CHAPTER TWO HUNDRED TEN

LARGE DIAMETER POLYETHYLENE SUBMARINE OUTFALLS

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1.0 INTRODUCTION

This paper presents the state of the art that has now evolved in Australia and shows the trend towards using high density polyethylene pipes for submarine conditions and the varying techniques and materials utilised.

Prior to 1981 High Density Polyethylene (H.D.P.E.) was not produced in Australia in diameters larger than 630 mm and even in the available sizes submarine outfalls were in the main constructed of mild steel or concrete pipes.

In 1980 the Gold Coast City Council called tenders for the supply and installation of a 1500 metre, 1 metre diameter, outfall across the Southport Broadwater which is an active tidal estuary area. The proposed route crossed a main navigation channel and required trenching up to 8 metres into sand and sandstone. After consideration of the special requirements and high tender prices for conventional materials, Council constructed a temporary 400 mm diameter H.D.P.E. outfall while the design of the permanent outfall was re-evaluated. The outfall was eventually constructed by day labour utilising a 1 metre diameter H.D.P.E. at a cost saving of approximately $1.5 million over the lowest tender price utilising steel pipes.

Manufacturing facilities were imported into Australia for this job and now other large diameter submarine H.D.P.E. outfalls have been constructed in Australia and this material is now gaining acceptance.

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2.0 MATERIAL AND DESIGN CONSIDERATIONS

H.D.P.E. is a flexible material and as such the design and installation techniques vary considerably from conventional pipe materials.

The properties are summarised as below:-

Density - 0.96
Min. Bending Radius - 33 x Pipe O.D.
Flow Characteristics - $C(20^{o}) \approx 155$ (max.)
Tensile Strength - 24 MPa
Impact Strength - 18 mj/mm^2
Flexural Strength - 32 MPa
Hardness - 63
Co-efficient of Linear Expansion - $2 \times 10^{-4}/^{o}C$
Thermal Conductivity - 0.37 K. Cal/M.L.^{o}C
Crystalline Melting Point - 130^{o}C
Chemical Resistance - Not affected except by strong oxidising agents.

Thus in general H.D.P.E. is a material which has good flow characteristics, chemical resistance and is flexible but due to its low S.G. requires weighting to provide negative buoyancy. The minimum S.G. of the pipeline weighted system will depend on the wave, current and backfill material characteristics. Experience has shown that as the pipe is flexible, then unless the final weight is adequate and the weight spacing is not excessive, floatation can occur during backfilling.

Due to the flexibility and buoyancy of H.D.P.E. pipe, various construction techniques can be utilised as listed:-

(a) Fabricate the entire length, float into position and sink.

(b) Progressively fabricate on, and lay off, a barge.

(c) Progressively fabricate and bottom pull into place.

(d) Progressively fabricate and flange join each length above or below water.

The pipe may either be laid in place on the seabed or in a prepared trench, or, due to its flexibility, jetted into the seabed material or undercut and lowered by dredging alongside the sunken pipeline.

Because of its light weight, flexibility, and ease of welding, H.D.P.E. can be assembled and laid without expensive specialised equipment and with a minimum of construction personnel. Overheads are therefore low and the cost of stand downs during adverse weather conditions is minimal.

3.0 CASE HISTORIES

Three case histories of major H.D.P.E. pipelines which have been constructed recently in Australia follow. Each job involved construction problems associated with the site conditions but the total job budget could not accommodate the use of large expensive specialised equipment. Different techniques were evolved for each job to suit the conditions and each was able to be carried out using readily available equipment and labour at a cost less than on comparable pipelines of alternate materials. The location of each job is shown in Fig. 1.

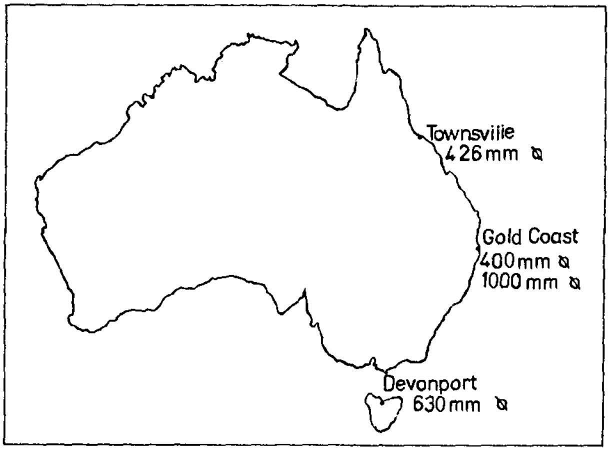


FIG. 1

(a) Gold Coast, Queensland (1982) (ref. Jackson, 1983 (2))

Location: Southport Broadwater (Nerang River Estuary)

Use: The pipeline serves as a submarine outfall to dispose of effluent from the recently constructed Coombabah carousel type sewerage treatment plant (50,000 e.p. capacity). Tenders for the pipeline construction were originally called but due to excessive costs the lowest tender utilising concrete lined mild steel was not accepted. Due to these delays it was necessary to provide a temporary outfall which was constructed by Council's day labour force utilising 400 mm H.O.P.E. at a cost of $200,000.

Site Description: The route traversed the wide estuary located at the mouth of the Nerang River and crossed two major navigation channels, which could not be closed, and the active sand bars of the internal delta. In the sand bar area up to 7 m of sand and 1.5 m of sandstone needed to be removed by dredging. The high tidal velocities made work difficult and caused rapid siltation/scour of the trench.

Length: 1450 m

Diameter: 1000 mm (nom.) O.D.

Wall Thickness: 43.5 mm to 50.9 mm

Pressure Rating: 45 m

Average Flow: 1800 l/s

S.G.: 1.26 (too low!)

Costs: Total = $2.5 million
Pipe Materials = $730,000 of MSCL $745,645
Concrete $538,013
F.R.P. $731,612

Contractor: Day Labour (Gold Coast City Council)

Consultant: Camp Scott & Furphy

Fabrication:
(1) 12 m plain ended pipes were butt fusion welded on land into lengths approximately 200 m long and progressively winched over steel rollers into a shallow holding area as each length added.

(2) Each fabricated length hydrostatically tested and refloated.

(3) Concrete weights were then attached to the floating length using a catamaran barge with lifting gantry.

Installation:
(1) Dredge trench progressively.

(2) Tow fabricated length and sink into position as trench prepared (end left afloat for dry attachment of next length).

(3) Level and backfill each length as laid.

(4) Attach next length above water using catamaran barge as trench prpeared and then sink.

(5) Place prefabricated flexible concrete scour matresses under channels.

Jointing: Grade 316 stainless steel flanges and bolts. (After corrosion was detected all joints were encapsulated and 50% plastic bolts used.)

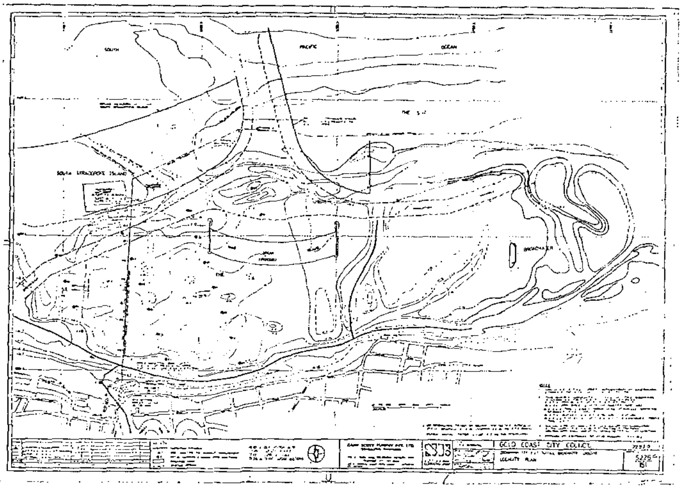


FIG. 2

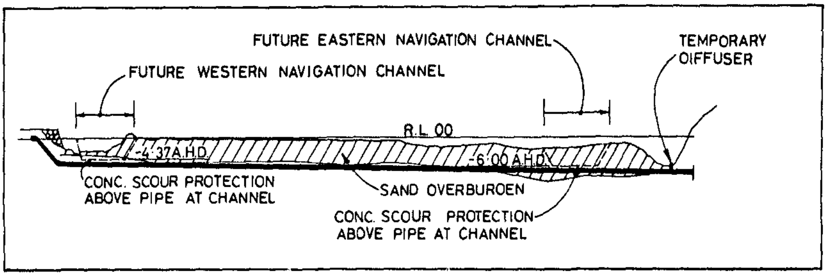


FIG. 3

(b) Townsville, Qld (ref Bryne & Reidel, 1983 (1))

Location: Cleveland Bay between Townsville and Magnetic Island (Fig 2).

Use: In order to provide water to the growing population on Magnetic Island, a new water supply pipe was required.

The material was not specified, but H.D.P.E. was nominated by the successful tenderer.

Site Description: The route traversed Cleveland Bay which is up to 5m deep with waves of 2.0m maximum and currents up to 1.5 km/hr. The bottom material varied from coral to soft mud in the intertidal zone.

Diameter:	426mm O.D.
Length:	5610m
Working Pressure (max):	0.7 MPa
Minimum Flow	155 l/sec
Burial 1.5m in the surf zone	
Water Temperature:	$26^{o} \pm 8^{o}C$
Design Waves: Height	4 metres
Period	8.5 seconds
S.G.:	1.5
Wall Thickness:	40mm
Cost:	$1.8 million ($321/m)
Contractor:	Construct Pty Ltd
Consultant:	Reidel & Byrne Consulting Engineers Pty Ltd

Fabrication:
(1) 17m plain ended pipes butt fusion welded into 400m lengths on beach.
(2) Concrete weights attached prior to launching by lifting and dragging.

Installation:
(1) Excavate trench progressively in reef, surf and intertidal zones using amphibious excavator.
(2) Lift pipe into water and tow with additional floats into place and sink completely into 1.5m (max) deep trench.
(3) Flange joint next pipe under water when next 400m of trench prepared.
(4) Bury seabed sections of pipeline using the diving operated jetting machine.

Jointing: Epoxy coated steel flanges and galvanised bolts (all cathodically protected).

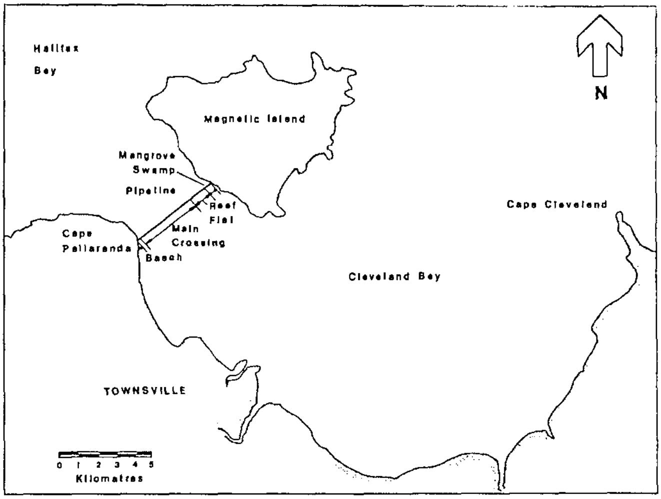


FIG. 4

(c) Devonport, Tasmania (1982)

Location: Mersey River

Use: The main carries raw sewage to the new East Devonport Plant.

Site Description: The main crosses the deep Mersey River which carries a high volume of commercial marine traffic which includes the Melbourne to Tasmania Ferry. In order to prevent excessive disruption the river could not be closed for more than 12 hours at any one time. Due to the site conditions, the need to be corrosive resistant both internally and externally and the need to be laid quickly at a reasonable cost, the Council selected H.D.P.E. over steel and concrete.

Length:	288m
Diameter:	630 mm
Wall Thickness:	30 mm
S.G.:	1.3
Costs:	$250,000 ($868/m)
Construction:	Day Labour (Devonpart City Council)
Consultant:	(Reidel & Bryne Consulting Engineers Pty Ltd

Installation:

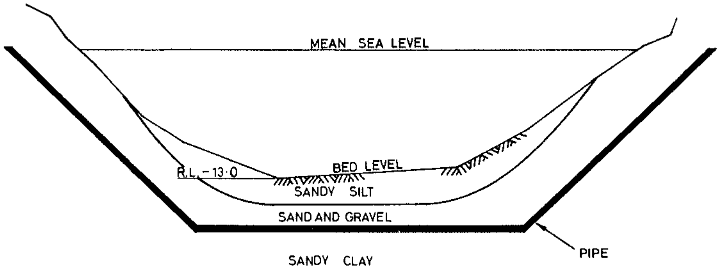
(1) Dredge 2m deep trench

(2) Fabricate one 288m length from 12m plain ended pipes using butt fusion welds on a nearby beach (4 days)

(3) The lower half of the 54 concrete weights were laid out on the beach along side the pipe and the pipe lifted onto the weights using a fleet of front end loaders. The top sections of the weights were then bolted on top. The operation was completed in 8 hours.

(4) The weighted pipe was then towed into the water over greased timber skids at high tide.

(5) Using a tug and several small work boats the pipe was towed into position and sunk into the trench by flooding with town water in 3 hours.



MERSEY RIVER CROSSING

FIG. 5

4.0 OVERVIEW

The three cases cited all involved difficult conditions but as illustraded by utilising the inherent flexibility of H.D.P.E., construction techniques such as prefabrication and above water flange joining were utilised to enable these projects to be carried out economically without the need forspecialised equipment or labour. Due to the nature of the pipe, detailed design of the weighting system, scour protection and corrosion protection/minimisation of joint materials are necessary.

References

1. Byrne Gt Reidel, H.P.: Townsville to Magnetic Island Submarine Pipeline - 6th Aust Conference on Coastal and Ocean Engineering, 1983.

2. Jackson, L. A.: Construction of a 1000 mm dia Polyethylene Effluent Outfall across the Southport Broadwater - 6th Aust Conference on Coastal and Ocean Engineering, 1983