

CHAPTER 208

Results from the Atlantic City, NJ Beach Nourishment Monitoring Program

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Abstract

A beach nourishment project was carried out at Atlantic City, NJ during the summer of 1986. One million cubic yards of sand was dredged from adjacent Absecon Inlet and placed over a 9000 foot long section of the beach. The authors monitored the fill for a period of eighteen months, including two winters, after placement of the fill.

This paper briefly summarizes the fill project and monitoring program. Key results of the monitoring program are presented and compared with results of the monitoring program for previous nourishment projects at the site in 1963 and 1970. Differences in the behavior of the 1986 fill vis-a-vis the 1963 and 1970 fills are discussed and possible reasons for these differences are given.

Introduction

It is still difficult to fully predict the behavior of a planned beach nourishment project. Season to season variations in wave climate, the impact of existing structures and proposed structure modifications, and the frequency and mode of fill placement can have a significant impact on the behavior of beach fill. Monitoring of completed beach nourishment projects will hopefully increase our understanding of fill behavior and continue to improve our ability to design such projects. The 1986 beach nourishment project at Atlantic City, NJ was monitored and results of the monitoring program are compared with the behavior of earlier fill projects at Atlantic City.

Project Site

Atlantic City is situated on the northern third of Absecon Island, a barrier island located 40 miles north of the southern tip of the Jersey coast. It is separated from Brigantine by the jettied Absecon Inlet (Figure 1). The shoreline has a general northeast-

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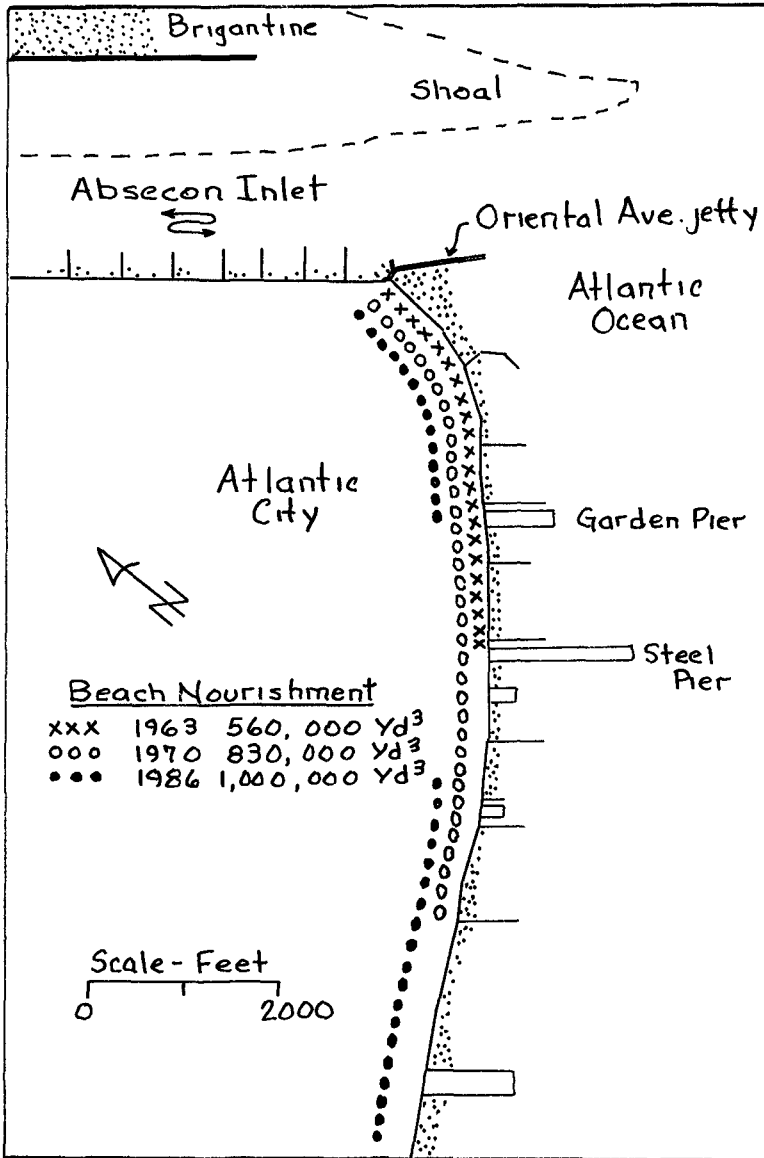


Figure 1 - Project site

southwest orientation.

The beach at Atlantic City is backed by wooden bulkheading and a boardwalk. There are five commercial piers which act as permeable groins as well as nine wood and stone groins varying from 100 ft to 800 ft (but typically 500-600 ft) in length. Beach berm widths vary from zero up to 500 feet (at Oriental Avenue jetty) out from the boardwalk. However, along several important beach segments, the berm width is typically fifty feet or less.

The U.S. Army Corps of Engineers (1974) estimates that there is a net southwestward transport of 150,000 cu.yd./yr. at Atlantic City (from a gross transport of 250,000 cu.yd./yr. northeastward and 400,000 cu.yd./yr., southwestward). Visual wave observations indicate dominant southwestward transport throughout the year except for some months during the summer. The dominant southwestward transport drives the Absecon Inlet Channel up against the Atlantic City side of the inlet. And it causes a large shoal to form on the Brigantine side of the inlet and extending over a thousand yards seaward of the head of the Brigantine jetty (Figure 1).

Although there is a general net southwesterly longshore transport in the study area, there is a local reversal of transport on the Atlantic City shore near the inlet. Observations of beach offsets at the groins taken from historic air photos and from onsite observations at different times of the year (Sorensen and Weggel, 1985) showed a diverging nodal zone that is consistently located between Carden Pier and Steel Pier (Figure 1). The nodal zone was generally located around Carden Pier during the spring to fall months, but it shifted to the vicinity of Steel Pier during the winter to early spring months.

Beach Nourishment Projects

Major beach nourishment projects were carried out at Atlantic City in 1948, 1963 (February-May), 1970 (June-July) and 1986 (April-June). The fill volumes and locations for the 1963, 1970 and 1986 projects are shown on Figure 1. The gap in the 1986 fill placement was due to ongoing construction work in the vicinity of Steel Pier.

The borrow area for all of the fill projects was the shoal area on the north side of Absecon Inlet. Sand was hydraulically dredged from various points along the channel side of the shoal and carried to the fill areas by pipeline. The four fill projects were essentially bypassing operations.

1963, 1970 Nourishment Projects

As a direct outcome of the damaging "five high" storm in March 1962, the U.S. Army Corps of Engineers established a beach monitoring program at Atlantic City which lasted from October 1962 to May 1973. Beach profiles, to wading depth, were measured at seven locations (Figure 2) on approximately a monthly basis (more frequently in winter, less frequently in summer). Note that profiles 1-3 are in the 1963 fill area; profiles 1-4 are in the 1970 fill area. The profile data are presented by McCann (1981) and discussed by Everts et al. (1974) in relation to the 1963 and 1970 fill projects. Owing to the truncation of profiles at wading depths, changes discussed by Everts et al. (1974) refer only to the portion of the beach profile above MSL.

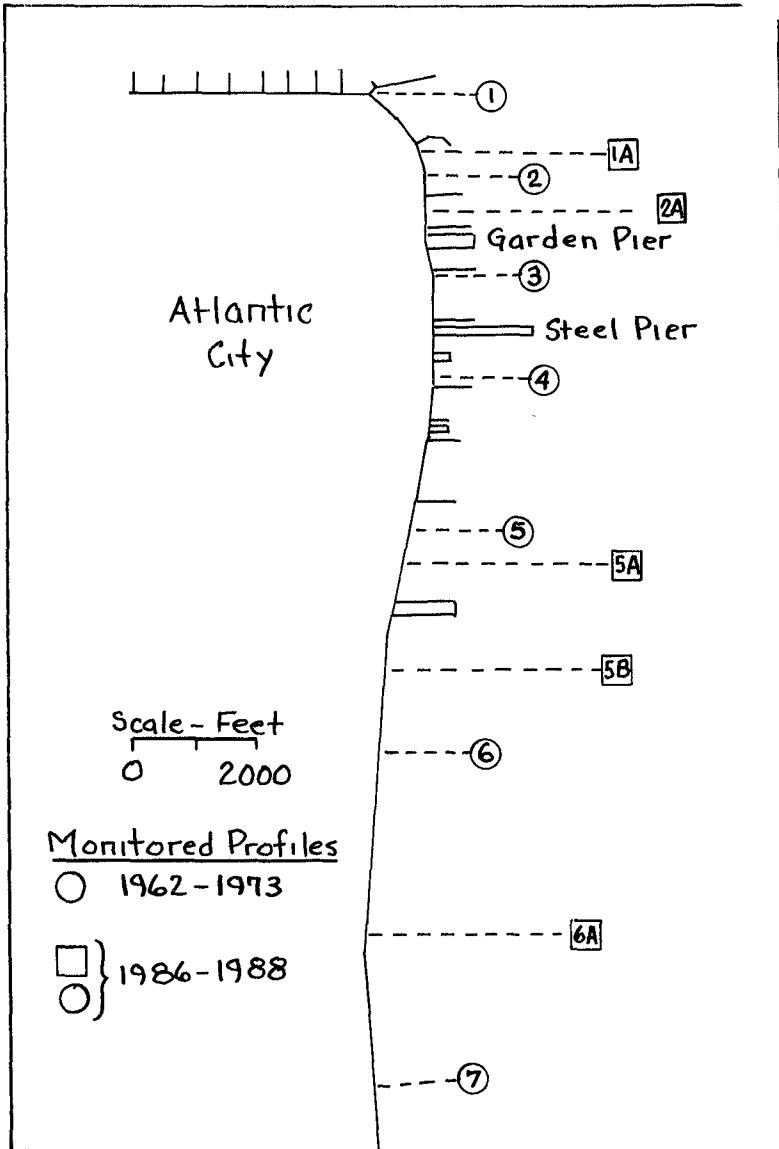


Figure 2 - Monitoring program profile locations

At profile 1, which is adjacent to the inlet, there was a rapid and constant loss of sand until the profile returned to its pre-fill volume. Ninety percent of the fill volume was lost in the first six months in 1963 and within eight months in 1970 (i.e. by December 1963 and February 1971 respectively). At profile 2, located about 1500 feet south of the inlet, there was an initial rapid loss similar to profile 1; but, when the volume loss reached seventy percent of the fill volume, the rate of loss dropped sharply to less than half the initial rate. Still, essentially all of the fill placed above MSL at profile 2 was removed during the first year of both fill projects. On profile 3, the loss rate was uniformly lower and large natural recoveries were observed during following summers. Four years passed before ninety percent of the 1963 fill volume above MSL was lost at profile 3. The profile lines south of the 1963 fill (lines 4-7) showed initial net erosion but within a period of one to three years after the fill, they showed net accumulation.

The trend in beach sediment losses at the successive profiles (1 to 7) indicated that sand moved alongshore to the southwest from the inlet (as well as having a net movement offshore). This was consistent with wave observations (1962-1967) which showed that the mean direction of wave approach during all months (except April when there was a reversal) was from the northeast.

Based on their evaluation of the profile data for the two fill projects, Everts, et al. (1974) offered the following interpretations and recommendations:

- 1) Predominant offshore loss of sand appears to occur between September and March, so fill should be placed in the spring for optimum residence time for the fill. Also, the larger the volume of fill placed at a given location, the faster it is lost; smaller volumes of fill placed more frequently would increase total fill residence time.
- 2) Fill should be placed in a localized feeder beach adjacent to the inlet (vicinity of profile 1) - because fill from that area moves along the shore to the southwest to nourish down-drift beaches and because that area requires the shortest pumping distance for fill material taken from the inlet.
- 3) Placement of fill in a localized feeder beach adjacent to the inlet should be done after April, when longshore current reversals are at a minimum and all of the fill material that moves alongshore can be expected to nourish beaches to the southwest.

Shore Structure Modifications, 1983-1984

During 1983 and 1984 four of the shore structures at Atlantic City were modified. These modifications, which are summarized in Figure 3, appear to have had an impact on the behavior of the 1986 fill project vis-a-vis the 1963 and 1970 fill projects.

The Oriental Avenue jetty, which had an original seaward crest elevation of +7 feet MLW and which had deteriorated some since its construction during 1946-1961 was rehabilitated with a raised crest elevation of +11 feet MLW. The first groin to the south was extended 200 feet (to yield a C rather than just a dog-leg alignment) and

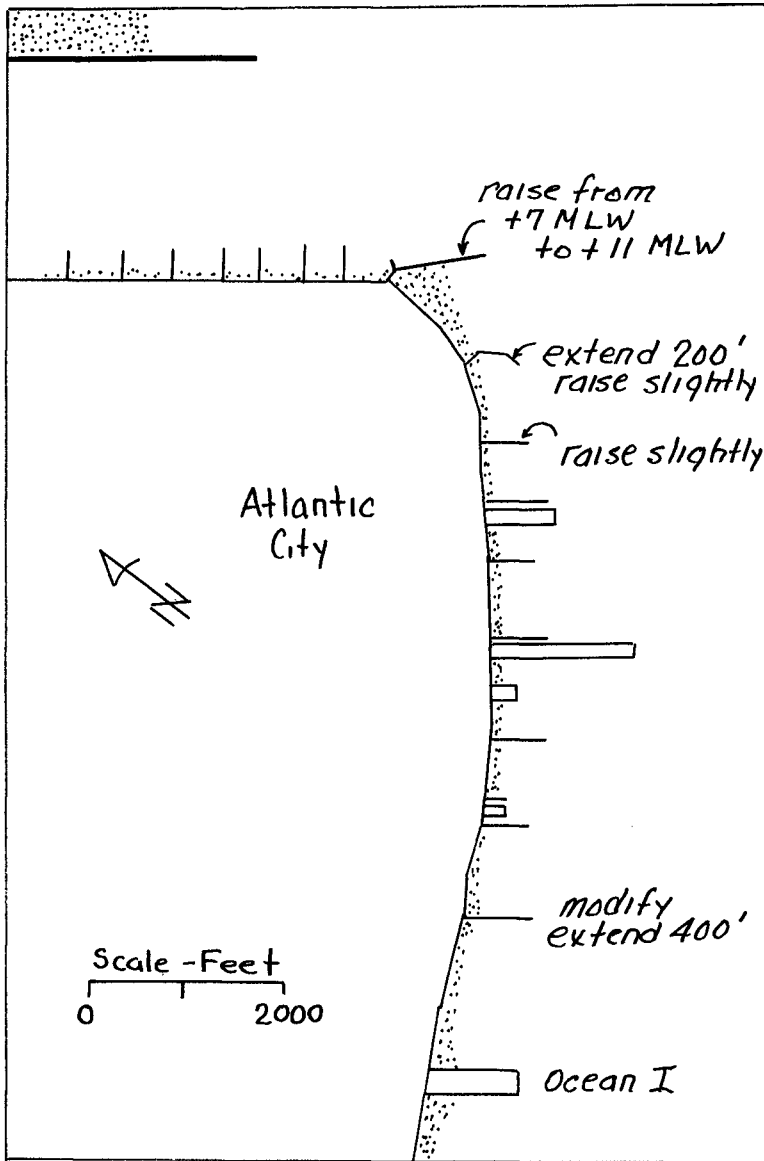


Figure 3 - Structure modifications: 1983 - 1984

raised slightly; and the second groin was raised slightly. A groin further to the southwest, which had been a timber groin, was reconstructed 400 feet longer with a stone seaward section. Also, in the early eighties, the Million Dollar Pier was removed and replaced with a new structure - Ocean I. Ocean I has a high density of relatively small support piles and, consequently, acts as a permeable groin.

Monitoring Program, 1986 Nourishment Project

The 1986 beach nourishment project was funded by the State of New Jersey and conducted through the New Jersey Department of Environmental Protection. NJDEP contracted with the authors to monitor the project for a year and a half period following completion of the fill. The monitoring program ran from August 1986 to March 1988, and included the collection of sand samples, visual wave observations, and beach profile data.

Sand samples were taken from the dredge discharge line and from the beach face during and after the nourishment operation. LEO visual wave observations (Schneider, 1981) were taken at a site in the fill area and at a site southwest of the fill area. Beach profiles (to wading depth) were taken at the seven profile locations used by the Corps of Engineers during 1962 and 1973, plus an additional five profile lines added by the authors. The locations of these twelve profile lines are shown in Figure 3. Profiles were taken on approximately a monthly basis from August 1986 to March 1988.

An NJDEP nearshore hydrographic survey was conducted in December 1985, approximately four months prior to the start of the nourishment project. Data from this survey do not cover all of the twelve profile lines, but data were taken sufficiently close to profile lines 1 through 6 to define the profile depths at these locations. Since the NJDEP survey was conducted four months prior to the start of the nourishment project, an allowance for this four month interval must be made when looking at the profile data.

1986 Monitoring Program Results/Discussion

The beach profile data were analyzed to determine sequential volumetric changes between profiles. Key results are summarized in the Table where volumetric changes are given in cubic yards per yard of beach and in percent change from the volume tabulated in column two.

The second column in the Table gives the profile volume changes between the December 1985 NJDEP survey and the end of the fill in August 1986, when the first monitoring program profiles were obtained. This column thus gives the fill volume plus changes in the beach profile during the previous four months. Fill was placed at profiles 1, 1A, 2, 2A, 5 and 5A; and some of the fill may have been placed in the vicinity of profile 3. Thus, the accumulation of between 40 and 65 cu.yd./yd. at profiles 4, 5B and 6 gives an indication of the natural change from December 1985 to August 1986. The accumulations at profiles 1, 1A, 2, 2A, 5 and 5A should be reduced by about that amount to give a truer indication of the fill placed at each profile line. This yields values of between 400 and 500 cu.yd./yd.

The third column gives the volume changes during the first year after fill placement (and the percentage of the second column). Note that both gains and losses occurred at the unfilled profiles. The

Table - Profile Unit Volume Changes - Yd³/Yd and (%)

Profile No.	Fill* (12/85 - 8/86)	Change Yr 1 (8/86 - 8/87)	Change Yr 2 (8/87 - 3/88)	Σ (%)
1	465.0	-39.0 (-8.4)	-105.0 (-22.6)	(-31.0)
1A	460.0	-200.0 (-43.5)	-20.0 (-4.3)	(-47.8)
2	505.0	-200.0 (-39.6)	-5.0 (-1.0)	(-40.6)
2A	437.2	-81.5 (-18.6)	-51.3 (-11.7)	(-30.3)
3	162.9	-21.4 (-13.1)	-55.6 (-34.1)	(-47.2)
4	43.2	+54.4 (+125.9)	-18.8 (-43.5)	(+82.4)
5	561.2	-72.4 (-12.9)	-30.0 (-5.3)	(-18.2)
5A	567.3	-95.4 (-16.8)	-40.9 (-7.2)	(24.0)
5B	65.7	-15.0 (-22.8)	-7.5 (-11.4)	(-34.2)
6	50.0	-84.3 (-168.6)	-51.3 (-102.6)	(-271.2)
6A	-	+24.5	-21.8	-
7	-	+62.2	-72.2	-

* Includes any natural profile changes between 12/85 and end of fill project in 8/86.

fourth column gives the volume change for the remainder of the monitoring program - essentially these values represent changes that occurred during the second winter season after fill placement. The final column gives the percent change during the monitoring program compared to the approximate fill volume (in the second column).

The major difference in the behavior of the 1986 fill and the 1963 and 1970 fills is the greatly reduced rate of loss of material above MSL, north of the nodal point. Profiles 1 through 2A lost a total of 30 to 40 percent of their volume after two winters compared to a loss of essentially all of their volume during the first winter during 1963 and 1970. Four possible reasons for the improved behavior of the fill in this area are: improved quality of sand fill, less fill placed at a given location (less berm extension and beach face steepening), milder wave climate, and the structure modifications. Each is discussed below.

Pipeline outfall sand samples showed very little difference in median particle diameter from the contemporary native sand on the beach face. Earlier studies (McMaster, 1954, Ramsey and Galvin, 1977 and Sorensen and Weggel, 1985) showed that there is very little difference in the range of sand sizes at the inlet borrow area and on the beach face.

Making allowances for the nonfill changes included in the tabulated values in column 2 of the Table and for differences in the profile volume analyses techniques for the 1963/1970 fills and the 1986 fill, it appears that the volume of fill placed at profile lines 1 and 2 was approximately the same during all three nourishment projects. Comparison of the volumes of fill and the lengths of beach filled for the three projects (see Figure 1) confirms that the volumes of fill per unit length of beach were about the same.

It appears that differences in the wave climate partially account for the observed differences in beach fill behavior. No uniform set of wave data is available for the year following the 1963 and 1970 fills and the two years following the 1986 fill, from which a definite comparison can be made. Hindcast wave data (Jensen, 1983) are available for Atlantic City for the period 1956-1975. From these data, the winters of 1963-1964 and 1970-1971 can be compared to the average 1956-1975 data to see how relatively mild or severe they were. This can then be compared with the experience of the authors and others active along the New Jersey shore during 1986-1988.

Comparing mean monthly significant wave heights for September through April in 1963-1964, 1970-1971, and 1956-1975 (Figure 4) indicates that the winters following the 1963 and 1970 beach fills were essentially average for the twenty year period. Also shown on Figure 4 are the average significant wave heights for March and April of 1962 when the major beach scour that instigated the 1963 fill occurred. These monthly averages are significantly higher than any of the monthly averages in 1963-1964 or 1970-1971. The 1986-1987 winter had two big storms that were coincident with unusually high astronomical tides. Overall, however, this winter was average or slightly milder than average. The winter of 1987-1988 had essentially no major storms until April which was just after the last beach monitoring profiles were taken. Comparison of the first and second year changes in the Table confirms the comparatively milder conditions in 1987-1988 versus 1986-1987.

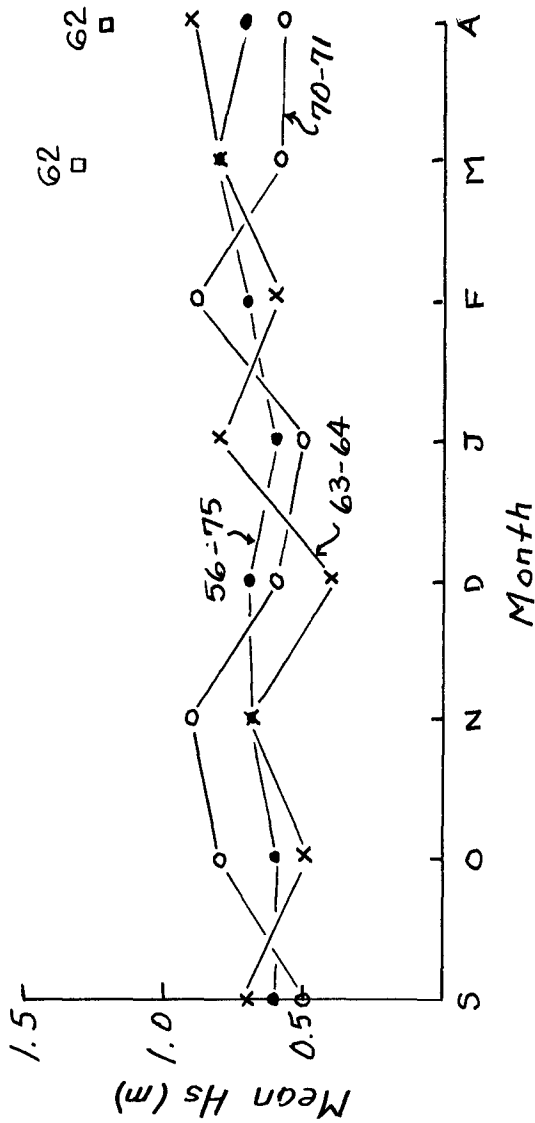


Figure 4 - Atlantic City wave hindcast data

Thus, it appears that the winters following the 1986 fill were somewhat milder than those following the 1963 and 1970 fills. However, there is another cause for the improved behavior of the 1986 fill versus the fills in 1963 and 1970, in the vicinity of profiles 1 and 2. That is the structure improvements made in 1983-1984.

Although Everts et al. (1974) suggest that beach fill placed between the Oriental Avenue jetty and Garden Pier (see Figure 1) moves to the southwest (and offshore), the observed nodal zone position suggests otherwise. Much of the fill place in this region in 1963 and 1970 probably moved toward the northeast, over and around the jetty, and into the inlet. The 1983-1984 structure modifications (Figure 3) limited this movement and subsequent loss. Everts et al. (1974) also suggest that after April dominant transport each month is to the southwest. However, LEO observations made in 1987 showed north-eastward littoral transport to dominate in June.

The fill placed at profiles 5 and 5A suffered an immediate and consistent but small rate of loss. The rate of loss was about half that which occurred at profiles 1 through 2A. In 1963, no fill was placed at profile 5 which showed little net change after the first year and then showed a net accumulation (over the condition at the time of fill) for the next several years - likely because of the transport of sand from upcoast. Compared to the post-1986 fill behavior at profiles 1 through 2A and to the post-1963 behavior at profile 5, the post-1986 fill behavior at profiles 5 and 5A was excellent. Again, the probable causes for this behavior were the milder wave climate and the structure modifications.

Summary and Conclusions

Overall, the 1986 beach nourishment project at Atlantic City has been successful to date. Comparison of beach fill behavior at the six fill profile lines during the first and second winters after the fill (see Table) shows the importance of the milder wave climate during the second winter. Part of the reduced rate of loss is due to the typical exponential loss rate that occurs for beach fills; however, most of the difference is likely due to the milder wave climate.

Comparison of the behavior of the 1963 fill and the 1986 fill (given the differences in wave climate) demonstrates the improvement in fill behavior owing the improvement of some of the shore structures, which reduced the loss of sand alongshore to the inlet and to the southwest. The jetty, groins and piers do significantly improve the behavior of any beach fill placed at Atlantic City.

As Everts et al. (1974) recommend, future fills should be placed as often as possible rather than in larger volumes at longer intervals. Beach nourishment at Atlantic City should be thought of as a sand by-passing operation. The shore stabilization structures should not be allowed to deteriorate, and the fill should be placed over the entire beach length northeast and southwest of the nodal zone.

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