Appendix A.8.4

Pump Station Preliminary Sizing

Technical Note

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Project title	N6 Galway City Transport Project	Job number	233985
cc		File reference	GCOB-4.04-TN056_D1
Prepared by	Hazel King	Date	28 July 2017
Subject	Preliminary Sizing - Tunnel Pumping Station		

1 Introduction

A pumping station is proposed to convey flows occurring within the tunnel structure. The expected discharge will comprise minimal groundwater inflow through the tunnel sealing system, rainfall washed into the tunnel portals from vehicle wheels, effluent from tunnel wall washing and runoff generated by fire fighting in an emergency event. It is proposed to collect runoff at two sumps located outside both western and eastern tunnel portals. The effluent will then be pumped from the sumps and will discharge as trade effluent to the foul sewer.

As the tunnel is underground, rainfall falling on the surface will be collected and diverted elsewhere and will not for part of the runoff to the foul sewer.

A plan and profile of the proposed tunnels are shown on drawing GCOB-D-100-108 and GCOB-D-100-110.

The general layout of the pumping station can be seen in drawings GCOB-500-D-114 GCOB-500-D-120

A preliminary design of the rising main is shown on drawing GCOB-D-500-D-400

2 Design

As the load on the pumping station is low it is proposed that the pump stations will not be adopted by the water authority. Operation and maintenance costs will be covered under the maintenance program for the tunnel itself.

The flow rates and pumped head (known as the station duty) has been designed in accordance with 'Sewers for Adoption 7th Edition', CIRIA Report 121: Design of Low Lift Pumping Stations and BS EN 752:2008 Drains and Sewer Systems Outside Buildings.

The pumping installation includes the following elements:

- Proprietary package pumping station including duty and standby pump;
- Rising main;

- Break head manhole chamber;
- Storage tank;
- Control kiosk.

2.1 Calculation of Inflows to Tunnel

When designing the drainage system for the tunnel, a number of potential inflows are considered from the following sources.

(i) Groundwater

(ii) Rainfall

(iii) Tunnel Washing

(iv) Fire Fighting

Calculation of the expected inflows to the tunnel drainage system are contained in Appendix B.

2.2 Pumping Chambers

Sewers for Adoption requires the rising main velocity to be between 0.75m/s and 1.8m/s. Also, to reduce the risk of blockages the minimum rising main diameter is 80mm.

Using a rising main diameter of 100mm and a velocity of 0.75m/s the minimum duty flow for the system is as follows:

$$Q = vA = 0.75 \times \pi \left(\frac{0.10}{2}\right)^2 = 5.89\ l/s$$

Sewers for adoption requires the rate at which the pump cycles through on/off phases is limited to 15 starts per hour. Given the low inflow to the chamber, a rate of 6 starts per hour will be used for design. Based on this, the required sump volume can be given by the following equation:

$$V = \frac{0.9Q}{N} = \frac{0.9 \times 5.89}{6} = 0.884m^3$$

Allowing for a chamber size of 1200mm. Allowing for the volume taken up by the riser pipework, and assuming the benching ends prior to the low water level, the sump depth required is as follows:

$$h = \frac{V}{\left\{\frac{\pi D^2}{4} - \frac{2\pi d^2}{4}\right\}} = \frac{0.884}{\left\{\frac{\pi(1.2)^2}{4} - \frac{2\pi(0.1)^2}{4}\right\}} = \frac{0.884}{1.131 - 0.016} = 0.793m$$

This will be rounded up to 0.800m.

2.3 Rising Main

The rising mains will be DN 100mm diameter Ductile Iron SDR constructed at a uniform gradient. The rising main will be laid with a minimum of 1.2m cover or 0.75m cover with 150mm of concrete surround to pipe. Discharge from the rising main to the gravity sewer will be via a stand off manhole prior to connecting to the public sewer.

2.4 Pump Station Preliminary Sizing Calculations

2.4.1 Pumped Head and Head Losses – Racecourse Tunnel

The total pumped head required is given by: (H_T) = Static head + Frictional loss + other losses.

Static Head:

$$H = 50.800 - 38.465 = 12.335m$$

Frictional Losses:

As described above, the velocity of flow in the rising main has been set at 0.75m/s. The kinetic head is therefore given by:

$$v_h = \frac{v^2}{2g} = \frac{0.75^2}{2 \times 9.81} = 0.029m$$

Using this, the frictional head loss can be given using Darcy's equation:

$$h_f = \frac{fL}{d} v_h$$

Where *L* is the length of pipe run, *d* is the rising main internal diameter, and *f* is an empirical friction coefficient.

In accordance with Sewers for Adoption, the pipe roughness value *ks* for rising mains for mean velocities up to 1.1m/s is 0.3mm.

Using the Moody Diagram Friction Conversion, it can be shown that the friction coefficient is approximately 0.028 Therefore:

$$h_f = \frac{0.028 \times 15}{0.1} \times 0.029 = 0.122m$$

Other Losses:

Losses due to fittings and changes in alignment can be determined using the following equation:

$$h_f = k' v_h$$

Where *k'* is the loss coefficient determined by summating the losses from each fitting as follows:

Element Type	Number of Elements	K-Value
Sharp Edged Inlet	1	0.50
Close Radius 90° Bend	4	0.75
Reflux Valve	1	1.50
Sluice Valve	1	0.20
Outlet	1	1.00

$$h_f = 0.029\{(1 \times 0.5) + (4 \times 0.75) + (1 \times 1.5) + (1 \times 0.2) + (1 \times 1.00)\}$$

$$h_f = 0.029 \times 6.20 = 0.180m$$

Therefore the total Head Loss from the pump to the outlet is:

$$H_T = 12.335 + 0.122 + 0.180 = 12.637m$$

2.4.2 Station Duty – Racecourse Tunnel

Based on the above calculations, the station duty is therefore 5.89 l/s @ 10.369m head.

2.4.3 Pumped Head and Head Losses – Lackagh Tunnel

The plan and profile layout for the proposed rising main is shown on sketch GCOB-D-500-400

The total pumped head required is given by: (H_T) = Static head + Frictional loss + other losses.

Static Head:

$$H = 31.366 - 9.500 = 21.866m$$

Frictional Losses:

As described above, the velocity of flow in the new 100mm diameter rising main has been set at 0.75m/s. The kinetic head is therefore given by:

$$v_h = \frac{v^2}{2g} = \frac{0.75^2}{2 \times 9.81} = 0.029m$$

Using this, the frictional head loss can be given using Darcy's equation:

$$h_f = \frac{fL}{d} v_h$$

Where L is the length of pipe run, d is the rising main internal diameter, and f is an empirical friction coefficient.

In accordance with Sewers for Adoption, the pipe roughness value *ks* for rising mains for mean velocities up to 1.1m/s is 0.3mm.

Using the Moody Diagram Friction Conversion, it can be shown that the friction coefficient for the 100mm diameter pipe is approximately f_{100} = 0.028 . Therefore:

$$h_f = \frac{0.028 \times 1683}{0.1} \times 0.029 = 13.666m$$

Other Losses:

Losses due to fittings and changes in alignment can be determined using the following equation:

$$h_f = k' v_h$$

Where *k'* is the loss coefficient determined by summating the losses from each fitting as follows:

Element Type	Number of Elements	K-Value
Sharp Edged Inlet	1	0.50
Close Radius 90° Bend	7	0.75
Sluice Valve	2	0.20
Non Return Valve – Check Valve Swing	0	2
Air Valve	2	1.5
Scour Valve	2	3.0
90o Tee Branching Flow	1	1

Table 1 Table of Fittings – Proposed 100mm Rising Main

$$h_f = v_h\{(1 \times 0.5) + (7 \times 0.75) + (2 \times 0.2) + (2 \times 1.5) + (2 \times 3.0) + (1 \times 1.0)\}$$

$$h_f = 0.029 \times 16.15 = 0.468m$$

Therefore the total Head Loss from the pump to the outlet is:

$$H_T = 20.866 + 13.666 + 0.468 = 35.00m$$

2.4.4 Station Duty – Lackagh Tunnel

Based on the above calculations, the station duty is therefore 5.89 l/s @ 35m head.

DOCUMENT CHECKING (not mandatory for File Note)

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cc		File reference	GCOB-4.04-TN068_D1
Prepared by	Hazel King	Date	28 July 2017
Subject	Preliminary Sizing – Flood Relief Pumping Station at N17		

1 Introduction

A pumping station is proposed to convey flood waters from the enclosed depression at the low point of the existing N17 road. The expected discharge will comprise overland flow rainfall runoff from the adjoining lands. It is proposed to collect runoff in a flood relief swale to direct floodwaters to the flood relief storage area. A sump will be located in this area and rainfall will then be pumped from the sumps to discharge in the existing 900mm diameter surface water sewer located in the City North Business Park access road.

A plan of the proposed flood relief measures proposed at the N17 Junction are shown on drawings GCOB-D-500-600.

The general layout of the pumping station can be seen in drawings GCOB-500-D-118 and a preliminary design of the rising main is shown on drawing GCOB-500-D-402

2 Design

As the pumping station forms part of the flood relief measures for the scheme, it is proposed that the pump stations will not be adopted by the water authority and will be operated under the maintenance program contract for the proposed road development.

The flow rates and pumped head (known as the station duty) has been designed in accordance with 'Sewers for Adoption 7th Edition', CIRIA Report 121: Design of Low Lift Pumping Stations and BS EN 752:2008 Drains and Sewer Systems Outside Buildings.

The pumping installation includes the following elements:

- Proprietary package pumping station including duty and standby pump;
- Rising main;
- Break head manhole chamber;
- Flood Relief Storage Area;
- Control kiosk.

2.1 Calculation of Inflows to Pump Station

The preliminary Design of the Flood Relief Measures at the N17 indicate that the storage area is sufficiently large to cater for storm events up to the 1 in 100 year return period event with a pump flow rate of 250l/s.

Further Details of the expected inflow rates to the flood relief area are contained in the Flood Risk Assessment carried out as part of the EIA Report for the N6 Galway City Ring Road.

2.2 Pumping Chambers

Sewers for Adoption requires the rising main velocity to be between 0.75m/s and 1.8m/s.

Using a rising main diameter of 500mm the minimum duty flow for the system is 250l/s:

$$Q = vA = 1.27 \times \pi \left(\frac{0.50}{2}\right)^2 = 250\ l/s$$

The resulting velocity is 1.27m/s which lies between 0.75m/s and 1.8m/s

Sewers for adoption requires the rate at which the pump cycles through on/off phases is limited to 15 starts per hour. Given the low inflow to the chamber, a rate of 6 starts per hour will be used for design. Based on this, the required sump volume can be given by the following equation:

$$V = \frac{0.9Q}{N} = \frac{0.9 \times 250}{15} = 15m^3$$

V= effective volume of pump sump (m^3)

Q=design pump capacity (l/s)

N= required number of starts per hour*

Allowing for a chamber size of 4m x 4m. Allowing for the volume taken up by the riser pipework, and assuming the benching ends prior to the low water level, the sump depth required is as follows:

$$h = \frac{V}{\left\{\frac{\pi D^2}{4} - \frac{2\pi d^2}{4}\right\}} = \frac{15}{\left\{16 - \frac{2\pi(0.5)^2}{4}\right\}} = \frac{15}{16 - 0.565} = 0.97m$$

This will be rounded up to 1.000m.

2.3 Rising Main

The rising mains will be DN 500mm diameter Ductile Iron SDR constructed at a uniform gradient. The rising main will be laid with a minimum of 1.2m cover or 0.75m cover with 150mm of concrete surround to pipe. Discharge from the rising main to the gravity sewer will be via a stand off manhole prior to connecting to the public sewer.

2.4 Pump Station Preliminary Sizing Calculations

2.4.1 Pumped Head and Head Losses – Racecourse Tunnel

The total pumped head required is given by: (H_T) = Static head + Frictional loss + other losses.

Static Head:

$$H = 24.000 - 15.000 = 9m$$

Frictional Losses:

As described above, the velocity of flow in the rising main has been set at 1.27m/s. The kinetic head is therefore given by:

$$v_h = \frac{v^2}{2g} = \frac{1.27^2}{2 \times 9.81} = 0.104m$$

Using this, the frictional head loss can be given using Darcy's equation:

$$h_f = \frac{fL}{d} v_h$$

Where *L* is the length of pipe run, *d* is the rising main internal diameter, and *f* is an empirical friction coefficient.

In accordance with Sewers for Adoption, the pipe roughness value *ks* for rising mains for mean velocities between to 1.1m/s and 1.8m/s is 0.15mm.

Using the Moody Diagram Friction Conversion, it can be shown that the friction coefficient is approximately 0.016 Therefore:

$$h_f = \frac{0.016 \times 252}{0.5} \times 0.104 = 0.839m$$

Other Losses:

Losses due to fittings and changes in alignment can be determined using the following equation:

$$h_f = k' v_h$$

Where *k'* is the loss coefficient determined by summating the losses from each fitting as follows:

Element Type	Number of Elements	K-Value
Sharp Edged Inlet	1	0.50
Close Radius 90° Bend	4	0.75

Reflux Valve	1	1.50
Sluice Valve	1	0.20
Outlet	1	1.00

$$h_f = 0.029\{(1 \times 0.5) + (4 \times 0.75) + (1 \times 1.5) + (1 \times 0.2) + (1 \times 1.00)\}$$

$$h_f = 0.104 \times 6.20 = 0.645m$$

Therefore the total Head Loss from the pump to the outlet is:

$$H_T = 9 + 0.839 + 0.645 = 10.484m$$

2.4.2 Station Duty – N17 Flood Relief Measures

Based on the above calculations, the station duty is therefore 250 l/s @ 10.5m head.

DOCUMENT CHECKING (not mandatory for File Note)

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