

## CHAPTER 359

### LONG RANGE POSITIVE EFFECTS OF THE DELRAY BEACH NOURISHMENT PROGRAM

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#### INTRODUCTION

The success of beach nourishment projects is often questioned due to the observed losses of sand from the fill area and what appears to be a loss of benefits. Observations made by the authors indicate that there have been noticeable advances in the shoreline both to the north and the south of the Delray Beach, Florida beach nourishment project. The purpose of this evaluation is to show that much of the sand which moves out of the project can actually be accounted for and benefits the neighboring beaches.

The City of Delray Beach is located on the southeast coast of Florida approximately 80 kilometers north of Miami (Figure 1). A portion of the City encompasses about 4.8 km of the barrier island. The nourishment project is maintained over a distance of 4.3 km.

#### BACKGROUND HISTORY

In the 1960's, the Delray Beach shoreline was experiencing severe erosion. The public beach was almost non-existent and State Road A1A was damaged annually in winter storms (Figure 2). To combat this problem, the City constructed concrete and rock revetments along the public beach. In 1971, the concrete revetment failed and the City initiated a beach nourishment program.

The initial beach nourishment was completed in 1973. The project totaled 1,249,739 cubic meters of sand which was dredged from an offshore borrow area and placed in the project area. Subsequent to the initial nourishment the project area was renourished in 1978, 1984 and 1992 using sand volumes of 536,000, 994,000 and 770,000 cubic meters, respectively. The location of the various fill placements is shown in Figure 2.

The annualized cost of the beach nourishment program is approximately US\$980,000 (Coastal Planning & Engineering, Inc., 1991). The program is a Federally authorized shore protection project. As a result, the nourishments are designed consistent with Federal (U.S. Army Corps of Engineers) standards and are funded at both the federal, and local level.

The variation of fill volumes in this program (1973 to the present) is indicative of the expanded knowledge gained from both the monitoring of the beach fill and the advancement in beach nourishment design over this time period. A review of the initial 1973 fill placement has indicated that only enough material was placed to construct the design (storm protection) section of the beach. Virtually no sand was placed to account for end losses or background erosion losses (advanced nourishment). Subsequent nourishments have placed sufficient sand in an advanced nourishment section to maintain the design section through the nourishment interval. This design procedure is consistent with the National Research Council (NRC) recommendations (NRC, 1995).

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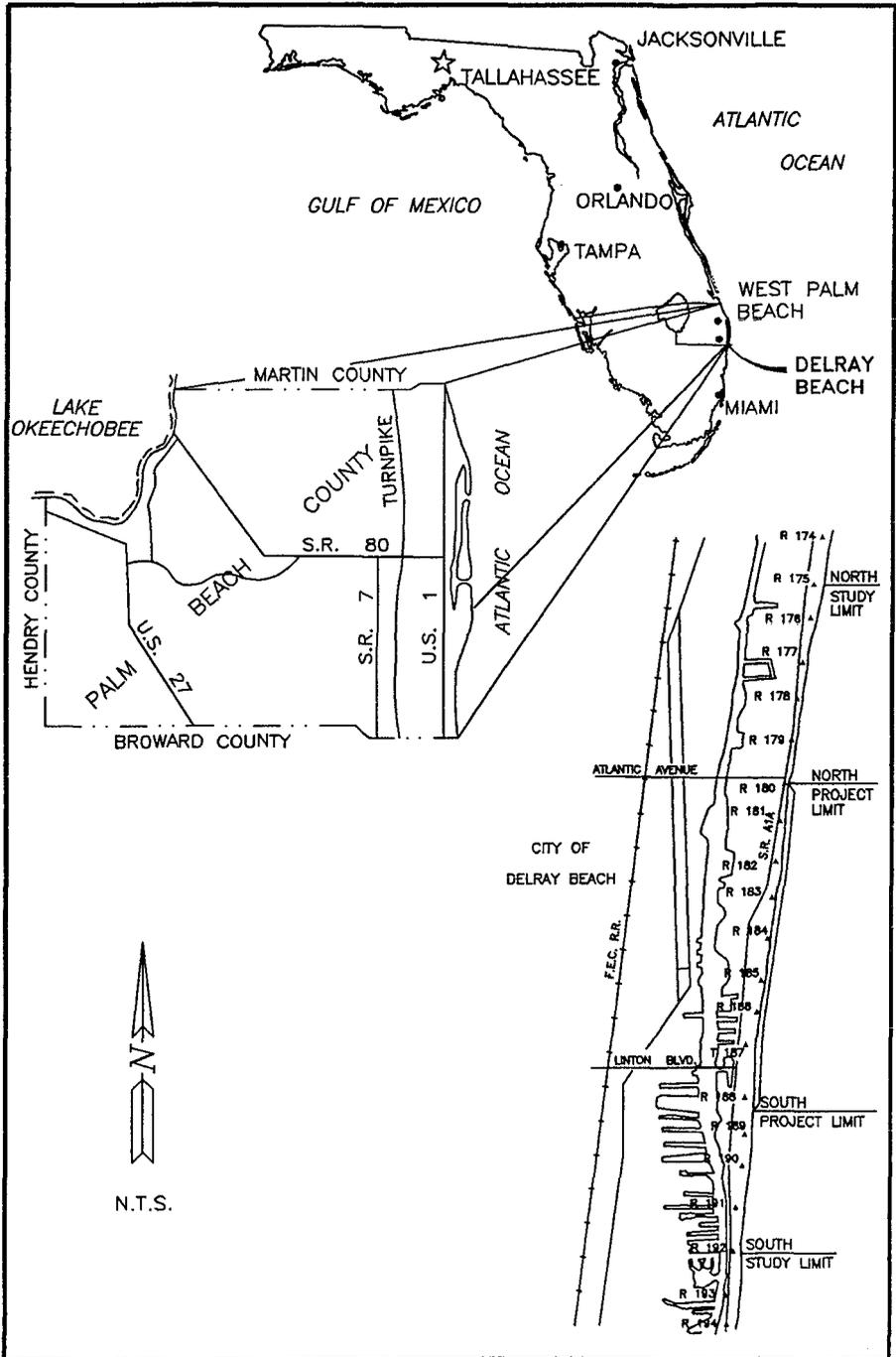


FIGURE 1

## **BEACH MONITORING, ANALYSIS, AND RESULTS**

Annual monitoring studies have been conducted by the City of Delray Beach since the initial restoration, providing data for the performance assessment. Survey data from the State of Florida Department of Environmental Protection collected in 1974, 1990, and 1995 was used to evaluate changes outside of the project area. The State of Florida maintains a series of beach profiles which are spaced approximately every 330 meters along the sandy shoreline of the State. The profiles in the fill area are shown in Figure 2. All beach profiles are surveyed from the upland limit to the depth of closure (approximately -10 meters).

Figure 3 shows the mean high water shoreline changes from 1974 to 1995 both within the fill area and on the adjacent shorelines. While the initial fill project occurred in 1973, no beach profiles were measured on the adjacent shorelines until 1974. As a result, the shoreline response in Figure 3 is not complete; nevertheless, the survey comparison represents one of the few extended (spatially and temporally) monitorings of a beach nourishment program.

The beach fill plan form demonstrates end loss or diffusion characteristics which are similar to those predicted by Pelnard-Consideré (1956) though a direct comparison has not been made. Accretion outside of the fill area is highest immediately adjacent to the fill and tapers to lesser amounts further from the fill (Figure 3). The length of the taper to the south is longer than the taper to the north which is consistent with the net littoral transport to the south. There are distinct points to the north (R165) and south (R201) where the data showed no change or erosion over the 21-year comparison. These end points are used as the lateral limits of the impact of the beach fill on adjacent beaches. It is probable that the beach fill impacts beaches further to the south, but that the accretion due to the fill is less than the existing erosion. The north limit is in the vicinity of a large natural limestone rock outcrop which tends to act as a groin and divides the beach into small littoral cells.

The monitoring data indicates that some of the sand from the nourishment project has moved about 3 kilometers north and south of the fill limits. This movement results in an advancement of the shoreline as well as increased volumes of sand on the beaches within the neighboring towns of Gulfstream and Highland Beach. The nourishment program has placed about 3.5 million cubic meters of sand on Delray Beach between 1973 and 1992. The beach profiles indicate that a total of 43% of that sand, about 1.5 million cubic meters, has been eroded from the fill area; however, the analysis found that 1.3 million cubic meters (85%) of that sand could be located between 2.7 km north of the project to 3.5 km south of the project. The total volume accreted to the north is 629,000 cubic meters over 2.7 km and to the south the accretion is 673,000 cubic meters over 3.5 km. Therefore, the majority of the sand that has eroded from the project has not been "lost" but rather has been deposited on adjacent beaches.

### **Nourishment Interval**

The nourishment interval for the Delray Beach nourishment project has increased from 5 years to the present 8 years (1984 to 1992). The design of the fill places an economically optimum amount of advanced nourishment on the beach. Currently, the advanced nourishment is designed to last 9 years (U. S. Army Corps of Engineers, 1992). The increase in the actual nourishment interval is a result of better estimation of end losses and the spreading of the beach fill. The diffusion theory indicates that a longer fill project will last longer than a shorter fill project. The accretion of sand on adjacent beaches has extended the "effective" length of the beach and has resulted in less diffusion loss and a longer nourishment interval.

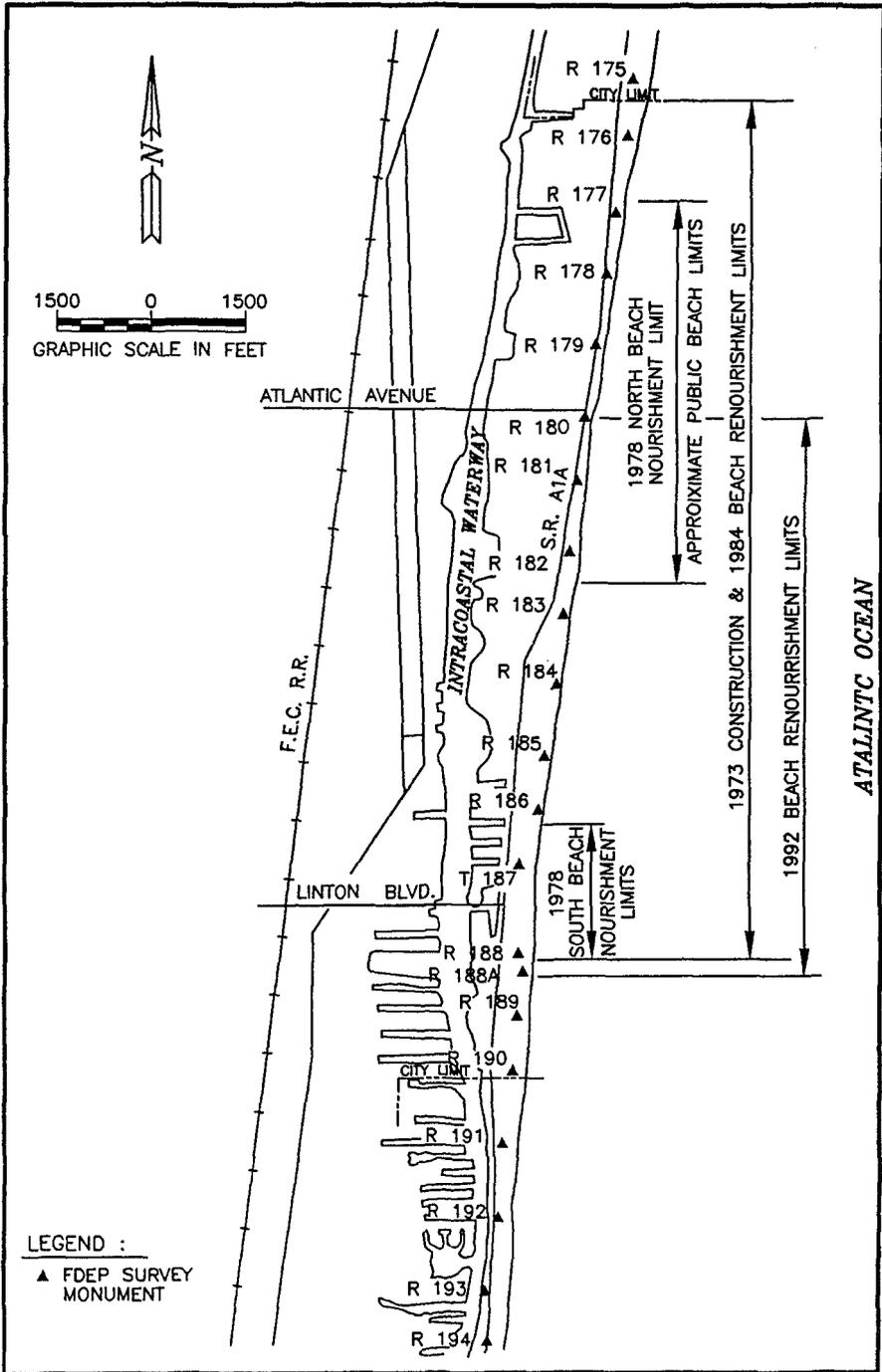


FIGURE 2

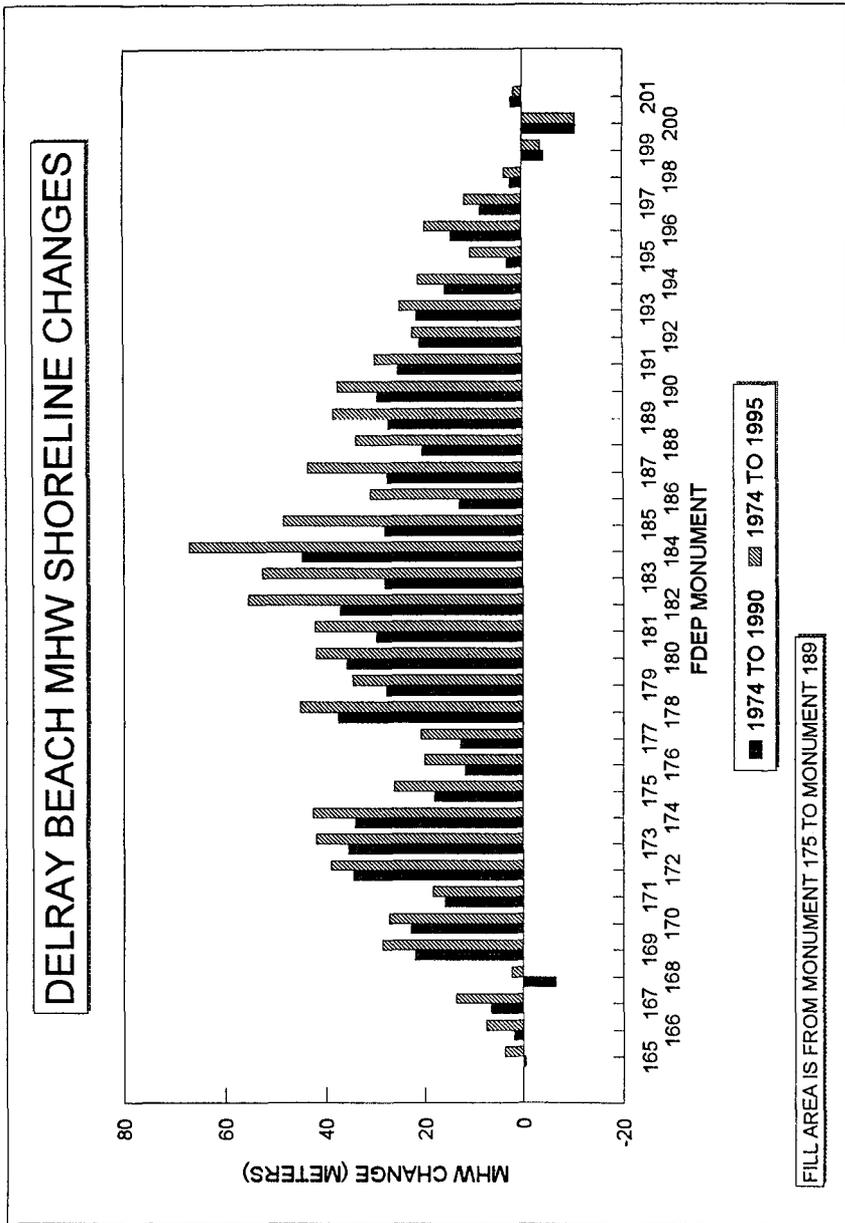


Figure 3

## **PROJECT BENEFITS**

Benefits of a beach nourishment project are attained in several ways. The most important are the protection of upland properties from coastal storm damage, the improved recreational value of the maintained beaches and the resulting increase in property values. The City of Delray Beach, who manages its beach program, requested that these benefits be determined to understand the positive impact of the beach program on the local economy.

### **Storm Damage Reduction**

Storm damage prevention benefits presented in this paper are limited to those that are recognized by the U.S. Army Corps of Engineers in their evaluation of Federal participation. Storm damage reduction benefits are estimated by comparing the with project damage to the with out project damage. Damages are limited to structural damage to upland structures and roads, the loss of fill from upland areas from extreme events, the loss of land from long term recession of the beach profile, and the damage to existing coastal armoring. In addition, the prevention of coastal armoring is also included as a benefit. The Florida coast is susceptible to large storm surge and wave events associated with tropical storms and hurricanes. As these storms are acknowledged to be random events, storm damages are calculated in a probabilistic method. The method of computing the storm damages is generally described by Bodge(1991). For this analysis, the computer program of Thomas(1990) was utilized. An interest rate of 7.625 percent was assumed for the economic calculations. While this interest rate is about twice the U.S. rate of inflation, it is the rate prescribed by the U.S. Army Corps of Engineers and results in conservative benefits estimates. All economic data is calculated in U.S. dollars.

The storm damage prevention benefits were calculated using land and property values from the 1995 tax appraisers roll. For the fill area only(R175 to R189), the storm damage reduction benefits are \$3,819,800 annually. The annual storm damage reduction benefit of the Delray Beach nourishment projects on the adjacent beaches is \$5,863,000. This can be further divided; \$2,552,500 for properties in Gulfstream to the north and \$3,310,500 for properties to the south in Highland Beach.

The storm damage reduction benefits are thus greater outside the fill area than inside the fill area. While this may appear counterintuitive since the fill material is placed only in Delray Beach, the benefits are higher due to the level of upland development in each area. The City of Delray Beach maintains a public beach which is accessed by a beach front road. The adjacent communities of Highland Beach and Gulfstream are heavily developed along the ocean with expensive private homes and multi-unit condominiums. In addition, the Town of Gulfstream was heavily eroded in the early 1970's. The accretion of sand on a heavily eroded and heavily developed beach generates significant storm damage reduction benefits.

### **Property Value Enhancement**

Recent beach nourishments within the state of Florida have resulted in increased property values. This increase in property values results in beach front owners receiving higher profits from their real estate investments as well as increasing the local property tax. A recent analysis of the study area was performed by Regional Research Associates(1996). They compared the unit property values(\$/square meter) for similar properties located on the barrier island and on the mainland(Figure 1). The Delray Beach nourishment project has resulted in beachfront properties costing 15-20% more than mainland properties due to the maintained beach. This increase is \$109.6 million within the fill area, \$31.0 million and \$58.4 million in Gulfstream and Highland Beach, respectively. The property value increase results in annual local taxes

of \$2.8 million, \$1.1 million, and \$1.9 million for Delray Beach, Gulfstream and Highland Beach, respectively.

### **Recreation Benefits**

Recreational benefits attributed to a beach nourishment project are due to the increase in available beach space. The Corps of Engineers limits the recreational benefits by the demand to go to the beach and by the availability of public parking. The maintenance of the beach nourishment results in the annual benefits of \$496,000 in Delray Beach (Coastal Planning & Engineering, Inc., 1991). Because there is no public parking or access within Gulfstream or Highland Beach, no recreational benefits accrue due to the project.

### **Benefit Summary**

The Delray Beach beach maintenance program generates approximately \$10.2 million annually in storm damage reduction benefits and recreational benefits to the City of Delray Beach and the adjacent towns of Highland Beach and Gulfstream. A common economic decision making principle is the ratio of annual benefits to annual costs. For this project, the benefit to cost ratio is 10.4. This excludes the increase in annual tax revenues due to the effect of the beach on property values.

### **CONCLUSIONS**

The Delray Beach nourishment program has had a positive effect on a total of 11.3 km of shoreline as a result of filling about 4.3 km on a periodic basis. The analysis showed average shoreline advances of 28.3 meters to the north of the fill and 23.1 monitoring to the south. This was confirmed by an analysis of total volume change over the 23-year life of this project. The study accounted for 85% of the sand lost from the nourishment project.

As a result of this accretion outside of the fill area in neighboring cities, it was found that storm damage prevention benefits amounted to \$3,819,800 within the fill area and \$5,863,000 outside of the fill area but as a direct result of sand moving from Delray Beach to neighboring shorelines. The fact that there is a beach in place within the fill area provides an increase of 15 to 20 percent in property values.

### **ACKNOWLEDGMENT**

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