Construction Challenges in an Ocean Outfall – a Case Study

***Sumon Ghosh**, M.E (Civil), Engineering Project Specialist, Clearford Industries Inc., Suite 100, 515 Legget Drive, Ottawa, ON K2K 3G4, Canada*

Abstract

This case study demonstrates the constructional challenges faced during the implementation phase of a marine outfall. The wastewater treatment plant for A'Seeb Wastewater Project was located in a high security area (being in close proximity to the royal establishments). Important decisions with respect to choice of material and construction methodology had to be adopted in order to overcome those challenges.

INTRODUCTION

The A'Seeb Wastewater Project consists of a collection network for primarily domestic sewage collected from three catchment basins of Greater Muscat area, its transportation through a Main Collector Sewer and treatment at a Wastewater Treatment Plant. The gravity sewers of the collection network totalled a length of approximately 2000 km while the Main Collector Sewer constituted a length of 23 km with the pipe diameter varying from 600 mm to 2000 mm. The designed maximum capacity of the treatment plant was 85,000 cum/day. Intended to be used for irrigation and landscaping purposes, an alternate arrangement for disposal of the treated effluent from this plant was to be made. The problem was addressed by making a bypass arrangement in the form of an Ocean Outfall to cover situations when demand for irrigation or landscaping water was not sufficient. The diameter of the proposed steel outfall pipe was 1350 mm and it discharged at a distance of 1 km from the shore line inside the sea. It needs mention here that a unique feature of this treatment plant was its proximity (within 500 m) to residences of highly placed officials and royal establishments.

LOCAL REGULATORY STANDARDS FOR TREATED EFFLUENT REUSE AND DISPOSAL

The Ministerial Decision 145/93 outlined the wastewater quality parameters with their limits as they relate to the permitted method of discharge. Based on the fact that the treated wastewater would be reused for irrigation or landscaping purposes, some of these parameters are set out in the Table 1 below:

Table – 1: Treated Effluent Quality for Irrigation and Landscaping

S.No	Parameter	Standard
1	pH (within range)	6 - 9
2	Biochemical Oxygen Demand, BOD (5 d, 20°C)	15 mg/L
3	Chemical Oxygen Demand, COD	150 mg/L
4	Suspended Solids, SS	15 mg/L
5	Total Dissolved (TDS)	1500 mg/L
6	Sodium Absorption Ratio (SAR)	10
7	Phosphorus (total as P)	30 mg/L
8	Nitrogen: Ammonical (as N)	5 mg/L
	Nitrate (as NO_3)	50 mg/L
	Organic (Kjeldahl)	5 mg/L

As mentioned earlier, it was necessary to keep a provision for marine disposal of the treated effluent having irrigation water quality. However, this called for a close review of the important provisions of Ministerial Decision No. 159-2005 applicable to discharge of liquid waste into the marine environment. These provisions are listed below:

- No liquid waste shall be directly or indirectly discharged in the marine environment without obtaining a prior Permit
- The Ministry may refuse awarding Permit if it considers it possible to reuse, recycle or treat such waste without causing any hazard to the human or environmental health
- The quality of liquid waste in relation to a few important parameters should be within the limits specified in Table 2 below:

Table – 2: Treated Effluent Quality for Marine Disposal

S.No	Parameter	Standard
1	pH (within range)	6 - 9
2	Temperature	<10°C above ambient temp.
3	Biochemical Oxygen Demand, BOD (5 d, 20°C)	20 mg/L
4	Chemical Oxygen Demand, COD	200 mg/L
5	Total Suspended Solids, TSS	30 mg/L
6	Nitrogen: Ammonical (as N)	1.0 mg/L
7	Nitrogen: Nitrate (as N)	15 mg/L
8	Nitrogen: Organic (Kjeldahl) (as N)	5 mg/L
9	Total Nitrogen	15 mg/L
10	Phosphorus (total as P)	2 mg/L

CONSTRUCTIONAL CHALLENGES

The challenges faced during the execution of works related to the ocean outfall can be broadly classified into 2 categories:

- Obtaining construction permit given the sensitive nature of the area
- Choice of material

Permits – During the design phase principal route approval was taken from relevant authorities for alignment of the outfall pipe. It was also determined at this stage that the point of disposal of the outfall shall be 1 km inside the sea pending a detailed dispersion modelling to be done during the construction phase. Typical proposed offshore sections and general arrangement plans during the initial stages are shown in Figure 1 and 2 respectively.

The guidelines provided in Ministerial Decision No. 159-2005 regarding obtaining permit are listed below:

- In order to obtain a permit, the following information concerning the discharge location is required:

a) Physical, chemical and biological characteristics of the water column and the sea bed in an area of (2 km) diameter from the discharge point, especially including benthic sea bed life such as sea weed and corals
b) Recreation areas and other usages of the concerned marine area
c) Evaluation of the contents of liquid waste currently discharged in the area, especially phosphate and nitrate

- The permit holder shall undertake to:
  a) Set the end of the liquid waste discharge pipe at a depth of not less than one meter below the lowest tide line
  b) Specify a circular area of 300 meter diameter, with the point of liquid waste discharge as its centre, as the initial mitigation area, whereby discharge of liquid waste in this area should not result in the following:
     i) Increase of the temperature of surrounding water for more than 1°C (weekly average)
     ii) Reduction of average dissolved oxygen for more than 10% (weekly average)
     iii) Changes in pH by more than 0.2 unit
     iv) Increase or decrease in rate of salinity for more than 2 salinity units (2 parts per thousand) of the daily surrounding average
- The discharge should be characterized in the form of three dimensional modelling covering one seasonal year and high and low tide cycles. Provided that this modelling shall be applied in the worst initial mitigation conditions, i.e. the lowest wind speed concurrent with the diminishing high and low tides, the lowest recorded current speed in the location and the tidal reflection in view of such conditions, unless otherwise decided by the Ministry.
- The said modelling should include the following data and information:
  a) Meteorology measurements: Wind speed and direction for at least one month during the south-western and north-eastern seasonal winds
  b) Marine currents measurements: High and low tide currents and the currents resulting from wind action on the surface, the central and sea bed waters covering an area of (1) km on either sides of the discharging point and for km into the sea
  c) Sea bed topography: Depth contours covering an area of (1) km on either side of the discharging point and for (1) km into the sea
  d) Multi-port diffusers should be used at the piped end provided they allow gradual dispersion and assist in preventing the liquid from reverting to the beach area

Although dispersion models developed during the implementation phase confirmed the suitability of the outfall point at a distance of 1 km from the shore line inside the sea, to be on the safer side the relevant approval authority (endorsing construction permit) advised the project team to increase this distance to 1.5 km. The approval agencies also requested the following modifications and precautions:

a) Re-alignment of the outfall pipe in some stretches because of its close proximity to royal establishments
b) Minimize disruption of traffic in the vicinity during installation of the onshore section of the outfall pipe

c) Some stretches of the alignment passed through high security area. It was pointed out that there could be restricted access to these areas during the operation and maintenance stage.

After presenting the results of the topographic and bathymetric survey along with results of the dispersion modelling and proposed plan and profile of the outfall to the appropriate authorities a permit was finally obtained. However, considerable time was lost by this time and it was important to cut down the construction time for the outfall in order to match with the overall project schedule.

Choice of material – The choice of pipe material accepted in the contract was steel with appropriate corrosion protection coating/film. However, at this stage the suitability of steel pipe in a marine environment was to be evaluated.

An alternate material for the outfall pipe (HDPE) was proposed during the tender stage. Although this proposal ensured longer life, faster method of construction and relative ease of maintenance there was an additional financial implication attached to this proposal. This proposal was to be re-evaluated at this stage.

OVERCOMING THE CHALLENGES

The following measures were taken to address the issues in hand at this juncture.

- Based on the recommendation of the approving authority the point of disposal of treated effluent was extended to a distance of 1.5 km inside the sea

Although this essentially translated down to additional cost to the project, the recommendation of the approving authority had to be taken into consideration. Necessary surveys for the additional 500 m had already been conducted earlier.

- Alignment of the outfall pipe (onshore) was revised in stretches that were close to royal establishments

A dedicated field team of surveyors and engineers was organized for the task of finding an alternate route in some sections. This task was quickly accomplished and plans and profiles for the alternate route were approved by the relevant authorities responsible for issuing construction permit.

- The onshore installation of outfall pipe was originally planned through open cut excavation only. However it was now to be dealt with a combination of open cut excavation and micro-tunnelling to keep traffic disruptions to a minimum.

Micro-tunnelling machines operating for the construction of main collector sewer under a different contract in the same project were getting released as that job was nearing completion. In order to save time on mobilization demobilization, these machines were to be utilized.

- HDPE was the preferred outfall pipe material at this stage although the original scope of work specified steel pipes

The decisive factors in this choice were i) there would be restricted access to some of the areas during O & M period - pipe joint achieved through electro-fusion held the promise of zero leakage (infiltration or ex-filtration) and thereby minimal maintenance ii) Resistance to corrosion in the marine environment iii) Light weight making transportation and handling easier resulting in reduced installation time

A cost benefit analysis helped in deciding to accept all these factors.

CONCLUSION

The following factors are some which probably go a long way into building an effective ocean outfall:

- Early planning and design inputs
- Choice of material
- Ease of maintenance and operation

It is extremely important that from the inception stage itself sufficient information on field conditions and provisions/standards of the local regulatory body are collected and analysed in order to design an effective outfall.

Metallic outfall pipes immersed in sea water have a greater susceptibility to corrosion due to galvanic action. Generally, the weakest sections in any piping system are their joints and therefore these areas are potential points of leakages leading to major pollution setbacks. It is extremely important that the joints behave as an integral part of the pipe at all times.

Aging infrastructure pose a serious challenge to the smooth operation of a facility. Every ocean outfall system has a design life beyond which its performance may deteriorate. The problem gets aggravated in the absence of a proper operation and maintenance system. In particular replacement of large diameter ocean outfall pipes could be prohibitive in today's world of strict budgetary control. At the same time accidental spills or leakages could lead to huge costs associated with emergency repair, finding alternate points of disposal, penalties and tidying the spillage site.

References

1. *Ministerial Decision 145/93: Sultanate of Oman*
2. *Ministerial Decision 159 – 2005: Sultanate of Oman*
3. *Design Report and Tender Documents - A'Seeb Wastewater Project*

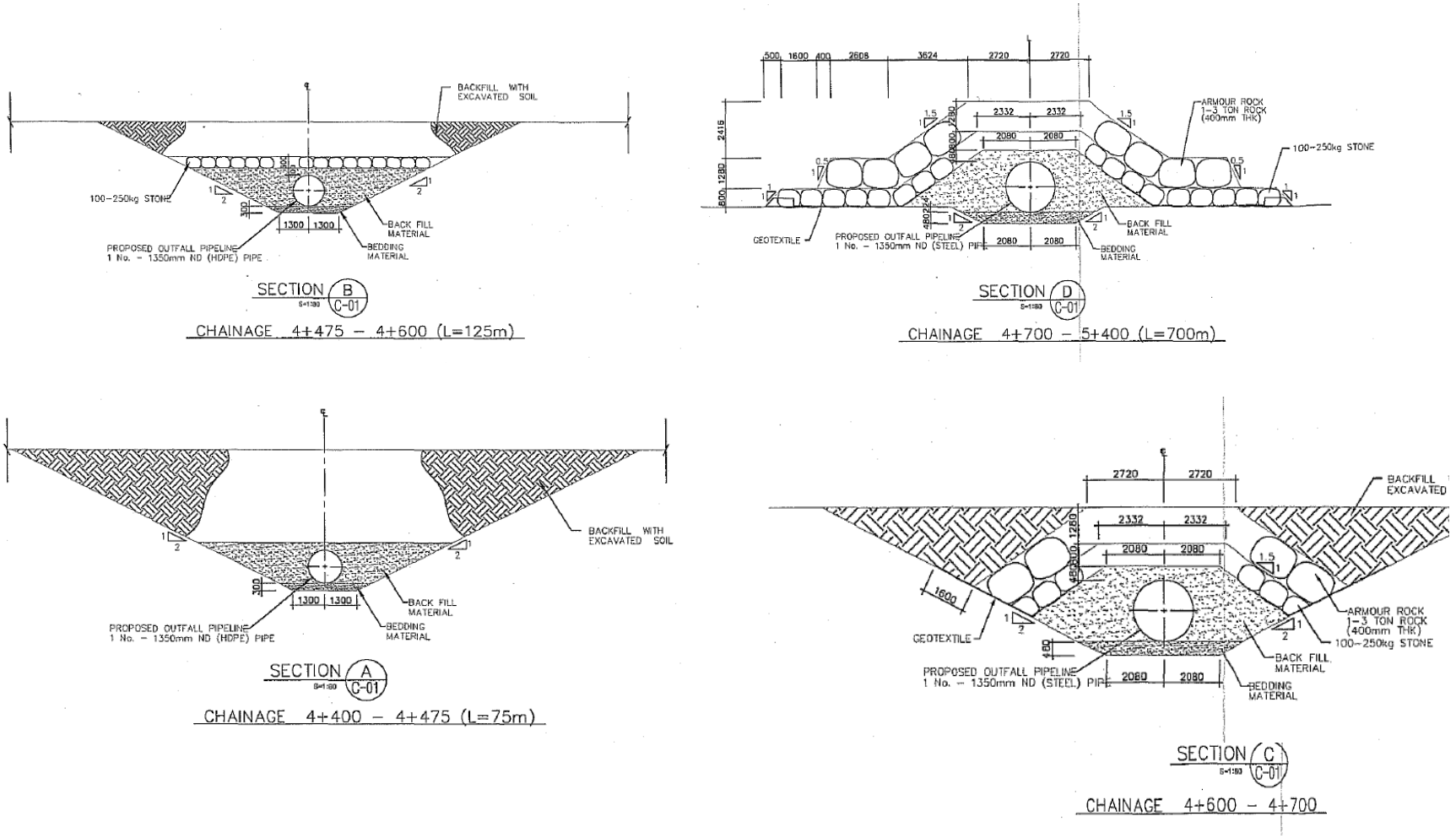

Figure 1 – Typical Offshore Sections

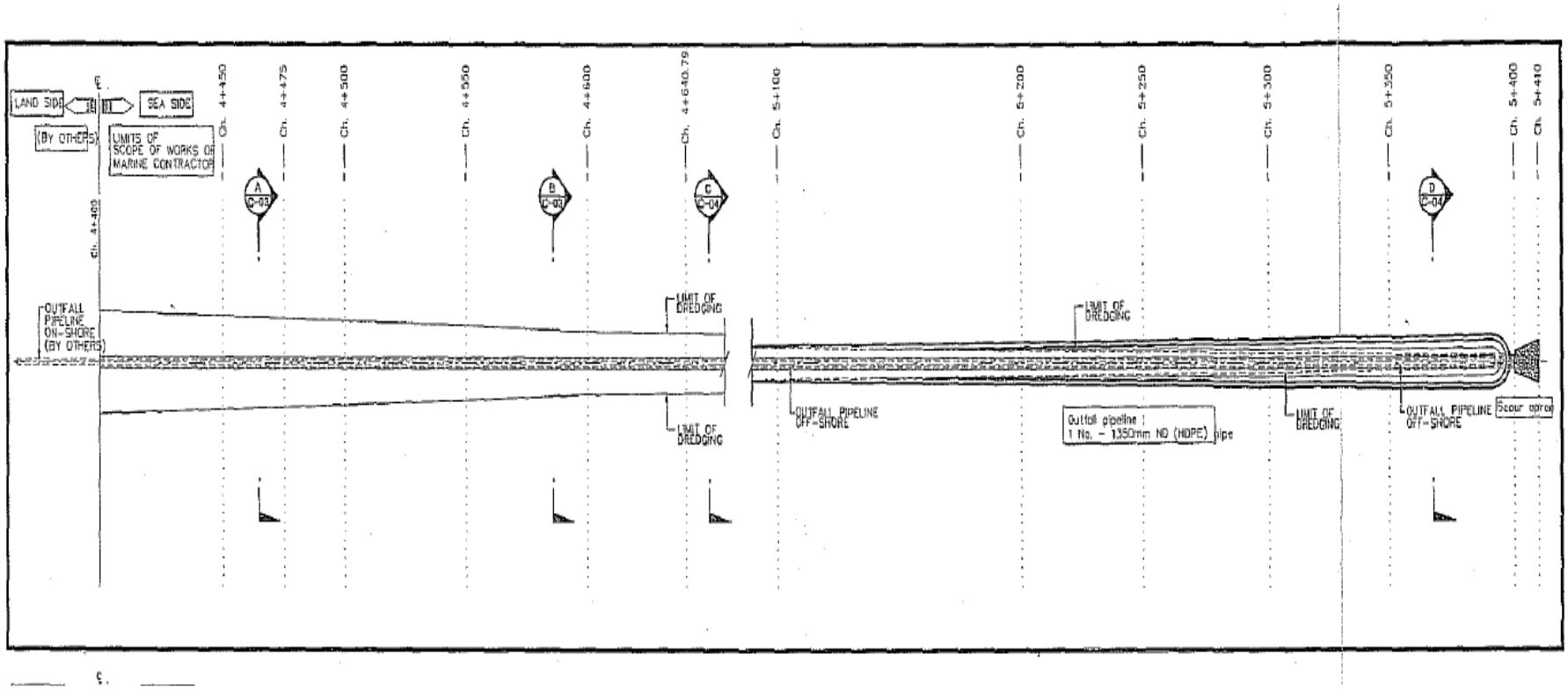

Figure 2 – General Arrangement Plan of Outfall (Offshore)