Bluff Erosion Rates in Complex Glacial Stratigraphy, Block Island, RI

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ABSTRACT:
Block Island, a small island located off the Rhode Island coast, formed as a result of the advance and retreat of the continental glaciers until about 10,000 years ago. The sediment comprising the island was deposited during two separate events and can be distinguished by color and composition. The lower sediment body consists primarily of coalesced till, while the upper sediment is composed of gravel and sand. The upper sediment is less permeable than the underlying strata. The island's stratigraphy is complex. Over-steepened bluffs rise more than 100 feet above the southeastern and southern shores of the island. Bluff erosion is both chronic (rain flows) and catastrophic (cliffs falls and slumping due to oversteepening of erodable material). The position of the bluff edge was determined from a 1923 aerial photograph, a 1978-1981 series, and a 2001 series of aerial photographs. The bluff edge was then calculated on the smoothed, rectified aerial photograph. The resulting average annual bluff erosion rates were low during this time period. These data will be updated in 2008 with our new aerial photographs become available in spring 2002.

The frequent and unpredictable weather of the island's complex weather poses management challenges. Current erosion setbacks in Rhode Island are based on the average annual erosion rate with a minimum setback of 30 feet. This works well in homogeneous stratigraphic environments such as coastal barriers. In areas with complex stratigraphy such as Block Island, setback modifications may be necessary. Maximum setback values may be a more significant measure than averages.

Introduction:
The Block Island stratigraphy is complex but is generally characterized by an upper layer of poorly permeable sediment coated by very permeable sediment. In our study area, erosion is accelerated in the upper layers. Catastrophic slope failures can occur when the underlying clay-rich tills layer loses strength. The island is composed of two types: gravel and sand, and it consists of the base of the bluff. These catastrophic occurrences are both unpredictable and unforseeable.

Methods:
Bluff erosion rates were calculated by delineating the edge of the bluff 1997, 1997, and 1999 1:32000 high resolution 500-foot (1:300) rectified aerial photographs. The photographs were geo-referenced with Geographic Transform using the RGS 1997 1:3000 rectified orthophotography as a reference map. A line was then added by delineating features such as bluffs, cliffs, and shore on the orthophotos. The shape file was used to calculate the accuracy of the calculations. In essence, using the computerized delineation of the bluff edges delineated from the 1997 and 1999 aerial photographs. The volume and length of each polygon was measured to calculate average annual erosion rates. Preliminary data were used for the 1978 to 1999 aerial view for comparison of rates over time.

Results:
Bluff erosion rates for Block Island are relatively low (0.5 feet per year average). Preliminary data for rates between 1972 and 1997 were similar to 1997 to 1999 erosion rates suggesting that there are forcing mechanisms controlling erosion rates. Slight differences in water elevation results in increased wave energy during winter months. Water levels can explain the rapid erosion in some sections, like the southeastern facing shoreline on the south bluff that experiences the most erosion. In other sections, stratigraphy may play an important role.

Discussion:
A catastrophic slope failure in April 2001 occurred along a section defined as a critical erosion area along the south shore of Block Island. In days, the eroding bluff that faced the ocean was eroded by the ocean, exposing an underlying clay layer that had weathered under the weight of the saturated upper strata. Calculated erosion rates in this section averaged 1.5 feet per year. This one catastrophic event represented 0.2 to 2.0 feet of erosion, 10 times the predicted rate.