HISTORY OF PALM BEACH COUNTY INLETS

SUMMARY

Four inlets link the Intracoastal Waterway with the Atlantic Ocean in Palm Beach County (figure 1). Jupiter Inlet, at the northern end of the county, was a natural waterway, connecting the Loxahatchee River with the ocean. Historically, the inlet has opened and closed to the sea by the forces of nature. Originally, the inlet was kept open not only by flow from the Loxahatchee River, but also by flow from Jupiter Sound and Lake Worth Creek. Some of this flow was diverted by completion of the East Coast Canal (now called the Intracoastal Waterway) in 1985, and Lake Worth Inlet, and by modification of St. Lucie Inlet. With the reduced flow, the inlet remained closed most of the time except when periodically dredged. Since 1947, it has remained open with regular dredging (McPherson, Sabanskas, and Long 1982).

Lake Worth Inlet (also known as Palm Beach Inlet) was first cut in the mid-nineteenth century to provide access to the ocean from Lake Worth. The inlet was prone to migrate and close and was even relocated to a different site north of the original cut; the new location also proved unstable. Beginning in 1918, the inlet was stabilized at its original location; at the same time, the Port of Palm Beach was becoming a vital shipping facility. The channel was widened and deepened in the following years, and in 1958 a sand transfer plant was constructed to bypass sand across the inlet from the north beach to the south beach.

As the population grew around Lake Worth, the lake became more polluted, and plans were made to create another inlet for better water circulation in the southern end of the lake. As a result, South Lake Worth Inlet (also called Boynton Inlet) was dredged open beginning in 1925 and was completed in 1927. The width of the inlet is stabilized by jetties and varies from 300 feet at the seaward entrance to about 135 feet at the inlet throat. The average depth is about ten feet and is naturally maintained to the underlying rock stratum by swift tidal currents (Olsen 1990). To help offset the erosive effects of the inlet to the downdrift beaches, a sand transfer plant was installed in 1937 on the north side of the inlet to pump sand across to the south side.

Boca Raton Inlet, located near the southern end of the county, was also a natural inlet, connecting Lake Boca Raton to the ocean. The inlet had a history of severe shoaling during storms even after jetties were built (around 1930) and improved. In 1972 the inlet, its jetties, and maintenance access easements were deeded to the City of Boca Raton. Maintenance dredging is performed regularly, and the spoil is deposited on the beach south of the inlet.

INLET LOCATION MAP

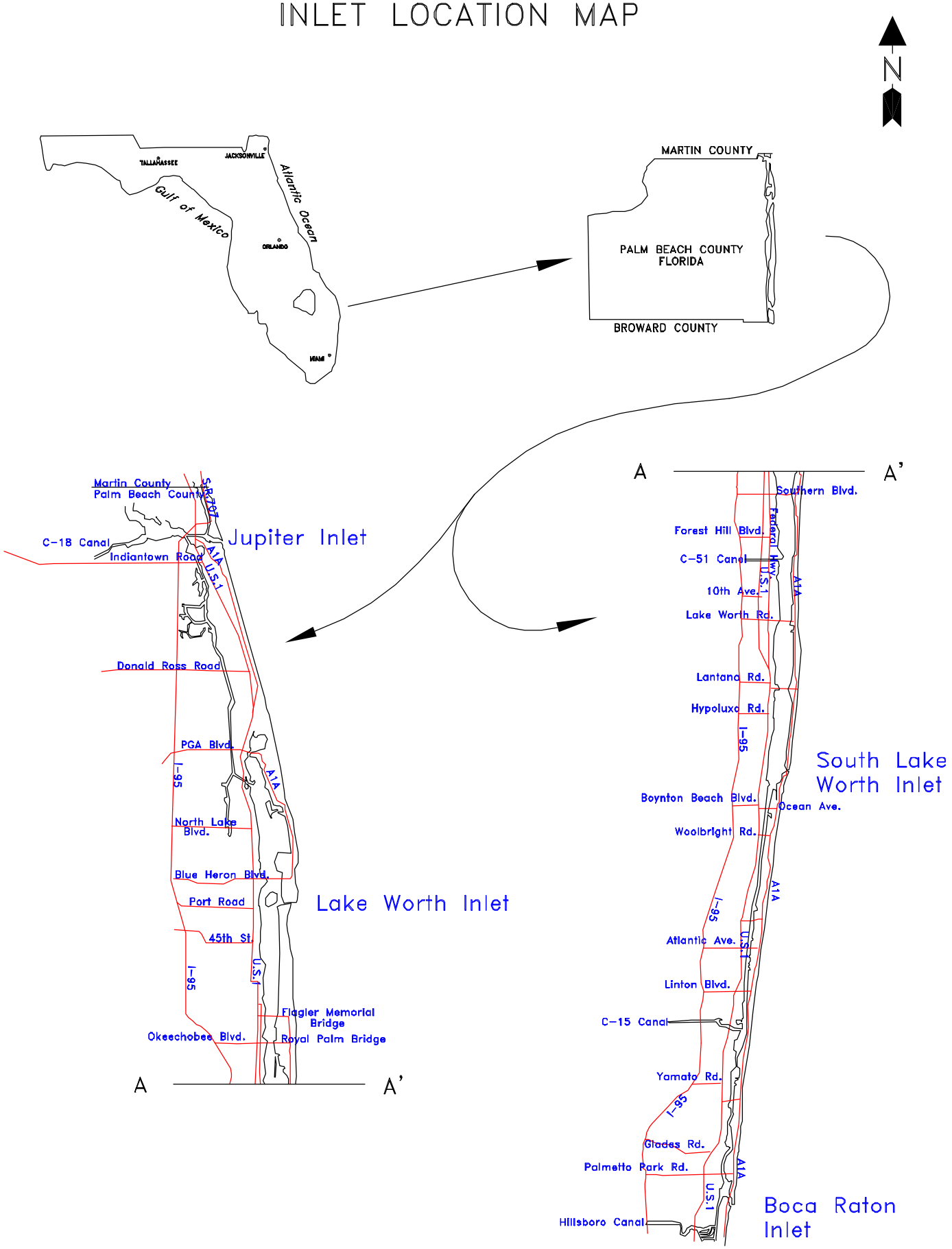

FIGURE 1

JUPITER INLET

Jupiter Inlet 189?

Jupiter Inlet has been considered one of the major natural inlets on the east coast of Florida. According to historical accounts, the size of the oyster shells found in the prehistoric shell mounds surrounding the inlet indicate that it must have been open 1,000 years ago. Jupiter Inlet may be the one Ponce de Leon visited on his way down the coast in 1513. Menendez used the inlet in 1565 as he traveled to Cuba (DuBois 1968), and it was first shown on explorers' maps in 1671.

The Quaker Jonathan Dickinson's journal recalls the inlet was open in 1696 during the shipwrecked group's encounter with hostile Indians (DuBois 1968). In 1773, a Dutch civil engineer named Barnard Romans related that the inlet was shut for many years before 1769, but he had seen it open until 1773 (DuBois 1968).

Jupiter Inlet has been known by several names. First it was known as Hobe, or Jobe for a tribe of the aboriginal Jeaga Indians who lived near the inlet. On the Spanish maps, the river appears as Jobe River, named for these natives. The English interpretation of Jobe was Jove, which in turn became Jupiter. On the DeBrahm map of 1770, it is called Grenville Inlet (Courier Journal 1988). According to DuBois (1968), in the early days the inlet was at times several hundred yards south of the present location.

John Lee Williams wrote in 1837 that Jupiter Inlet had opened and closed three times within 70 years. In 1837, the inlet had shoaled and appeared to be closing, which it did in 1838 shortly after the Battle of the Loxahatchee (DuBois 1968). According to the memoirs accompanying the Ive's Military Map of 1856, the inlet was closed from 1840 to 1844 (DuBois 1968). In 1844, a mail carrier and four helpers dug the inlet open with shovels. Water flooded through and created a channel nearly a quarter mile wide (Loxahatchee Historical Society). The inlet stayed open until 1847, and then it closed for six years. In 1853 the inlet opened only for a short time. In 1855, Major Haskin of the First Artillery tried to clear the channel, but the unusually dry year provided no flood waters to help open the channel (Loxahatchee Historical Society).

Jupiter Lighthouse

Construction of a lighthouse at the inlet began in 1855 and was completed four years later. Since the inlet was closed, transportation of building materials to the site was a great obstacle and required additional federal funds (Cary 1978, p. 22). One account from 1855 reported that the inlet was one-half mile south of its present location (Cary 1978, p. 24). The inlet remained open during the Civil War, but the lighthouse was darkened when Confederate sympathizers removed the light mechanism and hid it to prevent its use, presumably, by the Union navy. "Because the lens was impossible to duplicate, the original parts were recovered and saved until the end of the war when they were used to relight the beacon in June 1866" (State of Florida 1984, p.37). After the Civil War the inlet closed again, but was open in 1872 (DuBois 1968).

Unpublished accounts mention that the inlet was open in 1884 (DuBois 1968). The Tropical Sun in November 1894 (Loxahatchee Historical Society) wrote that the inlet was in the best shape it had been in years. Soundings showed a depth of 9 feet on the outer bar and 7.5 feet on the inner bar. However, by fall 1896, the inlet had to be re-opened, this time by hotel owner and contractor, Fred M. Cabot (DuBois 1968). By May 1901, the inlet was closed again, but reopened a month later by local residents and the federal government with 3 feet on the bar at low tide (Loxahatchee Historical Society).


Jupiter Inlet 1910

The autumn of 1910 found the inlet closed again, but record high flood waters created a channel a quarter mile wide after residents dug a ditch with a mule and scoop and shovels. Five years later the inlet closed again and was dug out when the fall rains flooded the back country (DuBois 1968: Loxahatchee Historical Society).

During the prohibition era, Jupiter Inlet stayed open and was used often by rum runners at night (DuBois 1968). The Jupiter Inlet District was established by a special act of the State Legislature in 1921 to maintain Jupiter Inlet and the Loxahatchee River in the best possible condition. In the summer of 1922, Captain J. 0. Webster began work to place rock for the first jetties, spaced 350 feet apart (Mehta, Montague, and Parchure 1990). Webster added more granite to the jetties in 1928; the north jetty was extended 200 feet, and the south jetty was extended 75 feet (DuBois 1968: Courier Journal 1988).


Jupiter Inlet 1924

In the 1930's, Jupiter Inlet opened to the ocean occasionally as far south as the present location of the Jupiter Beach Resort (formerly the Hilton Hotel and originally a Holiday Inn). In 1931, still more granite was added to the jetties, and the north jetty was recapped. Even with the jetties, the inlet continued to shoal and close. Local resident, Jack E. Horne, remembers the inlet being closed in 1933 (Cary 1978, p. 18). The channel was dredged in 1936 and badly shoaled again within 2 years. In 1940, two steel groins were constructed on the north side to stop erosion near the shoreward side of the north jetty. A converging steel pile groin was built on the seaward side of the south jetty to increase current velocities and induce scouring between the jetties (Univ of Fla. 1969). The channel was dredged to a depth of 6 feet and a width of almost 60 feet (Mehta, Montague, and Parchure 1990) in 1941, but the inlet closed again between 1942-1947. Mayo writes that the Coast Guard kept the inlet closed for the horse patrol that scouted the beach during World War II (Cary 1978, p. 50). In 1948 local interests dredged 37,000 cubic yards of material from the inlet to provide a channel 8 feet deep and 100 feet wide. For many years the sand dredged from the inlet had been deposited on the north side of the inlet, filling in what had been a marshy area. In 1954, Charles Martyn purchased this large tract of wilderness fronting the ocean and river and developed it as Jupiter Inlet Colony (Cary 1978, p. 140). In 1956, a 300 feet long concrete-capped sheet pile jetty was constructed 100 feet north of the existing north jetty (Mehta, Montague, and Thieke 1992).

Originally, Jupiter Inlet was the only outlet for the Loxahatchee River, Lake Worth Creek, and Juiter Sound (figure 2). Part of the discharge from the St. Lucie River and the southern part of Indian River was also diverted to sea through Jupiter Inlet. The total flow was sufficient to maintain adequate

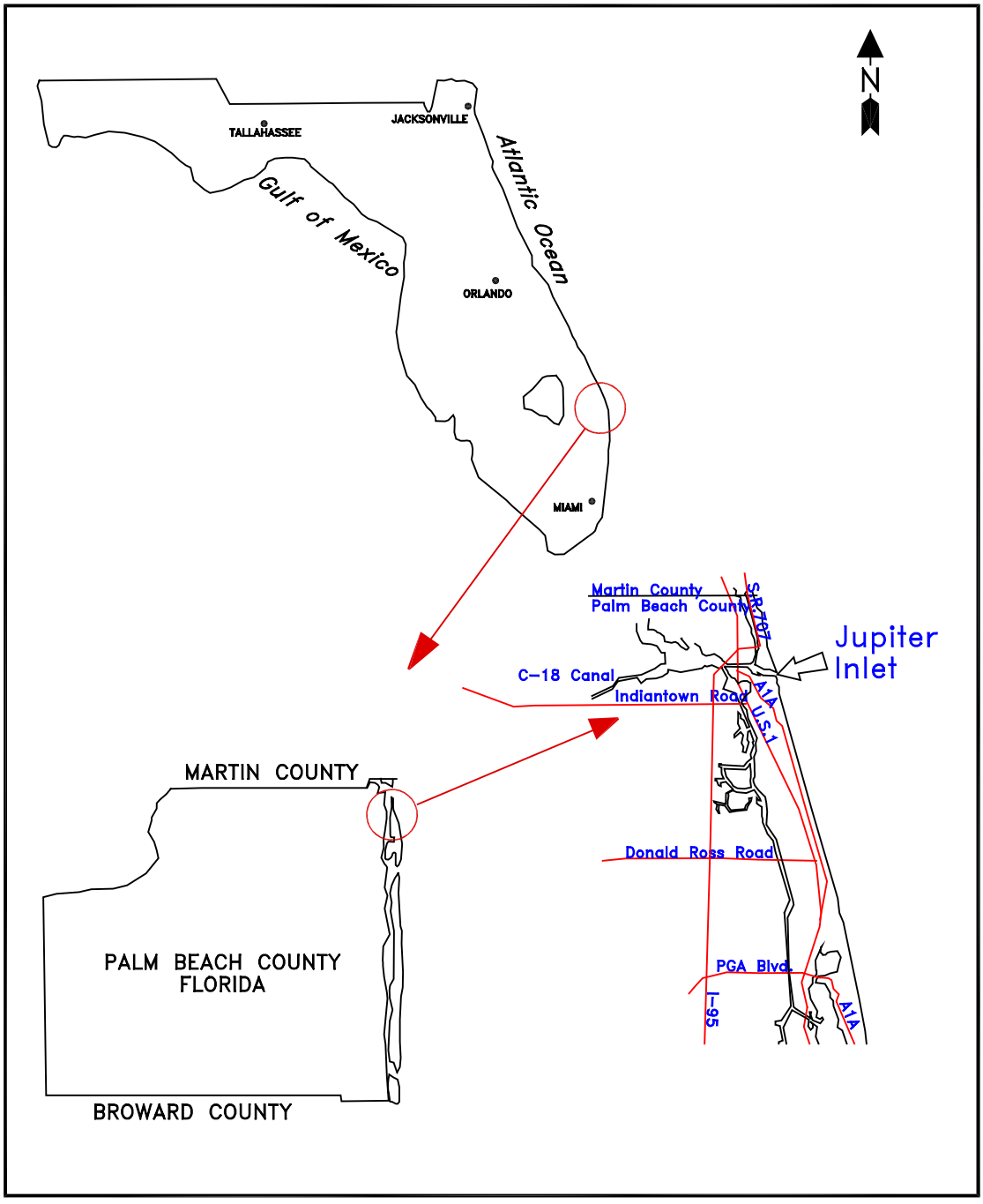

Figure 2. Area map of Jupiter Inlet

depth through the inlet except during severe storms when the inlet closed temporarily for short periods. When other inlets were cut (St. Lucie Inlet in 1892; Lake Worth Inlet in 1918; and South Lake Worth Inlet in 1927), the flow was considerably diverted away from Jupiter Inlet (Strock 1983). As a result of the loss of flow through the inlet, the frequency and duration of inlet closure greatly increased until 1947 when a regular inlet maintenance schedule, primarily consisting of dredging, was initiated by the Jupiter Inlet District. This schedule of periodic dredging has since prevented closure of the inlet and has maintained it in a navigable state. However, the inherent problems of shoaling near the mouth of the inlet and beach erosion south of the inlet have yet to be solved (Escoffier and Walton 1979, as seen in Buckingham 1984).

In the late 1960's, a sand trap was dredged approximately 1000 feet west of the inlet mouth, and the jetties were modified. The wing on the seaward end of the south jetty was removed in 1967 in an attempt to reduce shoaling within the inlet. Both jetties were extended landward to prevent flanking. The inlet channel is currently 195 feet wide and 6 feet deep (Mehta, Montague, and Parchure 1990).

In 1998, Applied Technology and Management, Inc. completed a 175' extension to the south jetty using limestone and granite armor stone weighing up to nine tons. The north jetty height and width were also increased.

Jupiter Inlet 1998

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LAKE WORTH INLET

Lake Worth was originally a landlocked freshwater lake, except at times of high water when the sea breached the ridge at the north end of the lake (Linehan 1980). Lake Worth Inlet was originally called Lang's Inlet after August O. Lang, and was located at the site of the present inlet (Palm Beach County 1979). Lang was the first white resident of the lake country (Curl 1986). In the early 1860's, Lang dug a narrow trench through the beach ridge, permitting the fresh waters of Lake Worth to rush through and cut an inlet and lowering the lake to sea level (Vines 1970). The inlet later closed, was reopened, and closed again at least twice before later settlers in 1877 relocated the inlet farther north (Palm Beach County 1979).

In the summer of 1877, the local settlers met to work out some plan to either improve the inlet or dig a new one. The existing inlet "was becoming quite a nuisance; it was continually closing when most needed, and the settlers were tired of having to open it every few months" (Pierce 1970, p. 106). One week after the meeting, an appointed committee reported that the best place to cut the new inlet was close to the rock point (called the Black Rocks) about a mile north of the old inlet. The beach ridge was quite narrow for two or three hundred yards south of the point, and the rocks would form a natural jetty (Pierce 1970; South Florida Water Management District 1977).

It took 20 men several weeks to clear the hammock, haul away tree trunks, branches, and stumps, and remove sand with shovels and wheel barrows. The inlet was then ready to open, and when the wind, sea, and tide were favorable, the last few feet of sand was quickly dug out with hoes and shovels. Within 24 hours, ocean water poured through, deepening and widening the inlet every hour (Pierce 1970).

The new location also proved unstable, and the inlet was prone to closing. Early in 1889, after a heavy storm and high seas, Lake Worth Inlet closed (Pierce 1970). The settlers depended on the inlet to ship vegetables out and bring store supplies in, since hauling over land by wagon was not feasible. They decided to open the inlet again near the Black Rocks. "As long as it was near the rocks the inlet was one of the best on the lower east coast, but it kept wearing away on the south bank until at the time of its closing it was nearly a mile south" of its former location (Pierce 1970, p. 222). At this distance, the rocks did not provide any protection in heavy ground swell from the north, and so it closed. The settlers worked together again to help "create an inlet on a grander scale than anyone at that time had dreamed" (Pierce 1970, p. 223). When they finished, the inlet was more than a hundred yards wide (Pierce 1970); but it was still far from stable (figure 3).

In 1893, Henry Flagler had the inlet enlarged. In 1905, Flagler said he would contribute funds toward reopening the inlet (Historical Society of Palm Beach County). Local requests for inlet improvements in 1912 found an unfavorable response by the federal government (Tropical Sun 1913).

In 1915, the Lake Worth Inlet District (later called the Port of Palm Beach District) was chartered by the Florida State Legislature. One year later, the public voted overwhelmingly to open the inlet (Knott 1980). Isham Randolph, the well-known engineer who had successfully reversed the flow of the Chicago River, conducted the survey to locate the present inlet. He selected the site of the Old

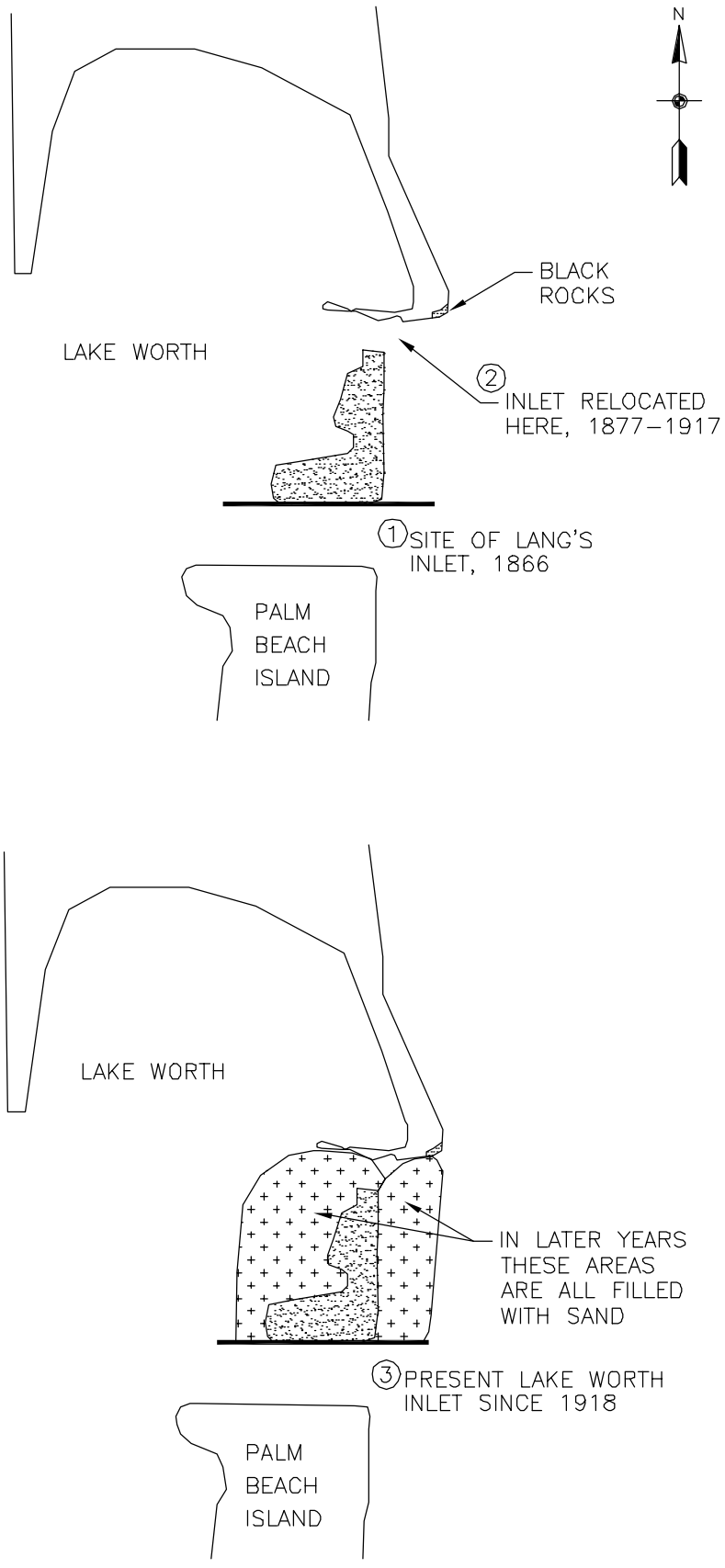

Figure 3. Present and former locations of Lake Worth Inlet (adapted from the Historical Society of Palm Beach County inlet files).

Lang's Inlet (Knott 1980). By 1917 the Port's entrance was opened with two short jetties and a low water level of just four feet (Knott 1980). Farmers and businessmen saw that the digging of the inlet would provide better shipping facilities for the enormous quantities of produce from the rich farming lands (Palm Beach Post 1917). In 1919, the channel was widened to 100-200 feet; the main channel was widened to 100 feet and dredged to ten feet at low tide.

In 1920, "real" jetties were built, and the channel was deepened to 12 feet. In 1923 the inlet was dredged to 16 feet, and the jetties were extended (Knott 1980) . All jetty construction was completed by 1925 (U.S. Army Corps of Engineers 1988) under the supervision of consulting engineer General George Goethals, builder of the Panama Canal. In September 1926, the inlet was dredged to 18 feet by Waldeck-Deal Dredging Company, and the jetty was extended out to a water depth of 21 feet (Palm Beach Post 1926). A few months later Waldeck-Deal removed 60,000 cubic yards of rock from the mouth of the inlet (Palm Beach Post 1927).

The Florida boom turned to bust in 1929, and the port development was set back 15 years (Knott 1980). In 1935, the federal government took over. In the next four years, additional jetty rocks and boulders were put in place, concrete caps were added to each jetty, and the channel was deepened to 20 feet (U.S. Army Corps of Engineers 1988; Knott 1980).

By 1941, the federal government had completed restoration of jetties, revetment of banks, widening of channels, and enlargement of the turning basin (U.S. Army Corps of Engineers 1988, p. 6). The inlet was dredged to 27 feet in 1948.

In 1965 continued deepening of the inlet to 33 feet met with some resistance (Ralls 1965). The residents of Palm Beach had already spent millions to protect their eroding properties, and a deeper inlet would only trap more sand, leaving even less for the downdrift beaches. In addition, deepening the inlet might be unnecessary if the Florida Power & Light Company continued to shift to natural gas and atomic power and away from oil--the port's main import. The inlet was dredged to 35 feet in 1967. Present depth of the inlet is maintained at 35 feet.

Stabilization of Lake Worth Inlet has resulted in the interruption of littoral drift which, in turn, caused the retreat of the shoreline south of the inlet. Studies completed by the Corps of Engineers in 1946 indicated erosion occurring along 8.5 miles of shorefront south of the Lake Worth Inlet south jetty.

Following a feasibility study, a sand transfer plant was installed on the north side of the north jetty in 1957-58 at a total cost of $544,539. The facility began operation in August 1958, pumping sand south across the inlet and depositing it on the downdrift beach.

In 1985, the Corps of Engineers "sand tightened" the south jetty by filling the spaces between the rocks with grout to prevent the transport of bypassed sand through the

jetty and back into the inlet. More rocks were also added to the south jetty.

The sand transfer plant at Lake Worth Inlet continued to function until 1990. It was shut down when the transfer pipe, which lay in a trench along the inlet floor, rusted through. The pipe had been damaged more than once by inlet dredging projects. Each time the pipe was re-welded, but the rust damage forced a modification (Palm Beach County Environmental Resources Management staff, pers. comm.). In May 1996, Counties Corporation completed directional drilling under Lake Worth Inlet to place pipeline from the sand transfer plant approximately 15 feet below the inlet floor. The sand transfer plant itself was upgraded in 1995, including installation of a more powerful engine and pump (from 525 horsepower at 5000 gallons per minute to 585 horsepower at 7200 gallons per minute). After 6 years of inactivity, the sand transfer plant was functioning again in May 1996. The average pumping rate increased from150 cubic yards per minute to 250 cubic yards per minute (Table 1).

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Table 1. Lake Worth Inlet Sand Transfer Plant

Fiscal Year	Total Cost	Total Cubic Yards	Cost/Cubic Yard
1985 - 1986	$ 121,269	102,300	$ 1.19
1986 - 1997	111,337	76,200	1.46
1997 - 1988	346,701	105,750	3.28
1988 - 1989	360,057	77,100	4.67
1989 - 1990	334,488	71,550	4.67
1990 - 1991	PLANT		
1991 - 1992			
1992 - 1993		WAS NOT	
1993 - 1994			
1994 - 1995			OPERATING
1995 - 1996	149,841	92,125	1.63
1996 - 1997	174,515	222,500	.79
1997 - 1998	151,654	66,125	2.29
1998 - 1999	137,022	64,500	2.12
1999 - 2000	182,511	220,250	.83

NOTE: For the 10 year period that the plant was operating, the cost per cubic yard ranged from a high of $4.67/c.y. to a low of $.79/ c.y. The average cost per cubic yard over the 10 year period is $2.29/c.y.

The cost of operation ranged from a high of $360,057 to a low of $111,337 per year. The total cost of operation for the 10 year period was $2,069,395, with an average cost of $206,939 per year.

The cubic yards transferred ranged from a high of 222,500 to a low of 64,500. The total cubic yards transferred for the 10 year period was 1,098,400. The average cubic yards transferred per year is 109,840.

It should be noted that this plant was upgraded in 1995. Upgrading included larger intake and discharge lines (from 12"/10" to14"/12") and a more powerful engine and pump (from 525 HP @ 5000 gpm to 585 HP @ 7200 gpm). The estimated pumping rate went from 150 cy/h to 250 cy/h. Since that time, the average cost per cubic yard has dropped to $1.53/cy. The average annual cost of operation has decreased to $159,108 per year and the average cubic yards transferred per year increased to 133,100.

SOUTH LAKE WORTH INLET

As early as 1913, citizens were discussing the idea of cutting another inlet in the southern part of Lake Worth (Tropical Sun 1913). The favored site of the inlet was about two miles north of the Boynton Beach Hotel (on AIA at Ocean Avenue), where the distance between the lake and the ocean was only 250 feet (Palm Beach Post 1992; Linehan 1980). The plan called for jetties 300 feet apart. Salt water was supposed to rush through tubes 25 feet wide and 15 feet high, and on an outgoing tide polluted water from the lake would flow into the ocean.

In 1915, the Legislature of the State of Florida approved an act to create a Special Taxing District in Palm Beach County known as the South Lake Worth Inlet District. The act granted the Board of Commissioners of this taxing district the authority to construct and maintain an inlet connecting the waters of south Lake Worth to the Atlantic Ocean. The inlet was deemed necessary for shipping and transportation, but primarily for health and sanitation purposes because water quality in Lake Worth was declining.

The United State Army Corps of Engineers issued a permit in April 1924, authorizing the District to construct the inlet at South Lake Worth. Precasting of concrete block began at the site in February, 1925, and in July of that year work crews started building the north jetty. The final cut was completed and the inlet initially opened in March 1927 (Karl Riddle, Engineer for the District, personal notes). Strock (1983) reported that the original jetties were constructed to an elevation of 5 feet mean low water (MLW) and extended approximately 350 feet from the centerline of Highway AlA. The channel was excavated to a width of 130 feet and a depth of 8 feet mean low water (MLW).

Watts (1953) suggests that due to a predominantly southward longshore transport, sand quickly filled the impounding area along the north jetty. The drift worked its way around the jetty, and tidal currents transported the sand inside the inlet, forming a large flood shoal . During this period of accretion along the north side of the inlet and accumulation of sand inside Lake Worth, the south side was sediment-starved, and the downdrift beaches eroded (Bruun et al 1966).

In 1932, a homeowner in Ocean Ridge recognized the potential erosional impacts along his property south of the inlet and constructed a protective seawall 2000 feet long known as the "McCormick wall". Erosion continued south of the inlet, and shortly after construction of the seawall, McCormick built seven groins to support the wall and protect it from being undermined. The volume of sand reaching the beaches south of the inlet, however, was so small that the groins were essentially ineffective, and the downdrift shoreline continued to recede. (Caldwell (1950) indicated that the groins were constructed in 1936; however, photographic records show that they existed prior to 1934).

According to an oral history interview with Glen Murray (Nichols 1979), AlA was extended through the Boynton Beach area in 1916 or 1917, and construction of the McCormick seawall followed. However, according to Murray, the seawall did not last long. It is possible that the seawall he refers to is the old wooden bulkhead visible today; the one constructed in 1932 is concrete.

By 1936, sand was spilling around the north jetty into the inlet creating significant shoaling problems inside south

Lake Worth. It then became necessary to raise the north and south jetties to a top elevation of 12 feet MLW (Strock 1983).

South Lake Worth Inlet Sand Transfer Plant

To help alleviate downdrift erosion, McCormick and the inlet district constructed a fixed sand transfer plant on the north jetty in 1937, the first such plant ever constructed. The original plant consisted of an 8-inch suction line connected to a 6-inch 65-horsepower centrifugal pump and 1200 feet of 6-inch discharge line. The pumping capacity was estimated at 55 cubic yards per hour (cy/hr) (Caldwell 1950). Within 6 months, a protective beach 120 feet wide fronted the McCormick seawall I. By 1942, the groins constructed prior to pump installation were filled to capacity and were buried by sand at some locations. The rate of shoaling inside Lake Worth had also decreased (Watts 1953). The transfer plant operated from 1937 through 1941 at a reported average rate of 50,400 cubic yards per year (cy/yr) (Caldwell 1950).

The sand transfer plant was shut down in 1942 as a result of fuel shortages during World War II. Accordingly, severe erosion occurred along the south beaches, and shoaling inside Lake Worth threatened to close the inlet. In 1945 the Inlet District resumed operation of the sand bypassing plant.

Despite the continuation of bypassing in 1945, large quantities of sand continued to accumulate inside Lake Worth. As a result, improvements were made to the sand transfer system in June 1948. Improvements included a 10-inch intake hose mounted on a swinging boom with a 30 ft radius. The intake was connected to an 8-inch centrifugal pump driven by a 300-horsepower motor. An 8-inch discharge line extended across the bridge and to the south shore. The average pumping rate of the improved system increased to 76 cy/hr (Watts 1953). From 1945 through 1951, the average bypassing rate was 74,150 cy/yr. The average rate from 1961 through 1966 was 46,900 cy/yr (Strock 1983).

Interior shoaling, however, continued to decrease tidal flow through the inlet, causing hazardous navigational conditions. In an effort to channelize the sand accumulation, a training wall was constructed in 1953 along the north side of the inlet into Lake Worth (Strock 1983).

Dredging of the interior shoals probably began in 1948; however, data prior to the 1960's are incomplete. Review of the 1926-1953 inlet budget records led Strock (1983) to conclude that interior dredging was funded from 1948 through 1952. The quantity and fate of the dredged material are unknown. The only notable fill placed along the lake's shoreline during these years was a small fillet south of the inlet, and it appears that this was reclaimed from shoaled sand adjacent to the shoreline and south of the west entrance channel. The 1948-1952 inlet shoal material may have been bypassed to the south beaches, or less likely, sidecast southward of the west entrance channel.

Between 1953 and 1961, interior dredging records are unavailable. However, by 1955, Beer Can Island (north of the west entrance channel) had more than doubled in size. The island's increase in size might have been attributable to sidecast disposal from maintenance of the channel. Additionally, by 1959, private interests had completed virtually all of the very significant fill projects along the lake's shoreline south of the inlet. The likely source of the fill material was excavation of the lake bed and inlet's interior shoals.

Dredging of the interior shoals and disposal to the south beach began in 1961 and continued through 1969 at an average rate of 42,600 cy/yr. This rate was likely in excess of the interior deposition rate because residual (pre-1961) material was probably still being excavated (Strock 1983).

In 1964, the University of Florida completed an engineering study which recommended improvements to the inlet and bypass system in order to decrease shoaling rates inside Lake Worth and increase the hydraulic efficiency of the inlet (Univ. of Florida 1964).

Based in part upon the findings of the 1964 University of Florida study and recommendations by Bruun (1965) and Bruun et al (1966), several modifications to the inlet and sand transfer plant were completed in 1967. These included a 410 ft curved extension to the north jetty, a 65 ft extension to the south jetty, and the addition of a training wall on the south side of the inlet into Lake Worth. Changes incorporated into the sand transfer system included shifting the plant 118 feet seaward, as well as increasing the size and capacity of the system to a 10-inch pump with a 400-horsepower engine (Strock 1983). It is noted, however, that Bruun (1966) recommended construction of a mobile bypassing plant with a boom length of at least 50 feet in order to meet a predicted 60% increase in bypassing requirements. Instead, the relocated plant remained fixed with a boom length of only 35 feet.

Portions of the north jetty were sealed, and a spur was constructed on the north jetty east of the bypassing plant in 1971 (Marino and Mehta 1986). The bridge spanning the inlet was rebuilt in 1974.

The sand transfer system consisted of a 12-inch suction intake and 10-inch discharge line, which was driven by a 400 horsepower diesel engine. The engine was rated to pump 4000 gallons per minute with up to 20 percent solids in suspension. The discharge line extends across the bridge to a location approximately 700 feet south of the inlet. Two discharge points are located south of the inlet. In 1985, a production monitor, consisting of a nuclear density meter and a Doppler flow meter, was installed on the discharge line to determine the pumping capacity of the bypassing plant. Estimates of average plant productivity varied from about 125 cy/hr to 160 cy/hr.

Subsequent to the 1967 inlet modifications, the bypassing rate of the fixed plant averaged about 70,000 cy/yr. Interior shoaling was successfully reduced, and bypassing from the shoals has occurred only twice since 1973. The total volume placed upon the south beach from the inlet's interior trap was between 50,000 cy and 70,000 cy since 1973.

Figure 4 depicts modifications and improvements at the inlet as of 1990. The sand transfer plant then transferred an average of about 60,000 cubic yards of sand per year. It was operated by the Inlet District until May 1996, when Governor Lawton Chiles abolished the taxing district. Palm Beach County now operates the plant and manages the inlet.

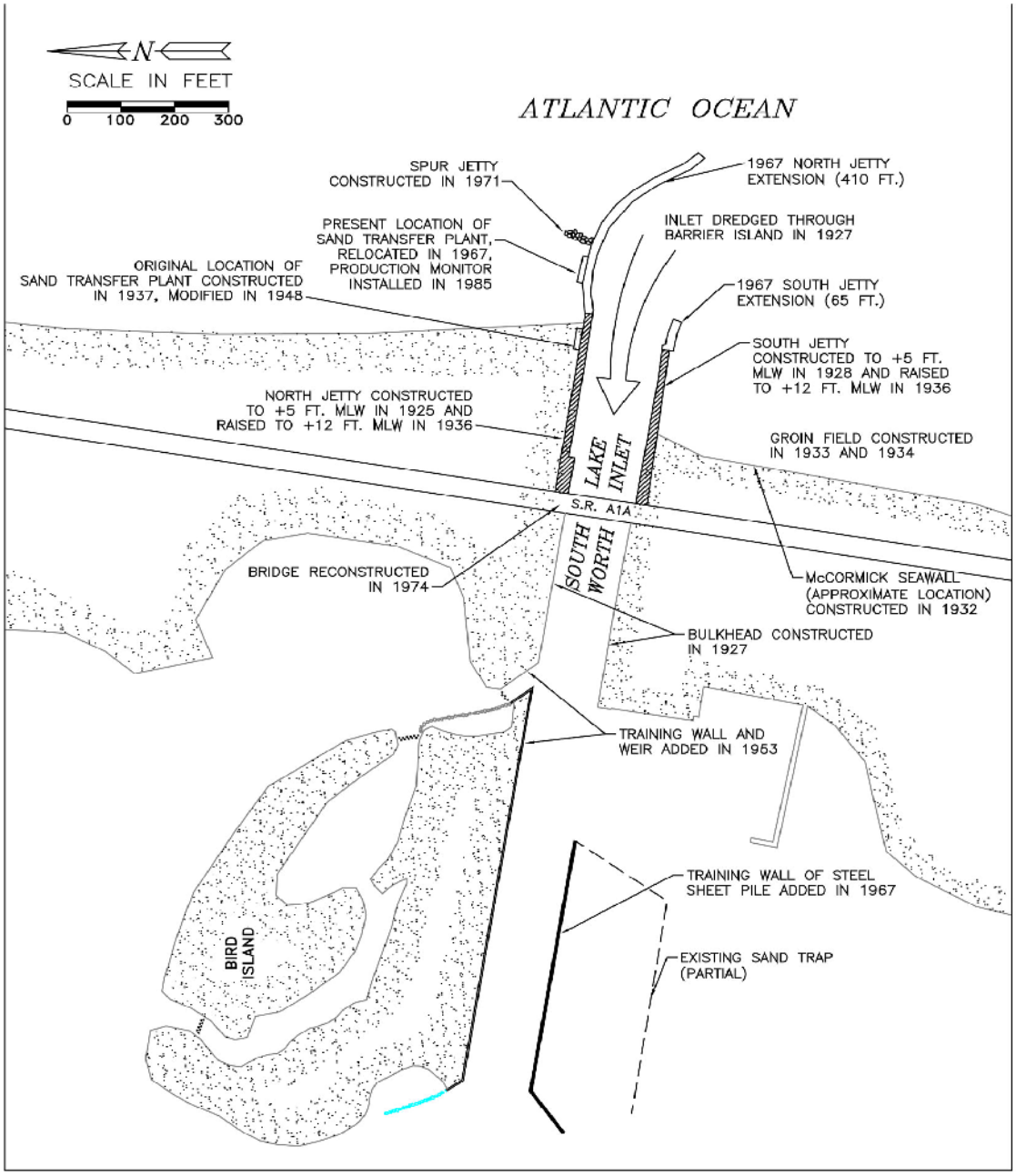

Figure 4. Overview of improvements to South Lake Worth Inlet

In the mid-1990's, Bird Island Trust hired Murray Logan Construction to conduct an enhancement project on Beer Can Island inside the inlet; it is now referred to as Bird Island. Australian pine trees and other exotics were replaced with native vegetation, and a least tern rookery was created.

Palm Beach County constructed a groin field and beach project south of the inlet in May 1998 to help mitigate for the erosive effects of the inlet. Also in 1998, the sand transfer plant engine was replaced with a 575 horsepower engine and the sand transfer capacity was increased to 200 cubic yards per hour (Table 2). Palm Beach County is in the design phase of replacing the sand transfer plant, which will include adding a third discharge point south of the two existing discharge points.

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Table 2. South Lake Worth Inlet Sand Transfer Plant

Fiscal Year	Total Cost	Total Cubic Yards	Cost/Cubic Yard
1985 - 1986	$ 95,315	71,070	$ 1.34
1986 - 1997	90,268	61,740	1.46
1997 - 1988	124,276	72,645	1.71
1988 - 1989	117,428	44,295	2.65
1989 - 1990	101,802	37,515	2.71
1990 - 1991	109,269	33,480	3.26
1991 - 1992	121,523	23,775	5.11
1992 - 1993	146,413	42,900	3.41
1993 - 1994	173,093	32,320	5.36
1994 - 1995	174,799	40,160	4.35
1995 - 1996	180,441	31,760	5.68
1996 - 1997	175,634	63,360	2.77
1997 - 1998	241,089	25,720	9.37
1998 - 1999	163,489	40,907	4.00
1999 - 2000	179,583	68,000	2.64

NOTE: For the 15 year period the cost per cubic yard ranged from a high of $9.37/c.y. to a low of $1.34/ c.y. The average cost per cubic yard over the 15 year period is $3.72/c.y.

The cost of operation per year ranged from a high of $241,089 to a low of $90,268. The cost of operation for the 15 year period was $2,194,422, with an average cost of $146,295 per year.

The cubic yards transferred ranged from a high of 71,070 to a low of 23,775. The total cubic yards transferred for the 15 year period was 689,647. The average cubic yards transferred per year is 45,976.

It should be noted that the highest total cubic yards transferred in one year (71,070) had the least cost per cubic yard ($1.34). The second lowest total cubic yards transferred in one year (25,720) had the highest cost per cubic yard ($9.37).

BOCA RATON INLET

Boca Raton Inlet is the southernmost inlet in Palm Beach County. Originally a natural waterway, the inlet has changed locations at least three times in the past 200 years (Bream 1990). In the late 1760's, the inlet was located in the northeast corner of the present Lake Boca Raton (figure 5). By the 1800's, the inlet had closed at its northern location and reopened in the southeast corner of the lake. Both inlet locations had opened and closed constantly with drifting sands. The Mackay-Blake map of Florida published in 1840 shows that there was no inlet at Boca Raton at that time (Austin 1976). When Florida became a state in 1845, the Bruff map included no inlet at Boca Raton; historical records even as late as 1914 showed no inlet (Austin 1976).

A map from the 1740's named the inlet Rio Seco, or Dry River (Austin 1976). In a map published in 1775, surveyor Bernard Romans agreed that Rio Seco was in fact this inlet. The waterway was not called Boca Raton Inlet until after 1838. Another inlet far down the coast at the north end of Biscayne Bay was named Boca Ratones (or Boca de Ratones) according to maps by De Brahm in the 1770's. The inlet has been named by the Spaniards, not for rats as is commonly thought, but for the sharp, submerged rocks found off the Atlantic entrance to the passage (Chardon 1975). The inlet was closed by 1822 by infilling sand, and by 1838 another inlet had opened to the south. This new inlet was called Boca Ratones by some, and Narrows Cut or Norris Cut by others. According to Chardon (1975), the issue was incorrectly resolved by giving the name Boca Ratones to a third inlet much farther north in present south Palm Beach County.

Engineering drawings by the Riddle Company in 1925 placed the proposed inlet location about 800 feet north of its former location and oriented east-west, stabilized by 400 foot jetties 200 feet apart. That site was dredged in 1926 (Boca Raton Historical Society).

The War Department authorized Spanish River Land Company on September 3, 1930 "to construct jetties and revetment, dredging and filling in Boca Raton Inlet" (Boca Raton Historical Society) . In 1930-31, local interests financed the construction of two parallel jetties at a cost of $130,000 in an attempt to solve the beach erosion problem (Strock 1979). From 1940-1945 the Army Air Force dredged 14,700 cubic yards of material from the channel. In the late 1940's 11,000 cu yd of material was dredged from the inlet and placed on the south beach.

In 1947, a hurricane destroyed the north jetty permitting sand and silt to clog the inlet (Delray News-Journal 1956). In 1951, Mr. J. M. Schine, then owner of the Boca Raton Hotel, had offered to donate land to either side of the inlet if the city would agree to repair the jetties. The city had to decline the offer because of a lack of funds to repair the jetties. Local interests spent $8,000 for repair of the damaged jetties and maintenance dredging of the inlet (Strock 1979). Repeated dredging gave only temporary relief until 1956 when new improvements were expected to remedy the situation. By then the inlet was largely blocked, making navigation hazardous and polluting the lake and the Intracoastal Waterway. In July 1956, the inlet was widened, and the inlet and Lake Boca Raton were deepened to 10 feet. Work also included rebuilding the north side of the jetty and capping the south side (Delray News-Journal 1956).

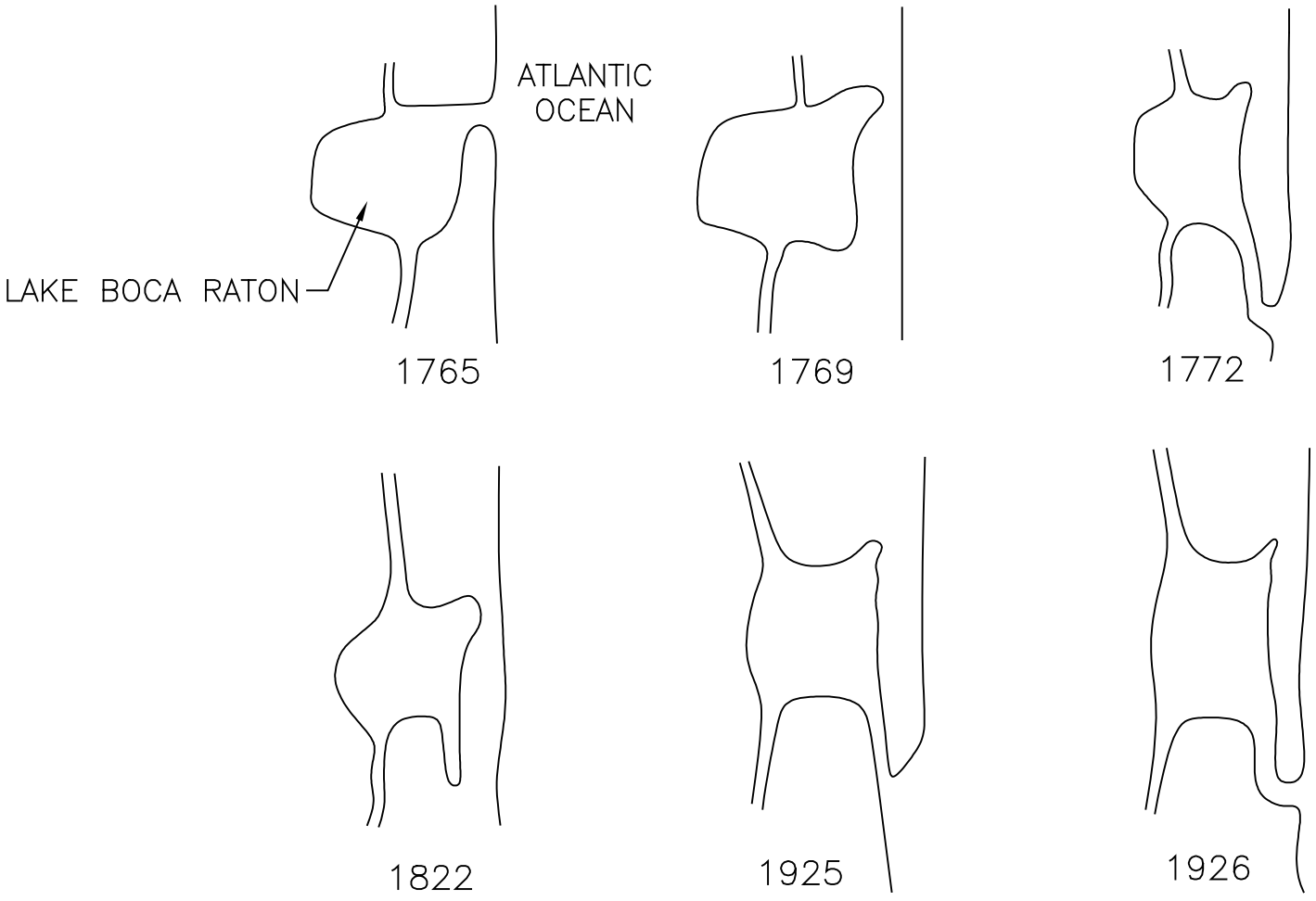

Figure 5. Migration of Boca Raton Inlet over more than 200 years (adapted from Boca Raton Historical Society Spanish River Papers, 1981).

For nearly 20 years, city agencies had come and gone, the problem of the inlet had been studied and re-studied, and part-way measures had been taken, but no solution had been found (Boca Raton News 1966). Early in 1966, the U.S. Army Corps of Engineers turned down a proposal for federal funding of a sand transfer system across the inlet because "benefit would not be sufficient to justify the costs" (Boca Raton News 1966).

A northeaster plugged the inlet during the 1966 Thanksgiving weekend (Boca Raton News 1966). Wind had blown sand over the jetty from the adjoining beach, and waves were high enough to break over the jetty, carrying even more sand directly into the inlet. Sand was also carried into the mouth of the inlet from the ocean. A sand bar formed all the way across the inlet and three feet above the high tide mark (Boca Raton News 1966). Weeds and trash were backing up for hundreds of feet. All flood water had to leave the Intracoastal through Hillsboro Inlet (which was also partially closed) or South Lake Worth Inlet. Dredging operations successfully reopened the inlet sometime before Christmas that year, with a small channel three feet deep and 15-20 feet wide.

After the inlet was reopened in December 1966, another storm hit and plugged the inlet. Following much debated over what to do, city workmen began work to reopen the inlet on February 1, 1967 (Rifenburg 1968). Water trickled through the inlet during the summer of 1967.

In the winter of 1967, high winds again put a sand bar across the mouth of the passage. After the Boca Raton News reported that the stagnant waters of Lake Boca Raton were indeed polluted, the city quickly ordered the inlet opened one more time. It was not, however, dredged to depths navigable for large boats (Rifenburg 1968).

The first phase of a three phase inlet program would fund the repairs and extension of the north jetty and dredging. Eventual completion of the program would apparently remedy a situation that had been a source of irritation for citizens, developers, and city officials for many years (Rifenburg 1968).

In April 1969, Arvida Corporation dredged the inlet open. It took 11 days to complete the 150 feet wide channel . Again, in February 1970, Arvida dredged the inlet; but this time, because of stormy weather, it took seven weeks to dig a channel 75 feet wide and six feet deep (Arvida 1970).

In 1972, the inlet, its jetties, and maintenance access easements were deeded to the City of Boca Raton with the stipulation that the inlet be kept navigable (Strock 1979). The city purchased an 8-inch hydraulic pipeline dredge to maintain the inlet and transfer beach material to the beach south of the inlet.

The Boca Raton Inlet Tax District was authorized in a bill passed by the Florida State Legislature April 20, 1972 and was submitted for approval by the people in a referendum July 18, 1972. The purpose was to have a body set up by law responsible to the public and with powers and duties clearly defined concerning inlet maintenance (Gallagher 1972). The bill was voted down.

In November 1972, the City purchased its own dredge for $112,000. The City also signed an agreement with Arvida, which owned the beach north and south of the inlet. The developer agreed to pay $10,000 per year until 1983 to have the inlet dredged (Rogers 1978). Since regular maintenance dredging began in 1972, the inlet has remained open (Morrissey 1992).

In 1975, the north jetty was extended 180 feet seaward and the south jetty was reinforced; flanking of the south jetty began, the horseshoe bar was eliminated, and shoaling in the inlet was reduced (figure 6). In 1977 and 1978, the city spent $71,300 to dredge the waterway (Rogers 1978). In 1980, a weir section 65 feet long was constructed in the north jetty to allow a portion of the sand accreting on the north beach to be transported south. The south jetty was extended landward to prevent flanking. Dredging operations placed 297,000 cubic yards of material on the south beach in 1985. Most of the sand was taken from the ebb shoal.

Today the entrance channel is approximately 150 feet wide and 10 feet deep. The north jetty is 650 feet long with a 65 foot weir section two-thirds of the way seaward. The south jetty is 800 feet long. The City of Boca Raton operates a dredge to bypass material from inside the inlet to the south beach. The City has transferred an average of 55,000 cubic yards of material per year to the downdrift beaches since 1980.

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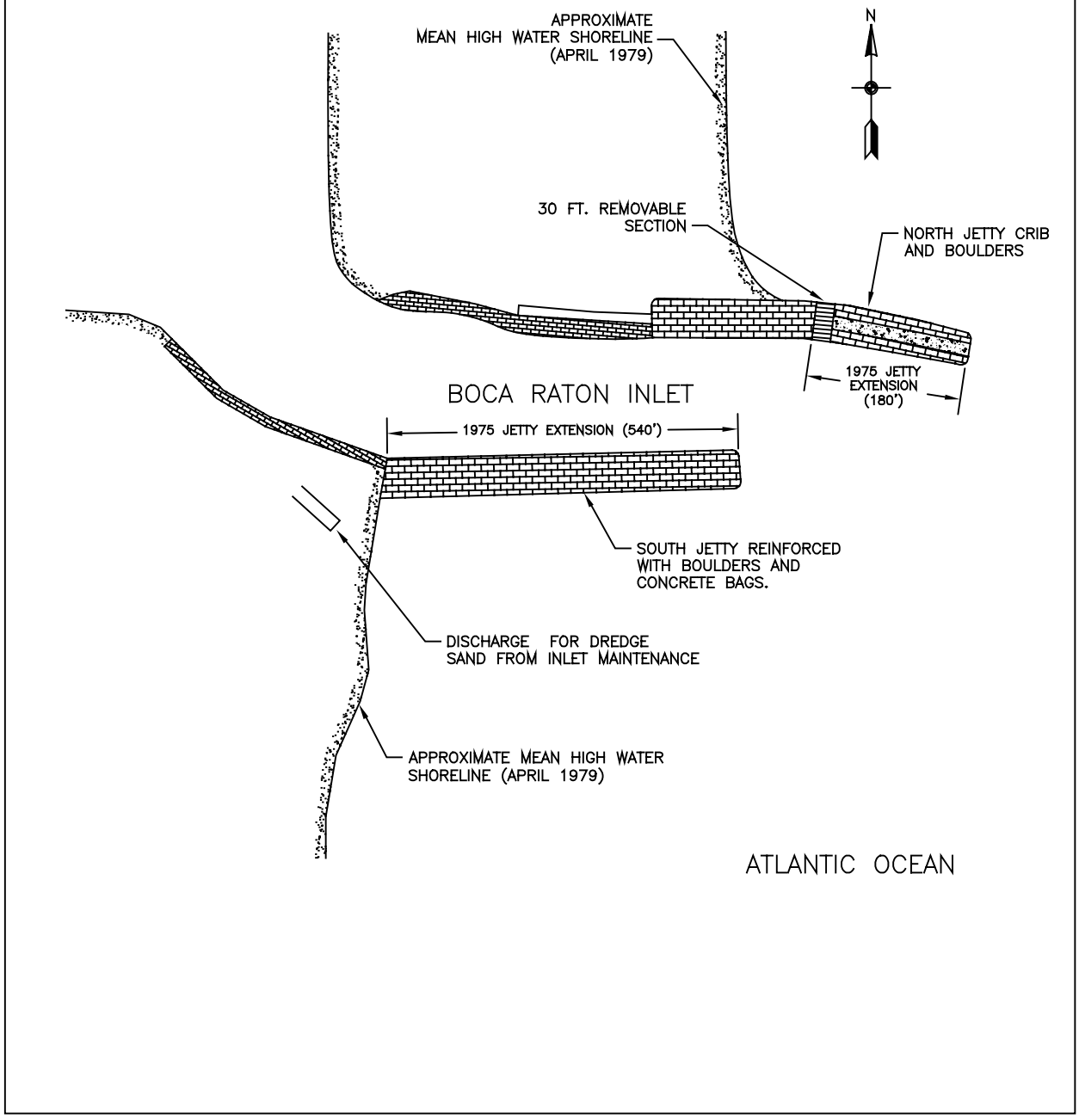

Figure 6. Boca Raton Inlet jetty improvements and adjacent shoreline

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