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A . Report Title: Jet Pump Sand Bypassing, Nerang River Entrance, Australia

B. DATE Report Downloaded From the Internet: 07/06/99

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D. Currently Applicable Classification Level: Unclassified

E. Distribution Statement A: Approved for Public Release

F. The foregoing information was compiled and provided by:
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DRP-3-01
November 1989

Dredging Research Technical Notes

Jet Pump Sand Bypassing, Nerang River Entrance, Australia

Purpose

This technical note describes the jet pump (eductor) sand bypassing system installed in 1986 at the Nerang River Entrance, near the town of Gold Coast, in Queensland, Australia. The Nerang system is noteworthy due to the magnitude of sand bypassed (650,000 cu yd annually) and a number of technical innovations including automated operation.

Background

Fixed bypassing plants have been used for over 50 years as an alternative to conventional dredging for reducing channel shoaling and bypassing sand to reduce beach erosion. These plants have operated with varying degrees of effectiveness, in part because virtually all were applied as remedial measures after channel structures had been in place for some time and problems already existed. A jet pump bypassing plant constructed in 1986 at the Nerang River Entrance in Queensland, Australia, appears to have made a significant step forward in fixed plant sand bypassing. While the plant still has some problems, it has been very successful in its first three years of operation in keeping the adjacent channel open.

Additional Information

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Introduction

The Gold Coast region of Queensland is located along the mid east coast of Australia (Figure 1). Local interests felt that further development of the region was hampered by lack of safe passage to the Pacific Ocean. Because of strong northerly sediment transport, the existing unstructured Nerang River entrance had migrated north at an average of over 120 ft/yr through this century, and was extremely treacherous for navigation. The decision was made to stabilize the channel with jetties. Plans for sand bypassing were included from the start, making the Nerang system perhaps the only bypassing system in the world designed and constructed as an integral part of a major channel stabilization project. Construction of the jetties and dredging of the new channel were completed by November 1985. Sand bypassing system trials were completed and the system started operations in June 1986.

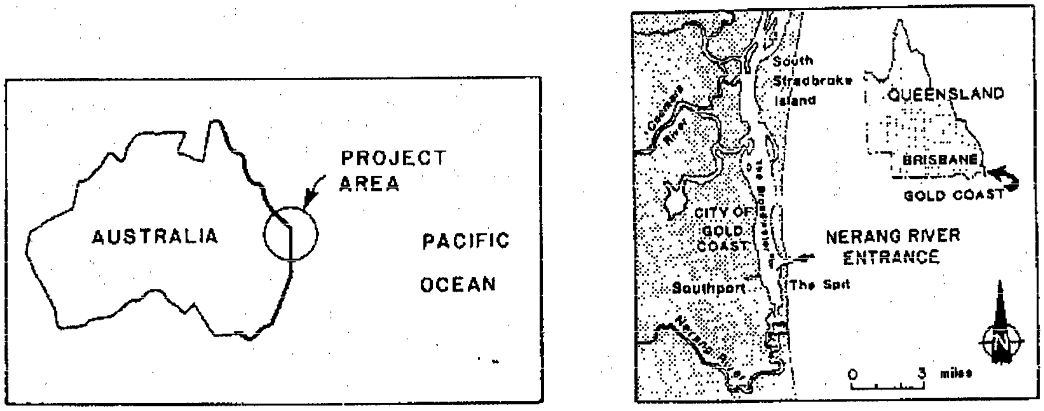


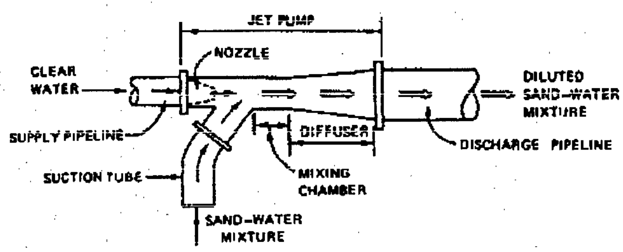
Figure 1. Location maps

This section of the Australian coast has a moderately active wave climate, similar to the southern California coast of the United States. Longshore transport for the area is almost unidirectional, with the average net transport estimated at 650,000 cu yd/yr to the north, the system design bypassing rate.

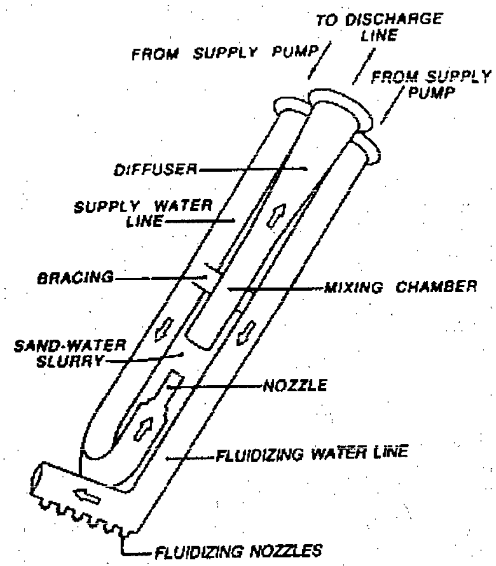
Bypassing Systems Considered

Several different bypassing schemes were initially considered, including a low weir section in the south jetty with deposition basin, an offshore breakwater with sand trap, a land-based fixed dredge, a land-based mobile dredge, and floating dredges operating at the inlet mouth or just south of the inlet. Eventually a trestle mounted jet pump system was considered and ultimately selected. Discussions of the alternatives and selection process can be found in Clausner (1988).

Jet pumps (also known as eductors) are hydraulically powered pumps with no moving parts (Figure 2a), relying instead on momentum exchange to entrain the slurry (Richardson and McNair 1981). A conventional dredge (or booster) pump located downstream of the jet pump can be used to help move the slurry through the discharge pipe.



a. Schematic of a simple jet pump



b. Genflo Sand Bug jet pump used in the Nerang River Bypassing System

Figure 2. Jet pump

Bypassing System Design Details

The design bypassing rate was based on cyclones (southern hemisphere hurricanes), where the maximum transport rate would require the system to bypass 90,000 cu yd over 5 days. To meet this requirement, the system was designed to bypass 750 cu yd/hr. Since this high rate would probably seldom be needed, the system was designed to operate at normal bypassing rate of 435 cu yd/hr, approximately 60 percent of maximum.

The final design of the system is shown in Figures 3 and 4. Ten jet pumps are spaced at approximately 100-ft intervals along the outer 900 ft of the 1,600-ft-long pier. Each individual jet pump is a 3.5-in. Genflo "Sand Bug" jet pump, rated at 135 cu yd/hr (Figure 2b). Water to power the jet pumps is drawn from the estuary using two low-pressure supply pumps (250 hp each). Water from these pumps flows through a pipeline 2,300 ft long to the main pump house, where it feeds dual 450-hp supply pumps. The supply pumps can operate in parallel and provide motive water to power the jet pumps. High-pressure water from the supply pumps flows from the pump house through a pipeline to the jet pumps. Supply water can also be directed to fluidizers on the jet pumps, which are used during installation and removal, and to improve transfer capacity when debris has collected around the jet pump.

The slurry is discharged through riser pipes into the elevated pipe flume (Figure 4). Slurry from the outer five jet pumps feeds into individual pipes that empty into the head of the flume. The inner five jet pumps feed directly into the flume. The flume allows gravity flow of the slurry to a conical buffering hopper. The free

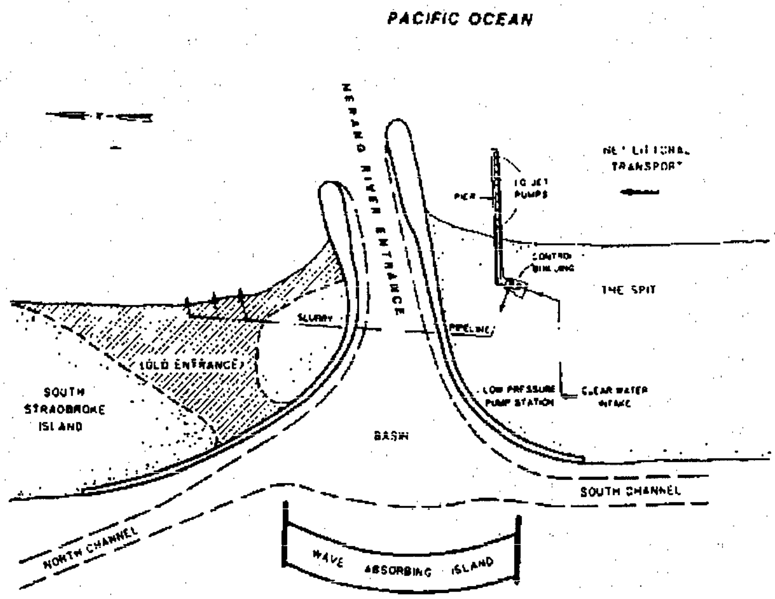


Figure 3. Nerang River Entrance Bypassing System, plan view

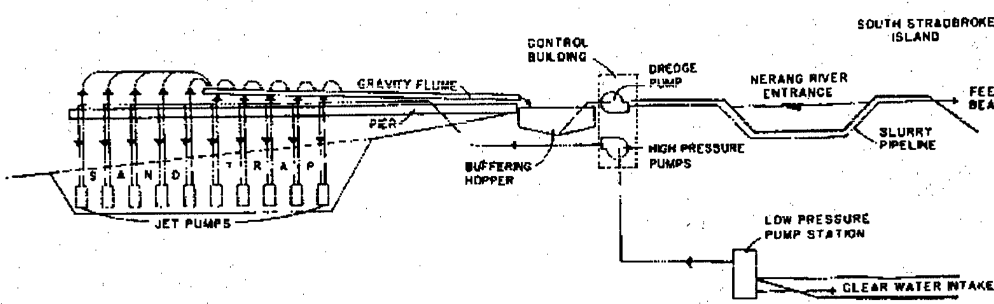


Figure 4. Nerang River Entrance Bypassing System, elevation view

flow flume and the buffering hopper allow the incoming slurry to vary considerably in solids content and still allow automatic control of a conventional booster pump that transfers the slurry across the entrance.

Slurry is removed from the hopper and transferred across the inlet to South Stradbroke Island by a 950-hp, variable-speed dredge pump. The discharge line is a 16-in.-diameter steel pipe with a polyurethane lining. Total length of the discharge line is 3,870 ft, with the most distant of the three discharge points on South Stradbroke Island 1,710 ft from the north jetty.

Bypassing Operations

The Nerang River Entrance bypass system has a number of unusual characteristics features associated with its operation. The bypassing system is operated by employees of the Gold Coast Waterways Authority (GCWA). Three full-time employees are on site 40 hr/wk, from approximately 7:30 a.m. to 4 p.m. During the day they perform maintenance operations and adjust discharge pipe locations. Before leaving, the operators check the level of sand in the jet pump craters with a lead line and program the sequence of jet pumps to be operated that night by the plant control computer. Electricity rates in Australia are $0.15/kWh ($Aust) during the day, but fall to $0.05/kWh from 9 p.m. to 6 a.m. Obviously, it is much less expensive to operate the plant, which is totally electric, during the low-cost hours. This is possible because the plant has been designed for automated operation by computer and the discharge site, South Stradbroke Island, is uninhabited. Consequently there are no safety problems on the downdrift beach associated with the unattended bypassing operation.

The system normally operates four jet pumps at one time. This requires the use of one of the low-pressure pumps at the estuary and one of the high-pressure supply pumps in the pump house. Operation of seven jet pumps (design maximum) requires using two low-pressure and two high-pressure supply pumps.

System Performance

During the first three years, the system has met most design standards, including the most important one of preventing inlet shoaling. Bypassing performance is summarized in Table 1. Maximum measured output from a single jet pump has been 140 cu yd/hr.

Table 1

Summary of Bypassing Performance

Time Period	Amount Bypassed (cu yd)
May 86 to July 87 (57 wk)	900,000
May 86 to Feb 88 (1.8 yr)	1,310,000
May 86 to April 89 (2.9 yr)	1,950,000
Maximum performance (1 wk)	54,000
Maximum performance (1 month)	117,000
Average monthly performance	40,000 - 50,000

As might be expected, the nearshore jet pumps have bypassed considerably more sand than the offshore jet pumps. On the average, the nearshore pumps have over 100 percent more operating hours than pumps further offshore.

The amount of energy required to date has been significantly higher than predicted because of debris reducing jet pump performance. The system was designed to require only 2.4 kWh of electricity per cu yd of sand bypassed. In fact, 3.4 kWh of electricity per cu yd have been required. The annual operating cost for the first year was approximately $0.60 per cubic yard, with electricity accounting for $0.25 per cubic yard. A detailed breakdown of operating costs can be found in Clausner

(1988). The operating costs are in Australian dollars, which are roughly comparable to US dollars. The operating costs do not include amortization of the original cost of the bypassing system, which was over $7.2 million dollars (Australian). This amount included a two-year maintenance agreement on the components.

Problems and Solutions

By far the biggest problem has been debris in the jet pump craters reducing performance. Virtually any item entering the littoral system (for example, rocks, bricks, wood, and trash) tends to find its way to the bottom of the craters. Eventually, this debris restricts the flow of sand enough to reduce bypassing ability from the system average of 400 cu yd/hr to less than 250 cu yd/hr.

Actual clogging of the jet pump is caused primarily by filter cloth from jetty construction and timber pieces from the Nerang River Entrance. This, along with nozzle replacement, requires periodic hiring of a 20-ton crane to remove jet pumps as necessary for servicing.

The GCWA has tried several solutions to the debris problem. The most successful has been a "clean-out" jet pump, with a mixing chamber opening of 10 in. as opposed to the 3.5-in. opening on the normal jet pumps. This pump was able to bypass a significant amount of larger debris. Increased wave activity during 1988 and early 1989 has increased the debris problem to such an extent that the GCWA is now planning to install the 10-in. jet pumps in place of the 3.5-in. pumps at each of the 10 locations along the pier. Since these larger pumps require the entire output from the supply pump, they are operated individually.

Finally, the increased wave activity has eroded dune grass that has formed a mat in the craters, further reducing performance. The GCWA is contracting with a local dredger to mount a cutterhead with a 12-in. suction on a trolley to remove the dune grass mat and other accumulated debris.

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Clausner, J. E. 1988. "Jet Pump Sand Bypassing at the Nerang River Entrance, Queensland, Australia," Proceedings, Beach Preservation Technology '88, Florida Shore and Beach Preservation Association, Gainesville, FL.

Richardson, T. W., and McNair, E. C., Jr. 1981. "A Guide to the Planning and Hydraulic Design of Jet Pump Remedial Sand Bypassing Systems," Instruction Report HL-81-1, US Army Engineer Waterways Experiment Station, Vicksburg, MS.