**Walker Associates Consulting Limited**

**Bourne Estate, Baldwins Gardens, Camden**

# Thames Water Sewer - Structural Impact Assessment

**Report No. L495-RE-01**

**January 2015**

BYRNE LOOBY PARTNERS

consulting engineers

## Document Control

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Project: Bourne Estate, Baldwins Gardens, Camden

Client: Walker Associates Consulting Limited

Report Number: L495-RE-01

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| 00 | 19-Nov-2014 | For Approval | PF | DRB | DRB |
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| 02 | 09-Jan-2015 | Incorporate TW comments | PF | DRB | DRB |

**Disclaimer:** Please note that this report is based on specific information, instructions and information from our Client and is intended to be used by our Client and Thames Water Utilities Limited. The report should not be relied upon by third parties.


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# 1.0 Introduction

## 1.1 Report Objectives

A new development is to be carried out in Bourne Estate, Baldwins Gardens, Camden. A 1067mm high, 610mm wide egg sewer made of brick runs under the Baldwins Gardens parallel to the development South boundary. In order to prove the proposed works will not have a detrimental impact Thames Water requires a structural impact assessment of their asset. The sewer is approximately 5m deep to invert level.

Byrne Looby Partners UK Limited (BLP) has been instructed by Walker Associates Consulting Limited to undertake a simple elastic calculation in relation to CFA piling adjacent to the sewer. The analysis covers the long term ground movements as a result of the change in ground stresses caused by the loadings from both the bearing piles and contiguous piled walls.

The basement excavation level is above the crown of the sewer and approximately five metres distance away from the sewer, therefore the lateral movement of the sewer due to the basement excavation is expected to be insignificant.

## 1.2 Information Provided

The following information has been received, which forms the basis of our analysis. The most relevant drawings and sketches have been included in Appendix A. BLP offers no guarantees or warranties on the completeness of the information provided.

Site Investigation

- Report No: 14.04.016a - Listers Geotechnical Consultants - Bourne Estate, HOLBORN, London, EC1N 7SD - Supplementary Geotechnical Investigation – June 2014.
- Report No: 14.04.016 - Listers Geotechnical Consultants - Bourne Estate, HOLBORN, London, EC1N 7SD – Supplementary Geoenvironmental and WAC Testing Investigation Report– May 2014.

Drawings & Sketches

- Sketch Existing Sewer 5m Zone, received 14/11/14.
- Impact Assessment - Pile Sketch 051114, received 14/11/14.
- Thames Water – Bourne Estate – Baldwin Gardens Sewer
- Drawing M. J. Rees and Company LTD – 8316 - Line and Level Sewer Survey Baldwin's Gardens London Borough of Camden.
- 6475-2-P2.0_E_Block 2 Ground floor plan sheet 1 of 3_CONSTRUCTION_1-50_A1
- 6475-2-P2.1_E_Block 2 Ground floor plan sheet 2 of 3_CONSTRUCTION_1-50_A1
- 6475-2-P2.2_E_Block 2 Ground floor plan sheet 3 of 3_CONSTRUCTION_1-50_A1
- 6475-2-PL1.0_D_Block 2 Pile Load Table_CONSTRUCTION_1-50_A1
- 9240 Bourne Estate, Camden – Pile Schedule. Rev K. 12/11/2014.

Reports

- Guidelines for Outside Parties working near Thames Water pipelines, sewers, structure or other apparatus.

- Piling Close Thames Water Sewers and Water Mains
- Assessment Criteria for Existing Thames Water Pipeline and Sewer Assets

## 1.3 Method of Assessment

According to Thames Water document “Assessment Criteria for Existing Thames Water Pipeline and Sewer Assets”, the level of the change in strain below which the risk of significant damage may be considered negligible is 500 microstrains for brick sewer. The change in strain affecting the Thames Water existing sewer has been estimated using the differential settlement at the crown and at the invert of the sewer. Thames Water has requested the predicted displacement, curvature and strain profiles along the sewer. The maximum increase in tensile strain will be compared with the acceptable limits by TW.

The assessment of the ground movements due to the bearing pile and contiguous piled wall loads have been undertaken using the soil displacement program Pdisp produced by Oasys. Pdisp is an elastic soil continuum program that models the soil layers elastically, allows vertical loads to be applied at any level in the soil mass and calculates the resulting settlements at any level of the soil mass.

Note Pdisp only allows for soil movements as a result of addition or removal of vertical loads and does not include the possible movements that may occur caused by the displacement of the contiguous piled wall or pile installation effects.

The assessment of the ground movements have been carried out for SLS conditions.

The Confinement Pressure Ratio (CPR), defined as the ratio of the Overburden Pressure to the Internal Pressure is assessed in relation to the adjacent piles and the basement excavation. It is assumed that the combined gravity sewer is assessed as the worst case scenario as fully surcharged to ground level and thus take the internal pressure as the static head in this location. The head of the water pressure is assumed to be from the ground level to the sewer axis level. Similarly, the soil overburden pressure is calculated at the sewer axis level.

# 2.0 Ground Conditions

## 2.1 Site Investigation

The British Geological Survey 1:50,000 scale map indicates that the site is underlain by superficial deposits of River Terrace Gravel over London Clay Formation. The River Terrace Gravel typically comprises sand and gravel, locally with lenses of silt, clay and peat. The London Clay Formation is generally represented by silty clay.

Ground conditions are based on Listers Geotechnical Consultants reports. Site investigation comprises two cable percussion boreholes and several exploratory holes.

## 2.2 Ground Model

### 2.2.1 Made Ground

Made Ground is described by the site investigation as mainly gravely fine to coarse sand with occasional cobbles of brick and some concrete. The Made Ground was found to a depth of between 1.1 and 5.1m. Exploratory holes within the South boundary prove Made Ground thickness of at least 3m, therefore a stratum thickness of 4m has been considered for the analysis.

Due to the stratum variability Made Ground has been conservatively modelled as drained with effective stiffness E'=10 MPa.

### 2.2.2 River Terrace Gravels

Encountered down to depths of 7.7m with an average thickness of 3.7m. The Site Investigation report describes the soil as generally medium dense to dense yellow brown and brown gravelly medium sand. 'N' values derived from standard penetration tests in the boreholes ranged from 26 to 35 with an average value of 32. A characteristic design 'N' value of 30 has been defined.

The stratum stiffness has been based on the relation E' = 1xN (Stroud, 1975), resulting on an effective stiffness of 30 MPa.

### 2.2.3 London Clay and Lambeth Group

London Clay is typically described as a firm to very stiff, very closely to extremely closely fissured clay. The two boreholes encountered London Clay between 7.7 to 22m depth. The soils on site are considered to be representative of the London Clay Formation indicated on the published geological map.

Based on the SPT values and typical values for London Clay a SPT 'N' values profile of 16+1.4z has been considered at the top of London Clay. Based on the ratio Cu = 5xN (Strout, 1989) a Cu profile of 80+7z kPa has been used.

A vertical Eu/Cu factor of 400 for London Clay has been defined, with effective stiffness being E'=0.8xEu. As a result, an effective stiffness profile of 25.6+2.2z MPa has been obtained.

Lambeth Group was encountered at borehole BHB2A at 22.5m extending to the full depth of the investigation (30m). The soils are described as very stiff to hard fissured clay. The Lambeth

Group formation Clays have been conservatively modelled with the same stiffness profile as the London Clay formation.

## 2.1 Summary of Soil Condition

A summary of the characteristic parameters to be used in the heave assessment is included in the table below.

| Strata | Top Level (mOD) | $\gamma$ ($kN/m^3$) | E' (MPa) |
|---|---|---|---|
| Made Ground | +19.3 | 18 | 10 |
| River Terrace Gravels | +15.3 | 19 | 30 |
| London Clay and Lambeth Group | +12 | 20 | 25.6+2.2z |

*z – Depth taken from the top of London Clay

**Table 1: Summary of Soil Parameters**

# 3.0 Basis of the Analysis

## 3.1 Settlement due to Piles

The area modelled includes Piles P110, P111, P184, P184a, P176, P177, P178, P179, P180, P180a, P181, P182, P183 and the contiguous wall piles C10 to C107. The centreline of the sewer has been assumed to be located 4m away from the centreline of the closer piles and the invert 5.3 m below ground level, which has been assumed to be 19.3mOD. The model geometry has been taken from drawings: “Sketch Existing Sewer 5m Zone”, “Impact Assessment-Pile Sketch 051114” and “6475-2-P2.1_E_Block 2 Ground floor plan sheet 2 of 3_CONSTRUCTION_1-50_A1”. Pile loads are taken from the pile schedule 9240 Bourne Estate, Camden. Rev K.

Two displacement lines have been defined in Pdisp in order to obtain the displacements at the crown and the invert of the sewer. The distance between the two lines has been defined as the distance between the midpoint of the top brick lining to the midpoint of the bottom brick lining. A brick thickness of 215mm has been considered so the distance between lines is 1282mm. A third displacement line provides displacements at the centreline of the pipe.

The vertical loads resulting from the bearing piles have to be applied on Pdisp as circular blocks around the piles at their corresponding level. For this analysis, as the piles are expected to spread the load mainly through the shaft it has been assumed the full load is applied to the soil as described by Craig (2004) for a pile group in clay (Figure 1). It assumes that the bearing piles loads are spreaded from the perimeter of the piles at a slope of 1 horizontal to 4 vertical to allow for the part of the load transferred to the soil by skin friction to a ‘equivalent raft’ located at a depth of 2L/3 where L is the length of the piles.

The vertical loads taken by the contiguous wall have been modelled as a rectangular load spreaded from the perimeter of the piles at a slope of 1 horizontal to 4 vertical and applied at a depth of 2L/3 where L is the length of the piles. A basic load has been defined for every contiguous wall and in order to model accurately the greater number of piles and the additional load applied below the columns an additional rectangular load has been applied for columns 31, 33, 34 and 35.

Figures 2 and 3 shows the loads as modelled with Pdisp.

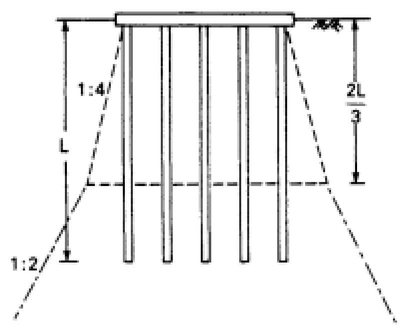


**Figure 1: Equivalent Raft Concept (Craig, 2004)**

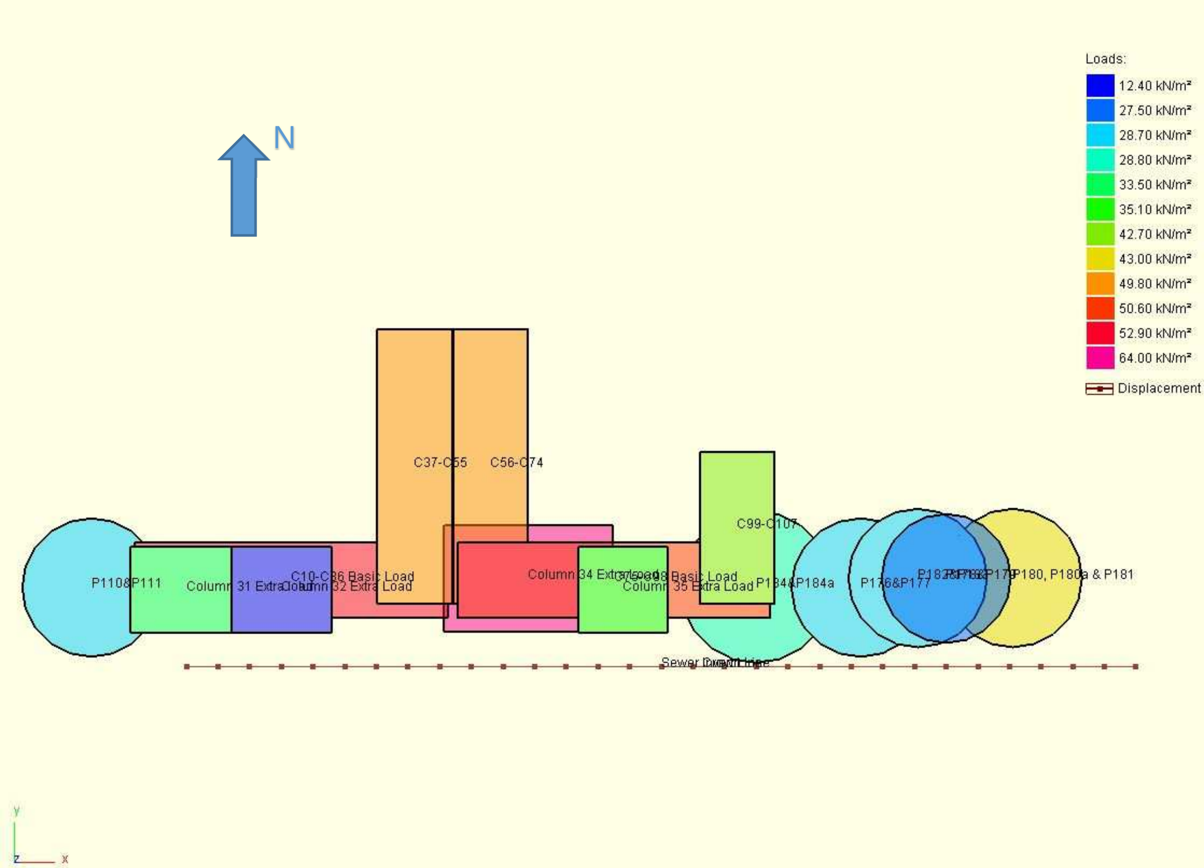


Figure 2: Plan of the model showing the bearing piles loads and the sewer centreline

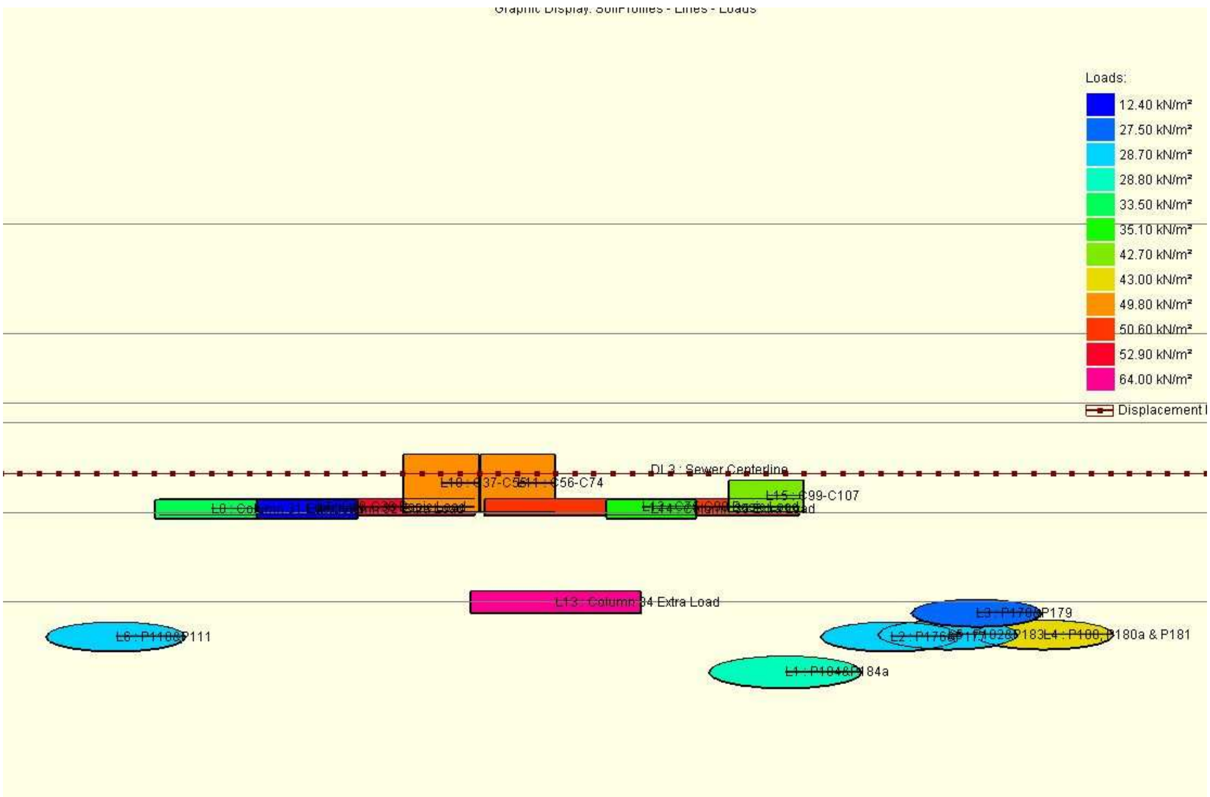


**Figure 3: View of the model showing the bearing piles loads and the sewer centreline**

### 3.2 Confinement Pressure Ratio (CPR)

The head of the water pressure in the sewer, defined as being from the ground level to the sewer axis level, is unaffected by the proposed construction. The soil overburden pressure, calculated at the sewer axis level, is unchanged by the presence of the loaded piles. The basement excavation is approximately 2m deep and some 5m away from the sewer such that the effects on the soil overburden pressure at the sewer axis level are considered negligible.

The Confinement Pressure Ratio (CPR) is unchanged.

## 4.0 Results

Figure 4 illustrates the settlement affecting the two displacement lines representing the crown and the invert of the sewer. The maximum settlement as a result of the applied loads is 7.11mm and the maximum differential settlement between the crown and the invert is 0.1mm. As a result the diametrical distortion between the invert and the crown is below 80 microstrains (=0.1mm/1282mm).

In addition, the maximum axial strain has been calculated based on the maximum pipe curvature. The maximum increment of axial tensile strain is 58 microstrains (calculations attached on Appendix B).

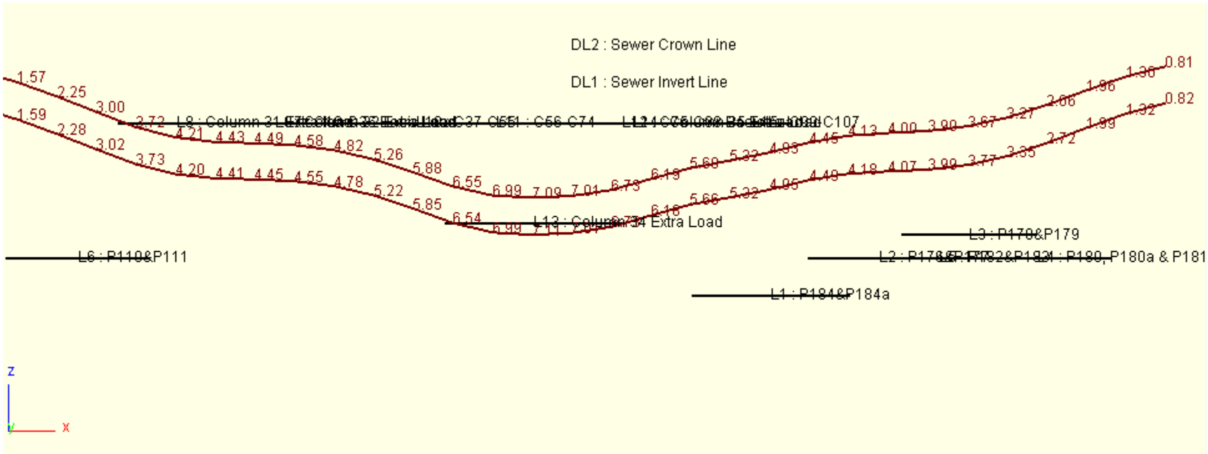


**Figure 4: Sewer displacements**

# 5.0 Conclusion

The ground movements produced by the bearing piles on Bourne Estate, Baldwin Gardens, Camden has been assessed. It has been found that the maximum settlement affecting the Thames Water existing sewer is less than 8mm with a maximum differential settlement of 0.1mm between the crown and the invert of the pipe. Additionally the maximum increment of axial tensile strain found is 58 microstrains. The resulting values are less than the limiting 500 microstrains and therefore the risk of significant damage is considered to be negligible.

The analysis has been carried out with the soil displacement program Pdisp, which models the soil layers elastically. The vertical loads resulting from the bearing piles have been applied in circular blocks with the loads and block dimension calculated as per Craig, 2004.

Note the analysis does not include the possible effects the contiguous wall or the basement excavation may have over the sewer. However the Confined Pressure Ratio (CPR) is unchanged.

# 6.0 References


1. Advanced laboratory characterisation of London Clay. A. Gasparre. 2005. PhD Thesis. University of London.
2. BS EN 1997-1: Eurocode 7: Geotechnical Design, General Rules.
3. CIRIA C580 (2003). Gaba et al. Embedded retaining walls – guidance for economic design.
4. Stroud, M.A. and Butler, F.G. (1975). The standard penetration test and the engineering properties of glacial material. Conference on the engineering behaviour of glacial materials, University of Birmingham pp124-135 U.K.
5. Craig, R.F. 2004 Soil Mechanics, 7th Edition, London: Spoon Press.

# Appendix A – Analysis Info


NOTES:

All levels are based on existing site datum

## STATION CO-ORDINATES

| Station | Description | Easting | Northing | Level |
|---|---|---|---|---|
| S10 | Road Nail | 531201.802 | 181817.648 | 19.971 |

N.B. Grid is related to existing site grid

Legend

CL Cover Level
DK Drop Kerb
(F) Foul
GL Ground Level
IL Invert Level
MH Manhole
SE Side Entry

BURIED SERVICES

Drainage Foul

Chamber

NOTES

1) Although every care has been taken in the location of buried services, due to the nature of the work their extent, position and accuracy cannot be guaranteed.
Trial excavations must be carried out to confirm service identifications, positions and depths.
2) Pipe sizes are in millimetres.
3) Pipe sizes within manholes are estimated.
4) Chamber depths are physically measured, but all other service depths are measured electronically and therefore may only be approximate.
5) Unless otherwise stated, all information shown on this plan has been surveyed.

| Rev | Date | Amendment |
|---|---|---|
| | | |
| | | |
| | | |

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THE SURVEY ASSOCIATION

LINK-UP 22128

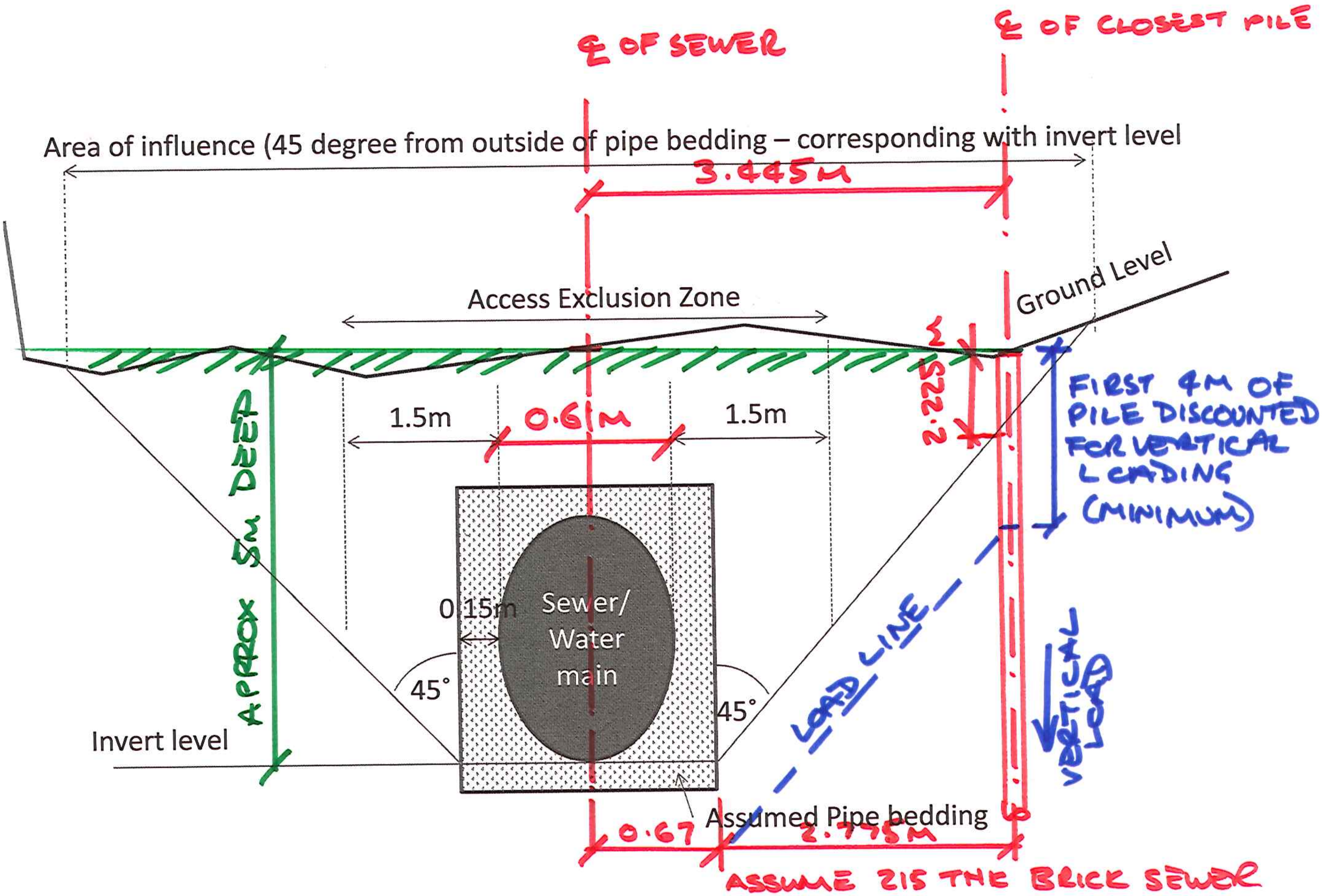
RICS

# LINE AND LEVEL SEWER SURVEY
# BALDWIN'S GARDENS
# LONDON BOROUGH OF CAMDEN

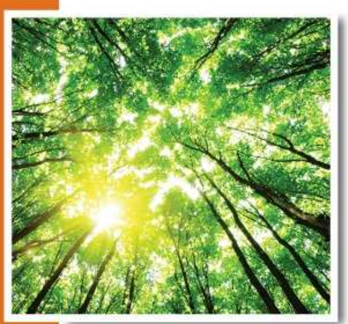
| | | |
|---|---|---|
| Job No: 8316 | Sheet 1 of 1 | Scale: 1/200 @ A1 |
| Drawn by: K.T. | Checked by: R.C. | Date: December 2014 |

Client

B P McKeefry
114 Grove Road
Maghera
BT46 5QZ



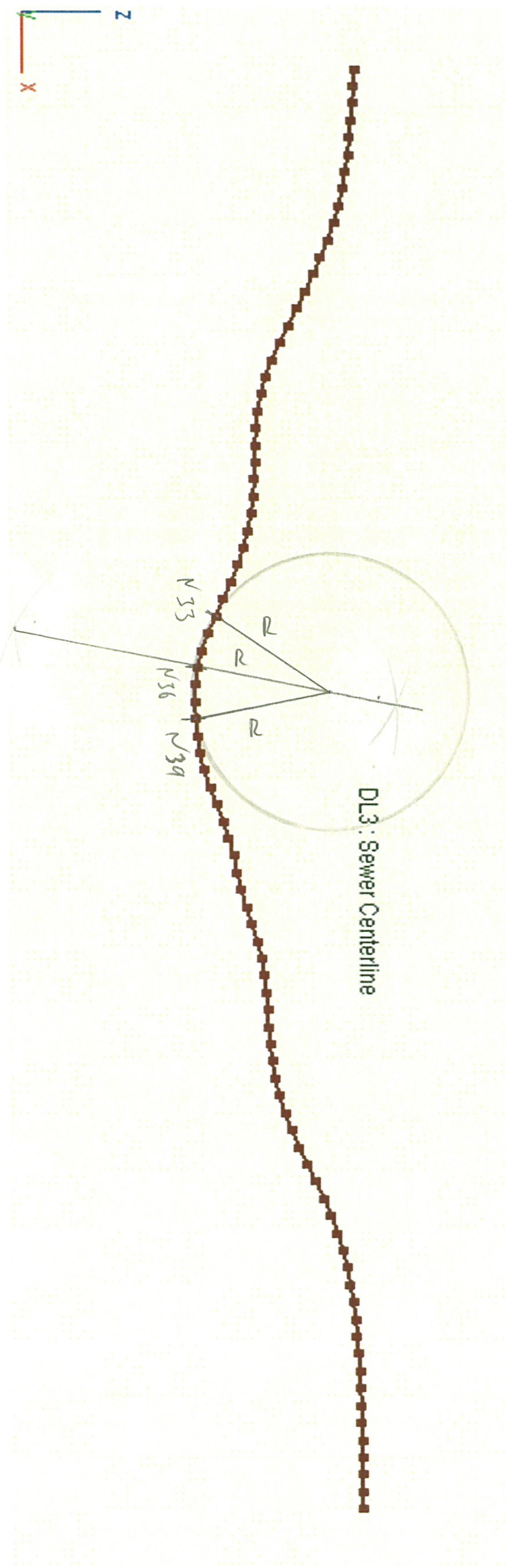
℄ OF SEWER
℄ OF CLOSEST PILE
Area of influence (45 degree from outside of pipe bedding – corresponding with invert level
3.445M
Ground Level
Access Exclusion Zone
2.225
1.5m
0.6M
1.5m
FIRST 4M OF PILE DISCOUNTED FOR VERTICAL LOADING (MINIMUM)
APPROX 5M DEEP
0.15m
Sewer/ Water main
45°
45°
Invert level
LOAD LINE
VERTICAL LOAD
Assumed Pipe bedding
0.67
2.775M
ASSUME 215 THE BRICK SEWER



# Appendix B – Pdisp Analysis

| BYRNE LOOBY PARTNERS consulting engineers | Project | Bourne Estate | Job No. | L495 | | |
|---|---|---|---|---|---|---|
| | | | Made by | PF | Date | 23/12/2014 |
| | Calc. Title | Axial Distortion | Chkd by | DRB | Date | 23/12/14 |
| | | | Sheet No. | | Rev | 00 |

| Reference | Calculations | Output |
|---|---|---|




NODE 33

$x = -7m$ , $\delta = 6.2168$ mm

NODE 36

$x = -4m$ , $\delta = 6.9928$ mm

NODE 39

$x = -1m$ , $\delta = 7.0731$ mm

| BYRNE LOOBY PARTNERS consulting engineers | Project | Bourne Estate | Job No. | L495 | | |
|---|---|---|---|---|---|---|
| | | | Made by | PF | Date | 23/12/2014 |
| | Calc. Title | Axial Distortion | Chkd by | | Date | |
| | | | Sheet No. | | Rev | 00 |

| Reference | Calculations | Output |
|---|---|---|

**Calculate Radius, Center of a Circle by Given Three Points**

Enter coordinates of three points

A(X,Y) -7000 6.2168 → NODE 33

B(X,Y) -4000 6.9928 → NODE 36

C(X,Y) -1000 7.0731 → NODE 39

Calculate Reset

Center Point

-2153.73004,-12936604.05264

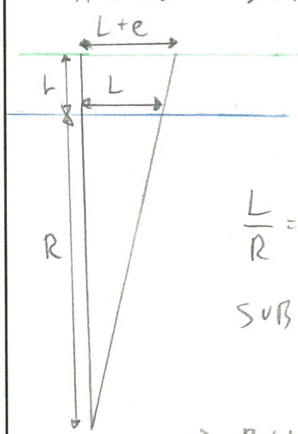
Radius of a Circle

12936611.18 = R

Cricle Equation

$(x + 2154)^2 + (y + 12936604)^2 = 12936611.18^2$

AXIAL STRAIN ($\varepsilon$)




$\varepsilon = \frac{e}{L}$, $e = \varepsilon \times L$

$\frac{L}{R} = \frac{L+e}{R+h}$

SUBSTITUTING $e \rightarrow \frac{L}{R} = \frac{L+\varepsilon L}{R+h} \Rightarrow \frac{L}{R} = \frac{L(1+\varepsilon)}{R+h}$

$\Rightarrow R+h = R(1+\varepsilon) \Rightarrow \frac{R+h}{R} = 1+\varepsilon \Rightarrow$

$\Rightarrow 1 + \frac{h}{R} = 1+\varepsilon \Rightarrow \varepsilon = \frac{h}{R} = \frac{\text{DIAMETRE}}{2R}$

PIPE EXTERNAL DIAMETRE $\simeq$ 1.5 m

$R = 12.94 \times 10^6$ mm

$\varepsilon = \frac{1500 \text{ mm}}{2 \times 12.94 \times 10^6 \text{ mm}} =$

$\varepsilon = 5.8 \times 10^{-5} \rightarrow 58\ \mu\varepsilon$

## Analysis Options

Analysis: Legacy Mindlin - Elastic analysis above loads
Soil above horizontal load on horizontal plane dampens displacements below load : No
Soil above vertical load on horizontal plane dampens displacements below load : No
Maximum allowable ratio between values of E: 1.5
Horizontal rigid boundary level: -10.00 [m OD]
Displacements at area centroids calculated.

## Soil ProfilesSoil Profile 1

| Layer | Level at top | Number of intermediate displacement levels | Youngs Modulus Top | Youngs Modulus Btm | Poissons ratio | Non-linear curve |
|---|---|---|---|---|---|---|
| | [mOD] | | [kN/m²] | [kN/m²] | | |
| 1 | 19.300 | 8 | 10000. | 10000. | 0.20000 | None |
| 2 | 15.300 | 7 | 30000. | 30000. | 0.20000 | None |
| 3 | 12.000 | 40 | 25600. | 76448. | 0.20000 | None |

## Soil Zones

| Zone | Name | X coordinates min | X coordinates max | Y coordinates min | Y coordinates max | Profile |
|---|---|---|---|---|---|---|
| | | [m] | [m] | [m] | [m] | |
| 1 | Ground | -40.000 | 45.000 | -15.000 | 30.000 | Soil Profile 1 |

## Load Data

| Load ref. | Name | Orientation | Centre of load (Global) X | Y | Z(level) | Angle of local x w.r.t. global X | Shape | Dimension Width x/ Radius | Depth y | Load value Normal z | Tangential x | Tangential y | Number of rectangles |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | [m] | [m] | [m] | [Degrees] | | [m] | [m] | [kN/m²] | [kN/m²] | [kN/m²] | |
| 1 | P184&P184a | Horizontal | 10.000 | 4.0000 | 6.5000 | 0.0 | Circular | 4.0000 | N/A | 28.800 | 0.0 | 0.0 | 21 |
| 2 | P176&P177 | Horizontal | 15.500 | 4.0000 | 7.8000 | 0.0 | Circular | 3.6500 | N/A | 28.700 | 0.0 | 0.0 | 21 |
| 3 | P178&P179 | Horizontal | 20.000 | 4.5000 | 8.6000 | 0.0 | Circular | 3.4000 | N/A | 27.500 | 0.0 | 0.0 | 21 |
| 4 | P180, P180a & P181 | Horizontal | 23.500 | 4.5000 | 7.8000 | 0.0 | Circular | 3.6500 | N/A | 43.000 | 0.0 | 0.0 | 21 |
| 5 | P182&P183 | Horizontal | 18.500 | 4.5000 | 7.8000 | 0.0 | Circular | 3.6500 | N/A | 28.700 | 0.0 | 0.0 | 21 |
| 6 | P110&P111 | Horizontal | -25.000 | 4.0000 | 7.8000 | 0.0 | Circular | 3.6500 | N/A | 28.700 | 0.0 | 0.0 | 21 |
| 7 | C10-C36 Basic Load | Horizontal | -14.500 | 4.5000 | 12.500 | 0.0 | Rectangular | 16.500 | 3.9500 | 52.900 | 0.0 | 0.0 | N/A |
| 8 | Column 31 Extra load | Horizontal | -20.000 | 4.0000 | 12.500 | 0.0 | Rectangular | 5.9000 | 4.5500 | 33.500 | 0.0 | 0.0 | N/A |
| 9 | Column 32 Extra Load | Horizontal | -15.000 | 4.0000 | 12.500 | 0.0 | Rectangular | 5.3000 | 4.5500 | 12.400 | 0.0 | 0.0 | N/A |
| 10 | C37-C55 | Horizontal | -8.0000 | 10.500 | 12.500 | 0.0 | Rectangular | 3.9500 | 14.500 | 49.800 | 0.0 | 0.0 | N/A |
| 11 | C56-C74 | Horizontal | -4.0000 | 10.500 | 12.500 | 0.0 | Rectangular | 3.9500 | 14.500 | 49.800 | 0.0 | 0.0 | N/A |
| 12 | C75-C98 Basic Load | Horizontal | 2.5000 | 4.5000 | 12.500 | 0.0 | Rectangular | 16.500 | 3.9500 | 50.600 | 0.0 | 0.0 | N/A |
| 13 | Column 34 Extra Load | Horizontal | -2.0000 | 4.5000 | 9.0000 | 0.0 | Rectangular | 8.9000 | 5.6000 | 64.000 | 0.0 | 0.0 | N/A |
| 14 | Column 35 Extra Load | Horizontal | 3.0000 | 4.0000 | 12.500 | 0.0 | Rectangular | 4.7000 | 4.5500 | 35.100 | 0.0 | 0.0 | N/A |
| 15 | C99-C107 | Horizontal | 9.0000 | 7.2500 | 12.500 | 0.0 | Rectangular | 3.9500 | 8.0000 | 42.700 | 0.0 | 0.0 | N/A |

## Displacement Data

| Ref. | Type | Name | Direction of Extrusion | First point X | First point Y | First point Z(level) | Second point X | Second point Y | Second point Z(level) | No. of intrvls across extrusion/line | Extrusion Depth | No. of intrvls along extrusion | Calculate | Show Detailed results |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | [m] | [m] | [m] | [m] | [m] | [m] | | [m] | | | |
| 2 | Grid | Sewer Invert | Global X | 0.0 | -10.000 | 14.000 | N/A | 14.500 | 14.000 | 15 | 30.000 | 30 | No | N/A |
| 3 | Line | Sewer Invert Line | N/A | -30.000 | 0.0 | 13.900 | 30.000 | 0.0 | 13.900 | 30 | N/A | N/A | Yes | Yes |
| 4 | Line | Sewer Crown Line | N/A | -30.000 | 0.0 | 15.182 | 30.000 | 0.0 | 15.182 | 30 | N/A | N/A | Yes | No |
| 5 | Line | Sewer Centerline | N/A | -39.000 | 0.0 | 14.540 | 45.000 | 0.0 | 14.540 | 84 | N/A | N/A | Yes | Yes |

## RESULTS FOR GRIDS

Analysis: Mindlin
Maximum allowable ratio between values of E: 1.5
Horizontal rigid boundary level: -10.00 [m OD]

| Type | Location X | Location Y | Location Z[Level] | Displacement X | Displacement Y | Displacement Z |
|---|---|---|---|---|---|---|
| | [m] | [m] | [mOD] | [mm] | [mm] | [mm] |
| | 10.000 | 4.0000 | 6.5000 | 0.0 | 0.0 | 8.7527 |
| | 15.500 | 4.0000 | 7.8000 | 0.0 | 0.0 | 10.333 |
| | 20.000 | 4.5000 | 8.6000 | 0.0 | 0.0 | 11.830 |
| | 23.500 | 4.5000 | 7.8000 | 0.0 | 0.0 | 8.8044 |
| | 18.500 | 4.5000 | 7.8000 | 0.0 | 0.0 | 11.838 |
| | -25.000 | 4.0000 | 7.8000 | 0.0 | 0.0 | 5.8603 |
| | -14.500 | 4.5000 | 12.500 | 0.0 | 0.0 | 13.478 |
| | -20.000 | 4.0000 | 12.500 | 0.0 | 0.0 | 14.729 |
| | -15.000 | 4.0000 | 12.500 | 0.0 | 0.0 | 13.318 |
| | -8.0000 | 10.500 | 12.500 | 0.0 | 0.0 | 13.685 |
| | -4.0000 | 10.500 | 12.500 | 0.0 | 0.0 | 14.367 |
| | 2.5000 | 4.5000 | 12.500 | 0.0 | 0.0 | 20.120 |
| | -2.0000 | 4.5000 | 9.0000 | 0.0 | 0.0 | 18.250 |
| | 3.0000 | 4.0000 | 12.500 | 0.0 | 0.0 | 19.070 |
| | 9.0000 | 7.2500 | 12.500 | 0.0 | 0.0 | 12.858 |
| Sewer Invert Line | -30.000 | 0.0 | 13.900 | 0.0 | 0.0 | 1.0282 |
| | -28.000 | 0.0 | 13.900 | 0.0 | 0.0 | 1.5911 |
| | -26.000 | 0.0 | 13.900 | 0.0 | 0.0 | 2.2835 |
| | -24.000 | 0.0 | 13.900 | 0.0 | 0.0 | 3.0203 |
| | -22.000 | 0.0 | 13.900 | 0.0 | 0.0 | 3.7344 |
| | -20.000 | 0.0 | 13.900 | 0.0 | 0.0 | 4.2040 |
| | -18.000 | 0.0 | 13.900 | 0.0 | 0.0 | 4.4112 |
| | -16.000 | 0.0 | 13.900 | 0.0 | 0.0 | 4.4544 |
| | -14.000 | 0.0 | 13.900 | 0.0 | 0.0 | 4.5462 |
| | -12.000 | 0.0 | 13.900 | 0.0 | 0.0 | 4.7791 |
| | -10.000 | 0.0 | 13.900 | 0.0 | 0.0 | 5.2206 |
| | -8.0000 | 0.0 | 13.900 | 0.0 | 0.0 | 5.8499 |
| | -6.0000 | 0.0 | 13.900 | 0.0 | 0.0 | 6.5371 |
| | -4.0000 | 0.0 | 13.900 | 0.0 | 0.0 | 6.9937 |
| | -2.0000 | 0.0 | 13.900 | 0.0 | 0.0 | 7.1055 |
| | 0.0 | 0.0 | 13.900 | 0.0 | 0.0 | 7.0149 |
| | 2.0000 | 0.0 | 13.900 | 0.0 | 0.0 | 6.7300 |
| | 4.0000 | 0.0 | 13.900 | 0.0 | 0.0 | 6.1815 |
| | 6.0000 | 0.0 | 13.900 | 0.0 | 0.0 | 5.6587 |
| | 8.0000 | 0.0 | 13.900 | 0.0 | 0.0 | 5.3179 |
| | 10.000 | 0.0 | 13.900 | 0.0 | 0.0 | 4.9459 |
| | 12.000 | 0.0 | 13.900 | 0.0 | 0.0 | 4.4870 |
| | 14.000 | 0.0 | 13.900 | 0.0 | 0.0 | 4.1820 |
| | 16.000 | 0.0 | 13.900 | 0.0 | 0.0 | 4.0724 |
| | 18.000 | 0.0 | 13.900 | 0.0 | 0.0 | 3.9892 |
| | 20.000 | 0.0 | 13.900 | 0.0 | 0.0 | 3.7674 |
| | 22.000 | 0.0 | 13.900 | 0.0 | 0.0 | 3.3483 |
| | 24.000 | 0.0 | 13.900 | 0.0 | 0.0 | 2.7243 |
| | 26.000 | 0.0 | 13.900 | 0.0 | 0.0 | 1.9937 |
| | 28.000 | 0.0 | 13.900 | 0.0 | 0.0 | 1.3150 |
| | 30.000 | 0.0 | 13.900 | 0.0 | 0.0 | 0.81670 |
| Sewer Crown Line | -30.000 | 0.0 | 15.182 | 0.0 | 0.0 | 1.0220 |
| | -28.000 | 0.0 | 15.182 | 0.0 | 0.0 | 1.5730 |
| | -26.000 | 0.0 | 15.182 | 0.0 | 0.0 | 2.2533 |
| | -24.000 | 0.0 | 15.182 | 0.0 | 0.0 | 2.9960 |
| | -22.000 | 0.0 | 15.182 | 0.0 | 0.0 | 3.7246 |

| Type | Location X [m] | Location Y [m] | Location Z[Level] [mOD] | Displacement X [mm] | Displacement Y [mm] | Displacement Z [mm] |
|---|---|---|---|---|---|---|
| | -20.000 | 0.0 | 15.182 | 0.0 | 0.0 | 4.2109 |
| | -18.000 | 0.0 | 15.182 | 0.0 | 0.0 | 4.4340 |
| | -16.000 | 0.0 | 15.182 | 0.0 | 0.0 | 4.4885 |
| | -14.000 | 0.0 | 15.182 | 0.0 | 0.0 | 4.5831 |
| | -12.000 | 0.0 | 15.182 | 0.0 | 0.0 | 4.8195 |
| | -10.000 | 0.0 | 15.182 | 0.0 | 0.0 | 5.2606 |
| | -8.0000 | 0.0 | 15.182 | 0.0 | 0.0 | 5.8821 |
| | -6.0000 | 0.0 | 15.182 | 0.0 | 0.0 | 6.5511 |
| | -4.0000 | 0.0 | 15.182 | 0.0 | 0.0 | 6.9859 |
| | -2.0000 | 0.0 | 15.182 | 0.0 | 0.0 | 7.0908 |
| | 0.0 | 0.0 | 15.182 | 0.0 | 0.0 | 7.0055 |
| | 2.0000 | 0.0 | 15.182 | 0.0 | 0.0 | 6.7286 |
| | 4.0000 | 0.0 | 15.182 | 0.0 | 0.0 | 6.1949 |
| | 6.0000 | 0.0 | 15.182 | 0.0 | 0.0 | 5.6789 |
| | 8.0000 | 0.0 | 15.182 | 0.0 | 0.0 | 5.3198 |
| | 10.000 | 0.0 | 15.182 | 0.0 | 0.0 | 4.9260 |
| | 12.000 | 0.0 | 15.182 | 0.0 | 0.0 | 4.4538 |
| | 14.000 | 0.0 | 15.182 | 0.0 | 0.0 | 4.1289 |
| | 16.000 | 0.0 | 15.182 | 0.0 | 0.0 | 3.9962 |
| | 18.000 | 0.0 | 15.182 | 0.0 | 0.0 | 3.8984 |
| | 20.000 | 0.0 | 15.182 | 0.0 | 0.0 | 3.6743 |
| | 22.000 | 0.0 | 15.182 | 0.0 | 0.0 | 3.2652 |
| | 24.000 | 0.0 | 15.182 | 0.0 | 0.0 | 2.6610 |
| | 26.000 | 0.0 | 15.182 | 0.0 | 0.0 | 1.9591 |
| | 28.000 | 0.0 | 15.182 | 0.0 | 0.0 | 1.3029 |
| | 30.000 | 0.0 | 15.182 | 0.0 | 0.0 | 0.81445 |
| Sewer Centerline | -39.000 | 0.0 | 14.540 | 0.0 | 0.0 | 0.11102 |
| | -38.000 | 0.0 | 14.540 | 0.0 | 0.0 | 0.14502 |
| | -37.000 | 0.0 | 14.540 | 0.0 | 0.0 | 0.18820 |
| | -36.000 | 0.0 | 14.540 | 0.0 | 0.0 | 0.24231 |
| | -35.000 | 0.0 | 14.540 | 0.0 | 0.0 | 0.31034 |
| | -34.000 | 0.0 | 14.540 | 0.0 | 0.0 | 0.39694 |
| | -33.000 | 0.0 | 14.540 | 0.0 | 0.0 | 0.50515 |
| | -32.000 | 0.0 | 14.540 | 0.0 | 0.0 | 0.64207 |
| | -31.000 | 0.0 | 14.540 | 0.0 | 0.0 | 0.81346 |
| | -30.000 | 0.0 | 14.540 | 0.0 | 0.0 | 1.0252 |
| | -29.000 | 0.0 | 14.540 | 0.0 | 0.0 | 1.2821 |
| | -28.000 | 0.0 | 14.540 | 0.0 | 0.0 | 1.5816 |
| | -27.000 | 0.0 | 14.540 | 0.0 | 0.0 | 1.9152 |
| | -26.000 | 0.0 | 14.540 | 0.0 | 0.0 | 2.2672 |
| | -25.000 | 0.0 | 14.540 | 0.0 | 0.0 | 2.6261 |
| | -24.000 | 0.0 | 14.540 | 0.0 | 0.0 | 3.0081 |
| | -23.000 | 0.0 | 14.540 | 0.0 | 0.0 | 3.3871 |
| | -22.000 | 0.0 | 14.540 | 0.0 | 0.0 | 3.7326 |
| | -21.000 | 0.0 | 14.540 | 0.0 | 0.0 | 4.0101 |
| | -20.000 | 0.0 | 14.540 | 0.0 | 0.0 | 4.2129 |
| | -19.000 | 0.0 | 14.540 | 0.0 | 0.0 | 4.3495 |
| | -18.000 | 0.0 | 14.540 | 0.0 | 0.0 | 4.4283 |
| | -17.000 | 0.0 | 14.540 | 0.0 | 0.0 | 4.4614 |
| | -16.000 | 0.0 | 14.540 | 0.0 | 0.0 | 4.4766 |
| | -15.000 | 0.0 | 14.540 | 0.0 | 0.0 | 4.5075 |
| | -14.000 | 0.0 | 14.540 | 0.0 | 0.0 | 4.5693 |
| | -13.000 | 0.0 | 14.540 | 0.0 | 0.0 | 4.6653 |
| | -12.000 | 0.0 | 14.540 | 0.0 | 0.0 | 4.8036 |
| | -11.000 | 0.0 | 14.540 | 0.0 | 0.0 | 4.9957 |
| | -10.000 | 0.0 | 14.540 | 0.0 | 0.0 | 5.2449 |
| | -9.0000 | 0.0 | 14.540 | 0.0 | 0.0 | 5.5410 |
| | -8.0000 | 0.0 | 14.540 | 0.0 | 0.0 | 5.8703 |
| | -7.0000 | 0.0 | 14.540 | 0.0 | 0.0 | 6.2168 |
| | -6.0000 | 0.0 | 14.540 | 0.0 | 0.0 | 6.5477 |
| | -5.0000 | 0.0 | 14.540 | 0.0 | 0.0 | 6.8151 |
| | -4.0000 | 0.0 | 14.540 | 0.0 | 0.0 | 6.9928 |
| | -3.0000 | 0.0 | 14.540 | 0.0 | 0.0 | 7.0824 |
| | -2.0000 | 0.0 | 14.540 | 0.0 | 0.0 | 7.1012 |
| | -1.0000 | 0.0 | 14.540 | 0.0 | 0.0 | 7.0731 |
| | 0.0 | 0.0 | 14.540 | 0.0 | 0.0 | 7.0142 |
| | 1.0000 | 0.0 | 14.540 | 0.0 | 0.0 | 6.9129 |
| | 2.0000 | 0.0 | 14.540 | 0.0 | 0.0 | 6.7350 |
| | 3.0000 | 0.0 | 14.540 | 0.0 | 0.0 | 6.4802 |
| | 4.0000 | 0.0 | 14.540 | 0.0 | 0.0 | 6.1943 |
| | 5.0000 | 0.0 | 14.540 | 0.0 | 0.0 | 5.9162 |
| | 6.0000 | 0.0 | 14.540 | 0.0 | 0.0 | 5.6734 |
| | 7.0000 | 0.0 | 14.540 | 0.0 | 0.0 | 5.4823 |
| | 8.0000 | 0.0 | 14.540 | 0.0 | 0.0 | 5.3215 |
| | 9.0000 | 0.0 | 14.540 | 0.0 | 0.0 | 5.1585 |
| | 10.000 | 0.0 | 14.540 | 0.0 | 0.0 | 4.9370 |
| | 11.000 | 0.0 | 14.540 | 0.0 | 0.0 | 4.7109 |
| | 12.000 | 0.0 | 14.540 | 0.0 | 0.0 | 4.4702 |
| | 13.000 | 0.0 | 14.540 | 0.0 | 0.0 | 4.2823 |
| | 14.000 | 0.0 | 14.540 | 0.0 | 0.0 | 4.1541 |
| | 15.000 | 0.0 | 14.540 | 0.0 | 0.0 | 4.0744 |
| | 16.000 | 0.0 | 14.540 | 0.0 | 0.0 | 4.0320 |
| | 17.000 | 0.0 | 14.540 | 0.0 | 0.0 | 3.9995 |
| | 18.000 | 0.0 | 14.540 | 0.0 | 0.0 | 3.9410 |
| | 19.000 | 0.0 | 14.540 | 0.0 | 0.0 | 3.8498 |
| | 20.000 | 0.0 | 14.540 | 0.0 | 0.0 | 3.7179 |
| | 21.000 | 0.0 | 14.540 | 0.0 | 0.0 | 3.5378 |
| | 22.000 | 0.0 | 14.540 | 0.0 | 0.0 | 3.3043 |
| | 23.000 | 0.0 | 14.540 | 0.0 | 0.0 | 3.0167 |
| | 24.000 | 0.0 | 14.540 | 0.0 | 0.0 | 2.6907 |
| | 25.000 | 0.0 | 14.540 | 0.0 | 0.0 | 2.3397 |
| | 26.000 | 0.0 | 14.540 | 0.0 | 0.0 | 1.9757 |
| | 27.000 | 0.0 | 14.540 | 0.0 | 0.0 | 1.6251 |
| | 28.000 | 0.0 | 14.540 | 0.0 | 0.0 | 1.3091 |
| | 29.000 | 0.0 | 14.540 | 0.0 | 0.0 | 1.0388 |
| | 30.000 | 0.0 | 14.540 | 0.0 | 0.0 | 0.81586 |
| | 31.000 | 0.0 | 14.540 | 0.0 | 0.0 | 0.63605 |
| | 32.000 | 0.0 | 14.540 | 0.0 | 0.0 | 0.49300 |
| | 33.000 | 0.0 | 14.540 | 0.0 | 0.0 | 0.38015 |
| | 34.000 | 0.0 | 14.540 | 0.0 | 0.0 | 0.29155 |
| | 35.000 | 0.0 | 14.540 | 0.0 | 0.0 | 0.22215 |
| | 36.000 | 0.0 | 14.540 | 0.0 | 0.0 | 0.16782 |
| | 37.000 | 0.0 | 14.540 | 0.0 | 0.0 | 0.12515 |
| | 38.000 | 0.0 | 14.540 | 0.0 | 0.0 | 0.091779 |
| | 39.000 | 0.0 | 14.540 | 0.0 | 0.0 | 0.065709 |
| | 40.000 | 0.0 | 14.540 | 0.0 | 0.0 | 0.045183 |
| | 41.000 | 0.0 | 14.540 | 0.0 | 0.0 | 0.029185 |
| | 42.000 | 0.0 | 14.540 | 0.0 | 0.0 | 0.016612 |
| | 43.000 | 0.0 | 14.540 | 0.0 | 0.0 | 0.0068411 |
| | 44.000 | 0.0 | 14.540 | 0.0 | 0.0 | -817.49E-6 |
| | 45.000 | 0.0 | 14.540 | 0.0 | 0.0 | -0.0067508 |