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BRINGING BACK THE BEACHES

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LOW COST SAND RE-NOURISHMENT TO COMBAT CHRONIC BEACH EROSION
LONG BEACH, CALIFORNIA

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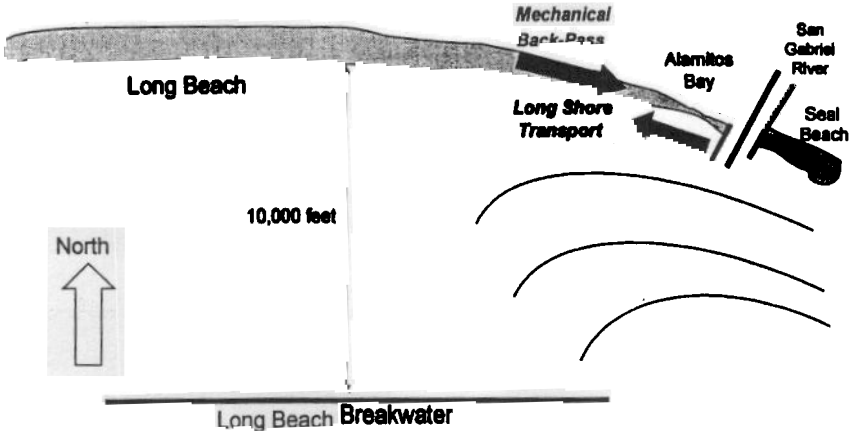
1. Overview

Since major beach widening was completed in the mid-1950's using large volumes of dredged sediments from Alamitos Bay, Peninsula Beach has suffered chronic erosion. As shown in Figure 1, Peninsula Beach is located on the far eastern end of the beachfront in Long Beach, California, adjacent to the entrance to Alamitos Bay. The Long Beach Breakwater, constructed by the Federal government in the late 1940's, protects the majority of the beaches of Long Beach from ocean wave impacts. The protection provided by the breakwater does not extend to the east sufficient to protect Peninsula Beach and ocean waves arrive at the shore causing erosion of the beach and alongshore movement of the eroded sand to the west.

Figure 1: Peninsula Beach Location Map and Erosion Process



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A variety of beach erosion control measures have been performed during the 1948-1999 period at Peninsula Beach, including timber groins, the importation of a coarse gravel berm, installation of artificial kelp, the construction of a submerged breakwater composed of large sand bags, and various beach nourishment options incorporating dredged offshore sand sources, inland sediment sources, and utilizing sand from the wide City beaches located to the west.

Table 1 summarizes the attempts to provide shore stabilization at Peninsula Beach since the late 1940's.

Table 1: Shore Stabilization Methods at Peninsula Beach

Method	Date
Timber Groin Field	1948
Sand from Offshore Dredge Source	1979, 1983
Gravel Beach (Inland Source)	1981
Artificial Kelp	1983-1990
Submerged Sand Bag Breakwater	1991
Perched Beach (Hydraulic Model Study)	1998
Beach Nourishment from Wide Adjacent Shores	1981-1993 (Trucks) 1994-1999 (Scrapers)

On seven separate occasions commencing in November 1994, the City of Long Beach performed beach re-nourishment operations using earth-excavation scrapers that have significantly reduced the annual cost of beach maintenance. These methods can be successfully applied to beach areas that exhibit wide sandy beaches adjacent to those experiencing chronic erosion. The unit cost of these beach nourishment operations have been about $1.40/cubic yard, substantially less than similar operations using conventional dump trucks.

2. Methods Employed to Reduce Beach Erosion, 1948-1999

A number of innovative methods have been undertaken by the City to reduce erosion rates along the beach. The various methods and the effectiveness of each is described below.

- Timber Groin Field

A groin field constructed of timber piling was placed along the eroding section of Peninsula Beach in 1948. Photos of that era indicate that the groins did not trap sand moving alongshore. It is conjectured that the timber groins quickly degraded, thereby allowing the beach sand to either pass through or over the top of these structures.

- Nourishment from Offshore Sand Source

After experiencing more rapid erosion in 1977 and 1978, Long Beach, dredged about 100,000 cubic yards of sand from the channel of the adjacent San Gabriel River and placed it in the narrowest portion of the beach. An analysis of the grain size found it was much finer than the existing beach sand and its longevity on the beach was in question. During the following year, the entire fill was lost to erosion.

In 1983, Long Beach performed beach nourishment using an offshore source composed of coarse sand. The sand source was conveniently located near the end of the west jetty of Alamitos Bay. The 300,000 cubic yards of sand that was pumped to the beach experienced stability comparable to the native beach sand. The cost of placement using the floating dredge and pipeline equipment, however, was judged to be too high to be used on a regular basis.

- Coarse Gravel Beach

Following significant beach losses suffered in 1977-1978, coarse gravel was transported to the beach in 1981. The gravel was placed in a trapezoidal cross-section to act as a containment dike for the fine-grained sand that was placed as backfill. The source of the gravel was an inland quarry in Corona, California. In total, about 25,000 cubic yards of gravel was installed, fronting 55,000 cubic yards of beach sand scavenged from further west on the beach. The gravel preformed well, with some breaching of the dike after wave overtopping. During the next two years the dike system degraded irretrievably. It was determined that the coarse gravel did not exhibit substantially better long-term stability on the beach relative to the native beach sand. The gravel was eroded and moved alongshore to the west.

- Nearshore Placement of Artificial Kelp

To promote a more stable beach, a synthetic kelp product known as "Seascape" was installed at Peninsula Beach in June, 1983. The artificial kelp was installed in three parallel rows in water depths of 6-8 ft. In theory, the kelp was expected to lower the speed of currents near the seabed thereby causing sediment to settle at the base of the kelp. The anticipated build-up of sand in a sand bar would then reduce wave energy much like a submerged reef, but at a substantially lower cost. Previous installations at Cape Hatteras National Shoreline in North Carolina and in the Great Lakes were reported to have been successful.

During the summer of 1983, the artificial kelp was judged to have performed successfully in protecting the beach from southern swell associated with tropical storm activity. In 1986, five additional rows of artificial kelp were installed. However, when the new units were installed, it was observed that the original installation was no longer present. The effects of the earlier kelp installation were

noticeable as the bottom seaward of the originally installation dropped away sharply. In 1991, Long Beach abandoned any further use of the artificial kelp. Its level of success in stabilizing the beach could not be determined. Despite positive indications of sediment accumulation around the base of the kelp during some periods, the beach was still eroding. The cost of continued re-installation was deemed to be too expensive for the undefined benefits.

- Submerged Sand Bag Breakwater

In 1991, large sand-filled polypropylene bags were filled in-situ in a parallel line 300 ft long located about 50 feet seaward of the low water Peninsula Beach shore. The submerged breakwater thus created was 300 feet long and 4 to 6 feet high. The elevation of the top surface of the reef was –1 ft (MLLW). Divers from the City life guard staff filled the bags in place, using hydraulically pumped sand-water slurry transported from shore in a 2-ince diameter hose. It was hoped that the breakwater would cause large waves to break further offshore, thereby dissipating wave energy prior to arriving at the beach. It was believed that sand would build up on the landward side of the reef thereby increasing the beach width in this area. Unfortunately, seabed scour was noted inshore of the sand bag reef shortly after construction was completed. The scour was 1-1.5 ft deep and ten feet wide, and extended the entire length of the bags. The scour was more severe near the end of the bags. The scour was also noted in surveys conducted in 1992 and 1993, deepening to two feet and moving two feet shoreward of the bags. In Spring 1992, observations indicated that the beach had widened east of the reef, rather than directly in its lee. By 1994, no appreciable effect on beach width was noted in the area of the reef. During this monitoring period, the scour remained relatively unchanged, with a clear trough landward and around the ends of the reef. One of the three layers of bags was removed in 1994, with the final bags removed in 1995.

- Perched Beach (Model Study)

A physical model study was undertaken of a perched beach concept to determine its behavior at Peninsula Beach. This concept requires the construction of an offshore dike followed by backfilling the intermediate space between the dike and the shore with sand. This elevates the nearshore bathymetry and causes waves to break further offshore during low and moderate tide conditions. The model test was conducted at Oregon State University, Corvallis, Oregon, in September 1998. The existing eroding beach behavior was replicated in the wave basin, followed by the testing of two different perched beach designs. One design incorporated a solid dike aligned parallel to the beach while the second design utilized a higher offshore perched beach elevation contained by a segmented dike aligned with a 10° angle to the shore. Both offshore dike configurations were located about 1,000 ft seaward of the backbeach. The outcome of the tests indicated that during low tide conditions, the perched beach caused offshore wave breaking and created high speed longshore currents within the wide surf zone. Under prototype conditions, it is feared that these

alongshore currents would scour the nearshore seabed (similar to that noted in the previously described submerged breakwater test) and would possibly negate the expected wave dissipation benefits of the perched beach. At high tide, the ocean waves passed over the perched beach unimpeded and caused comparable levels of beach erosion relative to the existing beach condition.

3. Beach Nourishment Program and Methods

During almost every year of the 1980 to 1994 period, Long Beach nourished Peninsula Beach using a dump truck and two bulldozers, in addition to or as part of all the other approaches. Loaders filled the dump truck at the borrow site along the wide western beaches of the City, and bulldozers pushed the sand out into the water and shaped the beach at the Peninsula Beach fill site. This was possible because the Long Beach shoreline is a closed littoral cell, with the sand moving along the beach and accreting west of the erosion area. The wide beaches where sand accumulates is located less than a mile from the eroding Peninsula Beach area.

In 1994, analysis of various potential options for stabilization of Peninsula Beach compared the long-term cost of nourishment to the long-term cost of "permanent" structures. The costs estimated by this analysis are presented in Table 2.

Table 2: Shore Stabilization Methods Cost Comparison, Peninsula Beach

Method	Cost
Groin Field	$2.5 Million (Initial)
Submerged Reef	$5.0 Million (Initial)
Perched Beach	$6.0 Million (Initial)
Segmented Reef	$4.6 Million (Initial)
Offshore Breakwater	$14.0 Million (Initial)
Beach Nourishment	$150,000 per Year

Prior to this study, it had been assumed that a permanent structure would be economical due to the savings of annual beach maintenance costs. Using a unit cost of beach nourishment of $2 per cubic yard and a project life of 50 years, this analysis indicated that annual beach nourishment was less costly than the permanent structures being considered. As local residents and beach users also preferred nourishment, Long Beach adopted a policy of including beach nourishment as an annual capital expenditure to address beach erosion.

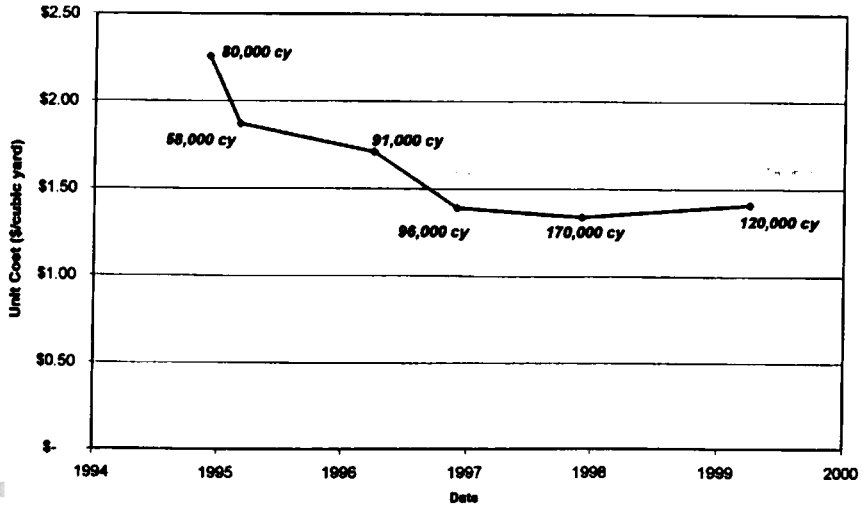
As Long Beach turned from viewing the nourishment process as an accessory in the battle against erosion to the primary weapon in the battle, Long Beach looked at how the nourishment could be done more efficiently. This sand "backpassing" operation could be conventionally performed using a mechanical conveyor system,

hydraulic dredge operations, or more traditional dump truck hauling. The most efficient method has been determined to be the use of self-loading earthmoving equipment (Caterpiller Model 639 Scrapers). These excavation/haul units each have a capacity of 30 cubic yards. They load at the western sand source and drive along the beach to place the sand at Peninsula Beach. The units are equipped with an aft yoke to allow multiple units to work together in a "push-pull" mode. It was concluded that using two earth excavation scrapers and a bulldozer (rather than two bulldozers and one dump truck), would more than double the amount of sand moved with the same number of workers. This approach was successfully employed during the spring of 1994, yielding an in-place sand cost of about $2 per cubic yard (cy). This compared to $4-$5/cy in 1993 using conventional dump trucks, and $5/cy for offshore hydraulic dredge in 1983. The comparison of 1993 to 1994 showed that the dump trucks were able to make more round trips per hour per truck, but that the loads delivered by the scrapers were larger and fewer persons were required per load.

Initially, Long Beach rented the scrapers and used city staff to operate them. In 1995, Long Beach began contracting for drivers with the equipment. The greater familiarity of the drivers with the equipment increased the efficiency of the operation, reducing the time per round trip, and thus the cost.

In 1996, the Long Beach increased the number of scrapers to three. This allowed the scrappers to work in loading teams and free each other when one of them became stuck in the sand. The unit cost of the beach re-nourishment effort was reduced to less than $1.50 per cubic yard. Figure 2 presents the unit cost history of

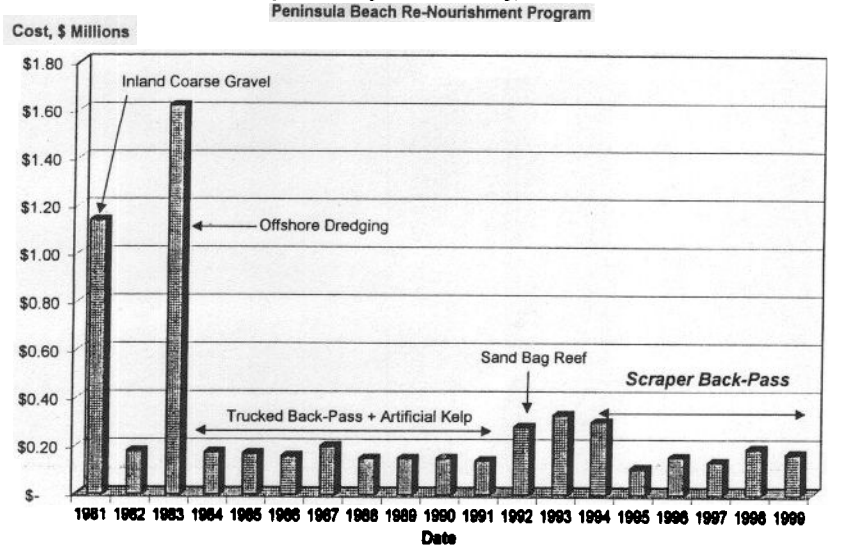
Figure 2: Unit Cost History, 1994-1999
Peninsula Beach Re-Nourishment Program



the beach nourishment operation during the 1994-1999 period. It is noted that during 1998 and 1999, when large nourishment volumes were transported and placed, the unit cost increased slightly. This is caused by the larger sand volumes which dictate greater average distances between the borrow and receiving sites. From a cost standpoint, this data indicates that the optimal volume of beach nourishment for Peninsula Beach relative to unit cost is about 100,000 cubic yards.

Figure 3 presents the time history of beach stabilization costs at Peninsula Beach. In the early 1980's, high cost options included beach nourishment from both inland and offshore sources. Later, costs became more modest as nourishment from adjacent wide beaches was accomplished on an annual basis. The scraper backpass method accomplished during the 1994-1999 period required annual budgets comparable with earlier periods, however, the greater efficiency of the scraper operations resulted in substantially greater sand excavation and placement than before when dump trucks were used.

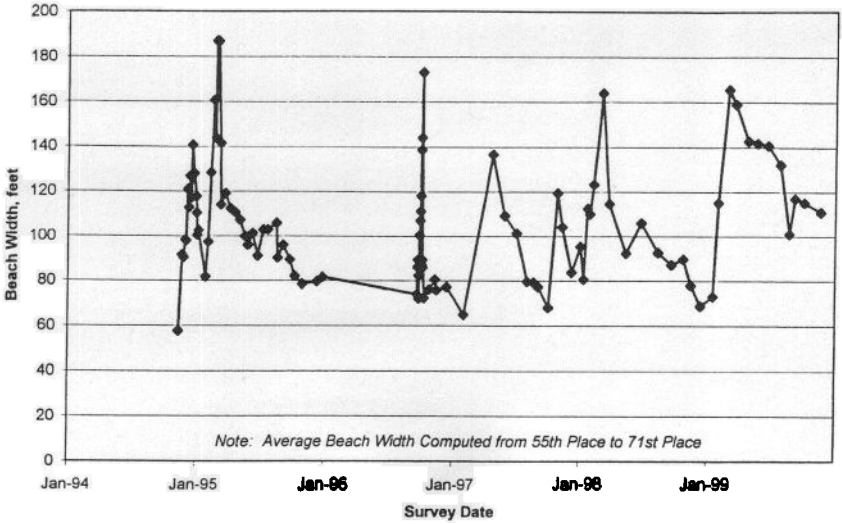
Figure 3: Project Cost History, 1981-1999
Peninsula Beach Re-Nourishment Program



4. Shoreline Movement History

Following beach nourishment, the shoreline would retreat, eventually returning to the pre-nourishment beach position. For the 1994-1999 period, the fluctuations of the beach berm position have been measured along Peninsula Beach. These results are presented in Figure 4, showing the average beach width, as defined by the distance from the back beach to the berm. Several observations are worthy of note, as follows:

Figure 4: Peninsula Beach Width History, 1994-1999



- When the beach is widened to 160 ft or greater, the retreat is initially quite rapid, as the steeply placed nourishment sand is reconfigured to milder slopes by the incoming wave energy. Such a wide beach cannot be maintained.

- The rate of retreat is quite variable from the initial post-nourishment condition to the more stable width of 80 ft. During the fall of 1996, the beach width was reduced by 80 ft in about one month, during an early winter storm period.

- The rate of beach retreat can be moderate during periods of calm weather, as was the case in 1995, 1998 and 1999. It is hoped that this improvement in beach stability is related not just to weather, but also to a build-up in the offshore profile as a result of the repeated beach nourishment program of the 1990's. It remains to be seen if the nourishment effort has a long-term positive effect on reducing the rate of erosion.

5. Contractor Payment Strategy

On a project management basis, the Long Beach experience also provides guidance on structuring payment to the beach nourishment contractor. It is unwise to consider determining a pay amount based on repetitive surveys of borrow and placement areas. As these projects require 30 to 60 days to complete, alongshore sediment transport can effectively mask work that has been performed. During the 1994 to 1999 beach nourishment program, the contractor that supplied the scrapers

and operators was paid per hour of work. This was much easier to monitor and verify relative to the ever changing borrow and placement sites. Hourly payment promotes expected progress to be made, while eliminating the incentive for the contractor to speed on the beach during the project. This was important to Long Beach, which wished to avoid safety hazards, and to minimize citizen complaints from dust creation and vibration adjacent to the seaside homes.

6. Conclusions

The City of Long Beach has analyzed and attempted numerous methods of beach erosion control and mitigation along Peninsula Beach. With the exception of beach nourishment, nothing has proven to be acceptable in terms of cost, recreational impact, compatibility with beach maintenance operations, and public acceptance. During five years of roughly annual nourishment projects, the beach nourishment technique utilizing earth-moving scrapers has been sequentially implemented and adjusted in order to reduce costs by 50 percent relative to dump truck use while excavating/placing annual nourishment volumes of as much as 170,000 cy. The nourishment program has maintained a beach width that is usable for recreation, visually pleasing to residents, while serving as the primary barrier to coastal flooding for seaside properties. The program has been performed at a reasonable cost so that, even as Long Beach suffered through a prolonged recession in the 1990's, the city management and City Council has been able to approve annual expenditures. Finally, the citizens have gained confidence in the effort resulting in improved relations between the residents and the City staff. For these reasons, the on-going re-nourishment program at Peninsula Beach has been judged to be a success.