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TECHNICAL INNOVATIONS IN THE NERANG SANDS BYPASS SYSTEM

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1. INTRODUCTION

The Nerang Sands Bypass System in Queensland is located immediately south of the Gold Coast Waterway entrance. The system was designed by Slurry Systems Pty Limited and constructed by McConnell Dowell Constructors Ltd. The system began operation in 1986 and was world's first technology then, and still remains very much at the leading edge of sands bypassing technology.

Because of the prevailing wave direction there is a littoral drift of sand northwards along the coast in this area averaging about 500,000 m^3 per year. The basis for the design was for 100,000 m^3 in 5 days Without any intervention, the sand would have built up against the southern groyne until eventually flowing around the tip of the groyne and forming sand bars in and offshore the entrance to the newly created Gold Coast Seaway. The conventional solution at that time would have been to periodically dredge the entrance but this method could not be guaranteed to keep the entrance navigable at all times. The Nerang Sands Bypass System was the world's first fixed sands bypass system capable of operating in all weather conditions.

The system consists of a 500 m long jetty with ten vertical jet pumps spaced in parallel along the jetty and buried in the sand at RL minus 11 m. The jet pumps recover the littoral sand and pump sand/water slurry vertically up to discharge into a sloping flume. The elevated fume transfers the sand slurry by gravity to a feed sump of the shore based sands transfer pump station. The transfer pump station incorporatesconventional centrifugal slurry pump which pumps the slurry through a submarine transfer pipeline laid under the entrance to the north for discharge on to the down drift beaches of South Stradbroke Island .

During its 27 years of operation the system has been extremely successful and has transported 15 million cubic metres of sand. It has proved capable of continuous operation during the severest storms.

Figure 1.1 shows a photo of system. A jet pump vertical discharge pipe is visible attached to the third vertical leg of the jetty and discharging into the top of the flume.

Figure 1.1
Photo of Nerang Jetty

2. BACKGROUND

In late 1983 the then Goldcoast Waterways Authority (GWA), Southport Queensland, issued a tender for expressions of interest for sand bypassing of a proposed new permanent entrance to the Nerang River. Slurry Systems Pty Ltd (SSPL) entered into an agreement with the contractor McConnell Dowell Constructors Limited to submit a “Turn-Key” contract for a permanent sands bypass system for the new Nerang River entrance. The basic, ocean engineering, system requirements such as littoral sand volumes and shore perpendicular sands recovery zone were defined by the Dutch Engineering Group Delft University of Technology. SSPL responsibility was to develop concept, engineer, specify the equipment, technical supervision of construction, start and commission the system.

SSPL had extensive internationally recognised experience in transport of solids by long distance slurry pipelines. In 1982, SSPL was working in a similar role with McConnell Dowell Constructors Limited on the development of a high pressure slurry transportation of ironsand for NZ Steel. The NZ Steel system incorporated two unique features:

1) A world's first system to construct a long life high pressure pipeline, lined with wear resistant polyurethane, weld jointed and buried using high pressure API technology.
2) Use of high pressure positive displacement slurry pumps to pump rapid settling ironsands slurry.

Both of these technical issues required development and testing as part of the design and specification of the system. The development of the Nerang fixed sands bypass system also required proving up technical issues prior to detailed engineering. These issues were:

1) SSPL were familiar with the development of a unique system for hydraulically hoisting coal in coal mining industry. The technology was invented by the University of NSW. It was termed the Hydro Lift Pump by the inventors. SSPL was confident the hydraulic hoisting of coarse slurry in a vertical pipe was technically feasible. The selected Genflo Jet pump pumps used a similar eductor process as the Hydro Lift Pump so SSPL was confident operation in a vertical configuration was acceptable.
2) SSPL sort to exclude any mechanical device that would be difficult to maintain in a sand leaden offshore environment, Hence the decision to install parallel jet pumps to cover the specified zone of sand recovery. The technical issue was how to safely direct the delivery slurry flow from the discharge of parallel jet pumps into a single transfer pipeline from the jetty to a feed sump at the main transfer pump station. A single pressurized transfer pipe would be subject to potential blockage, hence, the concept of an elevated flume. A sloped flume offers a wide range of flows whilst still maintaining a flow velocity above deposition velocity. Each jet pump has limited head capacity and hence limited capacity to provide both static lift and friction headloss. The outer jets discharged through individual pipes to discharge into the end outer end of the elevated flume. A pilot scale test of flume hydraulics were untaken to confirm basis for flume diameter and slope.
3) The submarine transfer pipeline adopted the recently developed technology for joint welding of polyurethane pipe for the NZ Steel pipeline. However, the NZ Steel pipeline was 200 NPS steel pipe with 9.5mm th. Polyurethane lining. The Nerang sands bypass system required a NPS of 400mm steel with 9.5mm th. Polyurethane lining therefore welding tests were undertaken to confirm the joint welding procedure for doubling of pipe diameter.
4) The submarine transfer pipeline profile included steep slopes both into and out of the Nerang entrance. SSPL was concerned with the effects of shutdown and restart of the pipeline whilst operating with sand in the pipe line. Would the pipeline plug and how difficult would it be to restart the pipeline after shutdown. These technical issues required pilot plant testing prior to final design.

3. DESIGN BASIS

<u>Sand Properties</u>

Specific Gravity	2.67	
Particle Size	d90=0.45 mm	
	d50=0.23 mm	
	d10=0.17 mm	

Design Sand Transfer Volumes
Annual average volume 500,000 m^3
Peak monthly volume 200,000 m^3
Peak 5 day volume 100,000 m^3

These sand volumes refer to the in-situ volume of settled sand at an approximate volume concentration of 60%. i.e. One cubic metre of in-situ sand is equivalent to about 1.6 tonnes of dry sand. Under normal operating conditions the system is designed to operate at approximately 60% of the design capacity, but is capable of operating below 60% at a reduced efficiency. The design criteria are summarised in Table 3.1.

Table 3.1
Design Criteria

Item	Unit	Maximum Condition	Normal* Condition
Sand throughput	m^3/h (in-situ)	585	335
Design sand slurry concentration	% solids by weight	40	31
Transfer pipeline flow	m^3/h (slurry volume)	1,760	1,420
Weekly operation	hours		30
Weekly sand throughput	m^3 (in-situ)		10,000

4. SYSTEM DESCRIPTION

4.1 General

The sands bypass system consists of a jet pump recovery system, a flume transfer pipe, a remote sea water supply pump station, a transfer pump station and a sand transfer pipeline.

A jet pump operates by providing a high velocity upwards flowing jet of water which entrains sand. Because of the high water velocity in the jet it is essential that the supply water be free of sand. Two low pressure vertical axial flow sea water supply pumps installed in a remote pump station adjacent to the Broadwater, supply water to the suction of two high pressure jet water supply pumps located in the main onshore transfer pump station. Ten Genflo “Sandbug” jet pumps are installed in parallel off a shore perpendicular off shore jetty to serve the full length of the sand trap with any four or any seven operating at any one time. Under normal operation one low pressure sea water pump and one high pressure jet water supply pump supply four jet pumps to transfer the average sand volume. When peak sand transfer rates are required during periods of maximum littoral drift the second sea water supply and jet water supply pump and the remaining three of the seven jet pumps are operated. Any combination of seven of the ten jet pumps covering the sand trap can be operated. Each of the ten jet pumps discharge into an elevated pipe flume transferring sand slurry to the transfer pump station.

The Genflo jet pumps are designed specifically for sand dredging operations and to be non-clogging under fully buried conditions. Each pump includes integral fluidising jets which expand and fluidise the sand bed, enabling sand to be freely entrained by the jet pump at a controlled concentration. As sand is excavated from the region around the pump, the sand bed collapses to maintain a fluid bed adjacent to the pump. The trap continues to expand until the walls stabilise at the prevailing angle of repose.

The pipe flume provides a non-blocking transfer system which has capacity to handle a wide range of flow rates and solids concentrations. With each jet pump discharging separately into the flume, jet pump performance is not affected by the discharge pressure of other jet pumps, enabling the jet pump units to be properly balanced for equal performance. The jet pump discharge and pipe flume are lined with polyurethane for extended life.

The pipe flume discharges into a cone bottom sump which supplies the centrifugal slurry transfer pump. During peak flow operation, excess water overflows the pipeline feed sump and the sand concentration automatically increases to the maximum design value in the transfer pipeline. A single DN400 steel pipeline, lined with polyurethane transfers sand under the entrance for discharge north of the northern groyne. The total length of the transfer pipeline is 1,430 m.

4.2 Major Equipment

Table 4.1 summarises the major equipment.

Table 4.1
Major Equipment Summary

2 x Sea Water Supply Pumps	K.L. Berkeley M12 two stage axial vertical turbine 150 kW
Seawater Supply Pipeline	600 NB, 540 m long
2 x Jet Water Supply Pumps	K.L. Worthington 10LN26B horizontal split case double volute 560 kW, nominal pressure 965 kPa
Jet Water Supply Pipeline	DN450, 500 m long along jetty
10 x Jet Sand Pumps	Genflo 90 mm Sandbug. Each deliver 137 tph of sand . The Jet pumps span a 270m long sand trap.
Elevated Transfer Flume	DN600, polyurethane lined, ID 584 mm, Slope 2.5%
1 x Transfer Pump	Warman 14/12 G-AH, 710 kW Max. flow rate 1,764 m^3/h at 40% concentration Normal flow rate 1,420 m^3/h at 31% concentration
Transfer Pipeline	DN400, internally lined with 9.5mm th. Polyurethane, ID 368. Length 1,430 m

5. JET PUMP DETAILS

Figure 5.1
Photo Jet Pump Installation

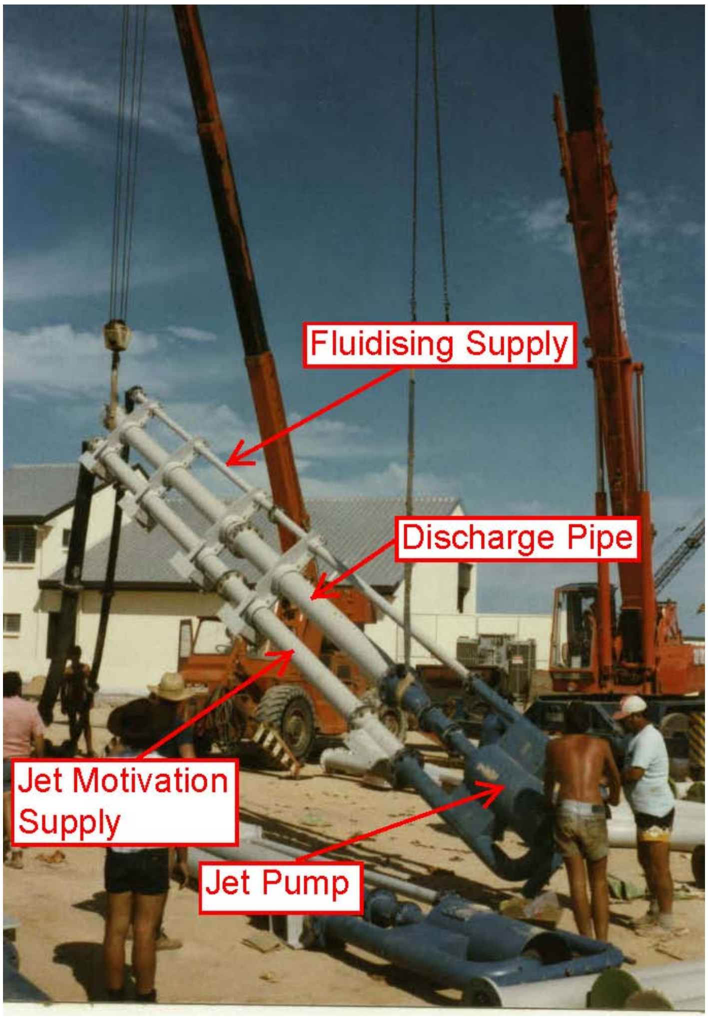


Figure 5.2
Drawing Typical Jet Pump

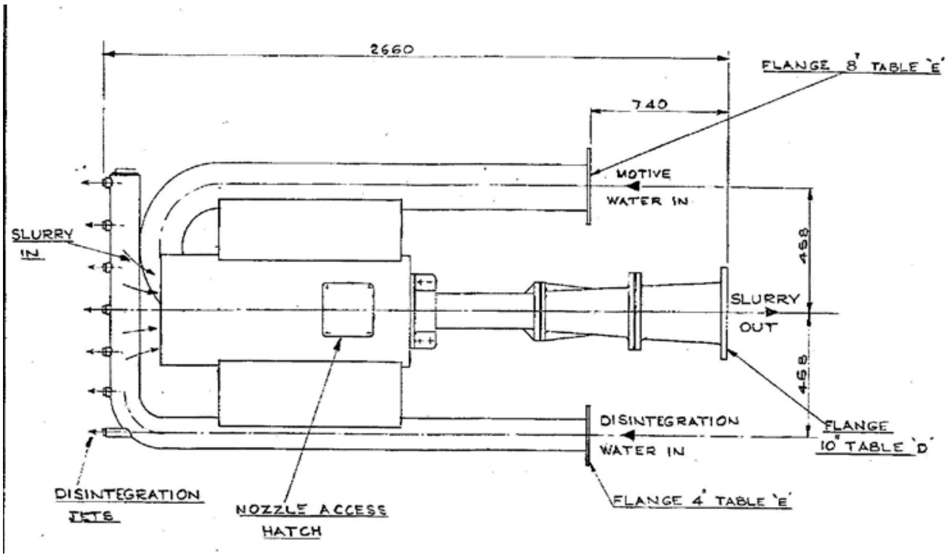
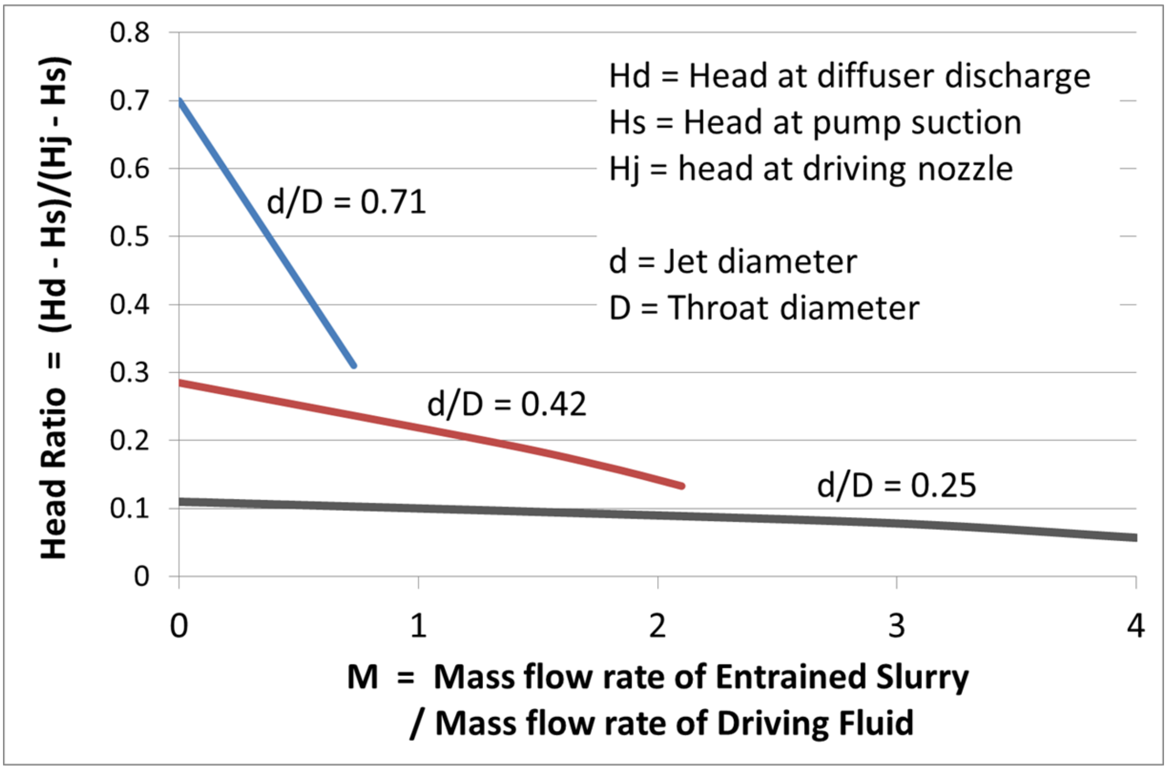


Figure 5.3 shows typical jet pump performance curves. The closer the jet diameter is to the throat diameter the higher the discharge head but the lower the flow rate. The Nerang mixer diameter is 102 mm and the pump can pass particles up to 100 mm. Sea weed is easily disintegrated by the high velocity jet. Jet diameters range from 40 mm to 48 mm giving d/D ratios from 0.39 to 0.47. The mass flow ratio is around 1.5. Efficiencies of jet pumps are low, around 35% maximum.

Figure 5.3
Typical Jet Pump Performance Curves
Bain and Bonnington, "The Hydraulic Transport of Solids by Pipeline"
Pergamon Press, 1970



6. FLUME TEST RIG

6.1 Description of Rig

Selection of the optimum pipe diameter and slope of the flume was very important, and to confirm and refine predictions a test rig was built and operated in Sydney. Also of importance were the ingoing and outgoing slopes of the buried transfer pipeline beneath the entrance. At the end of the flume tests the rig was reconfigured to investigate the potential for sliding and blockage in the downslope and upslope during shutdown/restart. Figure 6.1 shows a photo of the test rig .

Figure 6.1
Photo of Pilot Scale Test Rig

The test rig consisted of two 12 m long clear plastic pipes, one 200 mm diameter (190 ID) and one 100 mm diameter (94 ID), the slope of which could be varied. A centrifugal slurry pump driven by a diesel engine transferred slurry from the 3 m^3 collection hopper through 150 mm hose to either of the pipes. Flow exited from the sloping pipes into the hopper via a 1 m length of flexible hose which allowed the flow to be diverted into a 200 litre drum mounted on scales to measure flow rate and solids concentration. Measurements of slurry flow height and the height of any bed of solids, if present, were measured at locations 2, 4, 6, 8 and 10 m from the pipe entrance.

Shutdown/restart tests were also conducted by reconfiguring the 200 mm pipe to have a 4 m downslope, followed by a 4 m horizontal section then a 4 m upslope.

6.2 Some Test Rig Results

Figure 6.2 shows some results for water in the 190 ID pipe and illustrate that about 10 m length is typically required for the flow height to reach equilibrium.

Figure 6.2
Typical Flume Test Rig Results

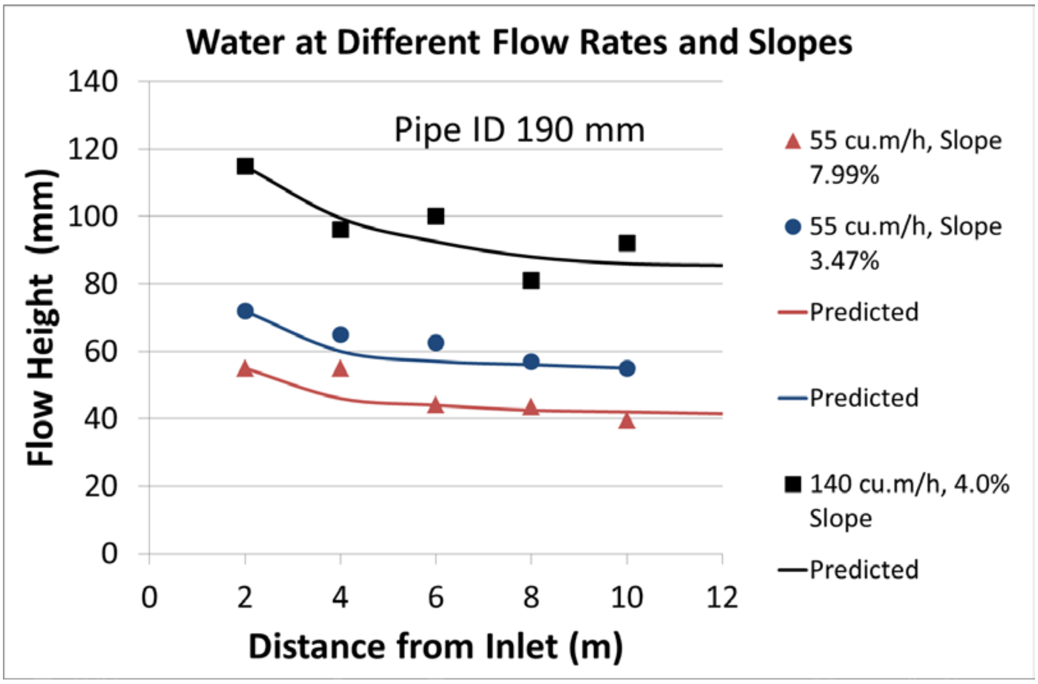


Figure 6.3 presents results for slurry flow at two different flow rates and approximately similar slopes. At the lowest, 80 m^3/h flow rate with a slope of 7.95%, a 30 mm high bed is present at 2 m from the entrance. Maintaining the same 80 m^3/h flow rate but lowering the slope to 5.2% results in the bed height at 2 m increasing to 110 mm and beds also appearing at 4 m and 6 m from the entrance, as seen in Figure 6.4.

Figure 6.3

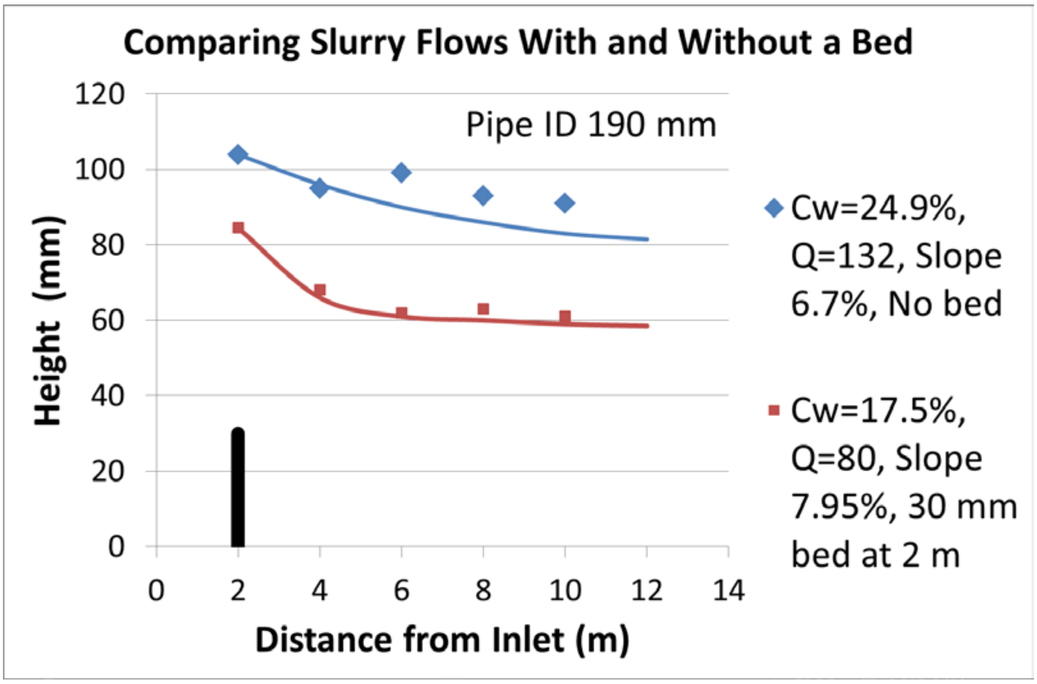
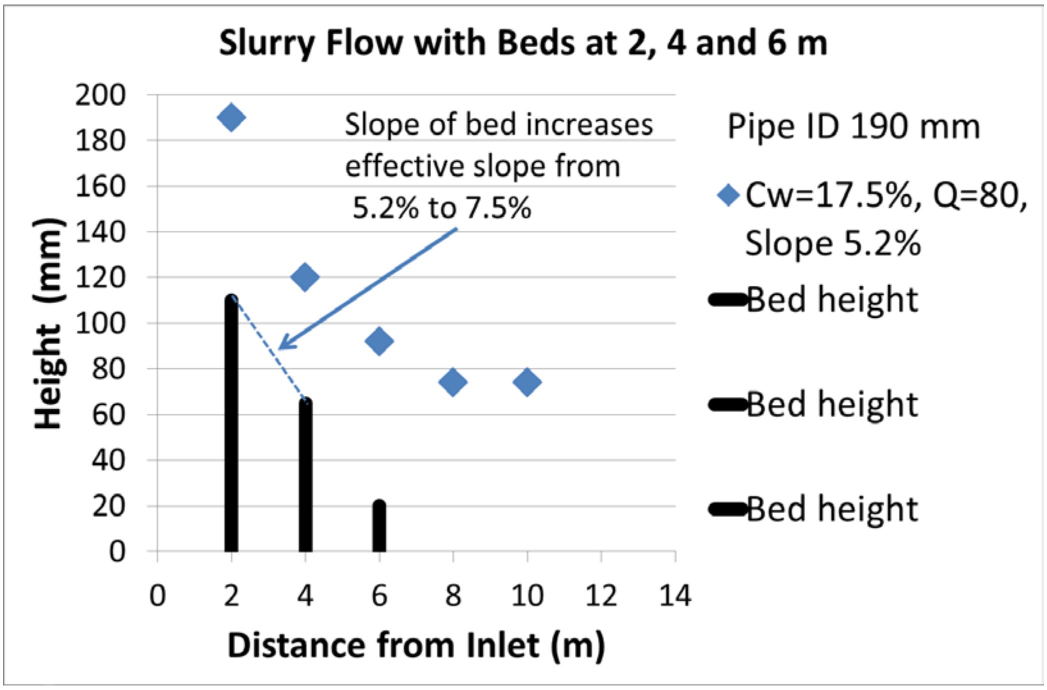


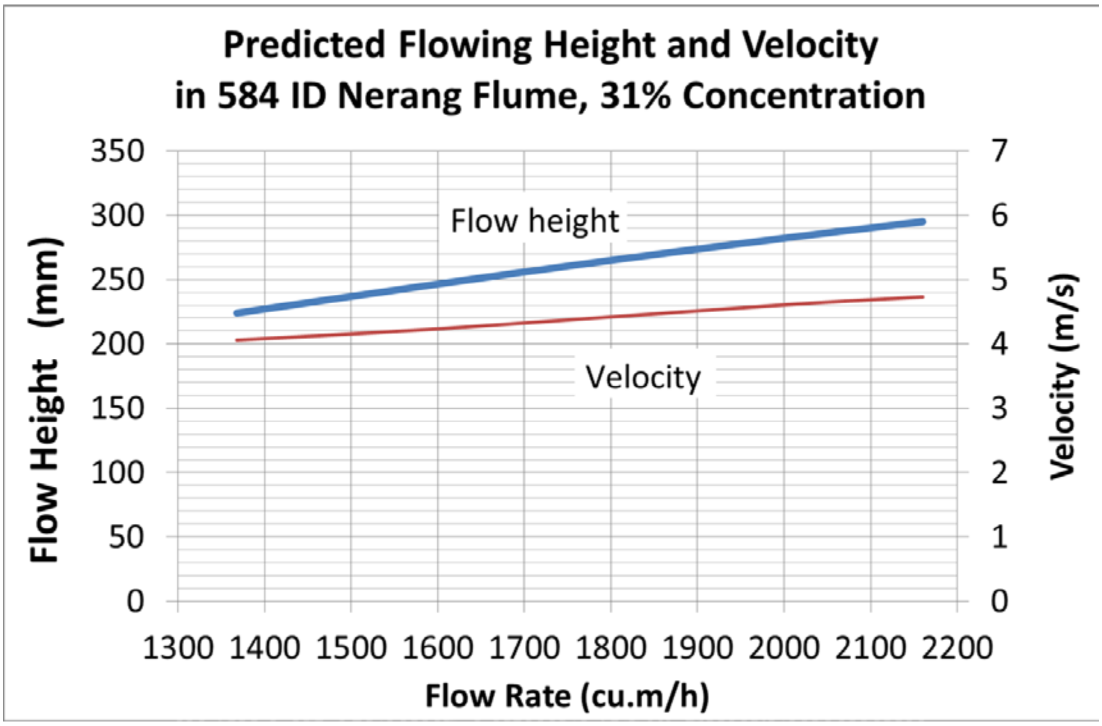
Figure 6.4



7. ELEVATED FLUME PERFORMANCE

After analysis of the flume test data, a DN600 spiral welded pipe was selected for the Nerang flume. The flume is 370 m long set at 2.5% slope and is lined with 6.4 mm of polyurethane. Figure 7.1 shows predicted flow height in the flume at 31% concentration.

Figure 7.1



8. CONCLUSIONS

The Nerang Sands Bypassing System has been a resounding technical success. It was the world's first fixed sands bypass system capable of operating in all weather conditions and after 27 years operation still represents the gold standard for sands bypassing systems. It has transferred 15 million cubic metres of in-situ sand.

The Nerang Sands Bypass system requires a jetty structure. More recently Slurry Systems embarked on the development of a significantly cheaper sand bypass concept not requiring a jetty. This concept can be applied more universally to the majority of ocean entrances.

The development resulted in the invention of a fixed submarine sand recovery system, the Slurry Systems Sand Shifter Unit (SSUnit^{TM}). The SSUnit development was trialled at Noosa Qld. The Noosa system recovers littoral sand which accumulates at the western end of Noosa beach and recycles the sand for beach nourishment at the eastern of Noosa beach. The trialled system was successful and the permanent system was installed a couple of years ago. The technology has been commercially proved and is available for installation for future fixed bypassing of ocean entrances.