



## TECHNICAL COMMUNICATION

## Beach Replenishment Activities on U.S. Continental Pacific Coast

T.D. Clayton<sup>†</sup>

Program for The Study of Developed Shorelines

Department of Geology

Duke University

Durham, NC 27708 U.S.A.

### ABSTRACT

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### INTRODUCTION

Beach replenishment, the creation and maintenance (nourishment) of artificial beaches is gaining popularity as a way to both stabilize a receding shoreline (thereby protecting ocean-front buildings in place) and maintain a recreational and protective sandy beach. Unfortunately, little field data has been systematically and consistently collected and analyzed on the performance of artificial beaches *in toto* (STAUBLE and HOEL, 1986; PILKEY and CLAYTON, 1987). Such analyses could yield important information on fundamental principles of coastal processes and provide a sound basis for cost/benefit evaluations of proposed beach erosion control projects utilizing artificial beach replenishment.

In an effort to gather together and evaluate data that has been collected, analyzed, and published, the Duke University Department of Geology's Program for the Study of Developed Shorelines conducted an historical survey of

beach replenishment on the U.S. Atlantic Coast (PILKEY and CLAYTON, 1987; PILKEY and CLAYTON, 1989) and Gulf of Mexico coast (DIXON and PILKEY, 1990), and an analysis of those results (LEONARD, 1988; LEONARD *et al.*, 1989a, 1989b, 1990; DIXON, 1988; DIXON and PILKEY, 1989).

This Pacific coast information is the product of an extension of those earlier studies. The data of this report were gathered from interviews of government officials and local scientists, media reports, and a wide variety of government reports, including Congressional documents and U.S. Army Corps of Engineers Annual Reports, as well as published technical literature. A brief, qualitative overview of many of the projects listed in this table is given in CLAYTON (1989).

### DATA TABLE

Table 1 contains the following information: location of the replenishment operation; date of the operation; "type" (*i.e.*, purpose); physical dimensions; cost; immediate effect; eventual fate; and sources of primary information. The information is current through 1987. Updates

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<sup>†</sup>Present address: Department of Marine Science, University of South Florida, St. Petersburg, FL 33701.

Table 1. Beach replenishment projects on U.S. Pacific Coast.  
 "Type" refers to purpose of sand emplacement (see explanation in text): N = byproduct of navigation project; HC = Harbor Construction; HB = Harbor Bypassing; BR = Beach Restoration; BW = Beach Widening; BEC = Beach Erosion Control; R = Recreational Beach; E = Emergency; U = Upland excavation spoils; FC = Flood Control project spoils. "Immediate Effect" refers to the immediate effect of the sand emplacement (i.e., the initial fill dimensions). "Eventual Fate" refers to subsequent behavior of the fill. The year cited refers to the year in which the noted observation was made or reported.

Table 1.

LOCATION	DATE	TYPE	VOLUME (cu yd)	LENGTH (mi)	COST (\$)	IMMEDIATE EFFECT	EVENTUAL FATE	REFERENCES
LaPush, WA	Every 2 years	N				Spoil is dumped on face of revetment on adjacent spit.	Due to high wave energy, sand quickly moves off the dump site, especially in conjunction with winter storms.	Clayton, 1989
Crescent City, CA	Every few years	HB	~3,500					Armstrong, 1987
Bolinas Bay, CA		BEC (groin repair)	~65,000					Armstrong, 1987
Ocean Beach, CA		U	All spoil from excavation for San Francisco sewage disposal "box"				Washed away in 1982-83 storms.	Armstrong, 1987
Seabright Beach, CA		HB						Griggs & Savoy, 1986
Twin Lakes Beach, CA		HB					Sand moves downcoast. Downcoast beach dependent on harbor bypassing.	CA Dept. Nav. and Ocean Dev., 1977a Armstrong, 1987
Capitola, CA	1970	BR (by city)	~20,000		146,100 (includes 1 groin)		1977: Has proven effective.	CA Dept. Nav. and Ocean Dev., 1976
Morro Bay, CA	1941-1943 1942-1946 1949 1964 1968 1971 1974? 1982 1985 1987 yearly	HC	1,000,000 3,071,000 822,000 702,000 406,000 190,000	0.7	155,000		1986: Beach removed by major storm waves $\geq 3 \times$ (1970-86); returned by northwesterly waves. 1987: Beach present.	CA Dept. Nav. and Ocean Dev., 1977a Griggs & Savoy, 1986 Shaw, 1980 Hall, 1962 U.S. Army Corps of Engineers, Los Angeles District, 1974a
East Beach, CA	1935 1938	HB HB	~120,000 cu yd 202,000 584,700	0.4 0.2	26,250 122,787	Deposited in ~20 ft water depth, 1000 ft offshore. Beach ~500 ft wide.	Lost within 2 years Sand flows south to "reef" then is directed offshore. Little storm recovery observed. 1986: Did not migrate ashore. Bar still visible on navigation charts. 1938: Sand moved downcoast (east) more slowly than expected due to unusually light wave activity. 1940: Sand had moved out of disposal area.	Sears, 1987 Converse, 1982 Armstrong, 1987 Sears, 1987 Griggs & Savoy, 1986 Hall, 1962 O'Brien, 1938 U.S. Army Corps of Engineers, Coastal Engineering Research Center, 1984 O'Brien, 1940 U.S. Army Corps of Engineers, Los Angeles District, 1986a

Year	Location	Project	Cost	Volume	Notes	Agency
1940		HB	697,700	0.5		U.S. Army Corps of Engineers, Los Angeles District, 1986a
1942		HB	600,110	1.0	131,424	Hall, 1952
1945		HB	717,773	1.0	170,112	Hall, 1952
1947		HB	642,977	1.0	109,306	Hall, 1952
1949		HB	638,152	1.0	122,525	Hall, 1952
1950-1952 (biennial)		HB	2,476,098			Shaw, 1980
1954-1972 (periodically)		HB				U.S. Army Corps of Engineers, Coastal Engineering Research Center, 1984
1972		HB	229,333			Shaw, 1980
1974		HB	388,000			Shaw, 1980
1975		HB	50,667			Shaw, 1980
1976		HB	402,667			Shaw, 1980
1977		HB	342,667			Shaw, 1980
1970	McGrath Beach, CA	HB	249,333			1986: Bypassing program effectively checked erosion, but did not restore anything that had previously eroded. In most areas, beaches did not recover full width. Shaw, 1980
1970	McGrath Beach, CA	HB	249,333			Shaw, 1980
1971	McGrath Beach, CA	HB	942,667			Shaw, 1980
1973	McGrath Beach, CA	HB	764,000			Shaw, 1980
1974	McGrath Beach, CA	HB	326,667			Shaw, 1980
1975	McGrath Beach, CA	HB	154,667			Shaw, 1980
1977	McGrath Beach, CA	HB	764,000			Shaw, 1980
1962	San Buenaventura Beach, CA	BEC (groin project)	197,500	~1.4	Beach 139-261 ft wide	1977: Effect of bypassing overshadowed by extremely high sediment flows in Santa Clara River. Migrated south, impounding on north side of groins. U.S. Army Corps of Engineers, Los Angeles District, 1976
1963		BEC (groin project)	633,333		Beach 150-170 ft wide	Shaw, 1980
1965		BEC (groin project)	235,000	0.5		Shaw, 1980
1967		SEC (groin project)	449,800	1.0	Beach 130-200 ft wide	U.S. Army Corps of Engineers, Los Angeles District, 1976
1976		HB			2,157,000 (7 groins plus sand fill)	U.S. Army Corps of Engineers, Los Angeles District, 1976
Occasionally	Silver Strand, CA	HB	200,000 cy/yr			1987: Current bypassing program has problems
1940	Port Hueneme, CA	HC (Port Hueneme)	1,360,000	0.8	295,800	1966: Beach > 500 ft wide
					Widened beach ~450 ft	Herron & Harris, 1966
					No surveys made; loss rate unknown. Rapid recession of shoreline in some places back to and beyond 1988 location. W/in 3	Armstrong, 1987



1963	H	< 7,022,667					appears to be no serious erosion of downcoast beaches at this time.	Shaw, 1980
1976		10,667						Shaw, 1980
1936	U/BR	1,800,000	1.8	Fill width = 200 ft			1987: Sand is transported south past El Segundo & Manhattan Beaches.	Hall, 1952
Early 1980's	BW	750,000						Pratte, 1984
1939	BEC	150,000						Shaw, 1980
1943								U.S. Army Corps of Engineers, Los Angeles District, 1986a
1950		1,000,000	1.0	250,000			1986: Nullified downdrift erosion damage caused by Santa Monica breakwater & resultant. Today's beach is totally artificial & much wider than natural beach of 50 years ago.	Hall, 1952
1947-1948	U	14,000,000	~7	Widened beach to average width of 600-800 ft.			Initial losses were ~1M cy/yr. Subsequently decreased. Combined effect of this fill plus subsequent smaller fills in a totally artificial beach from the general vicinity of the Santa Monica Canyon south to Redondo Beach, which is much wider than the natural beach of 50 yrs ago.	Johnson, 1950 Kenyon, 1960 U.S. Army Corps of Engineers, 1986a Clayton, 1989
1945	BR	140,000	0.6	10,500	Fill width = 75 ft		1949: Major portion of fill still in place	Johnson, 1950
1976		11,000					1952: Estimated life of fill = 10 yrs	Hall, 1952
1947	BR	57,000		\$7,000				Shaw, 1980
1956-1958	N/BEC							Hall, 1952
1968	BEC	1,405,961	1.2	1,500,000	Increased beach to average width of ~225 ft		Mid-1969: 30% had migrated north, causing accretion & shoaling at pier south of King Harbor.	U.S. Army Corps of Engineers, Los Angeles District, 1959b
1971		1,020,000 (groin & fill)		2,400,000			1970: Average width is 170 ft. First winter (1968-69), important losses occurred from above & below MLW. Sand moved to both north & south, creating shoaling problem at Redondo Harbor.	Shaw, 1980
1927	BR	500,000	0.2	100,000	Beach width: 200 ft		1981: After initial reshaping & construction of terminal groin (1970), the fill performed admirably.	U.S. Army Corps of Engineers, Los Angeles District, 1970
1948	BR	2,536,500	0.4	1,014,600	Beach width: 500 ft		1986: Destroyed in winter 1983 storms.	Saville, 1981
1964	N	1,226,667					1987: Sandy beach present Migrated east along breakwater & into harbor	Pipkin, 1986
							Migrated east along breakwater & into harbor. Also some offshore transport.	Hall, 1952
							Contained clay & cobbles. Originally formed cobble beach next to groin	Shaw, 1980
							Eventually, cobbles "shook down" & the sand migrated.	Hall, 1952
								Shaw, 1980
								U.S. Army Corps of Engineers, Los Angeles District, 1986a

Long Beach, CA	1942-43	BW/N	> 6,000,000	~4		1980: Beach stabilized by 1962 groin. 1986: Beach has remained stable. 1987: Beach is 250-300 ft wide & stable. 1988: Beach is in good condition	Kenyon, 1950 Herron, 1987 Kenyon, 1950 U.S. Army Corps of Engineers, Los Angeles District, 1986a Herron, 1987
	1945-46	N	800,000				
	1955	HC				1987: Beach is 250-300 ft wide & stable.	
Seal Beach, CA	1975-1985 1988	N	~2,025,670 800,000		Beach 300-1200 ft wide.		U.S. Army Corps of Engineers, Los Angeles District, 1980b U.S. Army Corps of Engineers, Los Angeles District, 1980a CA Dept of Nav. & Ocean Dev., 1976
	1980	BEC	250,000	1.0	286,000		U.S. Army Corps of Engineers, Los Angeles District, 1980a
	1966 1968		70,000				U.S. Army Corps of Engineers, Los Angeles District, no date Shaw, 1980 Marx, 1967
	Periodic nourishment					Successful. Protective beach has reached a state of stabilization requiring no beach replenishment. Eroded steadily. Within 2 yrs, another 1M cy was required. Eroded steadily. No more permanent than 1945 beach. Eroded steadily. 1961: Frequent inundation of 1st row of buildings	U.S. Army Corps of Engineers, Los Angeles District, 1980 Shaw, 1980 Marx, 1967 Marx, 1967 Shaw, 1980
Surfside-Sunset Beach, CA	1945		205,333				
	1947		1,245,333				
	1956		690,667				
	1961	E			Restored the beach buffer.		Marx, 1967 Shaw, 1980
	1964	BEC	4,000,000	1.7	2,082,000	1983-1986: Shifting of beach material to downcoast of Hilton Beach. Of the 4M cy placed, only 2,850,000 cy accounted for. 1989: Nourishes & stabilizes downcoast shore. Has controlled the erosion in this area.	U.S. Army Corps of Engineers, Los Angeles District, 1986b, 1980b U.S. Army Corps of Engineers, Los Angeles District, 1969, 1986b
	1971	BEC	2,364,000	1.1			U.S. Army Corps of Engineers, Los Angeles District, 1986b
	1979	BEC	1,664,000	1.7		Beach width: 500 ft.	U.S. Army Corps of Engineers, Los Angeles District, 1986b CA Dept. of Nav. & Ocean Dev., 1977a&b
	1985	BEC	2,293,000	1.1		Beach width: 480 ft.	U.S. Army Corps of Engineers, Los Angeles District, 1986a
						Periodic beach nourishment maintains beach stability.	



Year	Agency	BE/C	94,000	0.3	247,000 (groin & Beach width: 100-130 ft. fill)	0.9	713,000	840,000	365,000	128,000	125,000 906,667	204,000	255,000	10,000	1,605,000	220,000	46,000	1984	1944	1951-58	700,000	1,550,667	
1964	U.S. Army Corps of Engineers, Los Angeles District, 1978a CA Dept. of Nav. & Ocean Dev., 1976 Shaw, 1980	BEC	94,000	0.3	247,000 (groin & Beach width: 100-130 ft. fill)	0.9	713,000	840,000	365,000	128,000	125,000 906,667	204,000	255,000	10,000	1,605,000	220,000	46,000						
1966	CA Dept. of Nav. & Ocean Dev., 1976 U.S. Army Corps of Engineers, Los Angeles District, 1978a, 1986b Shaw, 1980	BEC	840,000	0.9	Intense runoff from San Juan Creek Dec. 1966 & Jan. 1967 caused groin to fail & at least 101 cy of impounded sand poured thru the stream channel & downcoast. Beach has been quite stable.																		
1969	U.S. Army Corps of Engineers, Los Angeles District, 1987b																						
1970	U.S. Army Corps of Engineers, Los Angeles District, 1987b Shaw, 1980																						
1970	U.S. Army Corps of Engineers, Los Angeles District 1987b																						
1964	U.S. Army Corps of Engineers, Los Angeles District, 1987b	U																					
1966	U.S. Army Corps of Engineers, Los Angeles District, 1987b	U																					
1967	U.S. Army Corps of Engineers, Los Angeles District, 1987b	U																					
1974	U.S. Army Corps of Engineers, Los Angeles District, 1987b																						
1977	U.S. Army Corps of Engineers, Los Angeles District, 1987b	U																					
1978	U.S. Army Corps of Engineers, Los Angeles District, 1987b	U																					
1984	Grove et al., 1987 U.S. Army Corps of Engineers, Los Angeles District, 1987b	Laydown pad released			1987: Sand hump migrated ~2m/day. Extremely rapid decay of volume (decrease to 1/2 every 200 days). Migrating hump preceded by erosion wave (8 km long in > 2 yrs). Sediment hump appeared to extend accretional influence only to a close vicinity, while erosional effect propagated many further time downcoast.																		
1944	U.S. Army Corps of Engineers, Los Angeles District, 1986a, 1987b	N			Held them for a year or two. Spoil contained cobbles, presently (1987) exposed on downcoast beaches.																		
1951-58	U.S. Army Corps of Engineers, Los Angeles District, 1960 Shaw, 1980	N/BEC			Fill started to move out of the area immediately. As of Dec. 1959 complete fill, plus ~300,000 cy of additional material, removed. A large portion migrated upcoast against the jetty & into the entrance channel.																		

San Onofre, CA

Oceanside, CA

1960	N	17,600		Eroded. Some sediment migrated north into entrance channel	U.S. Army Corps of Engineers, Los Angeles District, 1987b
1960	N	23,700		Eroded.	Shaw, 1980 U.S. Army Corps of Engineers, Los Angeles District, 1987b
1961	N	222,850		Eroded.	U.S. Army Corps of Engineers, Los Angeles District, 1987b
1961	N	265,333		Eroded 8-22 ft/yr in width.	Shaw, 1980
1963	BEC/HC (groin & fill)	265,333	3.3	Initially restored beach to pre-harbor configuration	U.S. Army Corps of Engineers, Coastal Engineering Research Center, 1984
				Erosion began immediately, leaving cobble dredge on beach permanently.	Moffatt & Nichol, 1983
				By 1968, the fill material was lost	Shaw, 1980 U.S. Army Corps of Engineers, Los Angeles District, 1987b
1966	HB	690,000	0.6	Eroded.	Shaw, 1980 U.S. Army Corps of Engineers, Los Angeles District, 1987b
1967	HB	177,900	0.3	Eroded.	Shaw, 1980 U.S. Army Corps of Engineers, Los Angeles District, 1987b
1968	HB	433,900	1.5	Eroded.	Shaw, 1980 U.S. Army Corps of Engineers, Los Angeles District, 1987b
1969	HB	353,000	0.8	Eroded.	Shaw, 1980 U.S. Army Corps of Engineers, Los Angeles District, 1987b
1971	HB	551,900	0.8	Eroded.	Shaw, 1980 U.S. Army Corps of Engineers, Los Angeles District, 1987b
1975	HB	559,750	0.8	Eroded.	Shaw, 1980 U.S. Army Corps of Engineers, Los Angeles District, 1987b
1976	HB	550,000	0.7	Eroded.	Shaw, 1980 U.S. Army Corps of Engineers, Los Angeles District, 1987b
Feb 1978	HB	318,550	0.7	Eroded in Feb. 1978 (storm). Cobbles thrown like artillery during storm.	Shaw, 1980 U.S. Army Corps of Engineers, Los Angeles District, 1987a, 1987b

1981	HB	463,000	1.6		Sand grain size was not coarse enough & an adequate amount of sand was not available to insure the safety of property in the area. Expected the fill to last 2-3 seasons. Had major storm. It lasted one season.	U.S. Army Corps of Engineers, Los Angeles District, 1987b
1982	HB/BEC	920,000		4,000,000	Minor storms of Nov. & Dec. 1982 shaped fill to normal contour and transported a major portion of the sand offshore. Storms (26 Jan. - 21 Feb. 1983) increased beach slope & cut beach back ~100 ft, removing all the sand & exposing cobbles that existed prior to restoration. In December, 1982, storm waves moved 75% of the fill offshore. Formed large protective bar. 1983: Subsequent swell has apparently returned some of the sand to the beach.	U.S. Army Corps of Engineers, Los Angeles District, 1987b Spencer, 1987 U.S. Army Corps of Engineers, Los Angeles District and the State of California, 1984
1984		4,080,000	1.0	2,500,000 (dredging & jetty construction)	Biennial bypassing program inadequate. Spoil immediately moved out into the surf zone, widening the beaches at Carlsbad by > 350 ft. 1980: Widened beach an average of 99 ft for 4 km.	Moffatt & Nichol Engineers 1983 Shaw, 1980 U.S. Army Corps of Engineers Los Angeles District, 1987a, 1987b
1985		111,000				U.S. Army Corps of Engineers, Los Angeles District, 1987b
1987		232,000				U.S. Army Corps of Engineers, Los Angeles District, 1987a
1960		371,000				U.S. Army Corps of Engineers, Los Angeles District, 1987a
1981		225,000				U.S. Army Corps of Engineers, Los Angeles District, 1987a
1983		308,000				U.S. Army Corps of Engineers, Los Angeles District, 1987b
1965		223,000				U.S. Army Corps of Engineers, Los Angeles District, 1987b
1967		160,000				U.S. Army Corps of Engineers, Los Angeles District, 1987b
1969		87,000				U.S. Army Corps of Engineers, Los Angeles District, 1987b
1972		200,000				U.S. Army Corps of Engineers, Los Angeles District, 1987b
1974		341,000				U.S. Army Corps of Engineers, Los Angeles District, 1987b

1976	392,000						U.S. Army Corps of Engineers, Los Angeles District, 1987b
1979	419,000						U.S. Army Corps of Engineers, Los Angeles District, 1987a, 1987b
1979	430,667						
1948	613,333	BR				Beach widened 300 ft max.	Migrated south. 1951 survey indicates width recession. By 1957 survey beach back to 1940 width (except at jetty). Shaw, 1980
1973	308,667						
1948	~ 600,000					Beach widened ~300 ft	Migrated south. Beach has progressively retreated. 1957: Shoreline only slightly seaward of 1940 position. 1960: Shoreline approaching the 1940 alignment. Has coped with the erosion problem since 1950. Shaw, 1980 U.S. Army Corps of Engineers, Los Angeles District, 1960, 1987a.
1950s	"large quantities"	HC					U.S. Army Corps of Engineers, Los Angeles District, 1986a
1960	67,000	BR	0.8	11,390		Widened beach to ~130-500 ft.	Within 6 mos., the beach returned to its normal state, & sand migrated north across San Diego River mouth. Hall, 1962
1955	275,000		0.3	161,000 (groin & fill)		Beach widened ~300-400 ft	U.S. Army Corps of Engineers, Los Angeles District, 1957, 1987a
1936	14,000,000	N					U.S. Army Corps of Engineers, Los Angeles District, 1986a
1940-41	2,260,000	N/R	1.0			Temporary maximum shoreline advance of 898 ft	Fill eventually migrated north, widening beach south of Zuniga Jetty. Shaw, 1980
1941-46	26,200,000	N	2.0			Advanced shoreline seaward > 985 ft	Shoreline adjustment rapid. By 1954, the 1937-46 rate of change in shoreline position had returned to nearly the 1933-60 National Ocean Survey map rate for those locations strongly affected by fill. 1958: Retreating back 501 ft 1976: Since 1946, shoreline has steadily retreated 1982: Some of the sand remains in the area. 1987: After 1960, shoreline behaved approximately as it had before 1933. Indicates the beachfill-forced shoreline adjusted to a dynamic equilibrium platform between 1954 & 1960. Moffatt & Nichol, Engineers, 1987
1944							Inman, 1976
1967	40,000					Net migration to north. Ultimately impounded by Zuniga Jetty or swept offshore to depths of 495-990 ft by ebb currents.	Moffatt & Nichol, Engineers, 1987 Shaw, 1980

1976		3,500,000	2.0	1987: Since 1978, the beach has eroded & the buildings constructed on the 1941-1976 fill can be completely surrounded by the sea during even small storms.	Moffatt & Nichol, Engineers, 1987	
1985		1,100,000	0.7		Moffatt & Nichol, Engineers, 1987	
1988	N	~ 1,000,000		Placed offshore in 25 ft water depth	Surfrider Foundation, 1987/1988	
				1987: Since 1941, most of fill has remained in the system. Appears 20-30% moved offshore because too fine to remain in dynamic equilibrium on shoreface. Somewhat < 40% of the beachfill that was reworked was lost offshore.	Moffatt & Nichol, 1987	
1977	Imperial Beach, CA	1,100,000	1.0	Beach width: ~150 ft	Jan-Feb 1978 storms eroded ~35 ft of the shoreline. June 1978: 50% has washed away Feb. 1983: Beach width at north and of project area = 100 ft. At south end, ~0 ft. Net migration to north. Fill contained foreign matter. Demonstrated winnowing will clean sand. Erosion at Imperial Beach has been countered by groins (ineffective) & periodic beach nourishment. 1986: Groins have not worked very well, because of fine nature of sand.	Van Deerlin, 1978 Shaw, 1980 U.S. Army Corps of Engineers, Los Angeles District, 1983 Moffatt & Nichol, 1987
1979		1,000,000			U.S. Army Corps of Engineers, Coastal Engineering Research Center, 1984 Converse, 1982 U.S. Army Corps of Engineers, Los Angeles District, 1986a.	

on some of the projects can be found in MAGOON *et al.* (1989).

## Type

Unlike replenished beaches on the U.S. Atlantic Coast, which were emplaced primarily for the purpose of beach erosion control, Pacific projects have been carried out for a wider variety of reasons: harbor construction and excavation, harbor maintenance dredging (by-passing), beach erosion control, and disposal of upland or flood control spoil.

### Harbor Construction

The excavation of harbors and marinas produces millions of cubic yards of dredge material. Often, this sediment (or some part of it) is placed on adjacent beaches.

### Harbor By-Passing

The 1928 construction of the Santa Barbara Harbor breakwater dramatically brought to light the consequences of interrupting natural sand transport within the littoral system. Severe downcoast erosion commenced immediately after breakwater construction while the sand trapped upcoast of the breakwater rapidly widened the beaches there (O'BRIEN, various dates; GRIGGS and SAVOY, 1986).

In recognition of these well-documented consequences, most port authorities now conduct by-passing operations on a semi-regular basis to mimic the stymied natural sediment transport system. Sand is dredged from beaches or shoals upcoast of the harbor or from the harbor channels and is deposited on adjacent beaches. These projects are usually considered part of the operation and maintenance (O&M) program of the harbor and are paid for from the harbor O&M budget.

### Beach Erosion Control

These operations are conducted as part of long-term Federal beach erosion control projects. Sometimes the beach replenishment is the primary aim of the project, whereas other times the sand is emplaced as part of a groin construction or maintenance program. Beach replenishment, in the former case, usually consists of an

initial restoration, followed by periodic nourishment.

### Beach Widening or Beach Restoration

These projects are not part of an ongoing beach erosion control problem, but are one-time operations undertaken (usually by local interests) to restore a beach, or to create a beach where there was none before.

### Emergency

These projects may or may not be associated with a long-term beach erosion control project. Typically emplaced in instances of severe erosion (*e.g.*, after a major storm), these projects are built to afford temporary protection to the upland and to "buy time" until a regular program can be implemented or continued.

### Upland Excavation

Occasionally, excavation for upland construction produces large volumes of sediment which are placed on nearby beaches.

### Flood Control

Occasionally, a river may be deepened for the sake of flood control, with the resulting dredge material deposited on a nearby beach.

### Cost

Operation costs, as reported in this table, have not been converted to present dollars; the information is presented here as stated in the primary reference(s). In addition, information on the economic benefits attributable to a fill is rarely available, so those benefits have not been factored into the costs listed here.

### Immediate Effect

"Immediate effect" refers to the immediate effect of the sand emplacement operation. Usually, this information is presented in the original reference in terms of overall beach width at the time of the completion of pumping (or dumping).

## Eventual Fate

"Eventual fate" refers to subsequent behavior or state of the fill. The year cited refers to the year in which the noted observation was made or reported. In each case, an effort has been made to recount closely the wording in the original reference(s).

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