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BEACH CHANGES ASSOCIATED WITH BULLDOZING THE LOWER FORESHORE OCEAN CITY, MARYLAND

by

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INTRODUCTION

In the past few decades, we have witnessed the transformation of Ocean City, Maryland from a quiet seaside village to a popular resort community. This transformation was inevitable as people discovered the pleasures of the seashore and its many recreational benefits. As summer populations increased, sometimes exceeding 200,000 on a weekend, the demand for housing also increased. To meet this need a major construction boom began in the early 1970's with the erection of multi-family apartments and high-rise condominiums. The desire of each of the developers was to construct as close to the ocean edge as possible so as to provide visiting tourists the advantages of the major attraction, the beach.

There is a problem inherent in the rapid development of ocean frontage; the dilemma of protecting the commercial developments and at the same time preserving the integrity of the beach. The approach to this problem appears simple: retard beach erosion and at the same time develop methods to increase the beach width. This simplistic approach provides for a wide beach that can act as a buffer from wave activity and preserve the recreational attraction. Yet, the methods employed to create this perfect solution do not always act as planned or envisioned. This paper describes one such attempt: bulldozing of the lower foreshore and the resultant beach changes associated with this activity.

ATTEMPTS AT BEACH EROSION CONTROL

Ocean City, Maryland is located on a barrier island known as Fenwick Island which incorporates from the Ocean City Inlet to the Maryland-Delaware line, approximately 8 miles of ocean front (Figure 1). Attempts at controlling beach erosion are not a new situation for Ocean City. One of the earlier attempts at beach erosion control occurred during the 1950's with the construction of a series of asphalt groins. These groins met with limited success but were generally ineffective. Following a devastating Ash Wednesday storm of 1962, the U.S. Army Corps of Engineers completely rebuilt the beach and dune system along the entire length of the Ocean City shoreline. Estimates of the total damage exceeded $7.5 million for this particular storm (Corps of Engineers, 1963). During the 1970's, groins were again constructed along the shoreline but with the escalation of costs a minimal number of groins were built at only selected sites.

The high construction costs of groins demanded that a less costly method of erosion control be explored. In the fall of 1976, the city devised a plan to artificially transfer sand from the lower foreshore to the backshore in attempts to rebuild the beaches. Actual work, involving the use of construction-grade bulldozers, began that same fall of 1976 and initially included the entire length of shoreline. For the next 18 months, the bulldozers were used periodically to rebuild certain areas of the beach. The Maryland Geological Survey's objective was to determine the beach changes associated with the bulldozing operations. The Survey maintains a network of beach profile, locations along selected sites (17) at Ocean City. These locations have been profiled semi-annually since 1972 and are used in this study as reference profiles for comparative purposes. To further document the beach changes during the bulldozing operations, supplemental beach profiles were collected at selected sites over an eighteen month period using the stake-horizon method (Emery, 1961). Although absolute vertical control was not established, permanent bench marks were installed in order to enable reestablishment of initial profile elevation.

BEACH CONFIGURATION PRIOR TO BULLDOZING

To evaluate the new beach configuration developed by the bulldozing of the lower foreshore, we reviewed the historical erosion rate data (1849-1965) and existing beach profile information for the period of 1971 to 1976. It was our intention to determine from the existing profile information if the beaches were in a state of equilibrium with the natural wave conditions or in a state of deterioration that called for immediate action at the time bulldozing began.

Historical Erosion Rates (1849-1965)

Historically, the average rate of erosion alone, the entire length of the Ocean City beach has been measured at 2 feet per year for the period 1842 through 1949 (Corps of Engineers, 1979; Dolan, et al., 1980). Slaughter (1974) in an analysis of the historical erosion rates (1849-1965) noted that although the average is 2 feet per year the greatest erosion occurred at the southern end of Ocean City between 13th and 61st Streets and the least erosion between 92nd and 120th Streets (Figure 2). Dolan, et al. (1980) in measuring the changes of shoreline position concluded that the rate of change is highly variable. Examination of their data also suggests the same erosional trends reported by Slaughter (1974). In an analysis of the historical erosion rates for the periods 1929-1947 and 1947-1965 Slaughter (1974) also recognized patterns of reversal from recession to progradation for various sections of the beach (Figure 2). He suggested that the reversals may be a result of alongshore migration of sand waves and onshore migration of the inner longshore bar system that is in evidence along the Ocean City shoreline. If this relationship exists as implied by Slaughter`s study, disruption of the sand waves and inner longshore bars may have a significant effect on the rates of erosion, both in the short-term and long-term, by reducing this alongshore-onshore migratory pattern.

Beach Profile Changes From 1972-1977

Beach changes over the period from 1972 to 1977 were examined at four different profiling locations with the express purpose of developing an understanding of the erosional and depositional responses occurring at the various sites. Those selected were at 25th, 65th, 76th, and 120th Streets (Figure 3). The 25th Street location is the only one of the four that has been modified by the construction of a groin. The remaining three sites are somewhat distant from any groin fields and represent more of a natural beach.

At the 25th Street location, the north side of the groin experienced continual growth of both the foreshore and backshore between 1972 and 1974. During this period the foreshore increased in height by approximately 4 feet with a lesser increase of 2 feet for the backshore. From 1974 to 1975, the backshore continued to accrete but the foreshore was undergoing erosion with a 2 foot loss in elevation. Following this brief period of foreshore erosion, the foreshore reestablished the profile configuration with progradation of the foreshore seaward. Foreshore accretion and progradation continued to the fall of 1976, the beginning of the bulldozing operations.

The south side of the 25th Street groin exhibited the same general pattern as the beach on the north side of the groin; accumulation and growth interrupted briefly by foreshore erosion in 1975. An interesting facet of the 25th Street location is the accumulation of sand on both sides of the groin even though the net longshore transport of sand for Ocean City is to the south (Corps of Engineers, 1968; Dean and Perlin, 1978). One would expect the classic beach configuration of updrift accumulation (north side) associated with downdrift erosion (south side). In the case of 25th Street, the timing of the construction of the groin appeared critical in the accumulation on both sides of the groin. Construction was completed in the spring just prior to the reversal of the longshore transport direction (to the north) that generally occurs during the summer. This accumulation on the south side of the groin during the summer may have offset any erosion that may have occurred in the winter when the longshore transport returned to the dominant southward direction.

The beach at 65th Street experienced a similar pattern of continuing growth and accumulation interrupted in 1975 with foreshore erosion (Figure 3). The general area surrounding 65th Street is one of the few remaining areas in Ocean City where any semblance of a dune system exists. The dune system, constructed in 1962 by the Corps of Engineers, increased in height from 17 to 20 feet along the foredune slope. In fact, the entire beach area prior to bulldozing increased in beach width from 110 feet in 1972 to 160 feet by 1977.

The beach area at 76th Street was the only site that showed a net erosional profile change from 1972 to l974, particularly along the foreshore. By 1974, the beach had eroded to its lowest profile level since the beginning of profile measurements. It was not until the spring of 1975 that a substantial rebuilding of the foreshore and backshore was evident and by 1977, the beach accreted to the 1972 profile level.

Superimposed on the erosional-accretional beach changes at 76th Street was an apparent tendency of the beach to adjust to the winter and summer seasons and prevailing wave conditions. Although it cannot be demonstrated conclusively that seasonality occurred along the Ocean City beaches there was evidence of minor seasonality adjustments. As shown in Figure 4, beach profiles during the summer were generally higher, wider, and flatter than the winter profiles, irrespective of the fact that the 76th Street beach was experiencing erosional conditions.

The beach area at 120th Street differed slightly from the general pattern observed for the sites in Ocean City. Instead of the observed pattern of accumulation followed by foreshore erosion, the beach continued to accrete until an equilibrium profile configuration was reached (Figure 3). The equilibrium profile configuration appeared to be maintained up to the time of bulldozing. As seen in Figure 2, the 120th Street area has the lowest historical erosion rate for Ocean City. Both of these factors tend to substantiate this area as one of stability.

The condition of the beaches prior to bulldozing the lower foreshore was one of relative growth and equilibrium to the prevailing wave conditions. The response of the beaches was erosion during storm-related events followed by repair and rebuilding during quiescent conditions. By 1977, the beaches were higher and wider than exhibited in 1972. Coupled with the rapid storm-related beach changes were the more subtle and longer-term seasonal adjustments. Whether or not the beaches were in an erosional or accretional response, the beaches showed a trend to develop a flatter and wider profile during the summer months.

BULLDOZED BEACH CONFIGURATION

After completion of the first phase of bulldozing in the spring of 1977, the first series of supplemental beach profiles were collected. Subsequent profiles were taken in June, September and October 1977. The October profile followed a "northeaster" coastal storm that struck Ocean City on the 13th of October. This coastal storm was the first of the winter season that proved to be one of the stormiest seasons in recent history. The second round of bulldozing began in March 1978, after the 1977-1978 winter season, but just before an April "northeaster." A series of profiles were taken following this operation.

The first step in the bulldozing operations involved making an uncontrolled cut at the lower foreshore and mounding of sand on the backshore. Immediately following the mounding of sand, the bulldozers redistributed the sand along the backshore and upper foreshore. Redistribution increased the profile height of the upper foreshore to the level that existed prior to the bulldozing but this did not occur along the lower foreshore. The lower foreshore-still retained the profile configuration cut by the bulldozer. Figure 5 is a series of photographs detailing the sequence of the bulldozing operations.

There are two noticeable features evident from a profile comparison of the bulldozed beach (Figure 6). The most obvious is the mounding of sand on the backshore. The second feature is steepening of the foreshore slope. The first bulldozing operation generally increased the backshore elevation by 3 to 4 feet while lowering the foreshore to the pre-1972 beach level. Essentially any accumulation on the foreshore was eliminated by the cut of the bulldozer's blade at all profile locations examined. The raising of the upper foreshore and lowering of the lower foreshore profile level caused an already unnatural foreshore slope to become steeper.

The unnatural foreshore gradient and redistribution of sand along the backshore and upper foreshore significantly altered the adjustment characteristics of the beach zone. This is evident in a comparison of Profiles collected in June 1977 and in September 1977. Although there is little evidence for major seasonal beach changes along Ocean City, the summer season (June-September) is generally a period of rebuilding and readjustment of the beach which develops a wider and flatter beach profile. The profile adjustment that has been observed in the past during the summer did not occur in 1977. Instead, the profile adjustment exhibited by the profile comparison in Figure 6 for June to September showed a lowering of the beach as the beach attempted to obtain the flatter gradient so noticeable prior to bulldozing. By the end of summer (1977), the beach configuration was still in the process of readjusting to the summer wave conditions.

The importance of this readjustment is not necessarily the new beach configuration or growth process, but the evidence of a non-equilibrium beach profile immediately preceding the winter season. This non-equilibrium condition was most pronounced following the first northeast storm of the year.

BULLDOZED BEACH RESPONSE TO A COASTAL STORM

The first coastal storm, or "northeaster", of the winter season hit Ocean City on the 13th of October. Beach profiles were collected on the 17th of October, immediately following the northeaster and were compared with the September 27th profiles.

The northeaster lasted from 13-15 October with the maximum intensity occurring on the 14th. This storm followed the typical pattern for the development of northeasters; a well-defined low pressure system off the southern east coast, progressing in a northerly direction to a high pressure system situated off of the New England Coast. Wind direction and velocity and maximum tide heights for this storm were recorded at the Coast Guard Stations at Indian River Inlet and at Ocean City, Maryland. Both stations recorded wind direction and velocities from the north-northeast at 20-25 knots on the 13th, intensifying to 30-40 knots by the morning of the 14th. By the afternoon of the 14th, the winds diminished and shifted to a westerly direction. Tide levels were recorded at both stations. The observed high and low tides were +4.7 and +2.4 mean low water, respectively. Based on the observed and predicted astronomical tides a storm surge of 5.3 feet was recorded. The storm lasted for a single tidal cycle and occurred on the ebb tide which allowed for a lower storm surge than would be expected from a storm of this intensity.

The storm parameters of this particular October "northeaster" were not significantly greater than northeasters that occurred in March 1974 or April 1975 as summarized by Leatherman (1979). The storm conditions of each of the three storms were approximately of the same strength and magnitude. The significance of the October storm was in the erosional response of the beach zone. Pre- and post-storm comparisons of the beach profiles indicated that an average of 12.1 cubic yards of sand per linear foot of beach were eroded, or a total of 500,000 cubic yards for the eight miles of ocean front beach.

A plot of beach erosion by street location at Ocean City (Figure 7) shows a gradual increase in the sand volume lost northward along the shoreline. The greatest volume loss was at 119th Street which lowered the beach by 10 feet (Figure 8). The least volume loss occurred at 17th Street. The northern Ocean City beaches showed the greatest volumetric loss, where these beaches were wider and higher in elevation than those to the south. So, the volume losses computed for the northern beaches must be tempered with the fact that greater sand storage existed at these areas.

Figure 7 also shows a repetitive pattern of high/low erosional volumes progressing northward. Apparently various sections of the beaches responded differently to the same storm and coastal processes along this 8 mile reach of shoreline. This variation in response may be the result of storage capacity of the beaches which is indirectly related to the bulldozing activities and secondarily, the characteristics of the beach profile. Other factors which have contributed to the response variation are the positioning of the shoreface-connected linear shoals and possibly the migratory characteristics of the sand waves which occur on the lower foreshore in the areas of low erosional response. Slaughter (1974) pointed out that the sand waves are very mobile along the beachface but are generally located in the middle section of Ocean City. This may account for the low erosional response in this section of the shoreline.

Although many factors were involved in the erosional response of the shoreline, one factor present that was not a natural process is the bulldozing of the lower foreshore. Beach profiles measured along a non-bulldozed, undeveloped reach of shoreline located 8 miles to the south on Assateague Island showed erosional response of 7.1 cubic yards per linear foot of beach as compared to the 12.1 cubic yards per linear foot at Ocean City for this same storm. Assateague Island is just south of Ocean City inlet which precludes any significant differences in the storm processes. One can assume that the same magnitude and strength of the storm struck both shorelines.

The data suggest that one factor not similar to both coastal environments is the mounding of sand on the backshore by bulldozing. The greater volume losses at Ocean City is related to the greater sand storage on the backshore with an increase in the foreshore slope, a direct result of bulldozing the lower foreshore. The bulldozing developed a non-equilibrium profile configuration which did not readjust to the natural coastal processes prior to the October storm.

Following the October storm, 26 coastal storms advanced through the area in the winter of 1977 and 1978. These coastal storms had two effects on the shoreline. The most significant effect was the hampering of any natural beach rebuilding process that may have occurred following each storm. The repetition and frequency of the storms completely disrupted any natural chance for beach rebuilding. Subsequently, during the early spring, bulldozing activities again commenced with the idea of rebuilding the beach to the conditions prior to the storms. Instead of creating a new beach configuration as noticed in the first bulldozing effort, this second effort was done only to repair the beach losses.

SUMMARY

The beach conditions prior to bulldozing (1972-1976) appeared to be generally stable with periods of growth and elevation increases of the upper foreshore and backshore. At four sites the average gain in elevation was approximately +2 feet with a noticeable seaward progradation of the foreshore. During this same time period we were able to document the beach response to two coastal storms (March, 1974 and April, 1975). Beach erosion occurred during these storms but immediately following the passage of the storms, the beach reestablished the pre-storm configuration. It is our contention that the beach configuration was in equilibrium with the processes before and after each storm and was not in a state of deterioration that called for immediate and drastic action.

The bulldozing of the lower foreshore during the fall of 1976 altered the summer readjustment process to produce a profile which was flatter and wider as observed in the 1971-1976 profiles. The beach profile was in a period of readjustment when the first coastal storm passed through the area. The storm parameters were not of such a magnitude as compared with other coastal storms (March, 1974 and April, 1975) to cause the extensive erosion of 12.1 cubic yards per linear foot of beach. In comparison the erosion of Assateague Island, a non-bulldozed reach of shoreline, during the same coastal storm, lost only 7.1 cubic yards per linear foot of beach. It is concluded that bulldozing of the lower foreshore completely altered the profile configuration and adjustment characteristics allowing coastal erosion at a rate greater than anticipated or expected.

The major impact of bulldozing on the beach environment is the change in the natural profile configuration and development of a steeper profile gradient. Given the coastal processes of the local environment, the beach profiles underwent a period of readjustment. This readjustment occurred during the summer months when the natural condition of the beaches is growth and winter repair. The readjustment was continuing when the first coastal storm hit Ocean City. Indiscriminant use of bulldozers does not add to the level of protection generally envisioned.

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_______________, 1979, Atlantic Coast of Maryland and Assateague Island Virginia: Draft Survey Rept. on Beach Erosion Control and Hurricane Protection, Baltimore District.

Figure 1: Study Location

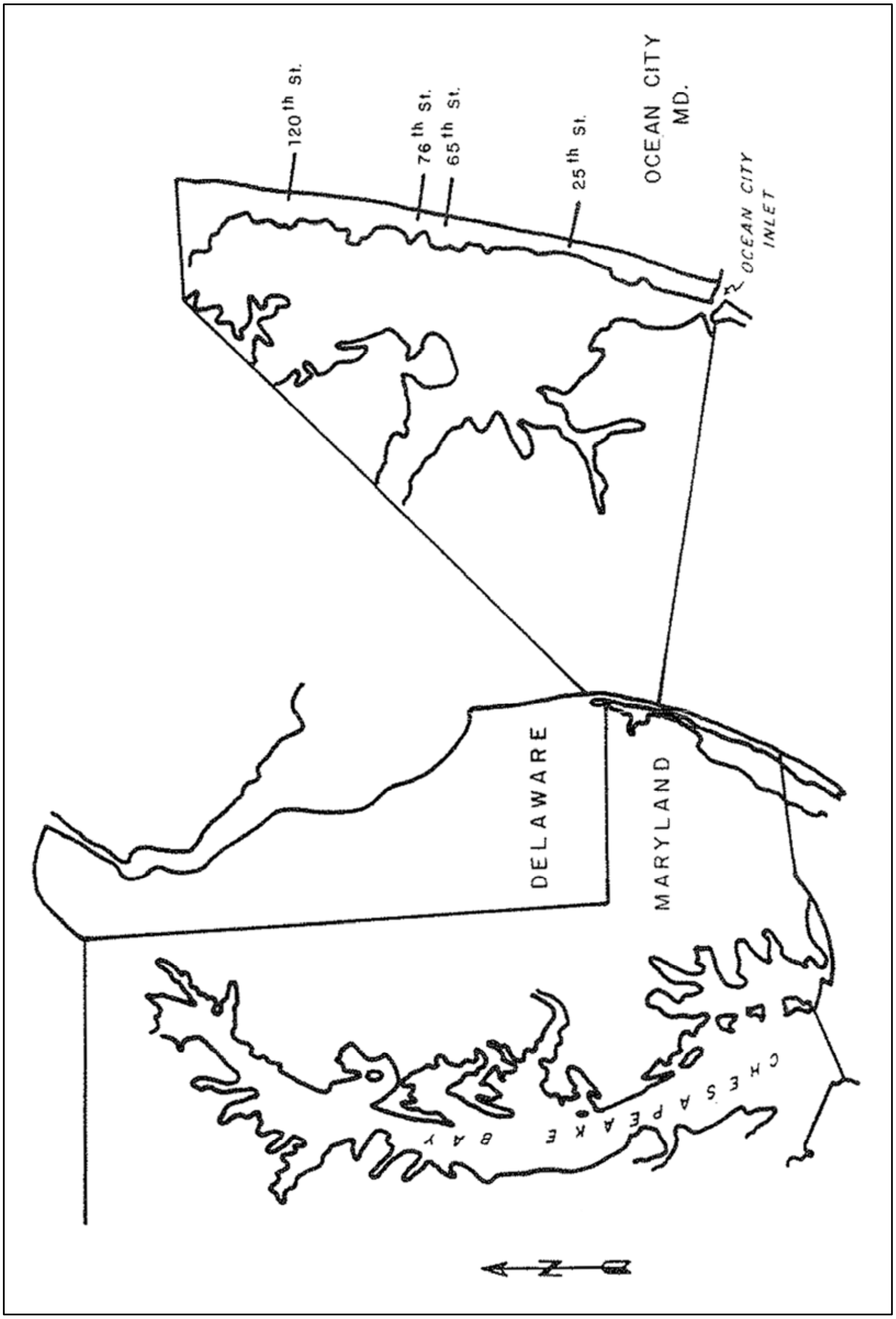


Figure 2: Historic Erosion rates

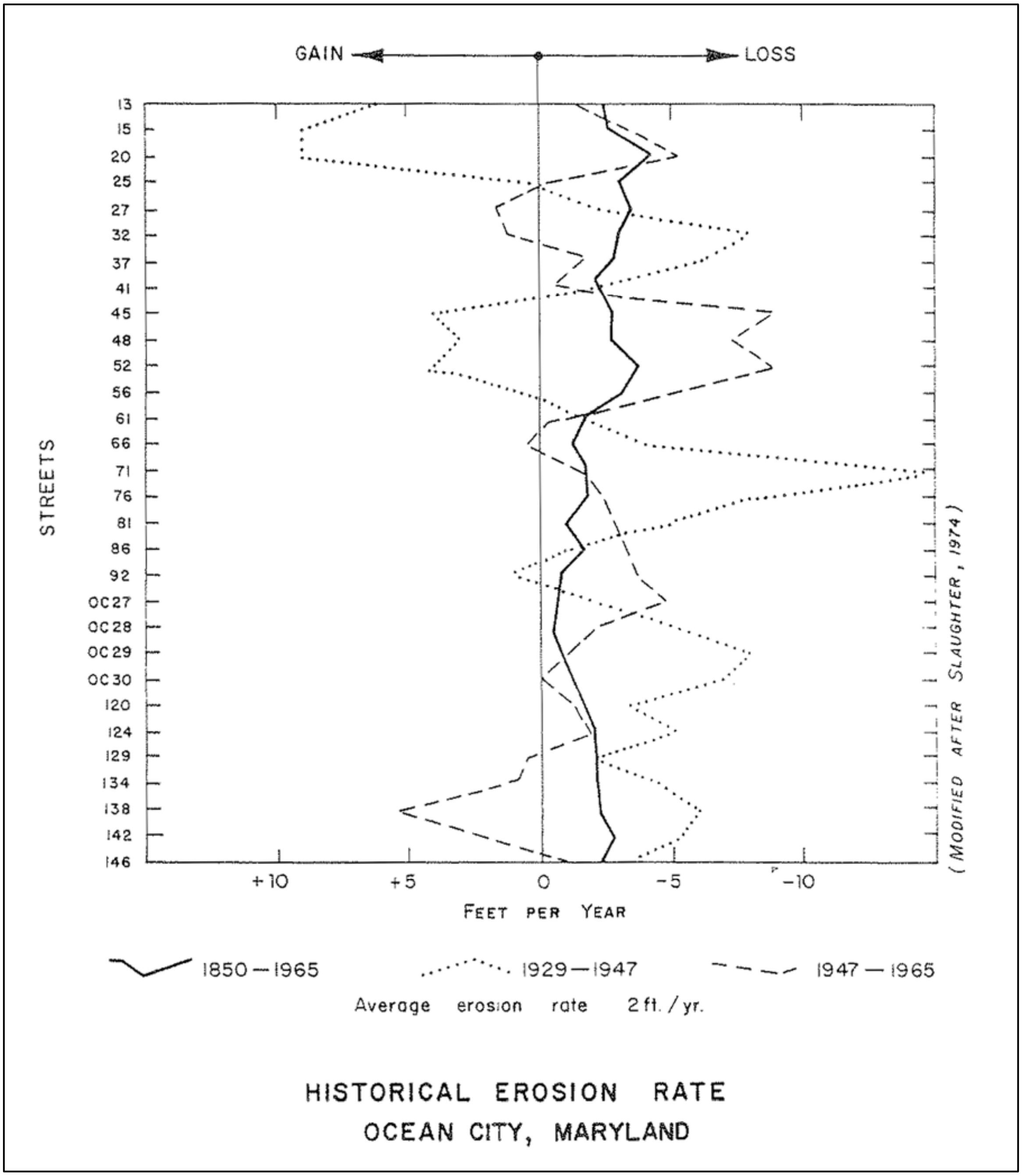


Figure 3: Selected Beach Profiles

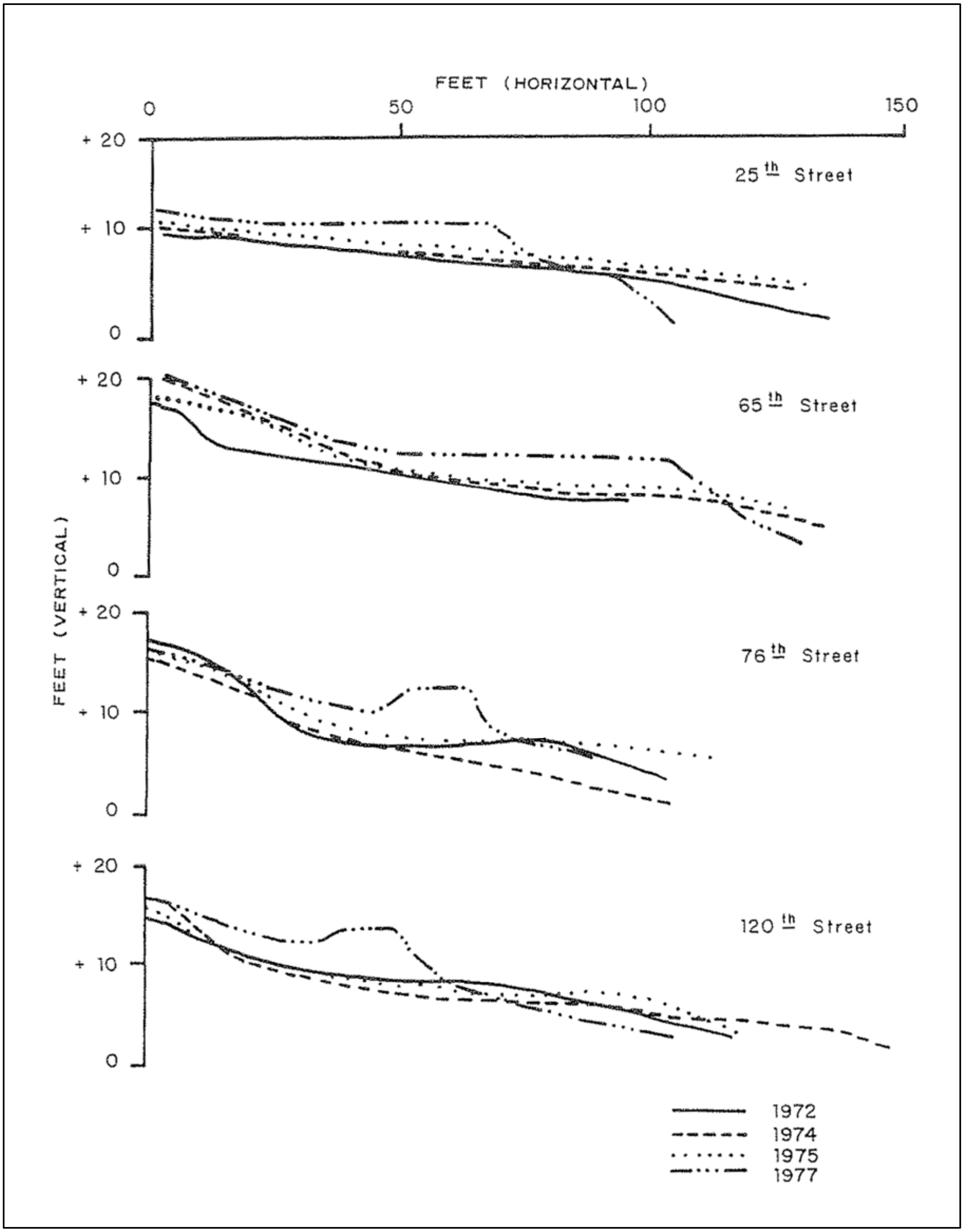


Figure 4: 76th Street Seasonal Variations

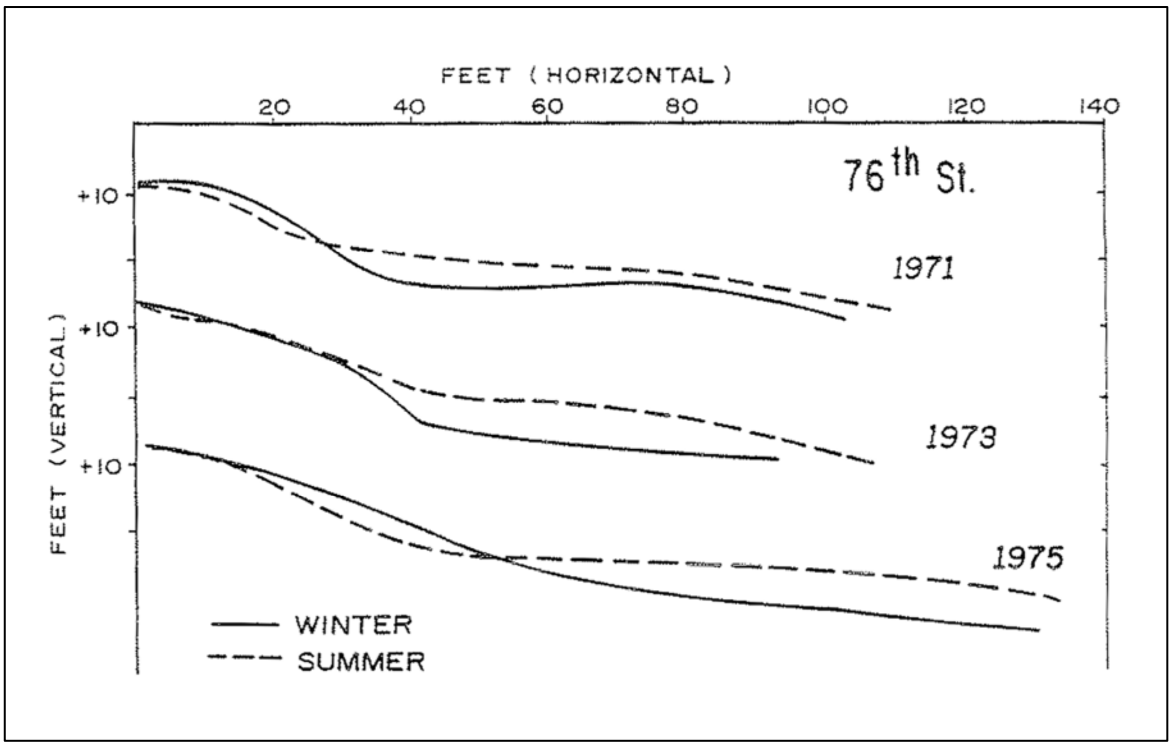
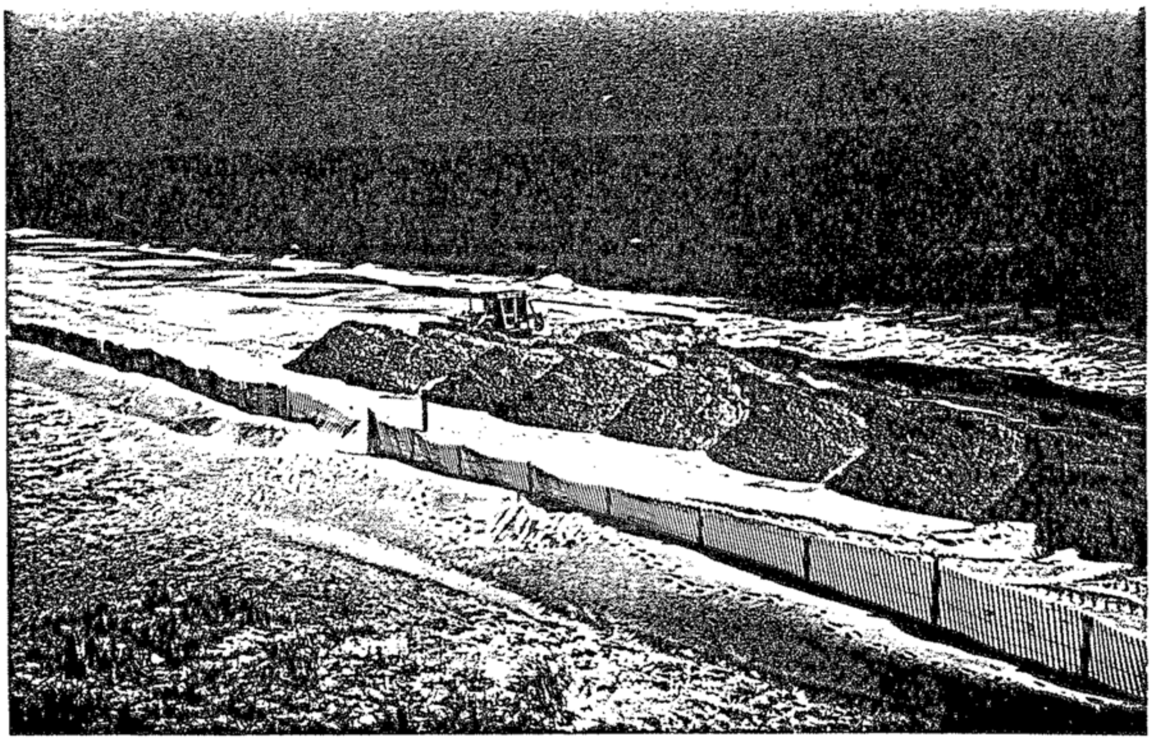


Figure 5: Beach Bulldozing



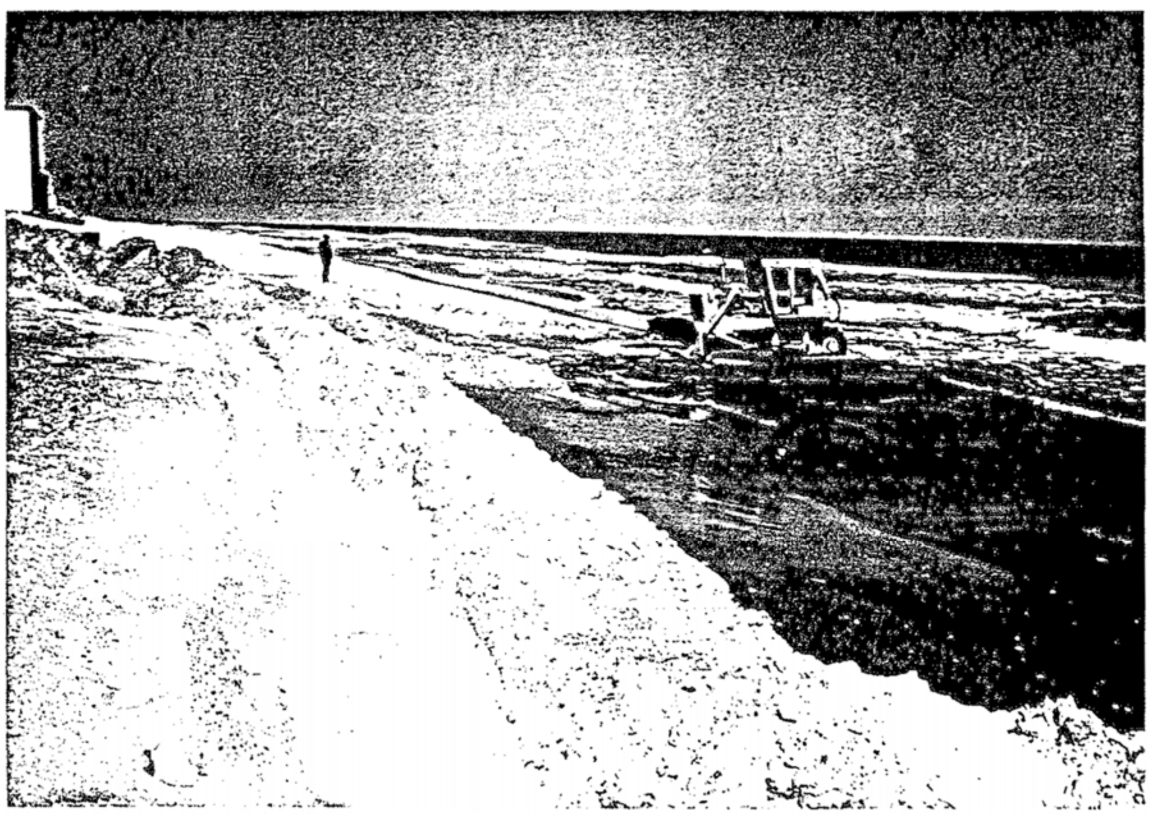
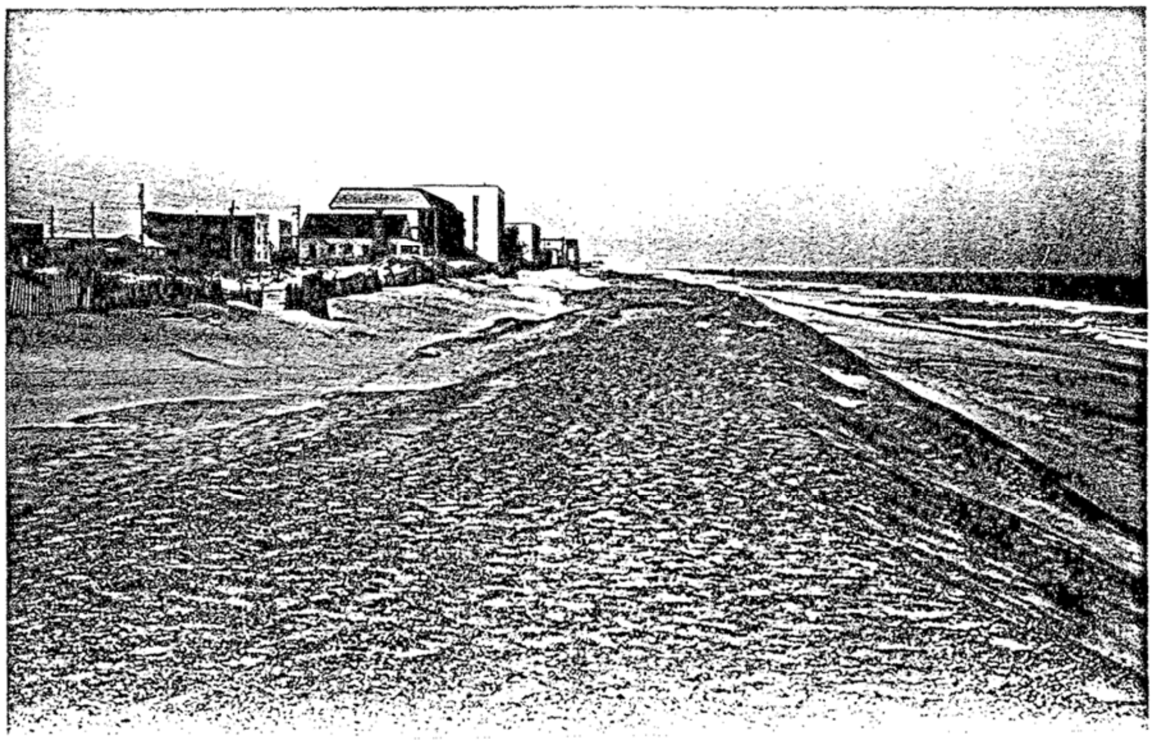


Figure 6: Completed Bulldozing Project



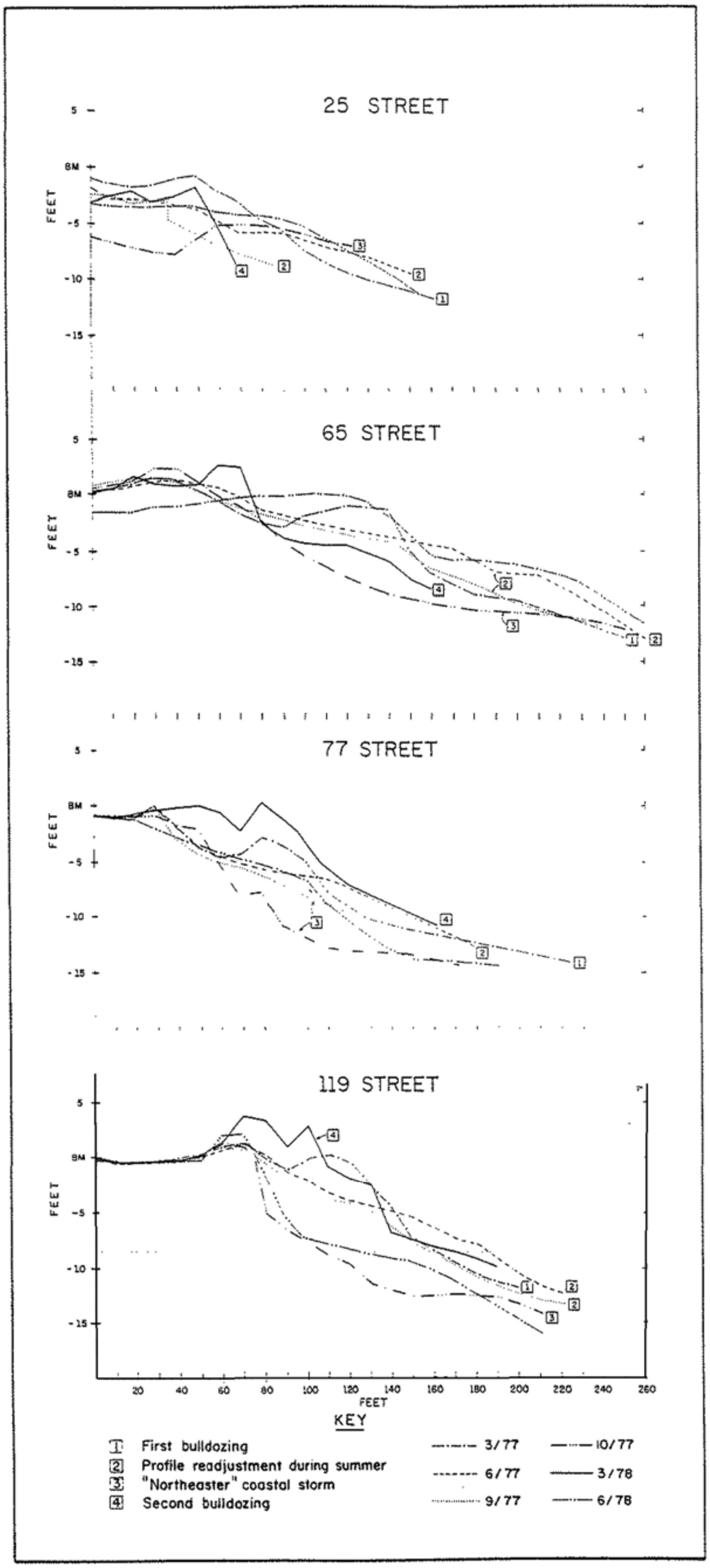


Figure 7: Beach Erosion by Street Location

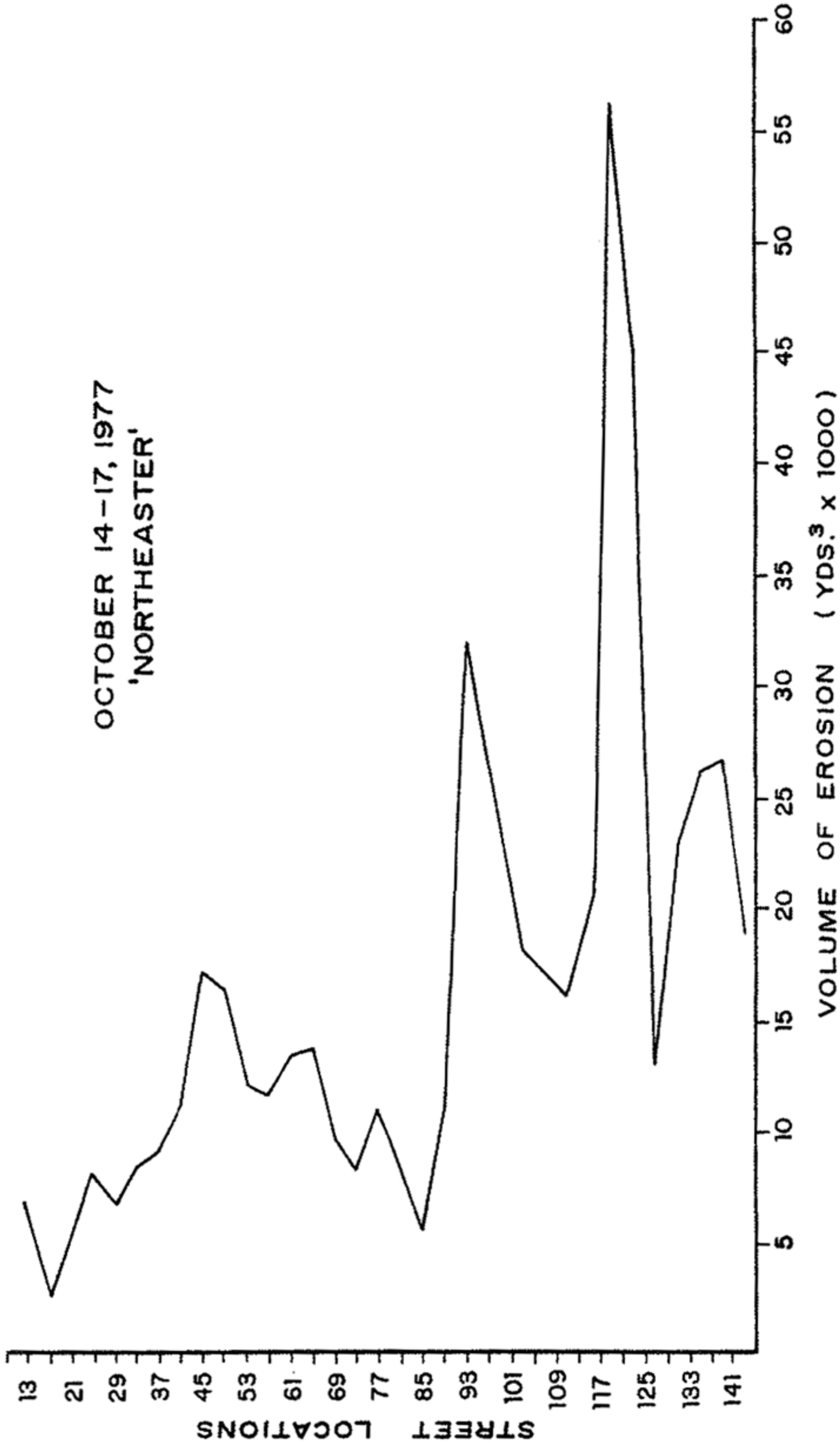
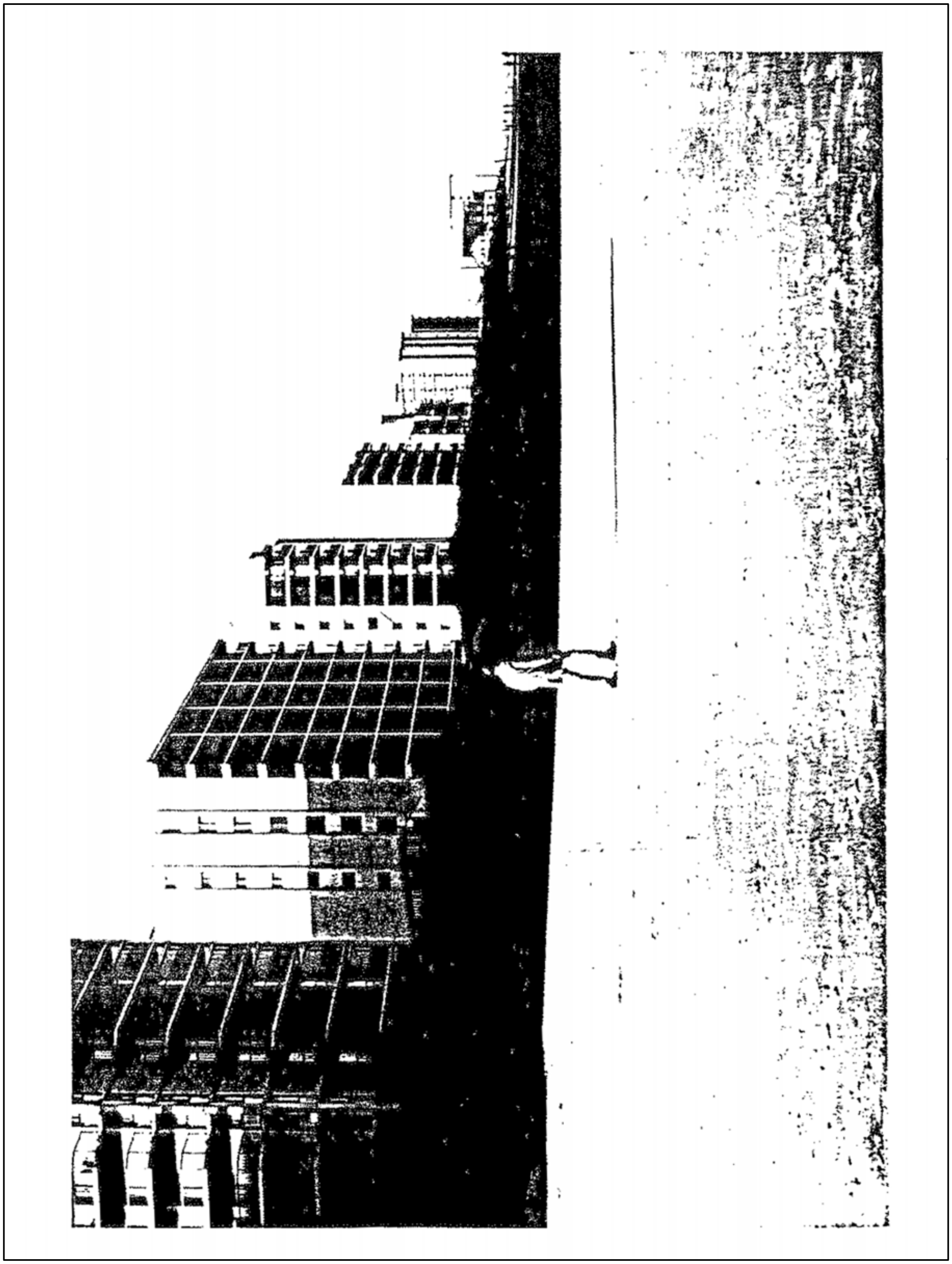


Figure 8: Storm Erosion, 1977

Figure 9: Beach Conditions after 1977 Storm, 119th Street



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