BLACK & VEATCH LTD

INTERNAL MEMORANDUM

To:	xxx	Date:	12th April 2016 (updated by SN 19/05/16, revised by DB 28/06/2016, updated by SN02/09/16)
From:	Pipelines and Outfalls Team	Subject:	Ardersier Outfall – Options Summary
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1. Purpose

The aim of this memo is:

- To summarise the options being considered for the outfall.
- To highlight advantages, disadvantages and restrictions of the different options.
- To summarise preferred option decision making process.

2. Introduction

This document compares the advantages and disadvantages of three different construction options based on Ardersier Wastewater Outfall Review version A March 2016 and subsequent findings.

The analysed options are:

1. Trenched outfall with additional weight (concrete mattress and concrete weight)
2. Horizontal Directional Drilling
3. Piled Outfall

3. Site Conditions

Tidal range:

The route crosses the intertidal zone to just below MLWS, a distance of 300m, via shallow and unstable sand flats where it can be exposed to strong waves and currents. The landward end of the pipeline is buried for all options. The whole length of the exposed outfall is covered at high tide; at MLWS half of the alignment is dry and beyond that it is covered at all states of the tide but water depths are very shallow. There are only short periods that there is dry access. More detailed description is given in the Ardersier Wastewater Outfall Review report.

Geology:

In February 2016 ESG carried out a geotechnical site investigation to obtain geotechnical and geo-environmental information to provide parameters for the design of the marine outfall. The investigation comprised of 2 number sonic bored boreholes, on and off shore geophysical surveys and laboratory testing – further information is provided in Appendix 1.

Other constraints:

Additional constraints include the firing range from Fort George, limited access to the beach from the land side, shallow water access from the seaward side, health and safety issues with working in the intertidal zone.

4. Trenched PE pipe

Description:

Based on initial calculations on the marine environmental loading, pipe installation in the shallow water and intertidal zone in a trench with a combination of permanent weight blocks and concrete mattresses to provide stability and scour protection is feasible. It is not recommended to lay the pipe on the seabed in the wave breaking zone.

Pros:

Use of simple construction methods will enable rapid trenching through the shallow water and intertidal zone. Minimal work is required in the water as the pipe can be weighted and lifted into the trench, followed by the mattresses.

Cons:

The hydraulic design cannot accommodate a fall all the way to the discharge point, which will mean there is a low point at the end of the pipe. However, a tideflex valve at the discharge will prevent sediment from entering pipe from the seaward end. In the initial period of operation of the outfall, the velocity in the pipe will not be as high as would be desired to provide self-cleansing. A regime of flushing would be recommended to prevent siltation.

Some diving work will be required at the discharge point.
Temporary Piling Works would be required in the inter-tidal zone.

5. Horizontal Directional Drilling

Description:

HDD is a method whereby a drill is launch from a pit on land and forms a bore in a “U” shape, emerging in the desired location. The method requires a flexible PE pipe to be dragged through the bore, so the ground material is required to be favourable.

Pros:

Employing HDD can offer greatly reduced impact on the beach and minimise construction work in the water and intertidal zone, avoiding the associated health and safety risks and costs.

The pipe will avoid the challenges associated with installation in the wave zone.

Cons:

A desktop feasibility study to review the HDD was undertaken by a specialist contractor, Stockton Drilling Ltd. The report concluded that although HDD may be possible, the ground conditions are not favourable for this method. See section 8.2 for further details.

The hydraulic design would recommend the selection of as small a pipe as possible to ensure self-cleansing of the inverted syphon shape, which may require review of the pumping system.

Some diving work will be required at the HDD termination and discharge point.

6. Piled pipe

Description:

The piled solution selected is a ductile iron pipe supported on piled cradles above the seabed. Socket/Spigot Ductile Iron pipes would be installed onto the cradle. The preferred pile type is tubular steel - Further review of the piling options is included in Attachment 1.

Pros:

The hydraulics would allow a free discharge, so reducing risks associated with sedimentation in the pipe. A non-return valve would be required to prevent sediment and marine growth encroaching up the pipe.

The least diving work is required for this option.

Cons:

Working in the intertidal /shallow zone will require specialist machinery. Access for large pile installation plant from both marine and shore will be difficult. Working times may be reduced due to water levels.

A large number of piles are required. These need to be long enough to found in suitable material and to withstand significant scour exposure.

A piled outfall will have the greatest visual impact of the options considered.

7. Further information required

- None.

8. Cost and Buildability Assessment

8.1 Trenched Outfall

Buildability Statement:
2No Contractors were approached for their opinion on buildability of this option. Both thought that it was buildable. This option would require a high level of temporary works to enable construction. The solution that was priced for this option was the most robust in terms of weather risk.

Scope of Work:
310m x 8m Cofferdam with 12m piles driven from a piling mat of a similar size. Once cofferdam piling is established the piling mat is removed internally and framing installed to support piles. Three frames of 356 x 406 UC 634 sections were assumed. The excavation would be brought to formation and the pipe would be installed, covered with revetment mats and backfilled. Cofferdam will then be removed and pipe connected to Discharge Manhole.

Cost:
LBE £5,562,601.32

8.2 HDD (Horizontal Directional Drill) Outfall

Buildability Statement:
A HDD contractor was approached regarding this option and quotation obtained.

Following review of the geophysical survey results (which identified gravels) the contractor withdrew the opinion stating;

"Our feasibility report regarding this project was based upon the geophysics results stating that there was bedrock beneath the sand. Having discovered that the bedrock as stated is actually a gravel bed, we can now state that HDD will not be feasible in these conditions, as it will not be possible to keep a bore open in a medium such as gravel."

Scope of Work:
An HDD would be carried out from land to the discharge point. Once the HDD was complete the head and drilling equipment would be retracted and pipe would be inserted. Marine work would be completed to the end of the pipe to fit the tideflex valve and headwall/discharge protection.

Cost:
LBE £2,235,193.79

8.3 Piled Outfall

Buildability Statement:
2No Contractors were approached for their opinion on buildability of this option. Both thought that it was buildable.

Scope of Work:

Rock armour would be partially removed from the shore to allow for piling plant to access the beach. The piles would then be bored to depth. The bottom pipe collars would be connected to the piles. The pipe would then be placed onto the collars and jointed using traditional ductile iron socket/spigot connections. Marine Piling would be completed at the same time as the onshore piling and pipe supports and pipes installed by divers. The tide-flex valve would be pre-fitted to the pipe avoiding the need for marine works at the discharge point.

Cost:
LBE £ 1,158,000.00

9. Scoring

Scoring system below is indicative and based on the current level of design, understanding and knowledge of the project. It mainly aims at facilitating the decision making process. Scores are relative to each other (1 highest cost/risk/impact and 3 the lowest), but do not represent a pro rata relationship between the options.

Category	**Potential showstopper**	**Weight**	**Trenched piped**	**Piled pipe**	**HDD[1]**
Technical risk	No	1	3	3	~~2~~
Construction and Programme Risk	No	3	1	2	~~3~~
Environmental risk during construction	Yes	5	3	1	~~2~~
Cost	Yes	5	1	3	~~2~~
Extendibility	No	1	2	3	~~1~~
Operation	No	5	1	3	~~1~~
Environmental/visual Impact post construction	No	4	3	1	~~3~~
Total	-	-	45	51	~~49~~

Score Key 3 – Very Good 1 - Poor
Weight Key 5 – High Importance 1 – Low Importance

[1] HDD scores have been crossed out due to the option being non feasible

10. Conclusion

The location of the outfall makes it challenging to achieve long term stability of the installation. Having considered the available options, we now consider the Piled option to be the best solution for this project.

Attachment 1

Ardersier Outfall – Piling options

1. Topography

The outfall alignment runs across the beach to just below MLWS, a distance of 300m. The bed level falls from +4m OD to -2.3m OD. The landward end of the pipeline is buried and surfaces at an elevation of about +1m OD. The whole length of the exposed outfall is covered at high tide. At MLWS the alignment is dry for the first 120m. Beyond that, the alignment is covered at all states of the tide but water depths are very shallow. The alignment remains covered at MLWN, so there are only short periods that there is dry access.

2. Geology

a. Ground conditions

Between ground level and 0.1m bgl (below ground level) Top Soil comprising light yellowish brown sand with rootlets was encountered. Underlying Top Soil in both exploratory holes are Tidal Flat deposits. Tidal Flat Deposits comprise dense to medium dense yellowish to light yellowish brown very sandy sand slightly silty gravelly to very gravelly medium to coarse sand and gravels. A single seismic horizon was identified during the geophysical investigation. This has been interpreted as the interface between a dense gravel band and the overlying sands. From the geophysical profile, the depth of the dense gravel band is approximately 5m bgl at the position of the manhole. This corresponds with dense to very dense sand encountered in BH01 and BH02 at depths of approximately 5.5m bgl. The depth decreases to approximately 1.6m below sea bed level at the location of the outfall.

b. Seabed Features

The majority of the seabed was found to display a smooth texture with occasional isolated texture with low reflectivity and low changes in relief. This was interpreted as sand with the occasion textured areas thought to be cobbles and boulders. An area of rough texture towards the east of the survey area has been interpreted as exposed gravels. The area just south of the gravels displays moderate texture and exhibits moderate reflectivity. This has been interpreted as sand with cobbles.

3. Types of pile

Piles used in this location should be augered rather than driven and should not be jointed.

- **Timber**

Timber piles are often used in a marine environment and with the choice of suitable wood, the design life is good. They are light and easy to handle and can be obtained in lengths up to 18m. Therefore it would not be necessary to splice them. As the timber density is low, it can float and immediately after driving as the skin friction may be low and the piles can float unless loaded. As the foundation is gravelly the pile toe would need a steel driving point.

- **Precast concrete**

Precast concrete piles can be cast to the length required, so that there is no need to cut off the pile head prior to installation of the pipe cradles and the pipe line. They are denser than timber, so do not float. Design life is good provided the cover to the steel reinforcement is sound.

- **Steel**

Steel tube piles would be suitable and allow for quicker and less intrusive installation. Steel is subject to corrosion and would need suitable cathodic protection. This is our preferred Material.

4. Piling layout

The outfall pipe is 500mm diameter and formed of 5.5m lengths. Each length needs to be supported, so piles will be augered in pairs, 5.5m apart. Each pair will be connected by a cradle which will carry the pipe. The first 17 to 20m of the 300m long outfall is buried in the slope above the beach. Piling is then required for the remaining 283m of pipeline. This is 53 pairs of piles, a total of 106 piles. Axial restraint is required to the discharge valve.

Based on the compressive, tensile and lateral loads and the foundation, a pair of 325mm tubular steel piles, 14.5m below existing sea bed will give the required capacity. This also allows for up to 1.8m scour.

The two piles of each pair should be 1.6m centre to centre, each 0.65m from the pile centreline. The pile heads should be at the same level so that a steel cradle can be placed across them to carry the pipe. The tolerances on pile position should not be greater than 75mm in any direction.

5. Piling rig access

Marine piling plant will be required to bore the piles, particularly at the seaward end. The shallow water depths may preclude easy movement of floating plant except at high tide. The use of land based plant is also limited to low tide.

6. Bill of Quantities

The bill given in this section is only for the piling. It does not include the supply and fitting of the steel saddle and cathodic protection. The split between land based and marine piling plant is somewhat arbitrary and will depend on the plant chosen.

Item	Description	Unit	No	Rate	Total
1	Mobilise contractor's facilities for the duration of the works	Sum	1		
2	Mobilise land-based piling plant	Sum	1		
3	Mobilise marine piling plant	Sum	1		
4	Supply 325mm, 15m lengths (on average)	No	106		
5	Auger piles to a depth of 14.5 below seabed using land-based	No	20		

	plant including setting out				
6	Auger piles to a depth of 14.5m below seabed using marine plant including setting out	No	86		