Coastal Process, Geohazard, Erosion and Infrastructure Sustainability Studies at Cabots Landing Provincial Park, Port Shoreham Beach Provincial Park, and the Proposed Replacement for Plaster Provincial Park, Nova Scotia

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Introduction

The Geological Services Branch works closely with the Department of Natural Resources (DNR) Parks Division by providing geological expertise in assessing park properties and infrastructure located along Nova Scotia's shoreline. Assessments of the general geology and coastal processes that affect the parks are provided to assist in developing long-term park management plans. A wide range of information on topics such as past, present and future sea-level rise, beach and cliff stability, storm impacts, and natural coastline evolution (to name a few) impact provincial park management and infrastructure development plans.

Recent studies have been completed at several provincial parks. At Cabot's Landing in Victoria County, northwest Cape Breton Island, I quantified purportedly high rates of unconsolidated shoreface erosion and identified factors that could be driving erosion, with the intent of advising on the construction of more sustainable beach access infrastructure. Studies at Port Shoreham Beach, Guysborough County, eastern Nova Scotia, investigated the history of natural barrier-beach breaching. The results of this study informed policy with respect to issuing permits to allow channel dredging to maintain access between Chedabucto Bay and the brackish lake enclosed by the barrier beaches. A third site in Victoria County, northeast Cape Breton Island, was examined in terms of its general geology and how it might influence the development, or lack of development, of sinkholes on the site. This site was being considered as a replacement for the now-closed Plaster Provincial Park. Plaster Park was closed due to extensive sinkhole development and the risk that these geohazards presented to park visitors.

Cabots Landing Provincial Park, Victoria County

Background

Cabots Landing Provincial Park—located in Victoria County, Cape Breton Island—is a day-use provincial park. It is located in Aspy Bay on the Cabot Strait and provides access to the coast for both picnic and recreational swimming. It has a small but well developed sandy beach. Significant shoreline erosion over many decades has negatively impacted park infrastructure, forcing the realignment of roads and parking areas, and destroying beach access ramps.

In August 2013, the author was asked by the Nova Scotia Department of Natural Resources Parks Division to undertake a geological assessment of the park. The purpose of the study was to 1) assess the ongoing erosion of the park coastline and 2) comment on the impact that the erosion is having, and will continue to have, on the sustainability of beach access structures and other infrastructure in the park.

On October 28, 2013, a field assessment of the site was undertaken. I was accompanied by Liam MacNeil, the region's Forest Resource Technician out of the Baddeck office. Mr. MacNeil described the erosion that he has observed at the site in recent

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years and provided details on an access ramp that was recently constructed under his supervision. He also assisted me in conducting measurements of the most recent erosion at the site.

Physiography and General Geology

Cabots Landing is located near the northeastern-most extremity of Cape Breton Island (Fig. 1). It is sheltered from the north and west by North Mountain, and from the south by South Mountain. Cabots Landing is located directly on the coast about 0.5 km north of North Harbour Beach. It is heavily exposed to northeast to east-southeast winds and by a lesser extent to southeast winds blowing off the Cabot Strait.

Cabots Landing is flat lying. Vegetation is grass except at the entrance and along the south side of the park where trees border Wilkie Brook. There is no bedrock outcrop along the shoreface of the park. The shoreface erosion scarp is predominantly composed of an unconsolidated, clast-supported, cobble-rich glacial outwash with a coarse sand matrix (Fig. 2). The outwash exhibits planar beds of finer grained sediment and cut-and-fill structures. This fine-grained sediment comprises the bulk of the material that forms the fronting beach.

The scarp is generally vertical and varies from approximately 2 m in height at the north end of the park to approximately 4 m at the south end of the park at Wilkie Brook (Fig. 2). The height of the scarp, measured from the top of the beach sand, depends on the amount of beach sand piled up against the base of the scarp (Fig. 3).

Rates and Causes of Erosion

There are sufficient long-term, stable control points available at this location to allow determination of multi-decadal rates of erosion. Aerial photographs were selected for the years 1984, 1999 and 2009. The images were rectified relative to the 2009 photograph. The respective positions of the top of the erosion scarps were traced on the 1984 base image (Fig. 4). The amount of erosion was measured between 1984 and 1999, and between 1999 and 2009. The 2009 image was the latest available for the study area. In order to extend the analysis to August 2013, the position of the top of the erosion scarp was physically measured relative to known control points and plotted onto the 1984 air photograph. In this way the amount of erosion between 2009 and 2013 could be measured.

Table 1 gives the average yearly rates of erosion calculated for the various time intervals between 1984 and 2013. The earliest 15-year interval has an average annual rate of erosion of 0.35 m/a. The intermediate 10-year interval has an average annual rate of erosion of 0.76 m/a. The most recent 4.3-year interval has an average annual rate of erosion of 0.96 m/a. In considering these values one needs to examine Figure 4. It is clear that the amount of erosion at the south end of the park near Wilkie Brook is higher than at the north end of the park. This is likely a result of realignment of Wilkie Brook, which in recent years has been flowing northward along the face of the scarp. This northward flow is eroding the corner of the south end of the park at a greater rate than along the central and northern parts of the cliff face. The position of the 1999 scarp in comparison to the position of the 2009 scarp at the south end of the park confirms this differential erosion.

In order to compensate for the effect of differential erosion, I recalculated the rates of erosion for the area directly seaward, or east, of the main parking area (Fig. 4; shaded values in Table 1). This was done so that the position of the 2013 scarp could be compared to the previous scarp positions along the same length of shore line; the position of the 2013 scarp was not measured along the south end of the park toward Wilkie Brook. However, this did not appreciatively change the average yearly rates of erosion of 0.33 m/a (1984–1999), 0.71 m/a (1999–2009) and 0.96 m/a (2009–2013), especially when one accounts for the considerable error in the methods used to determine scarp positions between successive aerial photographs. Although there are significant errors associated with this method, there aren’t any better alternatives available for this site. Nonetheless, it appears that the overall rate of erosion of the shoreface at Cabots Landing has increased significantly over the last 30 years. Other important considerations, in addition to the rates themselves, are the mechanisms and physical

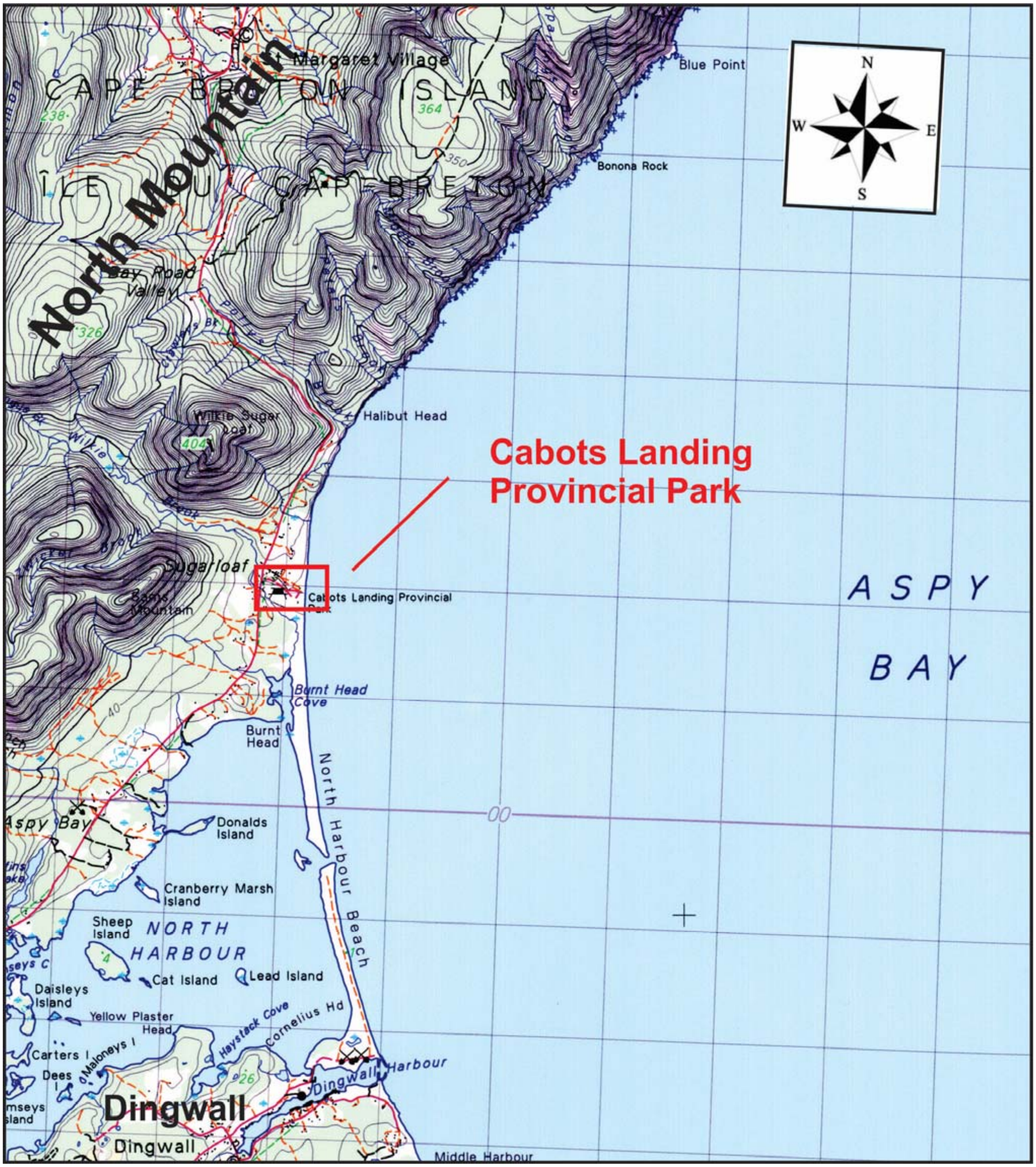

Figure 1. Location map for Cabots Landing Provincial Park.

processes that control coastal erosion. For example, major erosion events often correspond to major storm events; however, this is not always the case as a major storm may occur during low tide, in which case erosion would be less severe.

The length of time (or the length of the individual time intervals) upon which the average annual rates of erosion were calculated must also be considered because the longer the time interval, the greater the chance that individual, sporadic, extreme events

Figure 2. Eroded shoreface at Cabots Landing Provincial Park composed of outwash deposited by water derived from melting glacier ice.

average out with respect to 'background' steady-state rates of erosion. Thus, average rates of coastal erosion calculated over longer time intervals should be considered as more accurate indicators of longer term (e.g. multi-decadal) rates of erosion. However, this isn't necessarily the case if there is reason to assume that there is a coastal process or external driver that may be changing (in this case increasing) the longer term rate of erosion.

As discussed above, although the precise increase in the rate of erosion at Cabots Landing is uncertain, a trend of increasing rates of erosion since 1984 is clear. The most likely drivers of this trend include 1) an increase in the local rate of relative sea-level rise driven by a) climate change, b) natural variability in the rate of sea-level rise, c) crustal (land) subsidence related to melting of the last glacial maximum ice sheets, or d) natural variability in the local rate of relative sea-level rise; 2) an increase in the number or severity of easterly storms; 3) decreased or seasonal changes in sea-ice cover; 4) migration of the outlet of Wilkie Brook; and 5) a decrease (or increase) in sediment supply to the beach face area. The importance of each individual factor may have varied over this interval and will likely continue to do so in the future.

The closest tide gauge is located at North Sydney and has been in place since approximately 1975. The time period from 1984 to 2010 is approximately equivalent to days 3650 and 13000 in Figure 5, which shows data from the North Sydney tidal gauge. It is clear that sea level is rising with respect to the shoreline and that this will drive erosion. However, there is no obvious increase in the rate of sea-level rise between 1984 and 2010 compared to the trend from 1975 to 2010. This suggests that an increase in the rate of sea-level rise isn't a primary driver of the apparent increase in the rate of erosion at Cabots Landing. At the same time, this doesn't imply that any future increase in the rate of sea-level rise won't result in a further increase in the rate of erosion at the park.

As discussed previously, Cabots Landing is particularly susceptible to storms with easterly winds. Thus seasonal (winter) 'northeasters' and hurricanes are likely to cause significant erosion at Cabots Landing. Determining the variations in the number or intensity of these events is beyond the scope of this report. However, if one examines sea-ice extent data from the Canadian Ice Service (n.d.), over the last decade the extent of sea ice in the overall Gulf of St. Lawrence decreased, although the trend has sharply reversed in the last few years. It can be reasonably assumed that this is also true for the area of the Cabot Strait in the vicinity of Aspy Bay, that is, in the present study

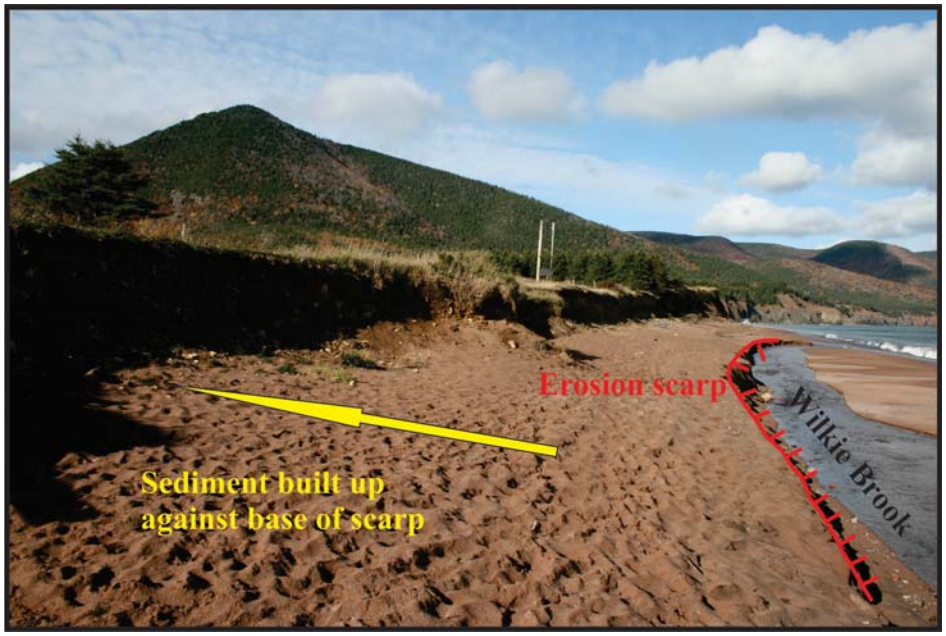

Figure 3. This image from Cabots Landing Provincial Park shows sand piled up against the erosion scarp and Wilkie Brook flowing north along the face of the scarp.

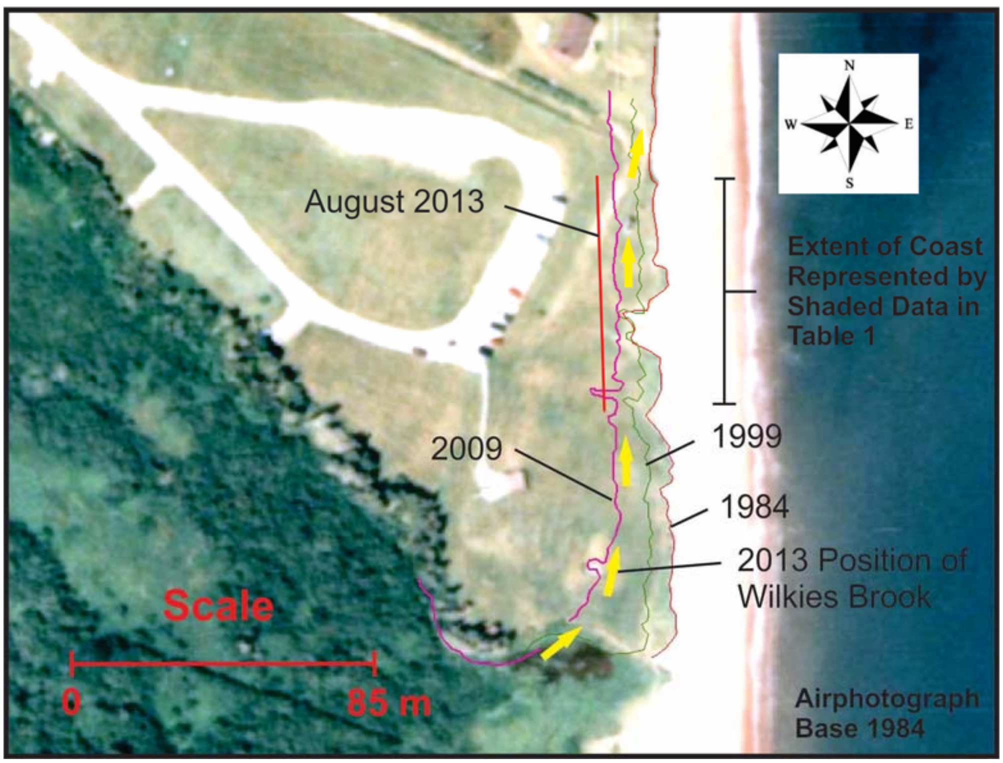

Figure 4. Approximate positions of the top of the beach erosion scarp at Cabots Landing in 1984, 1999, 2009

area. In the study area, the absence of sea ice would directly result in a decrease in the amount of 'land fast'—ice that is present on the shoreline— both within the intertidal and supratidal areas.

The presence of land-fast sea ice is recognized as a factor in reducing the vulnerability of a coastline to erosion. The ice serves to reduce, and in many cases eliminate, wave action on the shoreface. The

Table 1. Rates of coastal erosion at Cabots Landing Provincial Park, 1984 to August 28, 2013. Values from the area east of the main parking area are shaded, and these values correspond to transects measured in the area seaward (east) of the 2013 erosion scarp (Fig. 4).

Transects	1984 – 1999 (15 year interval)		1999 – 2009 (10 year interval)		2009 – 2013 (4.3 year interval)	
	Total (m)	m/a	Total (m)	m/a	Total (m)	m/a
1	4.65	0.31	6.80	0.68	4.68	1.08
2	4.79	0.32	7.03	0.70	4.57	1.06
3	4.91	0.33	7.07	0.71	4.52	1.04
4	5.04	0.34	7.20	0.72	4.39	1.02
5	5.16	0.34	7.11	0.71	4.24	0.98
6	5.31	0.35	7.31	0.73	4.08	0.94
7	-	-	-	-	4.16	0.82
8	-	-	-	-	3.82	0.96
9	-	-	-	-	3.75	0.88
10	-	-	-	-	3.63	0.87
11	-	-	-	-	3.53	0.84
12	5.45	0.36	7.83	0.78	-	-
13	5.59	0.37	7.88	0.79	-	-
14	5.74	0.38	8.61	0.86	-	-
15	5.88	0.39	8.05	0.81	-	-
16	6.02	0.40	8.25	0.83	-	-
Average erosion rate for total area:		**0.35**		**0.76**		-
Average erosion rate for transects seaward of the 2013 scarp:		**0.33**		**0.71**		**0.96**

late arrival and/or early breakup of land-fast sea ice enhances the rate of erosion on affected coastlines. It is unknown if this is indeed the case at Cabots Landing. Since this area is outside of the Gulf of St. Lawrence, it is doubtful that sufficient data exists, or if it exists that it is of sufficient resolution to make such a determination for an individual location such as Cabots Landing. However, reduced sea ice in the Cabot Strait is a plausible mechanism that could explain an apparent increase in the rate of coastal erosion at this location.

As discussed previously, migration of Wilkie Brook is believed to have increased the rate of erosion along the southern extent of the park shoreline. Whether this has had the effect of increasing the overall rate of erosion is unknown. It is possible that an increase in the rate of northward transport of sediment in the general study area has had the effect of blocking the outflow of Wilkie Brook, forcing it to flow northward along the face of the erosion scarp. This would be a situation where increased sediment supply, rather than decreasing coastal erosion, has actually increased coastal erosion by forcing a change in the outflow of Wilkie Brook.

Sustainability of Beach Access Infrastructure

The effects of changes in beach processes on future rates of erosion at Cabots Landing Provincial Park are difficult to assess. However, the impacts of erosion rates of 0.7 to 1 m/a on park infrastructure is more certain.

Beach access infrastructure, in my experience, is typically fixed in place. By this I mean that it is not capable of being removed in the late fall and replaced in late spring. This is true of the existing beach access ramp at Cabots Landing. Assuming a rate of erosion of 0.7 to 1 m/a, an 8- to 10-metre-

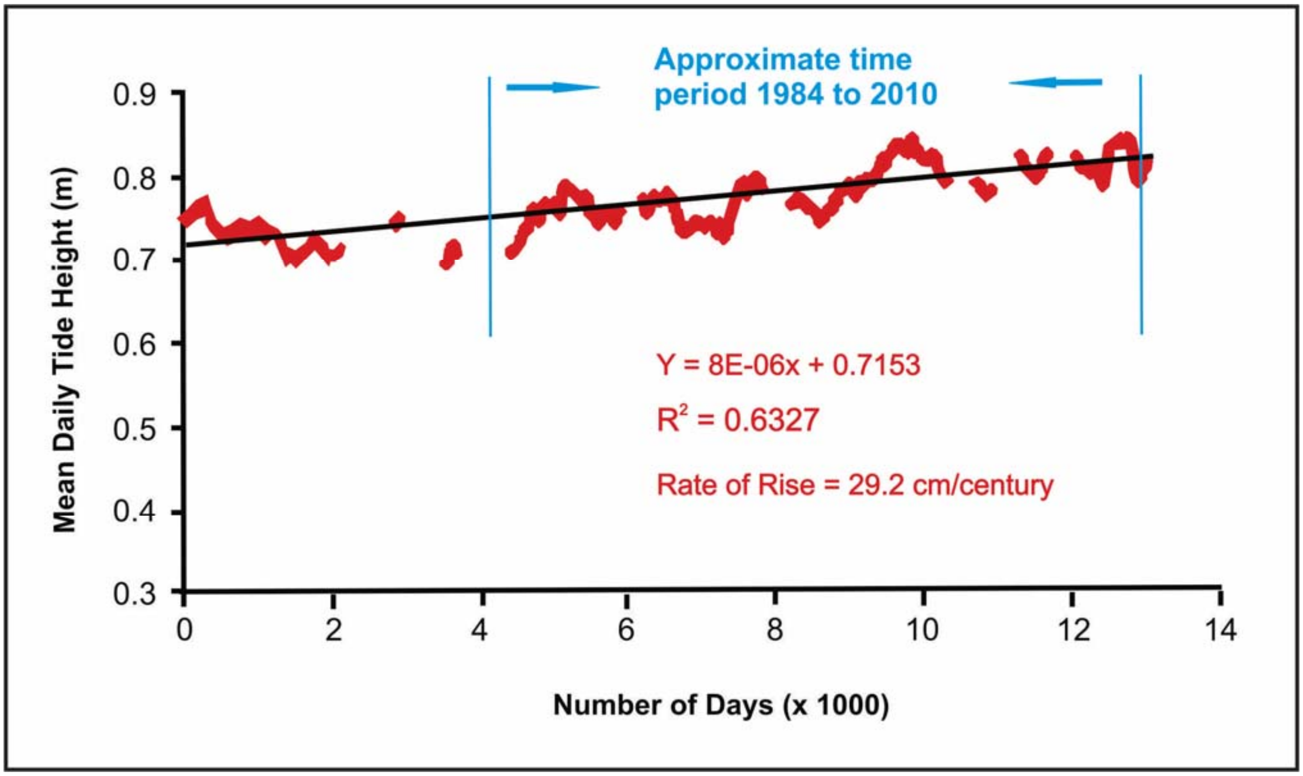

Figure 5. Tide data (daily mean water level) for the North Sydney tide gauge from Fisheries and Oceans Canada (n.d.), 1975 through 2010.

long ramp, fixed in place, will be seaward of the erosion scarp in 10 years. After only a few years it will be exposed to severe storms and sea-ice thrusting, and will possibly become unserviceable to park visitors.

I believe that a fixed ramp at Cabots Landing will not be sustainable for more than three to five years without modifications if present rates of erosion continue. The location of the ramp will not affect the sustainability of the structure as the rate of erosion is uniform across the main eastern face of the park and is even higher at the southern end of the park. Other, non-beach access infrastructure, such as roads, should be constructed with a 0.7 to 1 m/a rate of erosion in mind.

The Parks Division may wish to consider a moveable access ramp. As a general concept, this would be a ramp (with or without rails) that has sufficient structural integrity to be pulled up onto the flat grass in the fall and pulled back down in late spring. The ramp would be placed in a trench cut across the scarp at the appropriate slope. Truck access to the ramp area is readily accomplished so the ramp could be easily towed up onto the grass in late fall. In order to pull the ramp back down, a fixed point of purchase is necessary seaward of the end of the ramp. Various scenarios are possible, but a vertical heavy pole, deeply buried in the beach would likely serve the purpose. A moveable block could be easily fastened to the pole and would serve to allow the ramp to be towed down onto the beach. This solution is simple, quick, can be implemented by only one person, and allows for the ramp to be retracted in the case of a severe hurricane.

Port Shoreham Beach Provincial Park, Guysborough County

Background

The Department of Natural Resources will on occasion allow dredging of pre-existing channels across Crown Land. This activity is permitted where the dredging is undertaken to manage the depth of the channel. There have been ongoing requests to dredge a channel across the beach at

Port Shoreham Beach Provincial Park, Guysborough County, between Ragged Head Pond and Clam Harbour Bay. The channel serves to maintain boat access to the lake and to allow water circulation in and out of the pond, which reduces the potential for stagnation and associated odour.

On August 15, 2013, the Parks Division of DNR requested a geological examination of Port Shoreham Beach Provincial Park. The purpose of this study was to evaluate the historical occurrence of natural versus artificial or artificially enhanced natural drainage channels across Port Shoreham Beach. On October 30, 2013, I visited Port Shoreham Beach Provincial Park accompanied by Bernard (Gerard) Kelly, Forestry Technician from DNR's regional office in Guysborough County. The visit allowed me to gain an on-the-ground perspective of the beach system and to observe the nature and extent of the 2013 dredging carried out just west of Ragged Head. Excavator tracks were evident along Port Shoreham Beach Park when I visited the site on October 30th. However, the tracks were in an area that would be washed over by storms, thus eliminating them.

Geological Overview

Port Shoreham Beach is located on the north side of the western extension of Chedabucto Bay, Guysborough County, Nova Scotia. The beach is on the west side of Ragged Head (Fig. 6). It consists of a series of spits that have built seaward in a southeast direction from the mainland, ultimately joining to the west side of Ragged Head. An unnamed, stable barrier beach or bar extends from the east side of Ragged Head to the mainland in the vicinity of Carr Pond. The two beaches are distinct in that the beach on the east side of Ragged Head shows no signs of breaching or channel development and further shows no indication of historical spit development. This beach probably formed as a bar deposit that moved progressively landward in response to a gradual rise in sea level. In contrast, Port Shoreham Beach formed from the progressive southeastward extension of spit development and shows clear signs of historic breaching and tidal channel formation. Historic southeastward growth is evident from the geomorphological expression of numerous coalescent spits that show sequences of growth, erosion and truncation, and subsequent regrowth. The growth of the spit complex is further evident when one examines the 1864 map of the area by Church (Fig. 7). Church shows two well formed breaches in Port Shoreham Beach. The westernmost breach is two contours deep while the eastern breach is one contour deep. I wasn't able to locate information on the Church map stating what the contour interval represented. It may in fact be qualitative rather than quantitative. Regardless, I interpret the western breach as being an open channel even at low tide. The eastern breach may have been an intertidal channel. In the 1864 map, I interpret Ragged Pond as being an intertidal lagoon.

Overview of Historic Breaching

As discussed above, it is clear that there were two well formed and extensive breaches in what is now the Port Shoreham Beach prior to 1864. The next available image is the 1943 air photograph (Fig. 8.1). The extent of an interpreted pre-1943 and post-1864 back bar is shown by the red dashed line. This bar or spit extension is believed to have formed and closed the western-most channel shown on Church's 1864 map discussed above (Fig. 7). Subsequently, secondary spit development occurred seaward of the spit indicated by the dashed red line. Both spits were then breached prior to 1943, as shown by the yellow arrows in Figure 8.1. These two breaches appear to be inactive by 1943. A large and apparently natural breach formed by 1943 ('Natural Tidal Channel' in Fig. 8.1); alternatively, it is the same breach shown on the 1864 Church map. The above sequence of events can only be bracketed as having occurred after 1864 and prior to 1943. However, what it shows is a very dynamic beach-spit system with significant changes occurring over multi-decadal time frames.

The breach immediately west of Ragged Head was blocked at some time after 1943, and by 1954 a new, large breach developed farther to the west (Fig. 8.2). There also appears to have been further spit development (beach buildup) or sediment accumulation on the seaward side of the beach immediately northwest of the breach on the 1954 air photo. The breach shown in the 1954 photo (Fig. 8.2) is sinuous with ebb and flood tide channel bars and is therefore interpreted as being

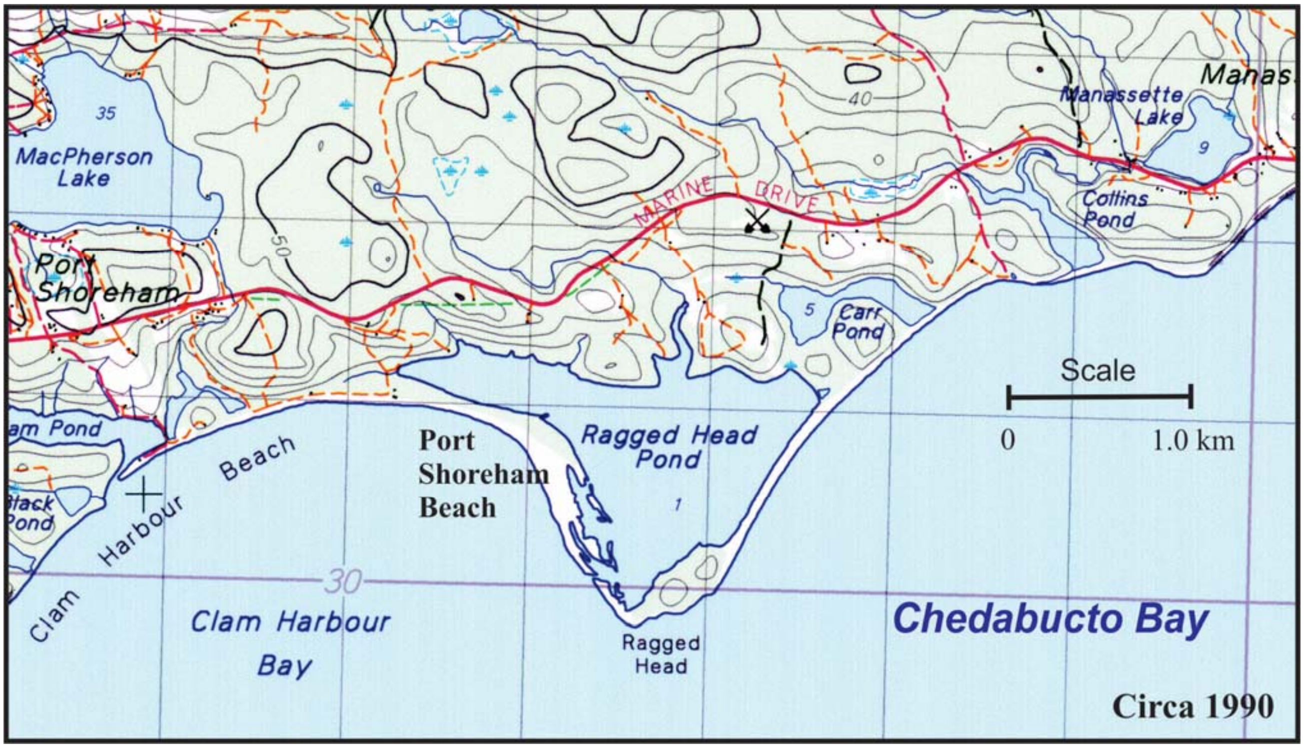

Figure 6. Overview of the Port Shoreham Beach study area.

natural. However, cribbing may have been installed in an attempt to keep the channel open. This is based on the observation of vertical poles forming what is interpreted to be a retaining wall; these poles can be seen in Figure 9 leading from the edge of the water-filled depression landward toward Ragged Head Pond.

By 1979 (Fig. 8.3), the large breaches had closed, leaving what appears to be two or three smaller channels allowing water to drain out of Ragged Head Pond when the pond water-levels were high. Between 1979 and 1990 (Fig. 8.4), there do not appear to have been any major breaches on the scale of the pre-1954 channels. In Figure 8.4, there is a possible lake drainage channel formed by an overwash event in a similar location to a pre-1943 breach. How this channel evolved between 1979 and 1990 is unknown; possibly it was a repeating cycle of growing bigger followed by infilling.

As part of this review, I contacted Art Lynds (Planner, Parks Division; pers. comm., 2013) who provided me with a timeline of requests from a local resident for a Letter of Authority to allow opening of a channel between Ragged Head Pond and Clam Harbour Bay. On April 16, 1991, the channel visible on the 1997 air photo (Fig. 8.5) was dredged open. From that point onward, the channel was periodically opened by private parties under the authority of permits issued by the Department of Natural Resources. The channel continued to be dredged from this point onward except for a few short interruptions while permits were waiting to be approved. The channel was last dredged in mid 2013. In the 1997 and 2007 air photos (Figs. 8.5, 8.6), material from the dredging is clearly visible.

Breaches and Tidal Channel Development

Breaches in bay-mouth bars and more extensive systems, such as at Port Shoreham, may form by a number of mechanisms. Breaches often occur during severe storms as washouts. A typical scenario is a breach formed through a cobble storm ridge, an example of which can be seen on the Eastern Shore of the province (Fig. 10). This was a large breach that may or may not have closed over time. It was decided that Natural Resources would artificially close this breach, which in fact reversed what was a natural process of beach evolution. In

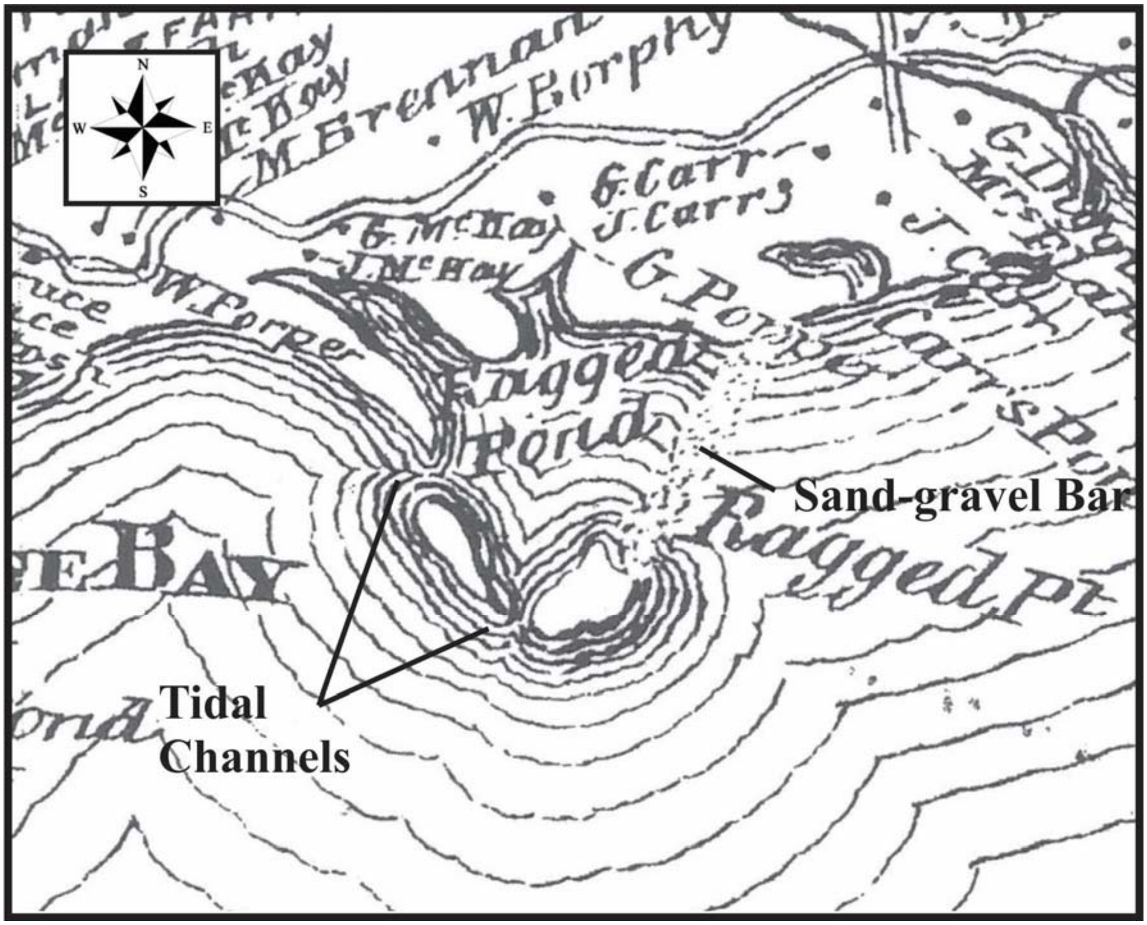

Figure 7. Map of the Port Shoreham study area by Church (1864).

other instances, breaches may occur due to a build-up of water on the landward side of a bar. The resulting pressure and water flowing seaward over the bar actually creates the breach, and the breach proceeds seaward rather than landward. Alternatively, barrier beaches, bars and spits may simply slowly erode, lose elevation, narrow and finally breach during a severe storm. A classic example of this is the eastern portion of Martinique Beach. In this case, the breach slowly closed and the beach rebuilt (to an extent) over succeeding months and years. Regardless of the mechanism, it is extremely difficult to predict whether a breach is permanent or temporary and depends on the time frame of reference, such as months to a few years versus several decades to a century.

The purpose of the above discussion is to illustrate that the evolution of breaches in beach systems, such as Port Shoreham, is complex. This pertains directly to the question of whether the Department of Natural Resources should allow the creation of an artificial channel in this area as opposed to other situations where limited dredging is permitted only to manage the depth of pre-existing (natural) channels.

Dredging to maintain the depth of natural channels in beaches, bars, barrier beaches and spit complexes may prevent channels from closing or migrating, or prevent the formation of a new channel (breach) somewhere else. Water that accumulates landward of the ‘beach’—either by storm overwash or by freshwater accumulation—has a pre-existing, but artificially dredged, drainage channel through which it can escape. The dredged channel is typically large enough to allow sufficient drainage to prevent blowouts of the bar, barrier beach or spit. Allowing dredging of a pre-existing natural channel is generally the same as dredging an artificial channel. In both cases the natural evolution of the drainage system and pattern is disrupted.

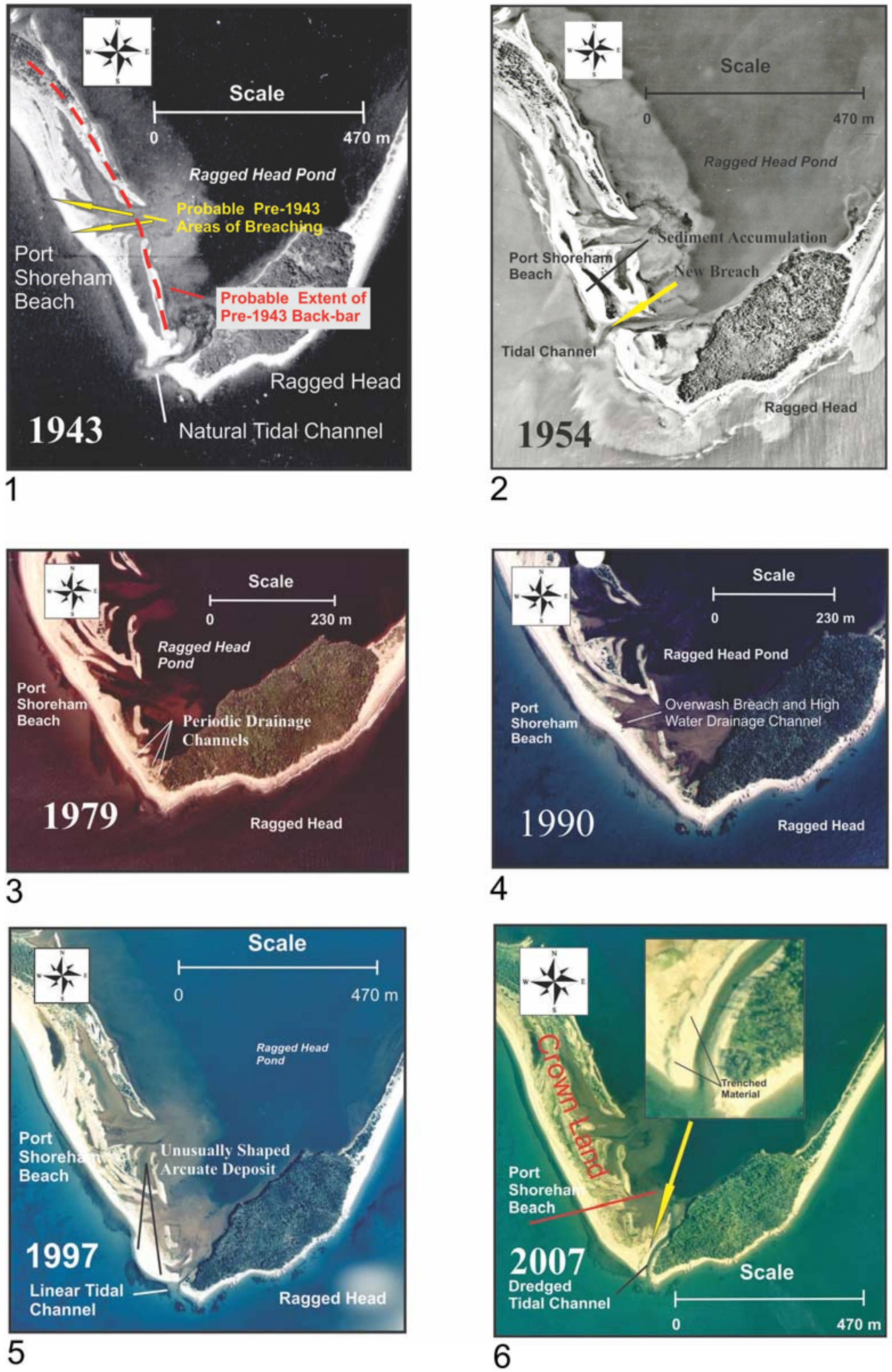

Figure 8. Composite of air photograph views of the Port Shoreham study area, 1943 to 2007.

Figure 9. Remnants of a wood retaining wall constructed in the mid-1900s on Port Shoreham Beach.

Conclusions

Port Shoreham Beach located east of Ragged Head is a dynamic beach-spit system with significant changes occurring over multi-decadal time frames. Since 1864 the spit complex has grown in size and length, and is now firmly anchored to Ragged Head at its southeastern extremity.

Several major breaches have opened and closed over the approximately 150 years of record. The location of the present dredged channel is in the same location as natural channels that existed at various times for over 100 years. Present dredging maintains the depth of an already naturally existing drainage channel.

Though not discussed previously, I noticed that the present channel interferes with people wishing to walk to Ragged Head from Port Shoreham Provincial Park. However, the part of the channel that exists above the mean high-water mark is on private property. Likewise, Ragged Head is private property except for that part of the shoreface that is below the mean high-water mark. If the present dredged channel was allowed to infill, past history indicates that the spit would breach again in the same location or in another location farther west. A breach farther west could be on Crown land (see Fig. 8.6) and would potentially reduce the ability of people wishing to walk along the beach toward Ragged Head more than the present channel in its present location.

Possible Replacement for Plaster Provincial Park, Victoria County

Background

Plaster Provincial Park located in Victoria County, Cape Breton Island, was recently closed to the public by the Department of Natural Resources due

Figure 10. A major breach in a cobble barrier beach east of Halifax, photographed on January 8, 2010.

to safety concerns (Fig. 11). The park was long recognized as having several sinkholes, which were caused by dissolution and karsting of gypsum bedrock that crops out in several areas in the park. However, over the last decade, unusually rapid and extensive sinkhole development was noted to be occurring. Due to safety concerns, the Parks Division of DNR asked the author to assess karst development in the park with respect to public safety. The geological assessment concluded that the ongoing sinkhole development represented a significant risk to visitor safety and subsequently the decision to close the park was made.

In August 2013, the author was asked by the Parks Division to assess a nearby municipal property as a possible replacement for Plaster Provincial Park (Fig. 11). Specifically, the property was assessed for coastal erosion, the potential for sinkhole development and any other geohazards. A site visit was undertaken on October 28, 2013. The author was accompanied by Liam MacNeil, the region's Forest Resource Technician out of the Baddeck office. The property is the site of a former school and is presently owned by the Municipality of the County of Victoria.

Overview and General Observations

Access to the property from the main road (Cabot Trail) is excellent via a U-shaped, dual entrance driveway that is in reasonable condition considering it has been abandoned for some time (Figs. 12.4, 12.5). The former school has been demolished, and only the concrete slab of the foundation remains (Figs. 12.1-12.5). The slab appears to be mostly solid, except for the rear, left corner (Fig. 12.3), which appears to have a cavity under the cement.

The overall site slopes gently to the east toward the coast. The entrance and turning area near the road

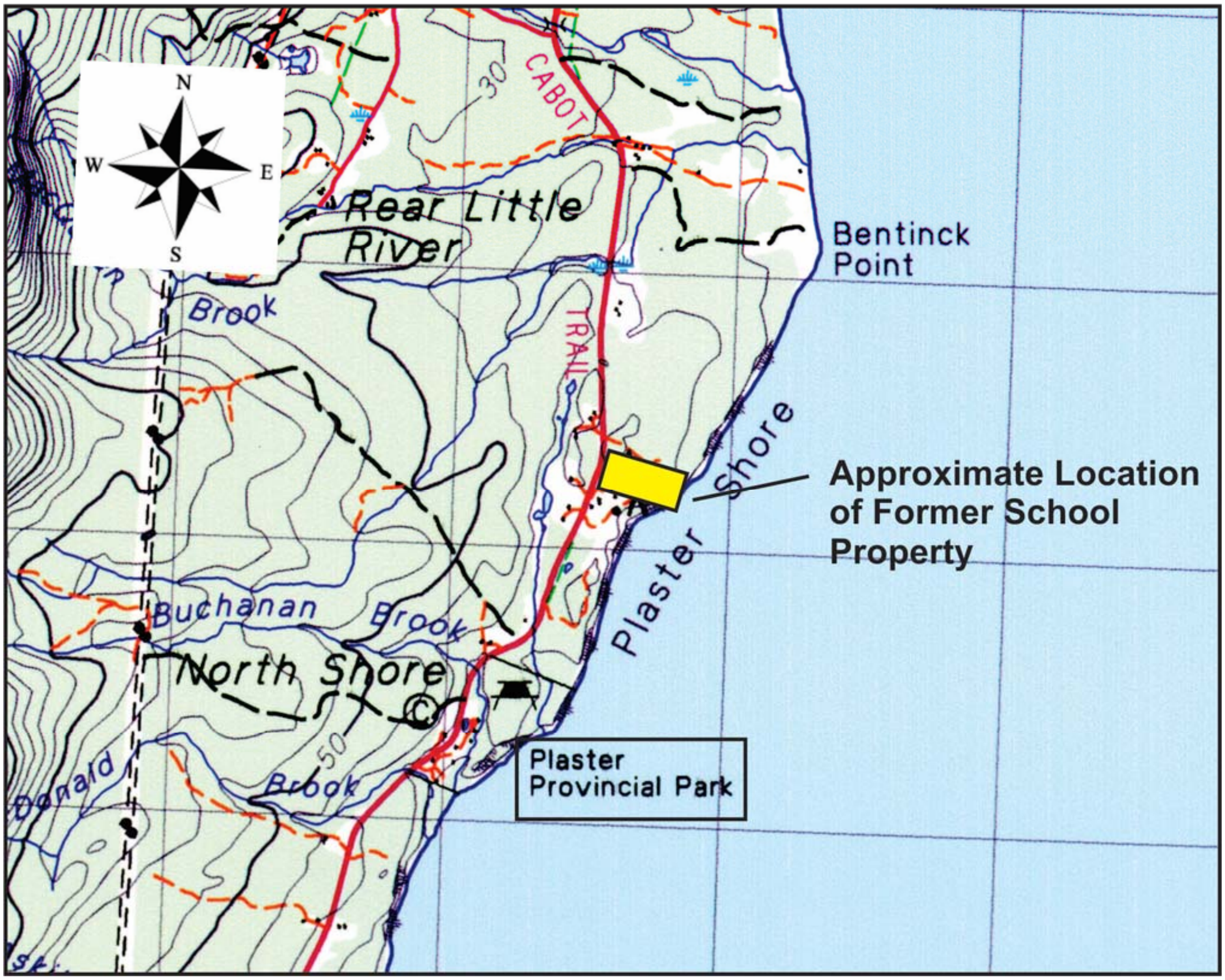

Figure 11. Location map of Plaster Provincial Park and the former school property.

is elevated with respect to the school slab. The slab likely has frost walls, and it may be costly to break-up and remove. Disposal of the construction debris (concrete) could be costly due to transportation costs. The presence of a well and disposal field was not clearly evident, and the presence and location of these would require clarification from the municipality.

Coastal Erosion

There is obvious erosion occurring along the shoreface of this property. Figure 13.1 shows the shoreline along the shoreface of the adjoining property to the south. The erosion is obvious, particularly in the immediate foreground where bedrock outcrop is low and sporadic. In the background, outcrop is more extensive and extends higher above the high-tide mark; consequently, erosion is somewhat reduced. Note that there are no trees along the top of the scarp on the adjoining property (Fig. 13.1). On the former school property the top of the coastal cliff is heavily treed. This coastal section is also undergoing erosion as can be seen by the dead trees collapsed over the top edge of the shoreface. The scarp is also eroding at its base causing rotational slumps. These slumps contain large amounts of material, and most translocate trees and vegetation down the slope in, or approximately in, their original growth positions. Such a slump is visible in Figure 13.2 on the far-right side of the photograph. These slumps are relatively competent and take some time to erode. No quantitative rate

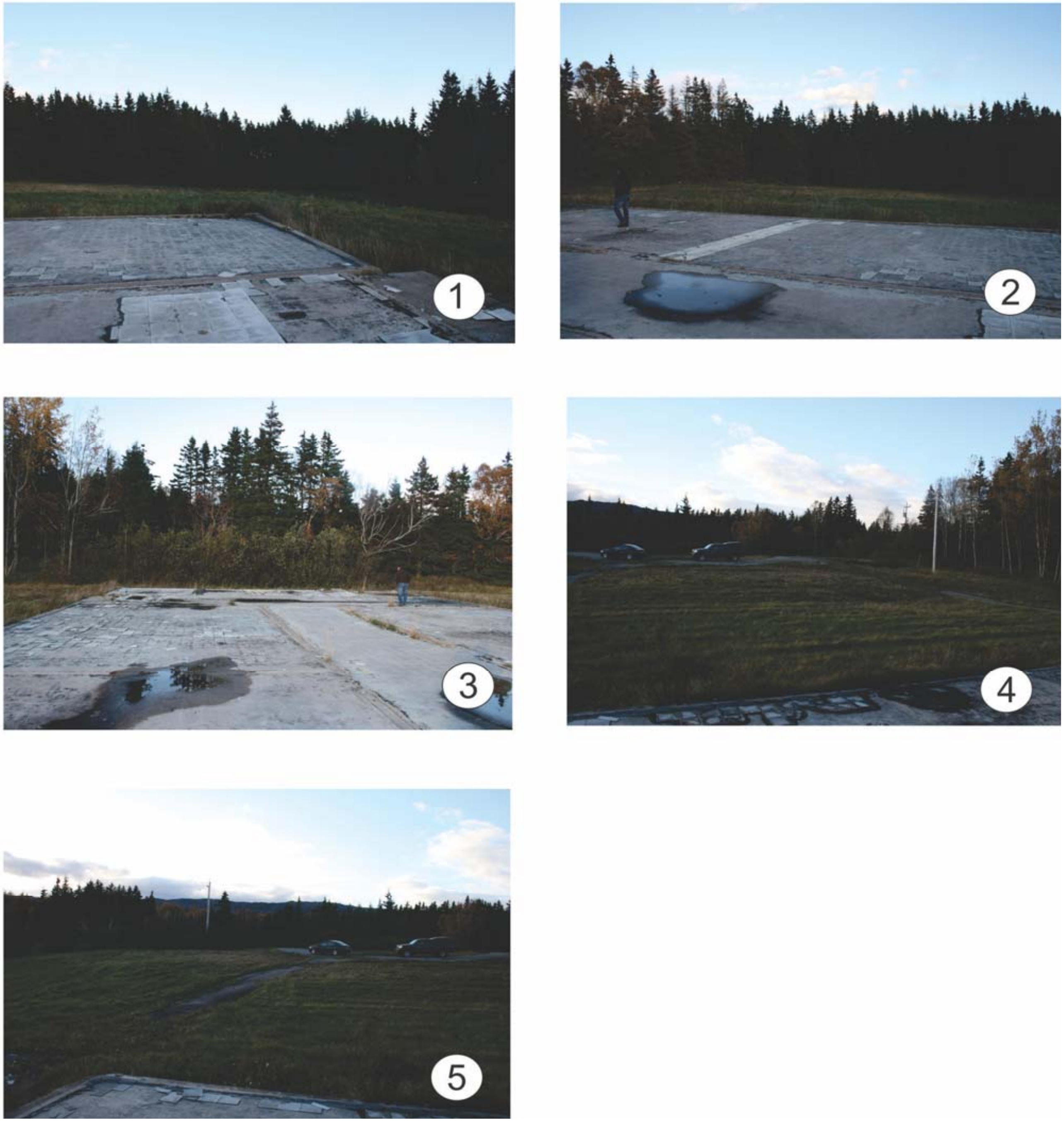

Figure 12. A 360 degree view of the former school site (open field): (1) looking east toward the coast and back, right corner; (2) looking east toward the coast and the back, left hand corner; (3) looking north; (4) looking west toward the road, left side; and (5) looking west toward the road, right side. All of the pictures are taken from a vantage point standing on the concrete slab of the former school.

of erosion was calculated. From a qualitative perspective, I would rate erosion in this area as moderate.

I do not feel that coastal erosion at this site is a major issue. The parcel of land is quite long, and there is ample area for development that would consider erosion in design and placement of infrastructure and recreational opportunities. I would be surprised to see multi-decadal erosion rates exceed 0.3 to 0.5 m/a (1 to 1.5 ft./yr.).

At the time of my visit, the tide was fairly high, so I did not walk the beach along the school property.

Figure 13. Erosion on the shoreface: (1) property immediately south of the school property and (2) along the shoreface of the school property.

It is also quite difficult to climb up and down the cliff face. At high tide, there is little beach present. The upper beach itself is a coarse cobble-rubble with abundant seaweed and driftwood. Like the former Plaster Provincial day park, I do not envision this park as being renowned for its beach. Regardless, visitors may wish to access and walk along the beach. Any shoreline access should be designed to be capable of withstanding winter sea-ice thrusting.

Sinkholes

Plaster Provincial day park was deemed unsafe and was closed due to the widespread development of sinkholes. The school property is approximately 800 m north of the former day park. Thus, there is concern regarding potential sinkhole development and surface instability.

The most detailed geology map of the area that I could locate was produced by Bell and Goranson (1938). It is clear from the Bell and Goranson map that Plaster Provincial Park was located in an area mapped as Windsor Series. Windsor Series is composed of limestone, anhydrite, gypsum, shale, arkose and conglomerate. This explains the extensive karst formation. Bell and Goranson (1938) mapped the location of the proposed new park as Windsor and Canso series. Canso Series is composed of conglomerate, arkosic grit, shale, and a few bands of limestone and grey calcareous shale. The Canso Series rock-types appear to crop out along the shore adjoining the school property to the south (Fig. 13.1).

Locating the bedrock contact between Windsor Series and Canso Series inland on the site of the former school is problematic (Fig. 14). The base for Figure 14 is at a scale of 1:10 000 while the Bell and Goranson (1938) map is at a scale of 1:63 360. In addition, the present road is farther to the east than the location of the road on the Bell and Goranson map. Thus, the location of the bedrock contact indicated in Figure 14, which is extrapolated from Bell and Goranson (1938), can only be considered as approximate. Nonetheless, these data suggest that the school property is underlain largely by Canso Series.

I am confident, based on my own observations, that the bedrock is Canso Series along the coast and inland within the wooded part of the school property. South of the school property and west of the road opposite the property, there appear to be sinkholes. However, the property immediately to the south and abutting the former school property was visually appraised from the main road and along the southern shared property boundary. That property contains a residence, outbuildings and a number of landscape features. There was no visual sign of sinkhole development. The open field on the former school shows no sign of subsidence that might indicate the presence of active sinkholes. Further, the wooded area east of the open field and foundation slab has no evidence of sinkholes. There is a linear depression just inside the edge of the trees running approximately north–south that is swampy. This may be the site of a former woods road or alternatively may have been created by land clearing when the original site was cleared for the school. The wooded area is generally open and

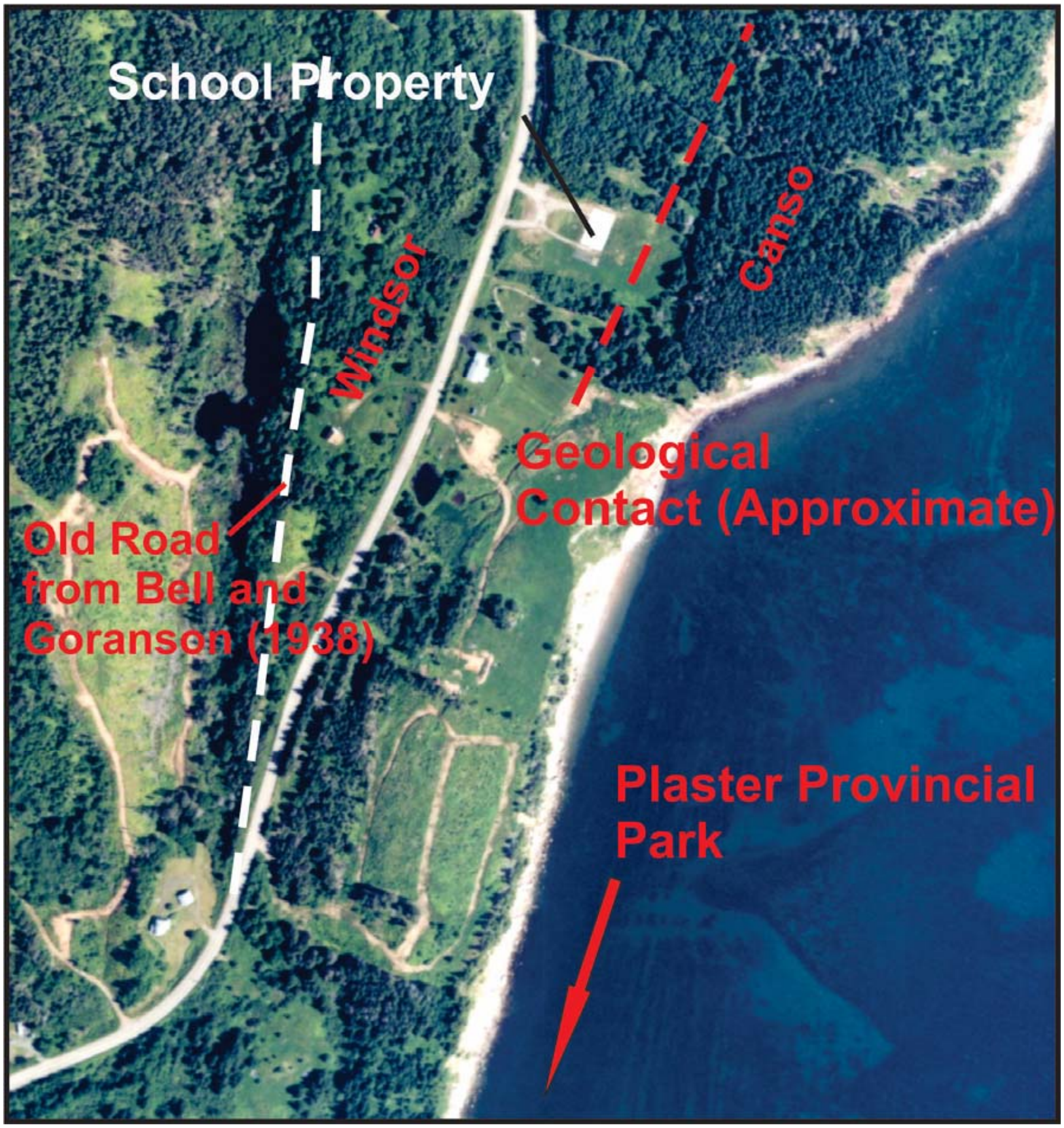

Figure 14. Bedrock geology in the vicinity of the former school property (from Bell and Goranson, 1938).

footing is quite good. I understand from Liam MacNeil (pers. comm., 2013) that the trees were overall in reasonable health.

Based on the available bedrock geology data and my observations, I believe that the school property is underlain by Canso Series bedrock. Even if there is some Windsor Series bedrock on the site, given that the school was present on this site for many years, and considerable construction activity would have taken place when the school was demolished, it is unlikely that any work on the site now would result in sinkhole development.

Conclusions and Recommendations

There are no specific geohazard risks associated with development of this former school property as a provincial park. If the site is redeveloped as a day park, care should be taken not to change natural drainage patterns. In particular, culverts or channels should not be constructed that would direct drainage onto the property. If Windsor Series bedrock is present, this can rapidly initiate karst development on time frames of only a few days or weeks.

Moderate coastal erosion is apparent, but in my opinion will not impact the overall viability of the park. It will impact construction of beach access if this becomes part of a future development plan. This can be mitigated by proper siting and design elements. I do not consider the erosion at the top of the slope to be particularly hazardous. However, undergrowth should be cleared back from the edge so that visitors have a clear view of the upper edge of the cliff. This is not a situation where there are 30-metre drops over vertical cliff edges. Appropriate signs should be erected warning of the steep, unstable slope and the potential for undercutting at the top of the slope.

A final important point to consider is that this is not a greenfield site. A full disclosure of past use and an environmental scan and assessment would be warranted.

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