

Synopsis

This document outlines a concept for a GREEN SHORES™ related demonstration project to be undertaken along the waterfront portion of the Milner Gardens & Woodland property. The opportunity for a demonstration project arises due to the recent cliff erosion experienced on the property in front of the lawn and gardens on the water side of the cottage and the need to stabilize the cliff and the large trees which exist in the area.

A demonstration of various shoreline treatments consistent with the GREEN SHORES™ principles is proposed to stabilize the shoreline. The projects would be coupled with monitoring activities undertaken by Malaspina College and public education programs in place at Milner Gardens.

Introduction

Erosion of the bluff and undermining of the large trees that existed at the edge of the lawn at Milner Gardens occurred during recent winter storms, Figure 1, and as a result Milner Gardens has placed interim rock toe protection at the base of the cliffs as shown in Figure 1.

Figure 1: View of Milner Garden exposed area, January 2008

(note: double posts below 3 trees has a surveyed elevation of + 5.7 m CD)



This portion of the Milner Garden property forms a small portion of the water frontage of the property, as indicated in Figure 2. For many years, since approximately the late 1960's, a natural cedar log seawall and groyne system extended along the water frontage and this system has reached the end of its useful service life. The seawall has been outflanked by recent erosion along the remainder of the property to the west, Figure 3 and the low lying bank along this portion of the property is starting to experience erosion at the seaward edge. Milner Garden has expressed an interest in undertaking a more permanent solution to the ongoing shoreline erosion that is consistent with the principles of the GREEN SHORES™ program.

Figure 2: Location Plan of Potential Pilot Project

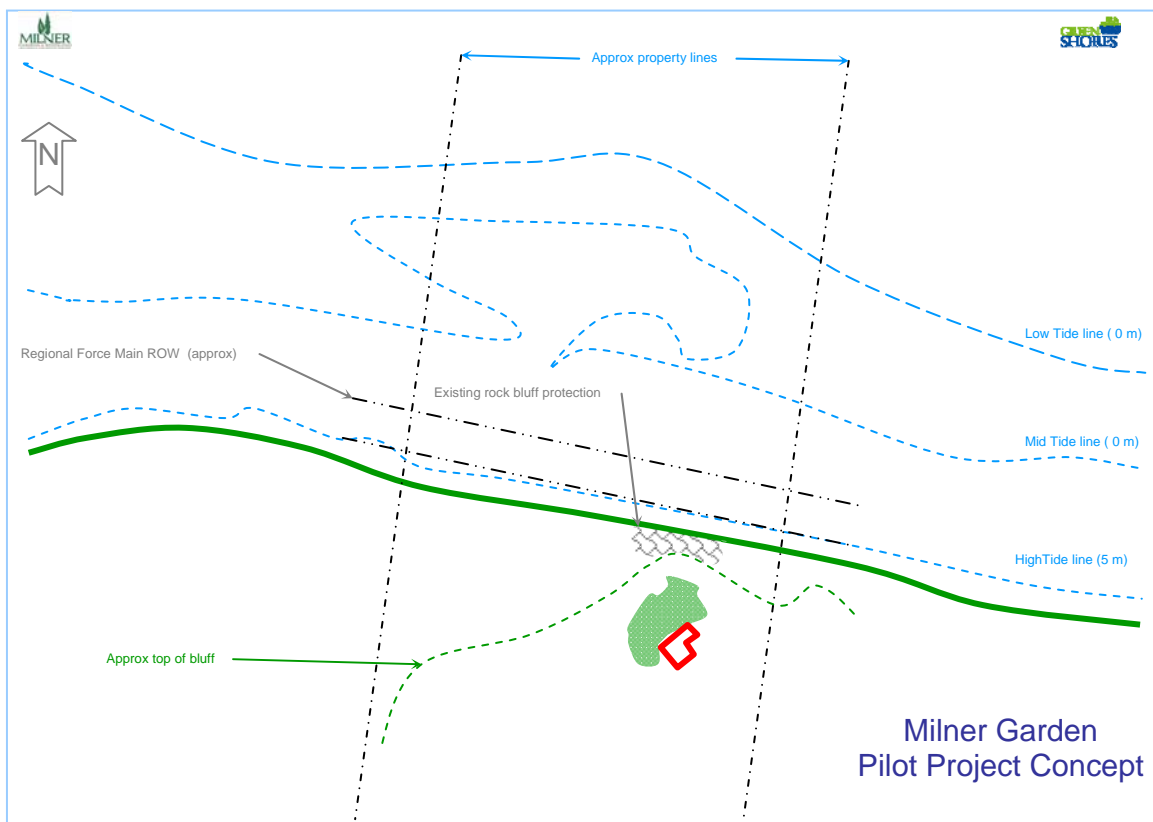


Figure 3: View of Shoreline Showing Remnants of Cedar Seawall

Potential Solutions

The immediate concern at Milner Garden centers around the likely undermining and sliding of trees at the top of the cliffs and the loss of the lawn in this area. The buildings themselves do not appear to be directly threatened; however, in time, if the base of the cliff is not protected from the reach of waves, then a cyclical process of base erosion by high water levels and waves, following by over-steepening of the cliff, and subsequent cliff face weather, sliding or slumping, will result in progression of an over-steepened slope back towards the buildings. If the existing toe of the cliff is protected from wave action, the present top of cliff will, over time, still progress towards the existing buildings and gardens unless cliff stabilization measures are also undertaken.

Prediction of a stable slope position requires geotechnical assessment and is beyond the scope of this assignment; however, a recession of at least 1.3 x height of cliff above the stable toe is possible.

The immediate concern can be addressed by one of three options:

- removal of the threatened trees, which might be accompanied with new planting to replace the trees
- protection of the base of the cliff against wave action, which will stabilize the cliff at its present position, but not remove the threat that exists because of the present oversteep cliff
- protection of the base of the cliff combined with slope stabilization measures.

In the long-term, the eventual threat to the cliff-top property and buildings can only be eliminated by protecting the base of the cliff from wave action. A large range of options exist for this approach and these might be combined with various cliff stabilization measures. Cliff stabilization measures are beyond the scope of this assessment.

Options to eliminate wave action against the cliff include:

- provision of a storm berm including materials ranging from coarse sand to pebbles and cobbles

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- provision of a storm berm, in conjunction with rock headlands, sills, groynes or offshore reefs
 - provision of a shore parallel bulkhead, seawall or rock revetment

These options have been evaluated in an earlier report provided to Milner Gardens.

After discussion with the GREEN SHORES™ Technical Advisory Committee, the concept of a demonstration project that would combine possible techniques for protection of the shoreline was considered and evaluated. This document describes a potential concept for such a project.

Due to the relatively short length of the property (approximately 255 m frontage) and the presence of the low bench shoreline to the west of the eroded bluff, it is suggested that Milner Garden consider a two part project for the permanent solution:

- along the east portion of the property a storm berm would be constructed that would cover the existing interim rock protection and extend over the existing upper intertidal portion.
- Along the west portion of the property the natural erosion of the shoreline and the resulting slow supply of sediment to the coastal processes, and the presence of the riparian vegetation, would be maintained.

The storm berm portion of the work would consist of a mixture of sand, gravel and cobble that would be expected to erode, and then be replenished, during the occurrence of large storms and high tides. A sketch of the “storm berm” portion of the work is shown in Figure 4. Along the storm berm portion of the work, riparian planting could be included to demonstrate the potential benefit of such vegetation in slowing the erosion rate of the storm berm.

Replenishment of the storm berm would be ensured over the years by the upgrading and maintenance of the access road that is understood to exist along the west boundary of the Milner Garden property.

The general layout and extent of the concept is shown in Figure 5.

Figure 4: Sketch of Storm Berm for East Portion of the Property
Note: Possible Riparian Vegetation not shown for clarity

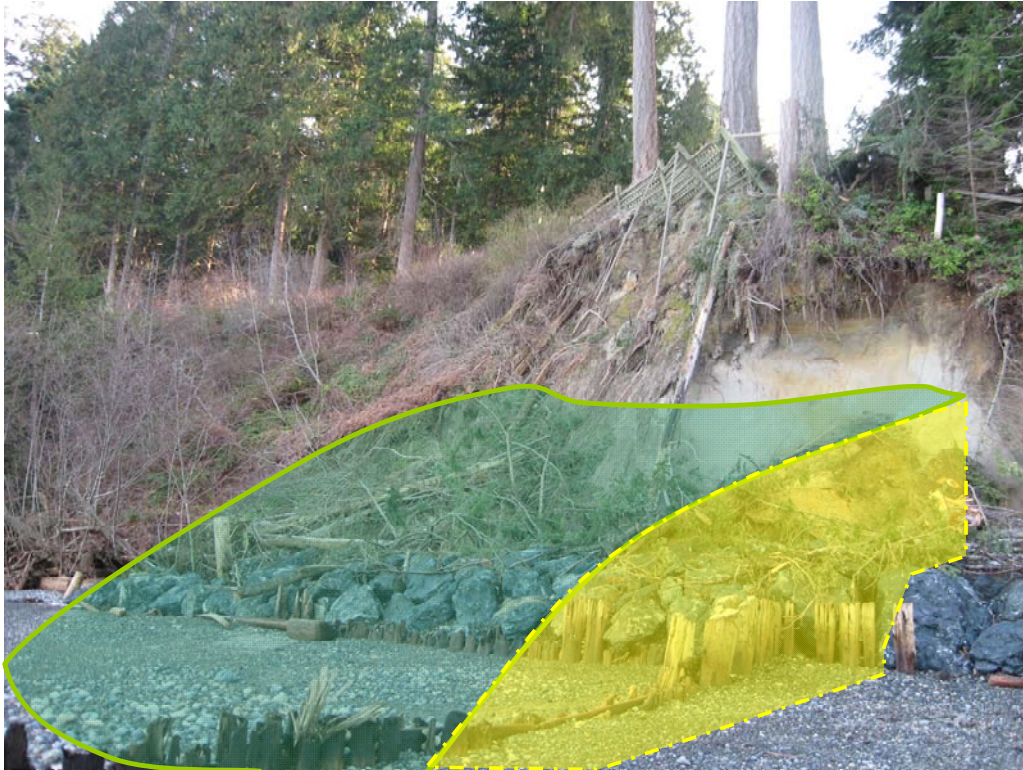
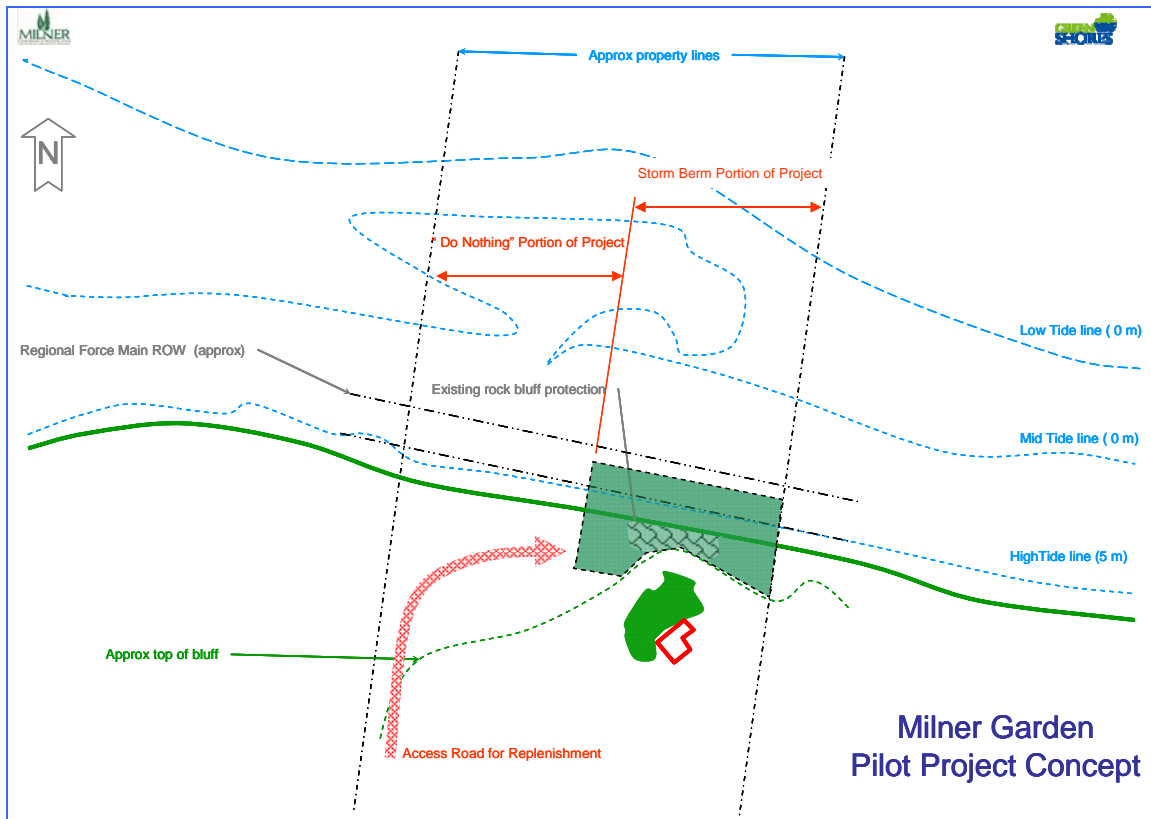


Figure 5: Proposed Extent of Demonstration Project



Advantages and Disadvantages

Some advantages of the proposed concept are:

- The storm berm portion of the project keeps the existing rock protection in place – providing security in the event of an unusually severe storm.
- The storm berm will provide a slow supply of sediment to the coastal system, as would an unprotected bluff.
- Material “removed” from the initial design volume will most likely be transported west, providing protection to the “Do Nothing portion of the property. During severe NW storm events, sediment will be transported east, minimizing the impact of any protection works on the adjacent neighbour. This sediment is likely be transported back to the property during subsequent SE storms.
- The project is not expected to have any adverse effect on the existing Force Main which runs along the shoreline just offshore of the present natural cedar seawall. This force main is a significant constraint on alternative measures and its presence likely means that in the long term, a storm berm which requires replenishment will still have a low lifetime cost.



A GREEN SHORE DEMONSTRATION PROJECT CONCEPT MILNER GARDENS



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- The slow supply of sediment (the storm berm materials will be specified to be similar to the existing beach (intertidal) materials in this area.

A disadvantage of the proposed concept is that a severe storm could remove a substantial portion of the storm berm. It will be essential to ensure that any cliff face stabilization measures undertaken allow for this possibility. A commitment to monitoring and replenishment will also be required.

ANNEX A

Milner Gardens Property - Shore Assessment

Statement of the Problem

Milner Gardens is a property located near Qualicum Beach and owned by the Malaspina University College. The property has frontage on the Strait of Georgia shoreline (Fig. 1). This survey is intended to provide a preliminary assessment of the foreshore and outline possible options for the land owner in terms of managing the property in a sustainable, environmentally friendly manner.

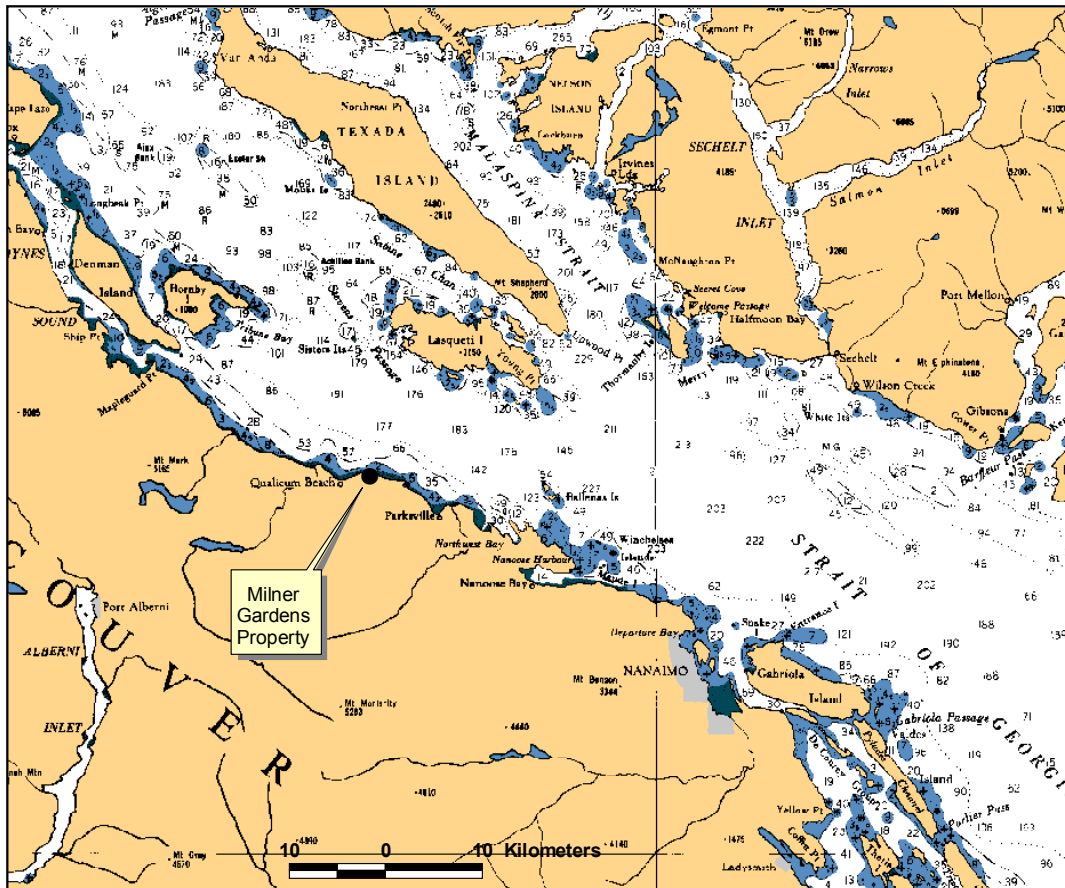


Figure 1 Location map showing the approximate location of Milner Gardens within the Strait of Georgia. Open-water fetch distance to the east are up to 35 km but are more protected from other directions. The Milner Gardens property exists at a promontory where there is a major change of coastal orientation.

General Description

The property sits approximately 20m above the beach level. The substrate at the site is unconsolidated glacial till and outwash sediments. Wave erosion has created a cliff along the much of the shore in this area. For the most part, this cliff is vegetated and stable. However, the cliff has recently been over-steepened at the Milner Gardens site and is failing (Fig. 2). Large trees located on the upper cliff edge are likely to topple down in the near future.

The beach in front of Milner Gardens includes a wide tidal flat in the middle and lower intertidal zone and a relatively narrow beach face in the upper intertidal zone. Both the tidal flat and the beach are covered with a veneer of boulders, cobbles and pebbles. Such a veneer is usually a good indication that the beach and flat originated from erosion of glacial sediments, where fine silts and sands were transported offshore, leaving a veneer of larger sediment.



Figure 2 Photo of the Milner Property, looking westward across the intertidal zone. While most of the cliff is covered with trees and shrubs, the bare portion in the centre has recently failed.

The intertidal flat width is 98m and the beach face approximately 20m (Fig. 3).

Shore protection in the form of a wooden bulkhead (vertical logs) was apparently placed on the upper beach several decades ago in attempt to stabilize the shoreline (Fig. 4). Other man-made modification has occurred in the intertidal zone. Bulldozers appear to have been used to clear away cobble and boulders from the beach at properties both east and west of the Milner Garden site (Fig. 5; see also air photos shown in Figure 7 and 8). Recent construction of rip-rap and concrete bulkheads to the west of the Mewburn property was noted (Fig. 6).

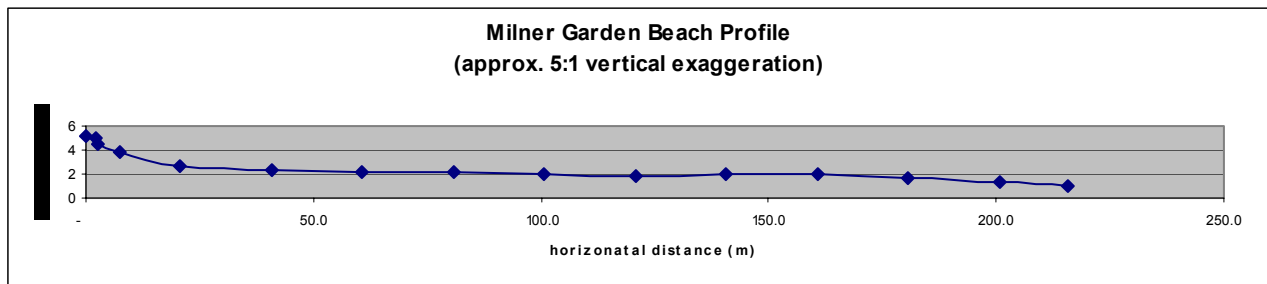


Figure 3. Surveyed profile of the intertidal zone from the Milner Gardens beach site. The tidal flat is approximately 200 m in width and the beach face (steeper section to left) below the sea wall is slightly less than 20m in width. The base of the scarp was measured at 5.2 m above tide datum (predicted maximum tidal level for this area is 5.1 m).



Figure 6. Photo of cliffs to the west of the Mewburn property. Rip-rap placed in the supratidal and intertidal below some of the properties (right portion of photo) to stabilize the cliff toe.

Shoreline Stability

In order to assess the shoreline stability of the Milner Gardens site, air photos were reviewed to evaluate the changes to the shore system over time. Two photos were selected for analysis: a 1978 vertical air photo and a 2001 vertical air photo (Fig. 7 & 8). Both are high resolution photos (scale of 1:10,000 or better) and both were taken at or near extreme low tide during the summer months. The photos were somewhat challenging to georeferenced in an absolute grid but the presence of very large boulders in the intertidal zone were used to reference the photos to each other. The comparative photos were used to assess the stability of the natural boundary (break between the terrestrial vegetation and the marine zone), the stability of the beach face and changes in patterns of sedimentation.

The interpretation of the natural boundary and the lower beach face are shown in Figures 9 and 10. Tree overhang significantly complicates the interpretation of the natural boundary (Fig. 9). No significant overall trend is apparent in the natural boundary position over time, and the section of shoreline immediately seaward of the Milner Gardens house is obscured by trees and can not be interpreted. The position of the lower beach face appears to have been displaced seaward in some places and landward in other places; no significant overall displacement of the lower beach face is evident in the photos (Fig. 10). The comparisons of these two features suggests that overall, the shoreline has remained relatively stable during the 23 year photo interval.



Figure 4. An photo of the beach at Milner Gardens looking alongshore to the northwest. a wooden seawall and groins are visible to the left. The cobble veneer over the beach face is also evident.



Figure 5. An photo from the Mewburn property looking north across the intertidal zone. The large trough area was probably created by bulldozers moving boulders and cobbles into groin-like features in attempt to create a boat launching/mooring area below the boat ramp. Such clearing are common along this stretch of shoreline and probably date back to the 1950s and 1960s.

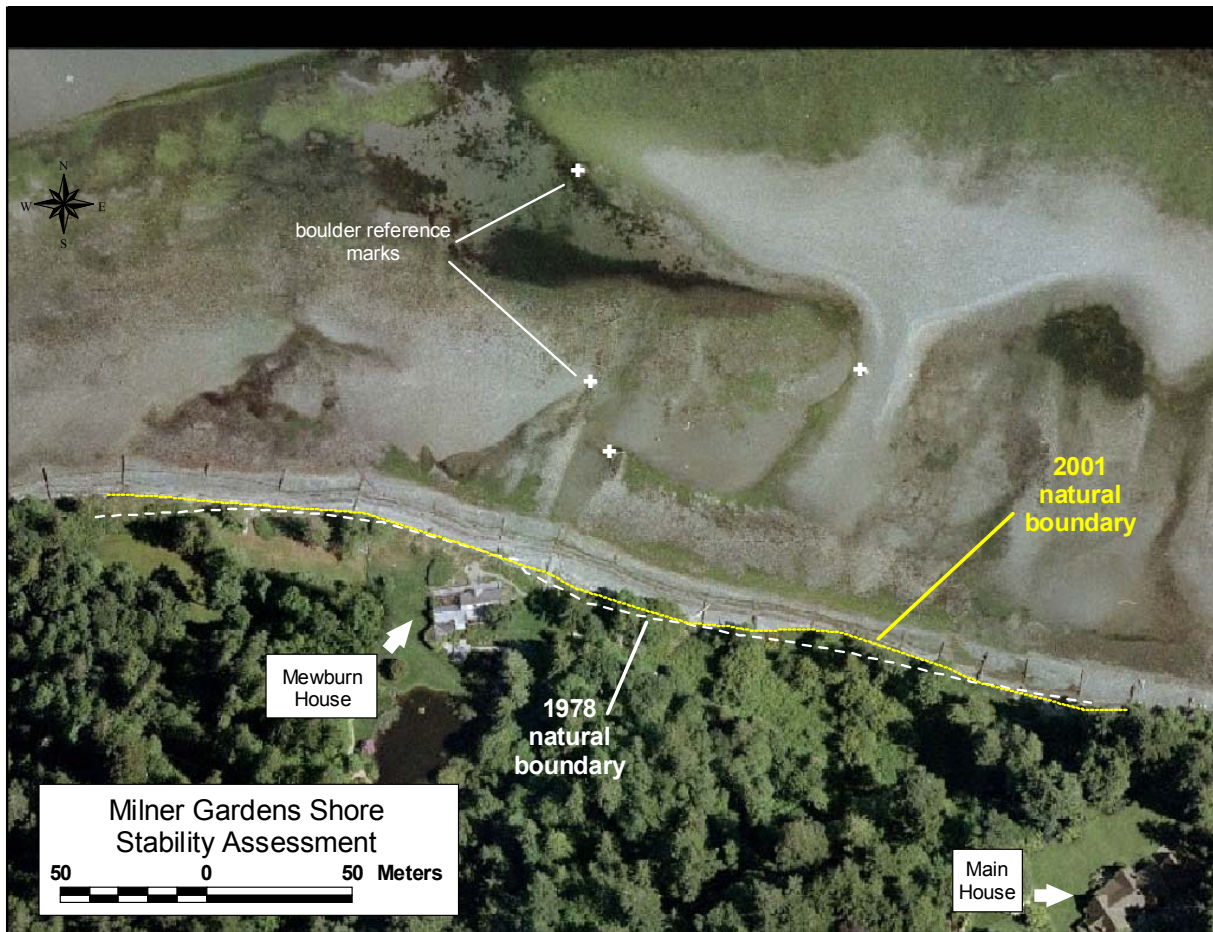


Figure 9. Interpretation of the natural boundary position from the 1978 air photo and from the 2001 air photo. There is no significant difference between the boundary positions. The interpretation of the natural boundary position is complicated by tree overhang in the cliffed section of the property and is regarded as approximate.

The two photos (Fig. 7 & 8) can also be used to compare morphological changes on the shore. There are a number of troughs and swash bars evident on the photos and these features have remained remarkably similar over the 23 years between photos. Two features that have changed include (a) the landward margin of the large swash bar (Fig. 8, Location A), which has migrated landward about 30m and (b) the large sand sheet (Fig. 8 Location B), which was not evident on the 1978 photos. This sand sheet was observed during the July 2007 site visit.

The stability of the intertidal bars and troughs over a 23 year interval suggests that the overall intertidal beach system is highly stable and to a large extent at equilibrium with wave processes. The accretion the large swash bar (Loc A) and the addition of the large sand sheet (Loc. B) indicate there has been some net sediment accretion on the shore although the overall volume is comparatively small.

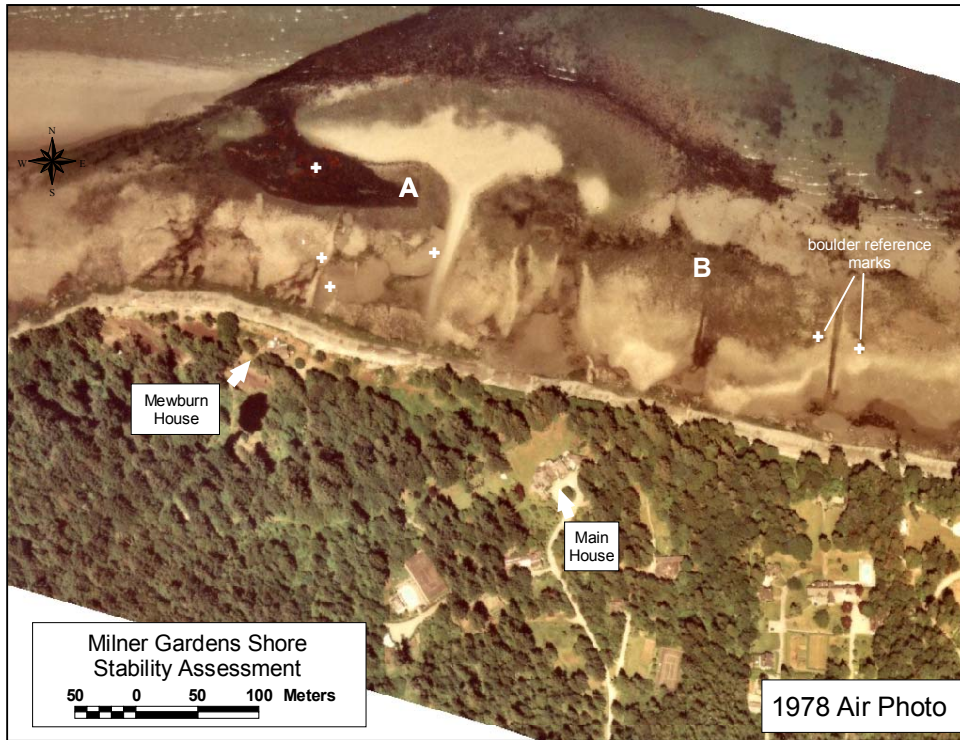


Figure 7. 1978 low-tide vertical air photo showing major shore features relative to the Milner Gardens property. Small white crosses mark large boulders, which were used to co-register the photos. Locations A and B are locations where significant sedimentation patterns have occurred over the photo interval (1978 to 2001).

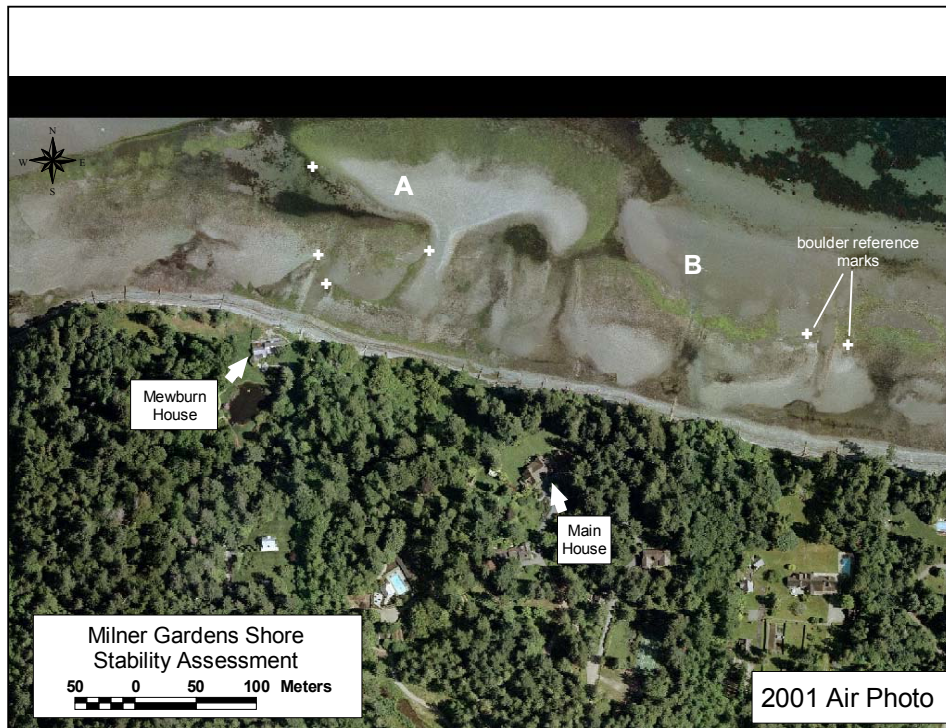


Figure 8 .2001 air photo of the same location, carefully referenced to the same boulders visible in the 1978 photo. The large swash bar (A) has undergone a shoreward migration of 30-40m. A large sheet of sand (B) is also present in the lower intertidal zone that was not present in the 1978 photos. Other intertidal bars have remained relatively stationary over the 23 year interval between photos.

Open-water fetch distances, which provide an indirect indication of wave approach directions, are summarized in Table 1. The largest fetch window is to the east and it is likely that strong southeasterly winds generated during storms (Fig. 11) would be effective at generating waves from the southeast. There are also some relatively large fetches open to the north, through the window between Hornby and Lasqueti Islands. Northwesterly and westerly winds, which are more common during the summer, are likely to generate easterly directed sediment transport at the site.

Table 1. Fetch Distances from Milner Gardens

Direction	Fetch Distance	Limiting Land
N	37 km	Texada Is
NE	13 km	Lasqueti Is
E	54 km	Sechelt
SE	18 km	Ballenas Is
S	0	Vancouver Is
SW	0	Vancouver Is
W	0	Vancouver Is
NW	18 km	Hornby is

Offshore bathymetry may alter the wave climate at the shore due to wave refraction. There is large shoal offshore (Fig. 12) and it is likely that this shoal causes significant wave refraction of wave originating from the east. Such refraction would tend to reduce any westerly directed sediment transport caused by the waves.

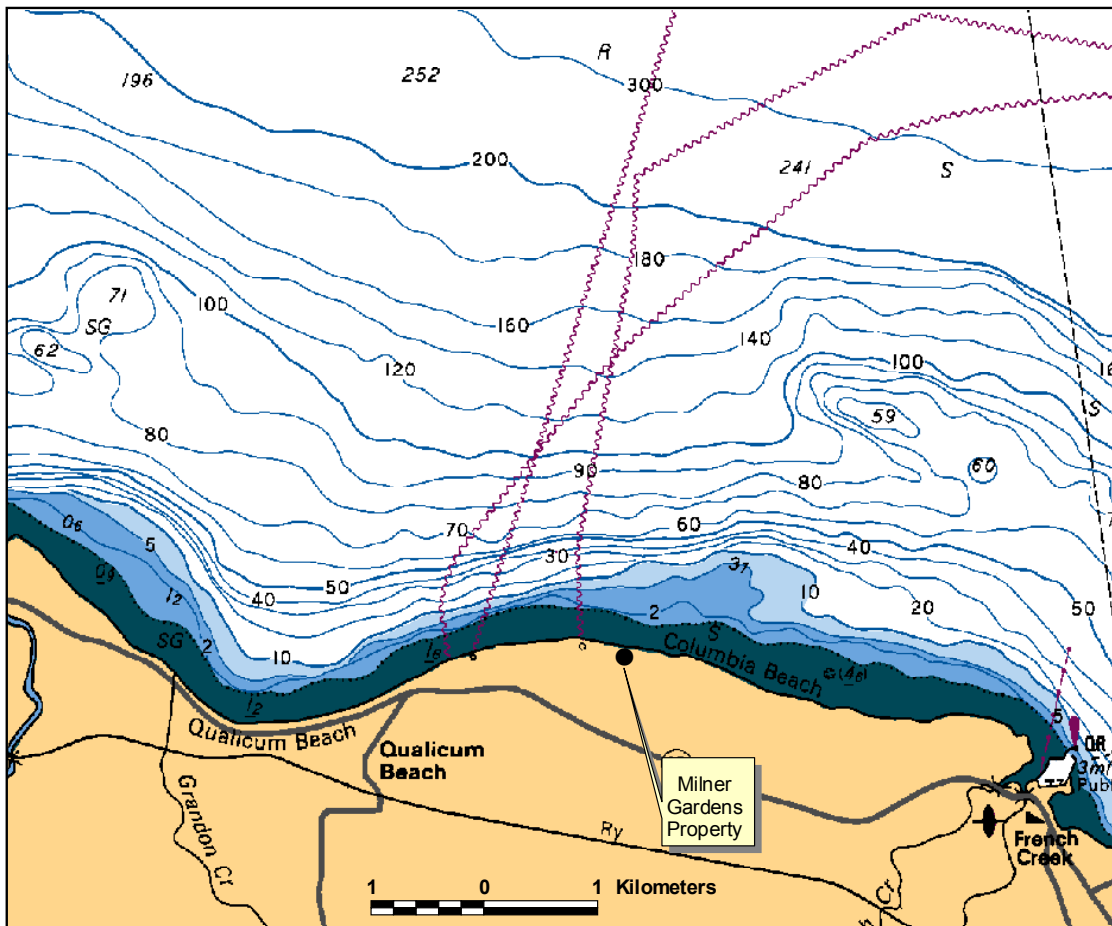


Figure 12. Offshore bathymetry in the vicinity of the Milner Gardens site. There is shoal (light blue) slightly to the north east of Milner Gardens and this shoal likely significantly refracts waves originating from the east.



Figure 10. Interpretation of the base of the beach face from the 1978 air photo and from the 2001 air photo. The difference between the two positions is within interpretative error and not regarded as significant.

Wave Climate

Understanding the wave climate and sediment transport patterns is a critical step in developing appropriate strategies for shoreline property management.

Winds generate waves as they blow over the water surface and the waves propagate in the direction that the winds are blowing. A summary of the winds in the area is derived from Ballenas Is light station data (Fig. 11). The annual data shows that the two dominant modes of direction in the Strait of Georgia are from the northwest and from the southeast. These are seasonally portioned with westerly winds dominating the summer months and southeasterly wind dominating winter months. Stronger winds are typically associated with the winter months.

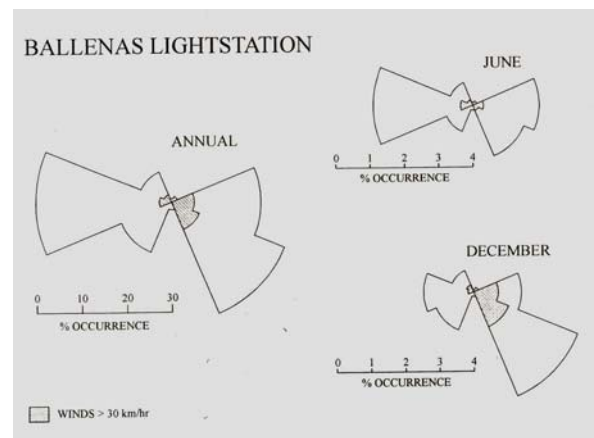


Figure 11. Summary of wind data, Ballenas Is Light Station.

Sediment Sources and Sinks

The sediment dispersal system at this site is complicated. There is no obvious dominant longshore sediment transport system. There are a few actively eroding cliffs at (a) the Milner Garden site and (b) cliffs to the west of the site. It is possible that some sediment from French Creek might be transported to the site but there is no obvious indications of this. It is likely that some surface wash erosion off the vegetated cliffs but this contribution is likely small. As such, the sources of sediment to the shore system in the vicinity Milner Gardens are limited.

There is some evidence of accretionary features near Milner Gardens. A seasonal accretionary berm was observed to the east of the property and a large swash bar in front of the Mewburn property was shown to migrate landward, indicating that sediment was captured in this bar over at 23 year period (see Fig. 8, Location A). A large sheet of sand appears to have accumulated directly seaward of Milner Gardens over the same 23 year period (Figure 8, Location B).

Overall, the general shoreline area appears to be in relative equilibrium with a relatively stable tidal flat, large stable swash bars and for-the-most-part, stable, vegetated cliffs, at least to the east of Milner Gardens.

Summary of Site Assessment

Assessment of shoreline stability indicates that there has been little measureable change in shoreline position over the past 25 years. Swash bars in the intertidal have remained relatively similar in size and form. Sediment transport at the site is complicated but there appears to be little *net* transport; it is likely that there is a seasonal variation in longshore sediment transport with summer westerlies generating an eastward transport and winter south-easterlies generating a westerly transport. Transport is likely concentrated in the upper intertidal as the middle and lower intertidal zones appear stable.

The erosion that is occurring at the Milner Garden site is likely the result of a few large storm events over the past few years that have concentrated their effect on the Milner Gardens cliffs - most of the adjacent properties are stable and cliffs are vegetated with large trees and shrubs. It is noted that a large offshore shoal (Fig.12) likely significantly refracts waves originating from the east. It is suggested that the right storm wave conditions, combined with an extremely high winter tides, may result in relatively unusual, focused wave conditions at the Milner Garden site.

There are a number of man-made modifications that have been made in the intertidal zone and supratidal zone. These include scraping of intertidal boulders and cobbles into groin-like features, construction of wooden bulkheads and groins and construction of concrete and rip-rap bulkheads both to the east and west of the Milner Gardens site. It is possible that recent construction of rip-rap bulkheads below the cliffs west of the Mewburn property may have altered the sediment budget at the Milner Gardens site but this cannot be determined with any certainty.

Although no direct observations were made of the waves at the site, one can make a few assumptions about probable nearshore wave conditions. The extremely wide intertidal zone (Fig. 3) will tend to reduce wave energy levels at the high water line because a significant amount of energy is lost as waves shoal and break across this wide tidal flat. As such, wave energy levels in the upper intertidal are likely to be considerably reduced from offshore, deep-water energy levels.

Some eelgrass was noted at the low-waterline during the beach profiling survey. Eelgrass is typically associated with lower wave energy levels and its presence is usually an indication of the either *protected* or *semi-protected* exposure levels (these are common exposure categories used in the BC provincial-wide ShoreZone mapping system). These observations suggest that this section has lower overall wave exposure than many of the open shores of the Strait of Georgia.

Sediment Transport

Most sediment transport is typically generated during winter storms when large waves are generated within the Strait of Georgia and when storms are more likely to combine with periods of high spring tides. The dominant storm wind is generally considered to be from the southeast (Fig. 11) and normally would generate longshore sediment transport to the northwest. However, review of air photos and of beach conditions at the site provide no morphologic indication of dominant sediment transport direction. The morphology of a large swash bar in the intertidal zone suggests a more or less neutral sediment transport, as indicated by the swash bar “tail” (Fig. 8), which is directed directly *toward* the shore. Photos of sediment build up on the wooden groins during March shows a weak indication of southerly transport at the site (Fig. 13).



Figure 13. Photo of build-up on right side of groin (west side) indicating right to left sediment transport (to the east) was occurring at the time the photo was taken (March 2007).

Most of the intertidal zone is armored with a veneer of boulders, cobbles and pebbles. While pebbles and sand may be transported during most moderate wave energy events, cobbles and boulders are only likely to be transported during the highest energy storm events. The armored surface of the tidal flat looked highly stable and supports a luxurious epibiota (Fig. 2, foreground). The upper intertidal zone consists of a comparatively steep beach face with an armor of small cobbles and pebbles (Fig. 13). This zone appears to be more mobile than that of the lower intertidal zone.

Storm waves occasionally reach the cliff and have caused some recent erosion of the glacial till and outwash. Over steepening of the cliff resulted in a small surface slide of sediment into the supratidal part of the beach.