

## Chapter 67

### CONSTRUCTION OF EFFLUENT OUTFALL DIFFUSERS FOR THE BOSTON HARBOR PROJECT

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This paper deals with the construction of the Effluent Outfall Diffusers which form part of the outfall for the Deer Island sewage project. The work was executed 15 km out to sea in Massachusetts Bay and required the drilling, installation, grouting and accurate determination of the actual position of 55 riser shafts in 33.5 m deep water.

The contractor's approach to the installation of the diffusers required the design and manufacture of many special pieces of equipment and the purchase of some major standard equipment.

The selection of the right drilling method and the right drilling equipment played a major role in the success of the project and the paper discusses these in the context of the overall working method.

#### INTRODUCTION

The Boston Harbor project is a wastewater treatment project undertaken by the Massachusetts Water Resources Authority (MWRA) under a Federal court order, which found wastewater discharges to Boston Harbor to be in violation of the Federal Clean Water Act of 1972.

The main part of the overall project consisting of a \$6.1 billion, 11-year effort, is comprised of the new primary and secondary waste water treatment plant at Deer Island, designed for a total capacity of 57.2 m<sup>3</sup>/s. In addition to the plant, new tunnels and headworks are being built to transport raw sewage from the metropolitan Boston area to the plant, as well as numerous ancillary facilities.

Treated sewage or effluent will be discharged through a 7.4 m (finished) I.D. tunnel, drilled approximately 15.1 km offshore by Tunnel Boring Machine (TBM) excavation. This project is currently under construction. (Figure 1 and 2)

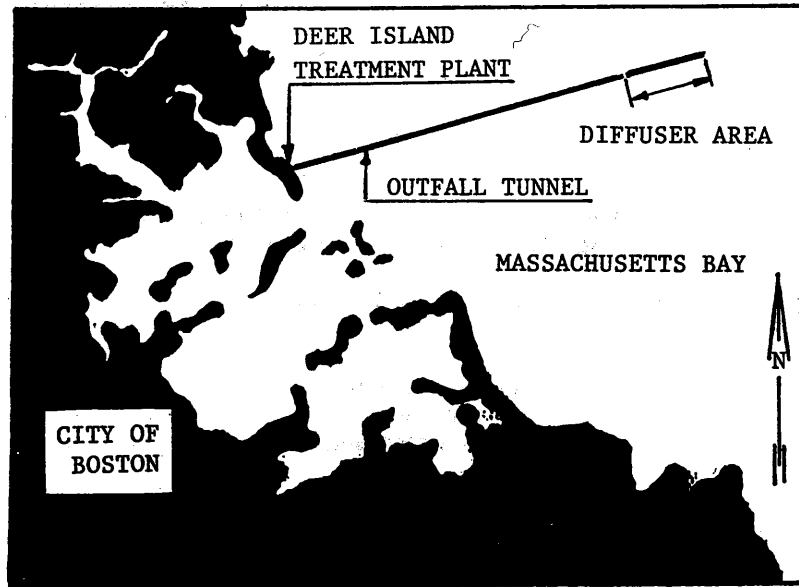


FIG 1 - KEY PLAN

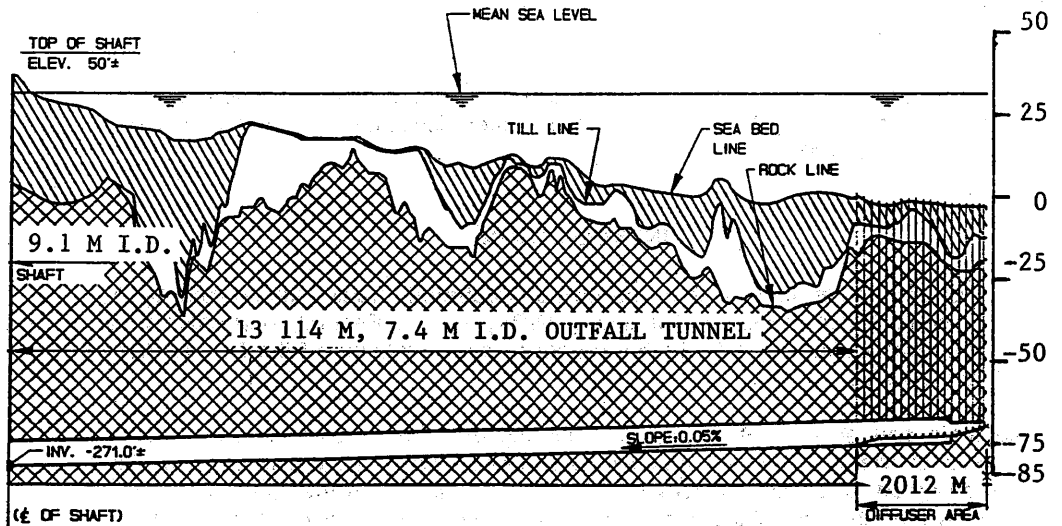


FIG 2 - OUTFALL PROFILE

The effluent discharge will take place over the last 2.0 km through lateral offtakes from the tunnel through the risers into the diffuser heads, which are located just above seabed level. (Figure 3)

The contract for the construction of the effluent outfall diffusers was awarded after a competitive bid in August 1990 by the MWRA to Cashman/Interbeton (CMIB Joint Venture). The contract amount was \$77 million and the project was to be completed in June 1993. However, the work was completed ahead of schedule, in November 1992.

The main piece of equipment utilized for the installation of the diffusers was the jack-up barge IB-909, a self-elevating platform. Dredging and stone placing was done by the crane barge, John Lyons II.

#### WORK ENVIRONMENT

The project site, approximately 15 km east of Boston in Massachusetts Bay is exposed to the sometimes hostile weather and ocean conditions prevailing in this area. In anticipation of these conditions the construction of the diffusers was scheduled during workable time periods of 1991 and 1992, i.e. from April through November. During these seasons, work offshore continued 6 days a week, 24 hours a day. Personnel were transported from shore to the jack-up barge by helicopter. Materials were supplied by barges from a staging area located at East Boston.

The water depth at the project site was approximately 33.5 m and the jack-up barge was equipped with legs long enough to allow for anticipated leg penetration and to ensure a safe deck elevation above sea surface.

While on site, the weather and sea state conditions were generally as expected. However, work was disrupted by hurricane "Bob" in August 1991, and again by the "No name storm" in October 1991.

#### SUBSURFACE CONDITIONS

Since the construction of the diffusers involved large diameter drilling through a total of approximately 4200 m of sediment and rock, knowledge of the site geology was of great importance.

The principal rock formation along the diffuser alignment is Cambridge Argillite, a slightly metamorphosed mudstone or siltstone, with an average compressive strength of 105 MPa. The rock was known to have numerous discontinuities, folded bedding and faulting. Core drillings of the bedrock, obtained during a prior geotechnical exploration program were examined during bid preparation. The rock typically appeared to be uniform and had high average Rock Quality Designation (RQD) values.

Due to the generally stable nature of the underlying bedrock, no collapsed holes were experienced during or after drilling.

Above the bedrock the stratigraphy is comprised of recent sediments, holocene marine clays and pleistocene tills. During construction the total thickness of these sediments appeared to vary between 6.0 to 21.0 m. The individual strata could not readily be discerned during drilling.

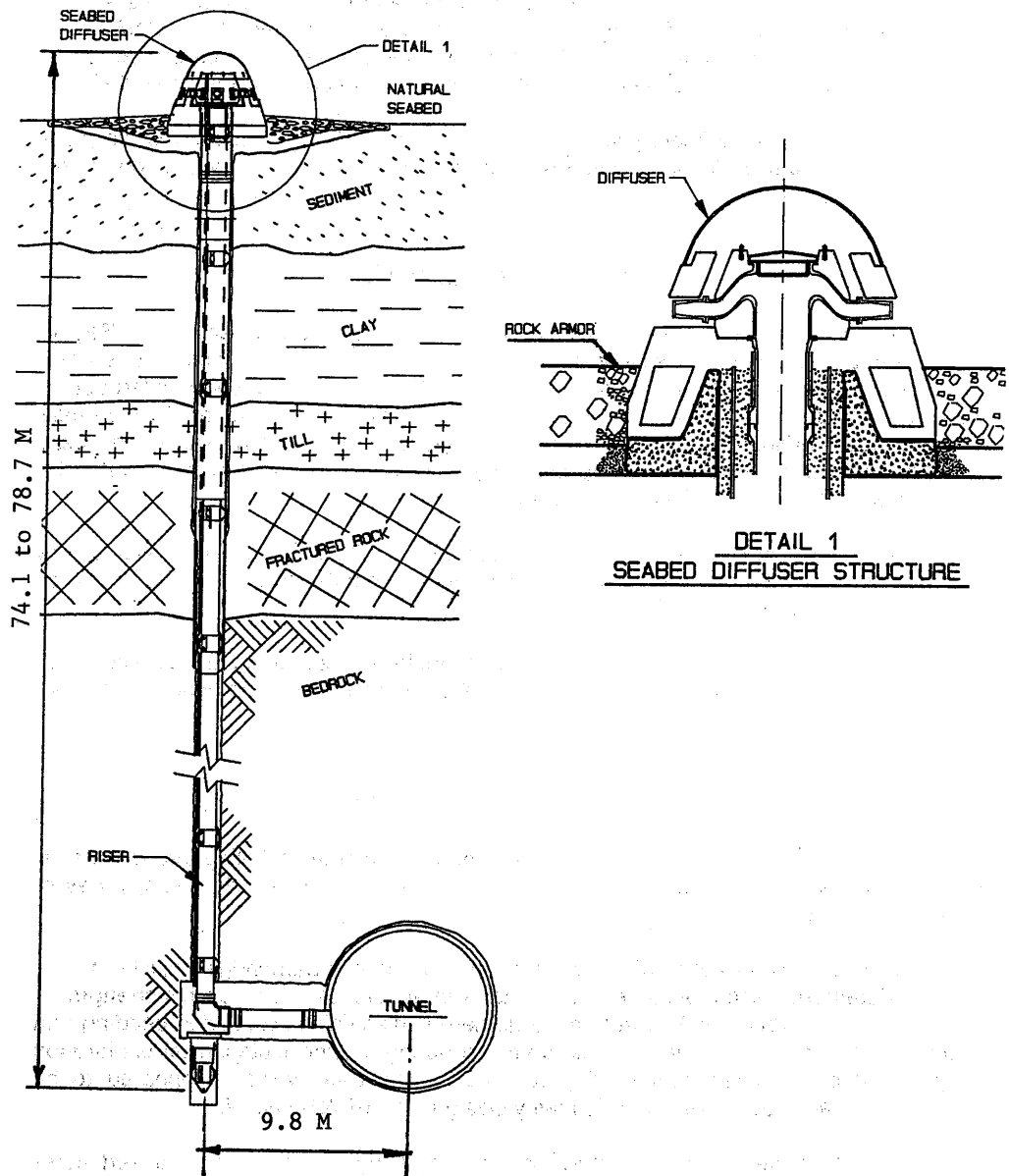


FIG 3 - DIFFUSER WITH TUNNEL CONNECTION

## MOBILIZATION

The time period between contract award in August 1990 and actual start of activities offshore in April 1991 was utilized by Cashman/Interbeton to prepare for continuous operations. Time and financial restraints would not permit undue experimenting once on site. Following were the main activities which took place:

### Procurement of permanent materials

Due to their unique character, as well as 100 year design life, the permanent risers and diffuser structures feature various complex and unusual materials, subject to high quality requirements. The main items being:

Fiberglass reinforced plastic (FRP) pipes. These heavy wall thickness pipes, which form the inner lining of the risers, are spirally wound and measure 12.0 m long by 0.76 m I.D. During flexural testing, each pipe was monitored for acoustical emissions.

Fiberglass reinforced plastic (FRP) manifolds. These components were located on top of each riser and formed the inner liner of the diffuser head. They include 8 port arms for the uniform dispersment of effluent at the ocean bed level. The FRP manifolds were fabricated of hand-laid fiberglass and concrete encased. Each was hydrostatically tested, while simultaneously being monitored for acoustical emissions.

Cast nylon nozzles and port caps. These units are attached to each manifold port arm and, they vary in diameter according to their location along the diffuser line. The port caps effectively seal the riser/diffuser assembly and will not be removed until commissioning of the outfall.

Cast steel clamps. These clamps, which weigh 545 kg per set, provide the connection for the FRP pipes.

Precast concrete diffuser head. These units comprise the concrete encased manifolds, mentioned above, the concrete base and the ringwall. This unit formed the protection at seabed level of the diffuser. The outer surface of the precast components are provided with a 3.2 mm polyurethane coating, which serve to provide additional mechanical protection to the installed diffuser. The total weight was 54 tonnes.

High density polyethylene domes. These units, located on top of the ringwall are designed to Deflect dragging wires, anchors, etc. for protection of the diffuser head. They were rotationally molded, using the cross-linked HDPE process.

Inconel™ (and high-grade stainless steel.) Inconel, a high nickel alloy is used in various connections, fittings, inserts, etc. Most of these parts are machined or fabricated assemblies and have been designed to provide highly corrosion resistant connections to the diffuser head components.

Various custom fabricated mild steel components Although most of these items performed a temporary function in the construction of the diffusers, they were manufactured under the same rigorous quality control standards as permanent materials and required the construction manager's review and approval.

Production of permanent materials was all done under purchase agreement by highly specialized companies throughout the U.S.A. as well as Australia, in case of the steel clamps. All materials were delivered at the staging area in East Boston where they were assembled in three sections (diffuser head and two riser sections) prior to shipment offshore for installation.

#### **Mobilization of equipment**

IB-909 The jack-up barge, IB-909, as the main piece of equipment utilized for drilling and riser installation and was mobilized from Singapore. On arrival in Boston, it was equipped with a Manitowoc 4100 S3 ringer crane with a 54.8 m boom. Its pontoon shaped hull measured 43.0 m x 30.0 m x 4.20 m, and had a carrying capacity of 3200 tons when jacked up. The 4 legs were extended to an overall length of 70.0 m. The jacking up system consisted of hydraulic driven rams with holding and working pins. Compressed air for drilling was provided by 4 compressors.

Electric power for the jack-up barge operation and drilling was provided by 3 synchronized 150 generators. Four submersible pumps were installed to provide a continuous head of water pressure in the drill casing to prevent hole collapse. For the specific purpose of casing-top drilling and riser positioning and installation the barge was equipped with 2 custom engineered templates, one to port and one to starboard side of the barge which could slide along a bullrail fixed to the barge deck. Each template was provided with a gate, which in turn could slide laterally to the barge for positioning purposes. The barge was equipped with a 6-point mooring system, used during repositioning of the barge.

In addition to the primary systems, the jack-up barge was fitted with a heli-deck, a 20 tonne hydraulic service crane, extensive diving and navigation equipment, and various storage compartments.

The advantages of a jack-up barge for this type operation are that it provides a stable platform relative to the seabed, and facilitates an accurate and safe riser installation. Virtually no shutdowns due to adverse weather and sea state conditions were encountered.

An added advantage of the specific jack-up barge selected was the hull size (beam 30.0 m). This allowed simultaneous work at two riser locations at each set-up. (The risers were located at 37.8 m centers). Figure 4 shows a view of bow side of the IB-909 while at a typical set-up. Figure 5 shows a picture of the IB-909 in operation.

Drilling Rigs For the actual drilling of the riser hole, 2 new Wirth B818/2500/300 casing top drilling rigs were purchased along with bottom hole assemblies containing weight cans and centralizers. Drill bits measuring 1.70 m and 1.35 m diameter were provided for the upper and lower portion of the drilled hole respectively. Both tooth cutters (for drilling through upper overburden) and disk cutters (for drilling through lower rock) were provided.

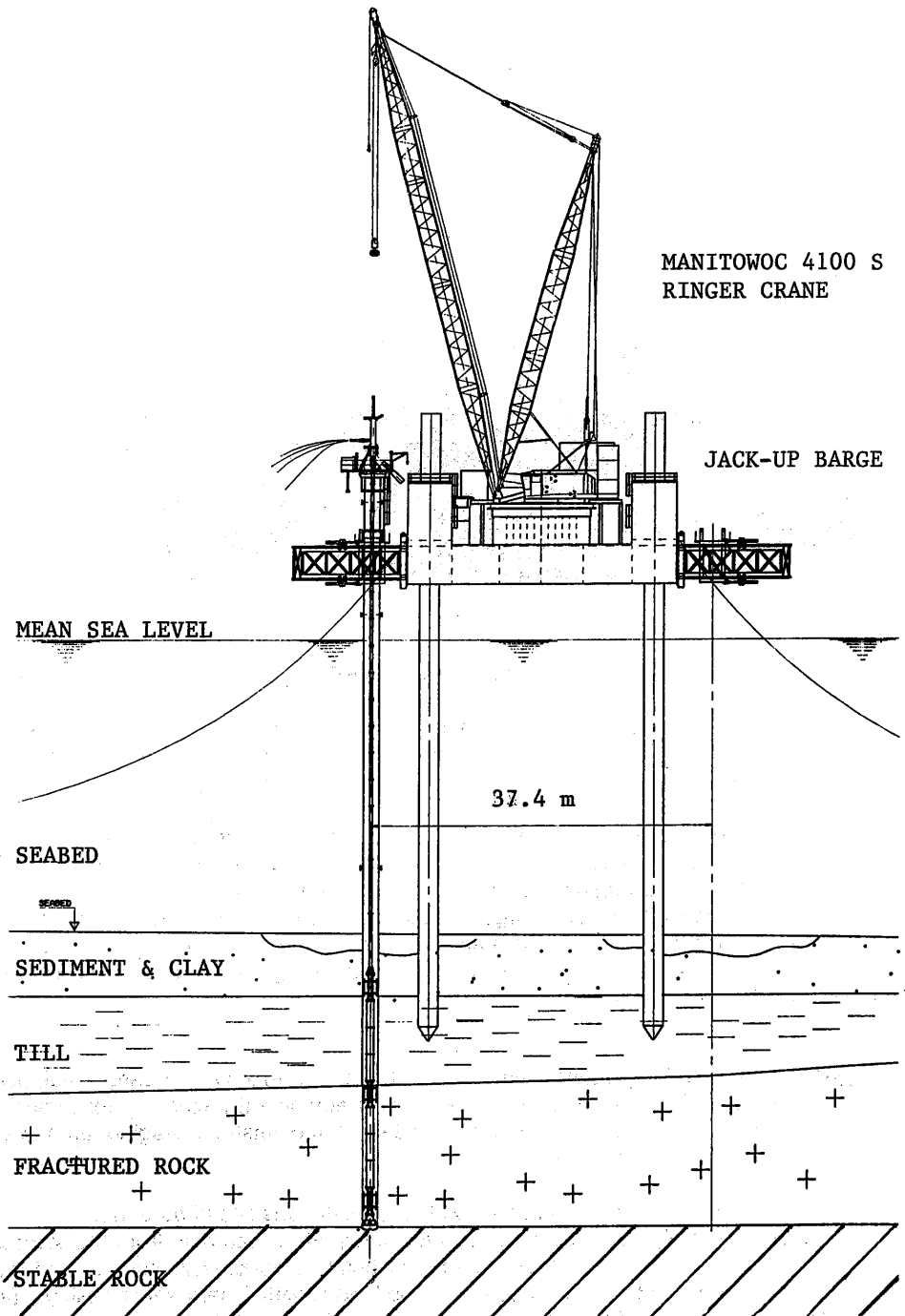


FIG 4 - TYPICAL SET-UP JACK-UP BARGE  
DURING FIRST PHASE DRILLING

