,000.00		
Geotextile	5700	sq.m.	$ 8.00	/sq.m.	$ 45,600.00		
Clear Stone	2200	tonnes	$ 40.00	/ tonne	$ 88,000.00		
Fill	15400	tonnes	$ 30.00	/ tonne	$ 462,000.00		
Concrete (reinforced)	210	cu.m.	$ 800.00	/cu.m.	$ 168,000.00		
Excavation	4300	cu.m.	$ 25.00	/ cu.m.	$ 107,500.00		
Steel - Supply and Install	129000	kg	$ 4.00	/ kg	$ 516,000.00		
Option E(a)3 - Armour Stone Retaining Wall with Rip Rap Berm						$ 2,390,000.00	$ 14,100.00 /m
Rip rap	18000	tonnes	$ 50.00	/ tonne	$ 900,000.00		
Geotextile	6000	sq.m.	$ 8.00	/sq.m.	$ 48,000.00		
Clear Stone	3100	tonnes	$ 40.00	/ tonne	$ 124,000.00		
Fill	6600	tonnes	$ 30.00	/ tonne	$ 198,000.00		
Excavation	3800	cu.m.	$ 25.00	/ cu.m.	$ 95,000.00		
Steel - Supply and Install	114000	kg	$ 4.00	/ kg	$ 456,000.00		
Concrete (reinforced)	400	cu.m.	$ 800.00	/cu.m.	$ 320,000.00		
Armour Stone	1220	tonnes	$ 150.00	/ tonne	$ 183,000.00		
Concrete Cap	170	m	$ 350.00	/m	$ 59,500.00		
Option E(b)1- Anchored Steel Sheet Pile Wall and Rip Rap Berm						$ 2,970,000.00	$ 22,200.00 /m
Removal of SSP wall	1	L.S.	$ 200,000.00		$ 200,000.00		
Rip rap	6700	tonnes	$ 50.00	/ tonne	$ 335,000.00		
Geotextile	6500	sq.m.	$ 8.00	/sq.m.	$ 52,000.00		
Clear Stone	2200	tonnes	$ 40.00	/ tonne	$ 88,000.00		
Fill	12900	tonnes	$ 30.00	/ tonne	$ 387,000.00		
Excavation	7800	cu.m.	$ 25.00	/ cu.m.	$ 195,000.00		
Steel - Supply and Install	426000	kg	$ 4.00	/ kg	$ 1,704,000.00		
Option E(b)2 - Rip Rap Berm with Armour Stone Protection						$ 2,730,000.00	$ 20,400.00 /m
Removal of SSP wall	1	L.S.	$ 200,000.00		$ 200,000.00		
Rip rap	27800	tonnes	$ 50.00	/ tonne	$ 1,390,000.00		
Armour stone special placement	4600	tonnes	$ 100.00	/ tonne	$ 460,000.00		
Fill	20000	tonnes	$ 30.00	/ tonne	$ 600,000.00		
Excavation	2400	cu.m.	$ 25.00	/ cu.m.	$ 60,000.00		
Geotextile	2500	sq.m.	$ 8.00	/sq.m.	$ 20,000.00		
Option E(b)3 -Anchored Steel Sheet Pile Wall with Retaining Wall and Rip Rap Berm						$ 2,290,900.00	$ 17,100.00 /m
Removal of SSP wall	1	L.S.	$ 200,000.00		$ 200,000.00		
Rip rap	6700	tonnes	$ 50.00	/ tonne	$ 335,000.00		
Armour stone special placement	960	tonnes	$ 150.00	/ tonne	$ 144,000.00		
Fill	5000	tonnes	$ 30.00	/ tonne	$ 150,000.00		
Excavation	7800	cu.m.	$ 25.00	/ cu.m.	$ 195,000.00		
Concrete (reinforced)	290	cu.m.	$ 800.00	/cu.m.	$ 232,000.00		
Clear Stone	3500	tonnes	$ 40.00	/ tonne	$ 140,000.00		
Remvoals	20	cu.m.	$ 200.00	/ cu.m.	$ 4,000.00		
Steel - Supply and Install	202000	kg	$ 4.00	/ kg	$ 808,000.00		
Geotextile	4500	sq.m.	$ 8.00	/sq.m.	$ 36,000.00		
Concrete Cap	134	m	$ 350.00	/m	$ 46,900.00		
Option 4 - New Steel Sheet Pile Wall without Berm in Front						$ 8,648,039.52	$ 28,500.00 /m
Removal of SSP wall	1	L.S.	$ 200,000.00		$ 200,000.00		
Fill	28300	tonnes	$ 30.00	/ tonne	$ 849,000.00		
Excavation	31000	cu.m.	$ 25.00	/ cu.m.	$ 775,000.00		
Clear Stone	15100	tonnes	$ 40.00	/ tonne	$ 604,000.00		
Steel - Supply and Install	1515000	kg	$ 4.00	/ kg	$ 6,060,000.00		
Geotextile	12800	sq.m.	$ 8.00	/sq.m.	$ 102,400.00		
Underwater Tie Installation Markup	28820	kg	$ 2.00	/kg	$ 57,639.52		
Centre Reach							
Option 1 - Rip Rap Berm with Armour Stone						$ 2,220,000.00	$ 5,800.00 /m
Rip rap	14400	tonnes	$ 50.00	/ tonne	$ 720,000.00		
Armour stone special placement	9400	tonnes	$ 100.00	/ tonne	$ 940,000.00		

Geotextile	7100	sq.m.	$ 8.00	/sq.m.	$ 56,800.00			
Fill	12600	tonnes	$ 30.00	/ tonne	$ 378,000.00			
Excavation	4700	cu.m.	$ 25.00	/ cu.m.	$ 117,500.00			
Option 2 - Cantilever Steel Sheet Pile Wall with Rip Rap Berm						$ 4,270,000.00	$ 11,100.00	/m
Rip rap	5400	tonnes	$ 50.00	/ tonne	$ 270,000.00			
Geotextile	3700	sq.m.	$ 8.00	/sq.m.	$ 29,600.00			
Fill	17900	tonnes	$ 30.00	/ tonne	$ 537,000.00			
Excavation	4100	cu.m.	$ 25.00	/ cu.m.	$ 102,500.00			
Steel - Supply and Install	817000	kg	$ 4.00	/ kg	$ 3,268,000.00			
Clear Stone	1500	tonnes	$ 40.00	/ tonne	$ 60,000.00			
Option 3 - Anchored Steel Sheet Pile Wall with Rip Rap Berm						$ 2,790,000.00	$ 7,200.00	/m
Rip Rap	3900	tonnes	$ 50.00	/ tonne	$ 195,000.00			
Geotextile	12000	sq.m.	$ 8.00	/sq.m.	$ 96,000.00			
Steel - Supply and Install	404000	kg	$ 4.00	/ kg	$ 1,616,000.00			
Excavation	8100	cu.m.	$ 25.00	/ cu.m.	$ 202,500.00			
Fill	13200	tonnes	$ 30.00	/ tonne	$ 396,000.00			
Clear Stone	6900	tonnes	$ 40.00	/ tonne	$ 276,000.00			
West Reach								
Option 1 - Rip Rap Berm with Cap stone						$ 1,920,000.00	$ 6,600.00	/m
Rip rap	32000	tonnes	$ 50.00	/ tonne	$ 1,600,000.00			
Armour stone special placement	800	tonnes	$ 100.00	/ tonne	$ 80,000.00			
Geotextile	3700	sq.m.	$ 8.00	/sq.m.	$ 29,600.00			
Fill	5800	tonnes	$ 30.00	/ tonne	$ 174,000.00			
Excavation	1200	cu.m.	$ 25.00	/ cu.m.	$ 30,000.00			
Removals	10	cu.m.	$ 200.00	/ cu.m.	$ 2,000.00			
Option 2 - Rip Rap Berm with Armour Stone						$ 2,190,000.00	$ 7,600.00	/m
Rip rap	26900	tonnes	$ 50.00	/ tonne	$ 1,345,000.00			
Armour stone special placement	5900	tonnes	$ 100.00	/ tonne	$ 590,000.00			
Geotextile	3700	sq.m.	$ 8.00	/sq.m.	$ 29,600.00			
Fill	5800	tonnes	$ 30.00	/ tonne	$ 174,000.00			
Excavation	1200	cu.m.	$ 25.00	/ cu.m.	$ 30,000.00			
Removals	100	cu.m.	$ 200.00	/ cu.m.	$ 20,000.00			
Option 3 - Rip Rap Berm with Armour Stone Wall						$ 2,100,000.00	$ 7,300.00	/m
Rip rap	24700	tonnes	$ 50.00	/ tonne	$ 1,235,000.00			
Armour stone special placement	2600	tonnes	$ 150.00	/ tonne	$ 390,000.00			
Geotextile	3200	sq.m.	$ 8.00	/sq.m.	$ 25,600.00			
Fill	6600	tonnes	$ 30.00	/ tonne	$ 198,000.00			
Excavation	900	cu.m.	$ 25.00	/ cu.m.	$ 22,500.00			
Removals	1100	cu.m.	$ 200.00	/ cu.m.	$ 220,000.00			
Option 4 - Cantilever Steel Sheet Pile Wall with Rip Rap Berm						$ 3,870,000.00	$ 13,300.00	/m
Rip Rap	20900	tonnes	$ 50.00	/ tonne	$ 1,045,000.00			
Steel - Supply and Install	599000	kg	$ 4.00	/ kg	$ 2,396,000.00			
Clear Stone	1700	tonnes	$ 40.00	/ tonne	$ 68,000.00			
Geotextile	1600	sq.m.	$ 8.00	/sq.m.	$ 12,800.00			
Excavation	500	cu.m.	$ 25.00	/ cu.m.	$ 12,500.00			
Fill	10900	cu.m.	$ 30.00	/ tonne	$ 327,000.00			
Option 5 - Anchored Sheet Pile Wall with Rip Rap Berm						$ 2,690,000.00	$ 9,300.00	/m
Rip Rap	12700	tonnes	$ 50.00	/ tonne	$ 635,000.00			
Geotextile	7000	sq.m.	$ 8.00	/sq.m.	$ 56,000.00			
Clear Stone	6600	tonnes	$ 40.00	/ tonne	$ 264,000.00			
Steel - Supply and Install	380000	kg	$ 4.00	/ kg	$ 1,520,000.00			
Excavation	800	cu.m.	$ 25.00	/ cu.m.	$ 20,000.00			
Fill	6200	cu.m.	$ 30.00	/ tonne	$ 186,000.00			
Shoreline East of Property Limit								
Option EPL - Armour Stone Revetment						$ 513,600.00	$ 6,100.00	/m
Armour Stone	3200	tonnes	$ 100.00	/ tonne	$ 320,000.00			
Rip rap	2700	tonnes	$ 50.00	/ tonne	$ 135,000.00			
Excavation	1800	cu.m.	$ 25.00	/ cu.m.	$ 45,000.00			
Geotextile	1700	sq.m.	$ 8.00	/sq.m.	$ 13,600.00			

Appendix D