# An Assessment of Coastal Erosion at the Malagawatch Graveyard Archeological Site

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## Introduction

The Geological Services Division of the Nova Scotia Department of Natural Resources (DNR) is engaged in coastal mapping, including the assessment of coastal erosion and hazards. One goal is to assess the various forms of coastal change throughout the province. This is necessary since the coastline of Nova Scotia is geologically diverse and the factors that influence coastal evolution are dramatically different, in both form and magnitude, in many areas of the province.

It is the role of the division to provide independent expertise to other government departments with respect to coastal processes and how they will affect social and economic development in the province. On September 24, 2009, the Geological Services Division received a request from Harold Carroll (DNR's Director of Parks and Recreation) for any insights on the surficial and the subsurface geology in the area of a Mi'kmaq burial site at Malagawatch, Cape Breton Island. The area is subject to shore-face erosion that is compromising the integrity of the burial site (Fig. 1).

This additional information was intended to supplement an engineering study of the site completed by Baird and Associates on February 13, 2009. In order to provide appropriate comment the author reviewed the engineering study and arranged a site visit.

The author visited the site on December 8, 2009, accompanied by Annie Johnson (Director of Administration, Unama'ki Institute of Natural Resources) and Shelley Denny (Biologist, Unama'ki Institute of Natural Resources). Approximately 1.5 hours was spent at the site, where the author was briefed on the history of the site and background to the issue at hand, specifically erosion of the historic burial ground.

**Figure 1**. Mi'kmaq burial site at Malagawatch, Inverness County.

Further assessment and analysis of the observations from that visit were carried out in 2010.

## Observations

Prior to the site visit the preliminary erosion mitigation report by Baird and Associates (2009) was reviewed. Baird and Associates (2009) presented detailed present and future water level calculations for the Malagawatch site. That information was detailed and accurate so there was no need to address it further. The author also agrees with the general site observations in the report. During the site visit those observations were examined in considerably more detail with respect to geomorphology, present erosion types and overall site stability. Observations noted during the site visit are summarized below.

The shoreline in the Malagawatch area is characterized by eroding, unstable sediment that appears to be being transported northward along the shore. This is revealed by the shape of the sand spit north of the graveyard site. The sand spit contains well developed prograding (advancing seaward) beach ridges. This indicates that not all

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areas of the shoreline are eroding. The northern-most end of the spit has eroded between the years 1953 and 2008 (NSDNR air photograph library). The landward side of the spit (to the west), however, appears to have remained relatively stable and the central-seaward part of the spit appears to have remained stable or even built seaward.

Based on a review of the regional coastal geomorphology and analysis of airphotographs north and south of the site, on a regional scale the shoreline is straightening and smoothing itself in response to hundreds of years of sea-level rise, forming bars across many coastal inundations. This answers the question regarding whether the connection between the 'mainland' and the graveyard site proper is natural or man made as a response to construction of the road in the past. The bar is a natural feature and would not erode without the presence of the road, so long as up-shore sediment supply was maintained. However, road maintenance has probably artificially prevented the bar from migrating westward. Thus, without the road the bar would likely move westward until it reached a stable position in balance with the shore-face erosion along the east side of the island.

The east side of the spit forms a series of concave shore segments that are considered to reflect a state of maximum geomorphological stability under the present conditions in the area.

The elevation of the north end of the island graveyard site on the east-northeast facing side is very low, only in the order of 1 m – 1.2 m above the common high tide line. Erosion is occurring above the high tide level by bank undercutting and collapse of the overlying sod (Fig. 2).

There was little evidence of driftwood, logs, piles of eel grass, or a rack line inland of the shore face in this low-lying area. There also wasn't any obvious scarring or other tree damage inland of the shore face that would be indicative of ice jams and thrusting of the ice inland. In addition, a small bungalow in this area that had to be removed due to coastal erosion, not ice effects, also suggests that shore ice is not a major hazard in the area (Fig. 3). Shallow water depth, low tidal range, and relatively low-energy conditions may contribute to the lack of ice hazard.

Based on discussions with Johnson and Denny, (personal communication, 2009), grave sites are known to be located in the main 'graveyard site'. Human remains were exposed by erosion in the 1970s and subsequently reburied when the original armour stone was placed. Old maps, however, indicate that grave sites may be scattered across the island (Johnson and Denny, personal communication, 2009).

The access road to the island across a former sand bar is clearly subject to continuing erosion. It is worth noting that the general high tide is lower than the base of the gravel road. The road base is also above the present eel grass strand line on the beach (Fig. 4).

## Discussion

Erosion at the Malagawatch graveyard site is serious and must be mitigated. Site conditions at

**Figure 2**. This low bank is being eroded by undercutting.

**Figure 3**. A small bungalow that had to be removed due to undercutting erosion.

Malagawatch, however, should be viewed through a province-wide perspective. Conditions causing erosion at this site are not particularly severe, although erosion may be locally severe. Erosion of the seaward side of the graveyard site is well advanced. Further erosion of the island will place graves at significant risk**.** It is recommended that the seaward side of the island be stabilized in its entirety. At the graveyard site, further erosion will cause significant damage. Because of this, and the obvious continuing erosion, investigations of monthly, yearly, or longer-term rates of erosion are not necessary or relevant to this specific site. The effects of rising sea level at this site will be minimal on a generational basis and need not be seriously considered. Variations in wave height and storm intensity are far more important.

Predicted storm surge wave heights of 0.5 m and a tidal range of +0.36 m to +0.46 m (Baird and Associates, 2009) are relatively low compared to coastal areas directly exposed to the ocean where storm surges and tidal ranges are much higher. This location also lacks exposure to deep water swells typical of exposed Atlantic shorelines (Fig. 5). Ice build-up and ice jamming were identified as potential problems when armouring a shoreline (Baird and Associates, 2009). This is correct and should not be discounted. It should be noted, however, that ice hasn't dislocated boulders in the remaining portion of the armour stone that was dumped over the cliff during the 1970s (Johnson and Denny, personal communication, 2009). Ice also doesn't appear to have affected the northern end of the island. In summary, it appears that ice, wind, wave, tide and surge hazards are much less severe than would be the case if this site was located on an ocean coastline.

Observations in this report agree with Baird and Associates (2009), who identified the graveyard site and the area south (to and including the access road) as requiring armouring. The low-lying area north of the main, northern section of the island to

**Figure 4**. Access road to the island; view to the south.

**Figure 5.** Plunging breakers approach the front, sheltered side of East Ironbound Island, Lunenburg County, during Hurricane Bill.

**Figure 6.** Note the repeating concave shape of the shoreline at Malagawatch.

the beginning of the main spit is also eroding (Fig. 2). This area may be of less concern to the various aboriginal communities. Regardless, it is strongly recommended that this section of shoreline also be stabilized to prevent flanking erosion of the graveyard site**.** In addition**,** it is recommended that the coastal armouring should attempt to replicate the geometric shapes observed along the front of the sand spit (Fig. 6) to ensure maximum stability and to decrease any undesired effects on coastal areas down current of the armouring (i.e. to the north).

A significant section of the previously placed armour stone is still standing and appears to have been highly effective in preventing any further erosion of the grave yard site behind the armour for 30 – 35 years. Johnson and Denny (personal communication, 2009) were not aware of any maintenance to this original armouring. This is important to consider as it has survived beyond the 25-year design life for the structure described in the Baird and Associates (2009) report. The present elevation of this armour has also been sufficient to prevent erosion overtopping. Near the top of the armour stone, driftwood was observed (Fig. 7). In addition, at the south end of the armour the landward extent and height of beach gravel is easily observed (Fig. 8). It is clear that the elevation of the gravel is well below the height of the existing armouring.

The present armour stone was dumped over the bank, with little or no placement (Johnson and Denny, personal communication, 2009). The presence and distribution of larger boulders at the base of the failed sections is suspect. It should be noted that there are only a small number of boulders in the failed armour observed on the beach (Fig. 9). It is suspected that this is why the northern end of the armouring failed.

Given the above observations and discussion, it is recommended that the various bands responsible for the maintenance of this site carefully consider whether or not a highly engineered coastal protection structure is really necessary. From a geotechnical point of view, and based on site observations, it is likely that armouring similar to what was done originally would suffice to protect the graveyard site. It is not recommended that simple dumping of stone over the cliff should be undertaken. From a geotechnical point of view, the necessity for large boulders along the toe and first lifts of the armouring is critical (as per the recommendations of Baird and Associates, 2009). Smaller stone against the back of the fronting toe boulders must be larger than any gaps to prevent wash out. Baird and Associates (2009) also recommended the use of a geotextile, but this may act as a sliding surface resulting in premature failure of the armouring.

It is recommend that minor ‘touch ups’ to the existing armour be done to ensure long-term stability. Given the vertical nature of the failed shore face at either end of the present armouring at the grave yard site**,** it is recommended that the armour be stepped out from the face toward the

**Figure 7.** Armour stone is still successfully protecting the site after more than 30 years. Note the lack of overtopping or erosion above the armour stone.

former armour location. This will allow for filling with clean material and the associated sloping and vegetation as described in Baird and Associates (2009).

Similar but smaller scale armouring along the road and northern part of the island is also required. The road could be moved landward (westward on the existing bar) using existing material. This should reduce wave attack but is not a long-term solution. In addition, some armouring would still be required. This is a cost/benefit question, given that protection would still be required. This option is not recommend as it has the potential to create unnecessary sediment runoff. This is particularly the case as there is no information about the composition of the road material at depth.

Baird and Associates (2009) suggest prices for armour stone (in place) of $40 to $55 per tonne and filter stone (in place) ranging from $35 to $40 per tonne. Based on discussions with stone suppliers, a reasonable estimate for the price of armour stone is $10 per. tonne FOB (from point of boarding, i.e. loaded at the quarry gate). Filter stone would likely be in the range of $8.50 to $9.50 per tonne FOB. Based on the delivered cost of stone products, the actual cost of the stone is only in the range of 25% of the final 'in place' cost. Transportation from the quarry to the site is a major contributor to the final cost in place, plus of course the machinery and labour to place the stone. As such, it is recommended that the nearest possible source for geotechnically suitable material be located. It is also recommended that quotes be sought from smaller local operators with the necessary equipment and experience in placing this type of armour stone. Ask to visit and examine similar projects that they have undertaken**.** Reducing the distance from quarry to project site should reduce the overall project cost**.** It is recommended that the time that heavy equipment is required at the project site be minimized. Specific recommendations are given below on ways this might be accomplished.

**Figure 8.** Gravel strandline against the eroding cliff face on the south side of the remaining armour stone.

Based on Baird and Associates (2009) estimated costs, the cost of armouring would range from $444,000 to $581,800. Note that this would not include additional armouring recommended along the shore north of the graveyard site.

Protecting the access road and the low area of exposed shore face north of the main graveyard site shouldn't be difficult or necessarily costly. Given budget concerns, the author enquired whether or not the local native communities have volunteers who have the expertise and experience necessary to safely undertake all or part of the required work. It appears that the band has access to logging trucks with associated boom capability. In mapping coastlines in various areas of the province, it is observed that many forms of shore-face stabilization are used. One such method (Fig. 10) uses large logs or beams to build low cribs filled with stone along the shore.

The crib in Figure 10 is over 40 years old and has withstood heavy drift ice and numerous hurricanes. There has been little or no maintenance, yet it exceeded the 25-year design life of the large scale armouring suggested by Baird and Associates (2009). Cribbing does not need to be solid as long as the fronting rocks are larger than any gaps between the cribbing.

These cribs, if properly constructed, can be highly effective in preventing shore-face erosion and may also be resistant to ice impact. Such structures may be built of marine-grade treated wood or a combination of treated and native trees (e.g. one lift of treated wood at the base). As a biologist, Shelley Denny is able to identify the most appropriate native species available having the greatest natural resistance to rot. Worm attack is not an issue as the crib would be above high tide**.** It is recommend, for at least the low shoreline and road, that the Unama'ki Institute of Natural Resources investigate the possibility of using qualified volunteers as a low cost alternative to undertake and/or supervise crib construction.

**Figure 9.** Remnants of failed armour stone. Note the lack of large boulders required for stability.

It has been noted that it is normal for contractors along the Northumberland Strait to undertake armouring during the winter months when the ground is frozen. This helps to prevent unnecessary damage to the work area, and is locally necessary because of the summer presence of cottage owners. The remains buried at the graveyard site were not buried in caskets. Thus, if the grave markers were carefully located and then temporarily removed, access to the shore face during the winter could be made from the top of the bank without collapsing the individual graves. This would remove any necessity of having heavy equipment on the beach. It should also make placing the filter stone a faster process, and should be a less expensive option. It would also lessen sediment runoff issues, especially if the shoreline is frozen. It is recommend that the main high bank armouring be undertaken during the winter when the ground and if possible the shoreline is frozen.

Finally, the author was asked about options to save a stone cross at the burial site that is deteriorating and is in danger of falling apart. It was advised that the marble quarry near River Denys may have equipment on site used to inject resin into marble blocks to ensure that slabs, when cut from the blocks, do not fall apart. If this is the case, this process should stabilize the stone cross.

An alternative (non-geological solution) could be to have a hollow stainless steel (or aluminum) cross fabricated (not closed at the bottom or top) that would be just slightly larger than the existing cross and slightly smaller in depth. It could be slipped over the existing cross, and the small gap between the steel and stone filled with resin or mortar. Drill the horizontal and vertical parts of the cross through the steel and rock, from side to side. Tighten with stainless steel bolts or stainless rods. Weld the two steel cross pieces together at the top. The cross is composed of marble blocks. Marble is a very soft rock and as such would be very easy to drill. The steel frame option is recommended as it does not require moving the cross.

**Figure 10**. A horizontal rock-filled crib (centre left, extending to the corner of the red building on the right) located on East Ironbound Island.

The author has interacted with a variety of contractors and land owners with respect to various forms of site remediation. A few tips for proponents of this type of project are given below. It is not an exhaustive list as tendering is a highly complicated process.

When tendering this type of work, proponents should seek several competitive bids. Cost estimates for government-funded projects of this type may have a benefit:cost ratio of up to 2:1 or 100%. There is considerable room for price negotiation on these types of projects. As a simple example, proponents should ask for costs to be highly broken down, and request the cost of stone delivered to the work site. This is called FOL or 'from point of landing'. Request the cost of placement per linear metre along the shore face given a 1 m height. This should be considered with respect to the height of the actual wall. It is critical that the wall be high enough to prevent overtopping, but excessive height is very costly and unnecessary. If costs for all parts of the project are broken down in this way, proponents can get a better understanding of the benefit:cost ratio. It also allows for the proponents to check the costs of individual parts of the tender responses.

## Reference

Baird and Associates 2009: Erosion mitigation assessment for Malagawatch graveyard, Bras d'Or Lakes; 9 p.