

TKRE DRAINAGE MANAGEMENT PLAN

TKRE, Grain-Tilbury and Kingsnorth-Tilbury 400kV Uprating FEED

REFERENCE: 30003364-BHK-XX-XX-RP-C-02060_TKRE DRAINAGE MANAGEMENT PLAN

NATIONAL GRID NUMBER: PDD-100116-REP-060

Prepared for:

National Grid

11 June 2024

DOCUMENT VERIFICATION

Project title: TKRE, Grain-Tilbury and Kingsnorth-Tilbury 400kV Uprating FEED

Project number: 30003364

Document title: TKRE Drainage Management Plan

Document reference: 30003364-BHK-XX-XX-RP-C-02060_TKRE DRAINAGE MANAGEMENT PLAN

Rev	Date				
P01	22/06/2023	File name	30003364-BHK-XX-XX-RP-C-02060_TKRE DRAINAGE MANAGEMENT PLAN		
		Description	For Acceptance		
			Prepared by	Checked by	Approved by
		Name	M. Devonald	S. Spencer	J. Spaul
		Signature			
		Date	21/06/2023	22/06/2023	22/06/2023
P02	22/09/2023	File name	30003364-BHK-XX-XX-RP-C-02060_TKRE DRAINAGE MANAGEMENT PLAN		
		Description	For Acceptance		
			Prepared by	Checked by	Approved by
		Name	R. Hayward	R. Barraclough	J. Spaul
		Signature			
		Date	22/09/2023	22/09/2023	22/09/2023
P03	11/06/2024	File name	30003364-BHK-XX-XX-RP-C-02060_TKRE DRAINAGE MANAGEMENT PLAN		
		Description	Updated in accordance with LLFA comments		
			Prepared by	Checked by	Approved by
		Name	C. Elsby	R. Hayward	R. Barraclough
		Signature			
		Date	11/06/2024	13/06/2024	13/06/2024

Revision History:

P01 – First Issue

P02 – Updated to latest drainage design philosophy. Design results included in Appendices.

P03 – Updated in accordance with LLFA comments

CONTENTS.

1.	Introduction	5
2.	Basis of Design	10
3.	Incoming Water Supply	16
4.	References.....	18
5.	Appendices	20

FIGURES

Figure 1: Tilbury existing road drainage.	6
Figure 2: Tilbury side proposed layout and location.	7
Figure 3: Aerial image of proposed Tilbury site area (ditch in blue).	7
Figure 4: Gravesend side proposed layout and location.	8
Figure 5: Aerial image of proposed Gravesend site area.	9
Figure 6: Extract from 108748 showing water main.	16
Figure 7: Extract from CEN26807 showing water main.....	17
Figure 8: Extract from 32/NG/0412 showing mains water connection to sink.	17

1. Introduction

1.1. *Project Overview*

The existing National Grid Grain-Tilbury and Kingsnorth-Tilbury 400kV circuits are forecast to become significantly overloaded in their current capacity and require uprating. The circuits are predominantly overhead line, with cabled sections installed within a deep tunnel crossing the River Thames.

BakerHicks have been appointed to undertake the Front-End Engineering Design (FEED) of the TKRE, Grain-Tilbury and Kingsnorth-Tilbury 400kV uprating scheme and associated works, which will support the project's development at TP500 stage 4.3.

The Front-End Engineering design (FEED) study for uprating of the Grain-Tilbury and Kingsnorth-Tilbury 400kV circuits involves:

- Installation of 400kV cables within a new tunnel connection under the river Thames to match the required 3325MVA maximum rating.
- Uprating of 400kV 4TK Grain-Tilbury and 4VG Kingsnorth-Tilbury overhead lines including downloads by reconductoring of the existing 4 x 400 ACSR (2780MVA) OHL sections of the Tilbury-Grain/Tilbury-Kingsnorth circuits (A784/A785) to make the entire route 3 x AAAC (3820MVA).
- Uprating of substation bays at Grain, Kingsnorth and Tilbury substations.

1.2. *Scope of the Document*

This report presents information relating to the below ground drainage scheme design and Surface Water (Pluvial) flooding flow protection measures for the two CSEC locations. The scope of the report is to:

- Provide outline details of the proposed Drainage Management Plan (storm and foul) for the proposed cable sealing end compounds, including the tunnel headhouse.
- Explore the use of sustainable urban drainage features (SuDS) and to implement such features where physically, practically and economically feasible whilst ensuring that national and local policies are met.
- Provide recommendation on overland flow management for the proposed substation to prevent potential flood water entering into the compound.
- Explore options for tunnel drainage systems.
- Highlight mains water connection points for each site.

This Drainage Management Plan has been prepared for the sole purpose described above and no extended duty of care to any third party is implied or offered. Third parties referring to this report should consult National Grid and BakerHicks as to the extent to which findings may be appropriate for their use.

1.3. *Development Sites and Locations*

1.3.1. *Tilbury*

The Tilbury headhouse compound is proposed on a brownfield site with hardstanding currently covering the full extent. A manmade ditch resides to the east of the development that has no clear outfall location but is likely designed to capture surface water runoff from the wider catchment area. A road passes along the western and southern sides of the compound providing potential access to the site.

STAT searches for the site are available in drawing CEN26806. The fusion plans shows no drainage or clean water assets along the road or within the site boundary.

The site has been surveyed both topographically and with ground penetrating radar, the data is contained within 108748_03_00.dwg. A network of mains water pipes was identified in the road west of the site and within the BH07 area. Drainage manholes and 150 mm pipe were identified within the road junction to the southwest of the site; however, the extent, condition and outfall of the pipe system are unknown.

Site visits to the area have shown that an unconventional method for disposal of the road surface water is present directly west of the proposed development. The road currently drains via gaps in the kerbing through an insitu cast hole to an unknown drainage system behind the kerb as shown in Figure 1.



Figure 1: Tilbury existing road drainage.

At FEED stage it is not our intention to reuse this system for the proposed system, however due to the constraints with the levels and SUDS, the entrance bellmouth could be left unconnected to the proposed system and would drain to this existing system across the road in the short/medium-term, until the road upgrade has been carried out.

Topography on the site is generally flat.

Superficial geology of the area is Alluvium comprising clay, silt, sand and peat; to be confirmed with on-site ground investigation data. As the site is brownfield, pollution mitigation must be considered as the pollution cannot be transferred to the surrounding land/watercourse – refer to the geotechnical desktop study (PDD-100116-DDR-001) and ground investigation (GI) interpretive report (PDD-100116-REP-073) for information on contamination.

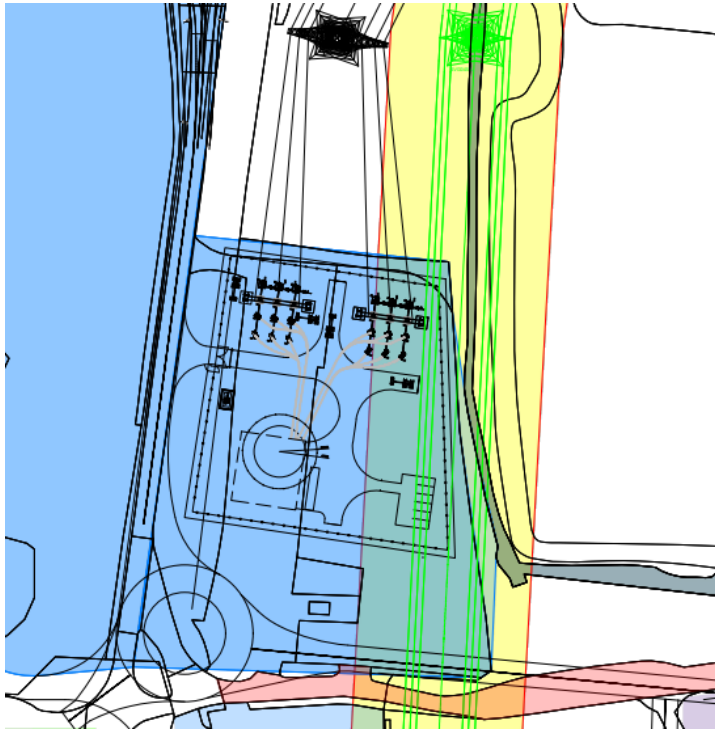


Figure 2: Tilbury site proposed layout and location.



Figure 3: Aerial image of proposed Tilbury site area (ditch in blue).

1.3.2. Gravesend

The Gravesend headhouse compound is proposed on a greenfield site south of the existing headhouse. A ditch resides to the east, south and west of the development that is hydraulically linked to the Thames through the flood defence via a non-return system.

STAT searches have been undertaken for the site and show no existing sewer or mains water networks available within the road or site boundary (refer to drawing CEN26807).

The site has been surveyed both topographically and with ground penetrating radar, the data is contained within 108567_03_01.dwg. No obvious drainage assets were recorded during the survey; however a section of water main was identified 'visible above ground' approximately 25 m west of the site boundary close to where the ditch is culverted under the road. The suitability for connection cannot be determined at the time of writing.

Topography on the site is generally flat with a slight fall from south to east, beneficial for overland drainage flow paths away from the headhouse building.

Superficial geology of the area is Alluvium comprising clay, silt, sand and peat; to be confirmed with on-site ground investigation data. No contamination is assumed as this is a greenfield site, subject to GI results.

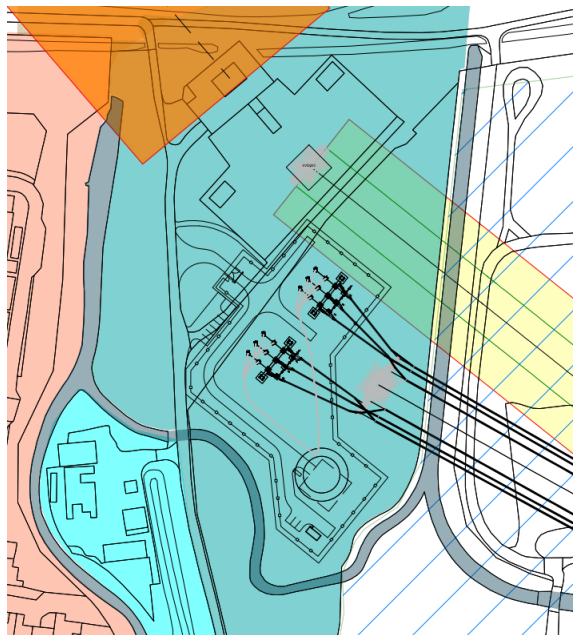


Figure 4: Gravesend site proposed layout and location.



Figure 5: Aerial image of proposed Gravesend site area.

1.4. *Flood Risk Assessment*

Refer to report PDD-100166-REP-015 for a comprehensive flood risk assessment on the Tilbury and Gravesend sites. It captures flood risk from pluvial and fluvial sources and gives recommendations for platform levels to mitigate damage from predicted flood water levels.

2. Basis of Design

The drainage management plan is based on the following which will need to be confirmed at detailed design stage.

2.1. *Existing Sewers*

Based on the available data, it is assumed that there are no existing sewer systems for foul or surface water drainage to connect into.

2.2. *Surface Water Drainage Design Strategy*

This section of the report outlines the surface water design strategy for the proposed development sites by setting out high level principles.

- The ground conditions have been confirmed to be a majority clay with some pockets of peat, therefore infiltration solutions (such as soakaways) are considered to be impractical. On top of this, with the Thames River in such close proximity, there may be a factor of Tidal Locking and high water table too, which would further remove the possibility of good infiltration.
- There is a local watercourse adjacent to the site that has been considered for discharge of the surface water run-off.
- The design catchment shall account for the area of land within the fence boundary only. Areas outside the fence line will be considered part of the enabling works drainage and are outside the scope of this report; however, it is likely that a filter / cut off drain shall be provided along the perimeter to convey any overland flows from external areas away from the CSEC.
- Flood estimation handbook (FEH13) data has been obtained for the site for use in simulation of rainfall events to inform concept and detailed design of the drainage network.
- The surface water drainage system has been designed and constructed so that:
 - No surcharging occurs in 1-in-2-year return period design storm.
 - No flooding in any part of the site during a 1-in-30-year return period design storm +CC.
 - No flooding of the critical infrastructure or buildings during a 1-in-100-year return period storm +CC.
- Climate change (45%) has been used as standard and follow recommendations from the flood risk assessment.
- Discharge rates from the surface water system shall be agreed with the local lead flood authority(ies). Practicalities of the result of this design philosophy will need careful consideration at the detailed design stage to ensure any potential attenuation is not onerously designed. At FEED stage the upstream attenuation systems requirements has been deemed to be not necessary and all water will be stored in the pipework, or within the filtration trenches across the site.

- Discharge consents will be required for surface water discharges from the Environment Agency, Essex County Council (Tilbury) and Kent County Council (Gravesend).
- The SUDS hierarchy has been followed taking account upon review of the ground investigation survey results.
- Oily water containment requirements are not relevant on this site.
- A penstock and sampling chamber shall be provided prior to where drainage discharges off-site (NGTS 2.10.09 cl.4.2).
- Rainwater harvesting shall not be considered due to envisaged minimal use of the headhouse toilet facilities.
- The design of the surface water system is to shed the road surface water to “French Drain” style filtration trenches which will collect and convey the water to a traditional piped drainage system. This will then pick up the roof water and any tunnel water seepage, before entering the watercourse. The proposed systems will be restricted back to greenfield run-off rates for each site, which have been calculated to be 0.4l/s for both sites. Such a low discharge rate is due to the low amount of hardstanding area being proposed.
- With the discharge rates being so low, the resulting flow controls will result in a small orifice, which increased the risk of blockage significantly. A minimum recommended discharge rate which minimised the risk of blockage is 5l/s, however this design has not accounted for this uplift, however any increase in discharge rates, will reduce the need for storage.
- Below is “Table 26.2” from the SUDS manual (C753) which shows the pollution hazard indices for different site uses. Due to the low day-to-day usage of the site during the operational stage and the unique nature of the site, we have deemed that the site would be captured under the 3rd category (Low), TSS=>0.5, Metals=>0.4 & Hydrocarbons=>0.4.

TABLE 26.2 Pollution hazard indices for different land use classifications

Land use	Pollution hazard level	Total suspended solids (TSS)	Metals	Hydrocarbons
Residential roofs	Very low	0.2	0.2	0.05
Other roofs (typically commercial/ industrial roofs)	Low	0.3	0.2 (up to 0.8 where there is potential for metals to leach from the roof)	0.05
Individual property driveways, residential car parks, low traffic roads (eg cul de sacs, homezones and general access roads) and non-residential car parking with infrequent change (eg schools, offices) ie < 300 traffic movements/day	Low	0.5	0.4	0.4
Commercial yard and delivery areas, non-residential car parking with frequent change (eg hospitals, retail), all roads except low traffic roads and trunk roads/motorways ¹	Medium	0.7	0.6	0.7

As an additional treatment measure to the Filter Strip, a “Downstream Defender™” (Hydro Int) is proposed upstream of the flow control chamber. As can be seen in

the table below, these two treatment system will deal with even the most heavily polluted scenario for the site with a combined total:

TABLE 26.3 Indicative SuDS mitigation indices for discharges to surface waters

Type of SuDS component	Mitigation indices ¹		
	TSS	Metals	Hydrocarbons
Filter strip	0.4	0.4	0.5
Filter drain	0.4 ²	0.4	0.4
Swale	0.5	0.6	0.6
Bioretention system	0.8	0.8	0.8
Permeable pavement	0.7	0.6	0.7
Detention basin	0.5	0.5	0.6
Pond ⁴	0.7 ³	0.7	0.5
Wetland	0.8 ³	0.8	0.8
Proprietary treatment systems ^{5,6}	These must demonstrate that they can address each of the contaminant types to acceptable levels for frequent events up to approximately the 1 in 1 year return period event, for inflow concentrations relevant to the contributing drainage area.		
Downstream Defender	0.5	0.4	0.8
Total Site Mitigation	0.65	0.6	0.8

The roof water will be captured by a “Green Roof” system. This has not been accounted for in the calculations to make it a more robust design, but it will reduce the flow from the building in reality and treat any windblown contaminants that may fall on the roof.

- Additionally, both systems have been tested to see what capacity they have should the outfalls become surcharged (tidal locking, etc), and no water would be able to leave site. As they currently stand, the systems can provide up to 1 days' worth of storage without any flooding of the site. This however would possibly be more as the filtration trenches (which will have 30% voids) have not been added to the simulation, however it is believed that 1 days' worth of storage is sufficient, especially as tidal locking will only last half a day.
- Drainage Calculations for each site and conditions can be found in Appendix A (Tilbury) and Appendix B (Gravesend).

2.2.1. Tilbury

Anticipated surface water catchment areas are as follows:

New Compound Total Area	6,000 m ² <i>Fenced perimeter plus 2m clearance</i>
Total Impermeable Compound Area	1,400 m ² <i>Roads/car park @ 1,000 m²</i> <i>Headhouse @ 400 m²</i>

Tunnel / Shaft	See section 2.4 – anticipate up to 3m³ per day (approx. 0.03 l/s average i.e. negligible) Unfilled cable trough 15m from Headhouse will be subject to rainfall, resulting run-off will be carried into the Headhouse building and added to the tunnel discharge. Resulting Run-off will still be lower than the 0.1l/s allowed for in the calculations.
----------------	--

With the development removing a significant portion of the hardstanding and predominantly replacing it with a permeable surfacing (approx. 75%), the overall impact to the drainage ditch will be a nett positive. Both the peak discharge rate, and total volume of runoff from the site are likely to reduce.

The strategy is to reconnect the surface water system to the ditch via a new headwall to the east of the site and to limit the peak flow rate to an agreed rate.

The intention is to take all hardstanding areas (access road, car park and roof drainage) and pass it through a Downstream Defender and then a flow control system, with upstream attenuation being supplied by the pipework and filter strips, to restrict the flow to an agreed rate. All other areas will be permeable covered with single sized stone chippings and free draining sub-base.

An alternative proposal was made for the site to be drained via a new pump chamber from the existing Heading House compound to the south. This would be undesirable since the existing site is situated at least 400m south of the new development. Even with laying a pipe at the minimum gradient of 1:400, this would mean a minimum fall of 1m to the site. Due to the sites being at similar level and the requirement to have at least 1.2m of cover over the pipe, it would not be feasible to reach the required level of the new outfall as it stands. The proposed pump system would need to be lowered by another 1-2m.

This is not just a maintenance liability if the pumps were to fail, but also an expensive method of discharging water, especially as there is a watercourse next to the site. There are also H&S and environmental benefits associated with avoiding construction of >400m or new underground drainage pipe.

If connection to the watercourse was not possible, then this may become the only solution and amendments to the proposed pump system to the existing network would need to be carried out.

A preliminary design of the site can be found in Appendix C.

2.2.2. Gravesend

Anticipated surface water catchment areas are as follows:

New Compound Total Area	6,500 m² <i>Fenced perimeter plus 2m clearance, and external car park</i>
Total Impermeable Compound Area	1,400 m² <i>Roads/car park @ 1,150 m²</i>

	<i>Headhouse @ 250 m²</i>
Tunnel / Shaft	Negligible as tunnel falls towards Tilbury end Unfilled cable trough 15m from Headhouse will be subject to rainfall, resulting run-off will be carried into the Headhouse building and added to the tunnel discharge. Resulting Run-off will still be lower than the 0.1l/s allowed for in the calculations.

The proposed site for the compound is the greenfield area directly South of the existing Eastcourt Marshes Substation. Due to the permeable nature of the existing site, flows from the site will be restricted back to "greenfield run-off rate".

The strategy is to connect the surface water system to the ditch via a new headwall and to limit the flow rate to the greenfield run-off rate.

The intention is to take all hardstanding areas (access road, car park and roof drainage) and pass it through a Downstream Defender and then a flow control system, with upstream attenuation being supplied by the pipework and filter strips, to restrict the flow to an agreed rate. All other areas will be permeable covered with single sized stone chippings and free draining sub-base.

A preliminary design of the site can be found in Appendix D.

2.3. *Foul Water Drainage Design Strategy*

This section of the report outlines the foul drainage strategy for the proposed development site by setting out high level principles.

- Neither site is understood to be 'permanently manned' and as such in accordance with TS 2.10.09 the preference is to discharge foul water to existing sewer, with the backup option to provide a 9000 Litre cess tank.
- The available GPR suggests there are no public foul sewers available for either site therefore a 9000 Litre underground cess tank will be provided at both sites. The cess tank will be positioned adjacent to a road to allow access for maintenance / emptying.
- Necessary discharge consents shall be obtained from the relevant regulatory authorities if a packaged treatment plant is used.
- Building drainage will be in accordance with the appropriate sections of BS EN 12056 'Gravity Drainage Systems Inside Buildings'. Gradients shall be adequate to achieve the required minimum flow velocities for self-cleansing.

2.4. *Shaft and Tunnel Drainage Design Strategy*

A permanent drainage system will be required to remove water build up from seepage as the shaft and tunnel are below the water table. The tunnel is to be constructed with a 1:1000 fall towards Tilbury which suggests the need for sumps and tunnel pipe/channel systems to contain the induced flow. The design shall be in accordance with NGTS 3.05.12 *Cable Tunnels*:

- The tunnel drainage system and sump will be suitably sized to accommodate all water ingress. The inflow rate limit is 0.1 l/m² of surface area in any 24hr period as per NGTS 3.05.12, clause 3.1. As an estimate only, anticipate up to approx. 3m³ per day, which equates to a constant discharge rate of 0.035l/s. Due to the limitations of the design software, the minimum additional discharge rate that can be added to the system is 0.1l/s. This is an overestimation of the rate by a factor of 29.
- Discharge from the shaft and tunnel will need to pass through an interceptor to ensure no contamination of water courses, as per NGTS3.05.12, clause 5.2.6.
- A pumping main will be provided from the sump to a surface level valve chamber that connects into the surface water drainage system. The chamber shall be equipped with a flow meter to monitor discharge rates.
- In general, it is understood the HV cable troughs will be filled with Cement Bound Sand (CBS) or similar and as such no drainage provision is made. However locally at the tunnel shafts, it is understood there will be 'un-filled' sections of trough where the cables enter the tunnel shaft at a relatively deep level. At the base of these sections, at outlet pipe through the shaft wall and down to the shaft slab perimeter drainage channel and/or sump will be provided. The runoff will be pumped out along with any infiltration from the tunnel.
- The additional catchment area is approx. 110m² and as such, at FEED stage this is deemed to have a negligible impact on the drainage network and is included within the 0.1l/s in the simulation models. The sump pump will need to be suitably specified to cope with this additional volume of water, but this is not considered to be onerous. Particularly as a lot of this runoff may not actually be conveyed via the troughs and instead run into adjacent chippings / road network.

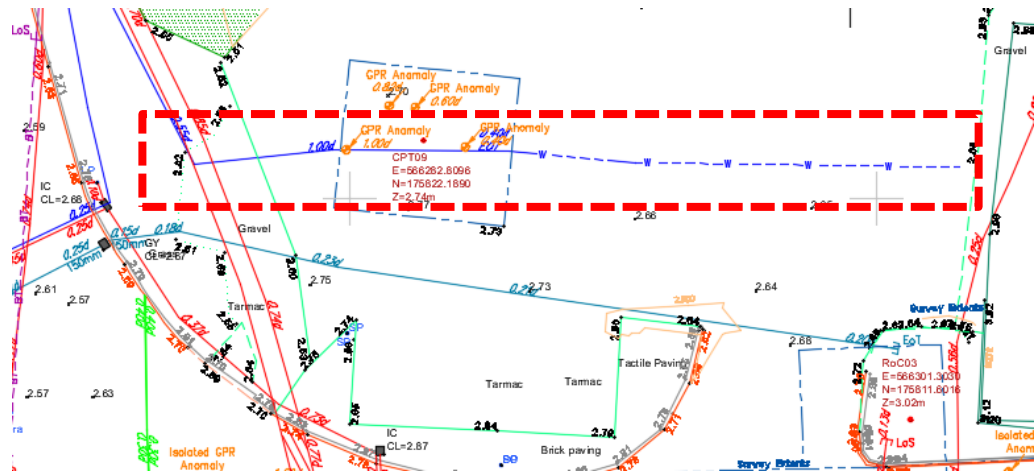
3. Incoming Water Supply

A mains water supply will be required for each headhouse to facilitate amenity features such as sinks, basins, showers and toilets.

Installation of below ground mains water shall be in accordance with Southern Water guidance, as they are the local water authority.

3.1. Tilbury

A water pipe within the proposed site boundary has been identified on drawing 108748_03_00.



3.2. Gravesend

A water pipe running parallel to the road that is assumed to connect to Eastcourt Marshes Substation Site was identified on Fusion Plan CEN26807. Evidence of the connection at the substation is shown on 32/NG/0411 (1981) & 32/NG/0412 (1981).

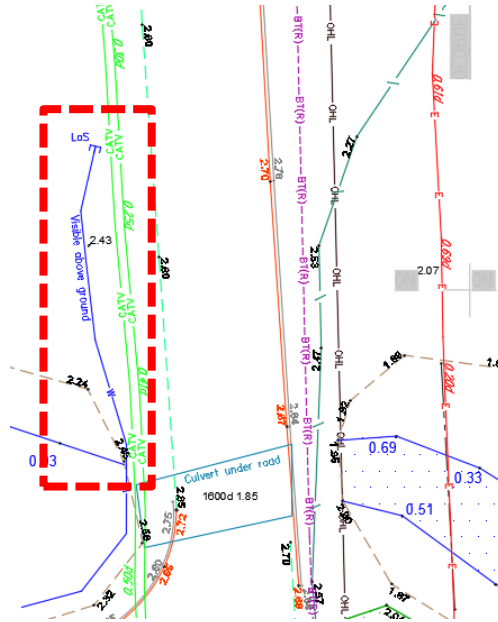


Figure 7: Extract from CEN26807 showing water main.

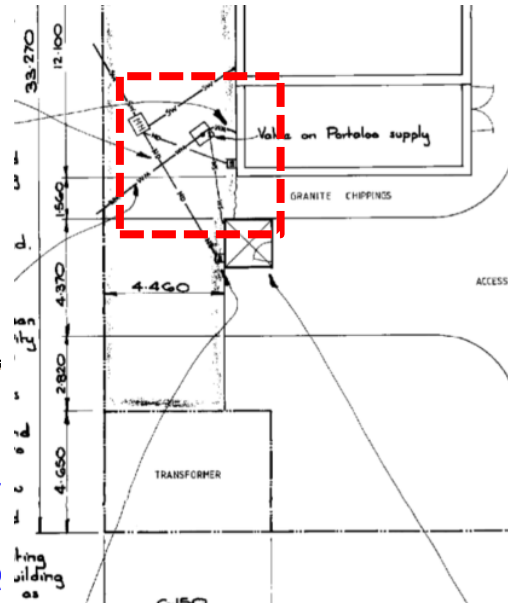


Figure 8: Extract from 32/NG/0412 showing mains water connection to sink.

A connection from the existing water main is proposed that will deliver potable water to the new headhouse.

Additionally, a mains water pipe was surveyed (CEN26807) in the road running parallel to the Thames and Medway Canal, originating from a junction on Mark Lane. This is assumed to feed the adjacent sites to the west of the proposed Gravesend site. Although the pipe does not extend to the existing substation junction at TQ673740, it could be extended to facilitate a connection to the new headhouse.

4. References

FEED STAGE DRAWINGS

REFERENCE	TITLE
30003364-BHK-XX-XX-DR-C-02039	Tilbury Drainage General Arrangement
30003364-BHK-XX-XX-DR-C-02041	Gravesend Drainage General Arrangement

- Tilbury Drainage General Arrangement
- Gravesend Drainage General Arrangement

POLICY

REFERENCE	VERSION	TITLE
NPPF	2019	The National Planning Policy Framework
NPPF-PPG		NPPF Planning Practice Guidance
Best Practice Guidance (NTSSD)		Non-statutory technical standards for sustainable drainage
https://www.kent.gov.uk	2019	Land-drainage-policy

GUIDANCE

REFERENCE	VERSION	TITLE
NGTS 2.10.01	2017	Oil Containment
NGTS 2.10.05	2017	Access Covers / Ducts / Trenches
NGTS 2.10.09	2017	Site Drainage
NGTS 2.10.13	2016	Flood Defences for Electricity Substations
NGTS 3.05.12	2021	Cable Tunnels
Kent County Council	2000	The Soakaway Design Guide
BS 8582:2013	2013	Code Of Practice For Surface Water Management For Development Sites
BS EN 752	2017	Drain and sewer systems outside buildings
BS EN 16933-2:2017	2017	Drain And Sewer Systems Outside Buildings – Design, Part 2 Hydraulic Design
BS EN 12056: 1-5	2000	Gravity Drainage Systems Inside Buildings

BS 9295	2020	Guide To The Structural Design Of Buried Pipes
C753	2015	CIRIA SuDS Manual
Building Regulations: Part H	2015	Approved Document H: Drainage And Waste Disposal
Sewerage Sector Guidance, water UK	2019	Appendix C – Design and Construction Guidance for foul and surface water sewers offered for adoption

REFERENCE

REFERENCE	VERSION	TITLE
PDD-100116-DDR-001	P01	Geotechnical and Geoenvironmental Desk Study
PDD-100166-REP-015	P01	Flood Risk Assessment
CEN26806	A	Fusion Plan – Tilbury Substation
CEN26807	A	Fusion Plan – Gravesend Substation
32/NG/0411	C	Existing & Revised Plan & Elevations of Headworks Building
32/NG/0412	C	Modifications – Details Sheet 1 Site Plan, Roof, Groundworks
108748_03_00	00	GRP Utility Mapping Survey, Presented on a Topographical Survey (Tilbury)
108567_03_01	00	GRP Utility Mapping Survey, Presented on a Topographical Survey (Gravesend)

5. Appendices

5.1. APPENDIX A

5.1.1. Tilbury Design

Pipe Number	Pipe Length (m)	Fall (m)	Slope (1:X)	Area (ha)	Time of Entry (mins)	Base Flow (l/s)	Pipe Rough. (mm)	US/IL (m)	US/CL (m)	Pipe DIA (mm)	Auto Design
1.000	9.177	0.055	167.0	0.010	2.00		0.600	1.925	2.727	225	🛠️
1.001	34.343	0.206	167.0	0.010			0.600	1.870	2.993	225	🛠️
1.002	48.428	0.290	167.0	0.000			0.600	1.664	3.000	225	🛠️
2.000	26.613	0.159	167.4	0.113	2.00		0.600	2.059	2.884	225	🛠️
2.001	5.181	0.526	9.9	0.000		0.1	0.600	1.900	3.022	225	🛠️
1.003	22.588	0.136	165.9	0.000			0.600	1.374	3.005	225	🛠️
3.000	23.671	0.142	167.0	0.007	2.00		0.600	2.223	2.983	225	🛠️
3.001	72.746	0.843	86.3	0.000			0.600	2.081	3.000	225	🛠️
1.004	10.696	0.101	105.9	0.000			0.600	1.238	3.000	100	🛠️
▼											▼

Pipe Number	Rain (mm/hr)	TC (mins)	DS/IL (m)	Σ Imp. Area (ha)	Σ Base Flow (l/s)	Foul (l/s)	Add Flow (l/s)	Pro. Vel (m/s)	Pro. Depth (mm)	Velocity (m/s)	Cap (l/s)	Flow (l/s)	Rain No.
1.000	0.00	2.15	1.870	0.010	0.0	0.0	0.0	0.00	0	1.01	40.1	0.0	1
1.001	0.00	2.72	1.664	0.020	0.0	0.0	0.0	0.00	0	1.01	40.1	0.0	1
1.002	0.00	3.52	1.374	0.020	0.0	0.0	0.0	0.00	0	1.01	40.1	0.0	1
2.000	0.00	2.44	1.900	0.113	0.0	0.0	0.0	0.00	0	1.01	40.1	0.0	1
2.001	0.00	2.46	1.374	0.113	0.1	0.0	0.0	0.55	4	4.19	166.7	0.1	1
1.003	0.00	3.89	1.238	0.133	0.1	0.0	0.0	0.21	8	1.01	40.3	0.1	1
3.000	0.00	2.39	2.081	0.007	0.0	0.0	0.0	0.00	0	1.01	40.1	0.0	1
3.001	0.00	3.25	1.238	0.007	0.0	0.0	0.0	0.00	0	1.41	56.0	0.0	1
1.004	0.00	4.13	1.137	0.140	0.1	0.0	0.0	0.27	9	0.75	5.9	0.1	1

5.1.2. Tilbury Results

Critical Summary of Results by Maximum Level (Rank 1)										
Pipe Number	US/MH Name	Event	US/CL (m)	Water Level (m)	Surcharged Depth (m)	Flooded Volume (m³)	Flow / Cap.	Overflow (l/s)	Pipe Flow (l/s)	Status
1.000	SW01	15 minute 100 year Summer I+45%	2.727	1.936	-0.214	0.000	0.01		0.3	OK
1.001	SW02	15 minute 100 year Summer I+45%	2.993	1.886	-0.209	0.000	0.01		0.6	OK
1.002	SW03	15 minute 100 year Summer I+45%	3.000	1.679	-0.210	0.000	0.01		0.5	OK
2.000	SW04	15 minute 100 year Summer I+45%	2.884	2.108	-0.176	0.000	0.10		3.7	OK
2.001	SW05	15 minute 100 year Summer I+45%	3.022	1.928	-0.197	0.000	0.04		3.8	OK
1.003	SW06	15 minute 100 year Winter I+45%	3.005	1.477	-0.123	0.000	0.10		3.7	OK
3.000	SW07	15 minute 100 year Summer I+45%	2.983	2.230	-0.218	0.000	0.01		0.2	OK
3.001	SW08	15 minute 100 year Summer I+45%	3.000	2.086	-0.220	0.000	0.00		0.2	OK
1.004	SW09	15 minute 100 year Winter I+45%	3.000	1.476	0.138	0.000	0.07		0.4	SURCHARGED

5.1.3. Tilbury Results (Tide Locked)

Critical Summary of Results by Maximum Level (Rank 1)										
Pipe Number	US/MH Name	Event	US/CL (m)	Water Level (m)	Surcharged Depth (m)	Flooded Volume (m³)	Flow / Cap.	Overflow (l/s)	Pipe Flow (l/s)	Status
1.000	SW01	1440 minute 100 year Winter I+45%	2.727	2.548	0.398	0.000	0.00		0.0	FLOOD RISK
1.001	SW02	1440 minute 100 year Winter I+45%	2.993	2.548	0.453	0.000	0.00		0.0	SURCHARGED
1.002	SW03	1440 minute 100 year Winter I+45%	3.000	2.548	0.658	0.000	0.00		0.0	SURCHARGED
2.000	SW04	1440 minute 100 year Winter I+45%	2.884	2.548	0.264	0.000	0.00		0.0	SURCHARGED
2.001	SW05	1440 minute 100 year Winter I+45%	3.022	2.548	0.423	0.000	0.00		0.1	SURCHARGED
1.003	SW06	1440 minute 100 year Winter I+45%	3.005	2.548	0.948	0.000	0.00		0.1	SURCHARGED
3.000	SW07	1440 minute 100 year Winter I+45%	2.983	2.548	0.100	0.000	0.00		0.0	SURCHARGED
3.001	SW08	1440 minute 100 year Winter I+45%	3.000	2.548	0.241	0.000	0.00		0.0	SURCHARGED
1.004	SW09	1440 minute 100 year Winter I+45%	3.000	2.548	1.209	0.000	0.00		0.0	SURCHARGED

5.2. APPENDIX B

5.2.1. Gravesend Design

Pipe Number	Pipe Length (m)	Fall (m)	Slope (1:X)	Area (ha)	Time of Entry (mins)	Base Flow (l/s)	Pipe Rough. (mm)	US/IL (m)	US/CL (m)	Pipe DIA (mm)	Auto Design
1.000	50.654	0.303	167.0	0.024	2.00		0.600	1.749	2.874	225	
2.000	15.769	0.275	57.3	0.014	2.00		0.600	1.721	2.846	225	
1.001	11.631	0.070	166.0	0.025			0.600	1.446	2.844	225	
1.002	38.433	0.230	167.1	0.014			0.600	1.376	2.844	225	
1.003	20.152	0.121	167.0	0.017			0.600	1.146	2.966	225	
3.000	5.799	1.294	4.5	0.000	2.00	0.1	0.600	2.450	3.350	100	
1.004	18.595	0.111	167.5	0.023			0.600	1.025	3.272	225	
4.000	18.408	0.961	19.2	0.022	2.00		0.600	1.875	3.001	225	
1.005	2.029	0.013	156.0	0.000			0.600	0.914	3.273	225	
1.006	13.121	0.131	100.2	0.000			0.600	0.901	3.283	100	

Pipe Number	Rain (mm/hr)	TC (mins)	DS/IL (m)	Σ Imp. Area (ha)	Σ Base Flow (l/s)	Foul (l/s)	Add Flow (l/s)	Pro. Vel (m/s)	Pro. Depth (mm)	Velocity (m/s)	Cap (l/s)	Flow (l/s)	Rain No.
1.000	0.00	2.84	1.446	0.024	0.0	0.0	0.0	0.00	0	1.01	40.1	0.0	1
2.000	0.00	2.15	1.446	0.014	0.0	0.0	0.0	0.00	0	1.73	68.8	0.0	1
1.001	0.00	3.03	1.376	0.063	0.0	0.0	0.0	0.00	0	1.01	40.2	0.0	1
1.002	0.00	3.66	1.146	0.077	0.0	0.0	0.0	0.00	0	1.01	40.1	0.0	1
1.003	0.00	4.00	1.025	0.095	0.0	0.0	0.0	0.00	0	1.01	40.1	0.0	1
3.000	0.00	2.03	1.156	0.000	0.1	0.0	0.0	0.82	4	3.68	28.9	0.1	1
1.004	0.00	4.30	0.914	0.117	0.1	0.0	0.0	0.21	8	1.01	40.1	0.1	1
4.000	0.00	2.10	0.914	0.022	0.0	0.0	0.0	0.00	0	3.00	119.4	0.0	1
1.005	0.00	4.34	0.901	0.139	0.1	0.0	0.0	0.21	8	1.04	41.5	0.1	1
1.006	0.00	4.62	0.770	0.139	0.1	0.0	0.0	0.28	9	0.77	6.0	0.1	1

5.2.2. Gravesend Results

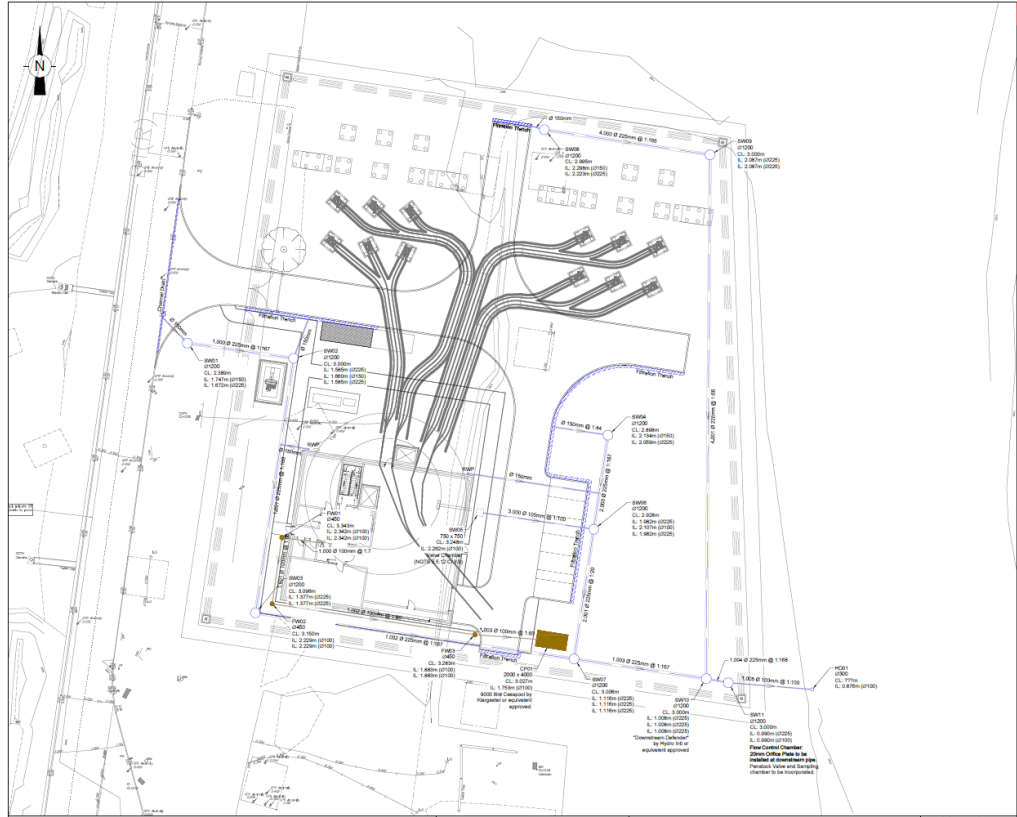
Pipe Number	US/MH Name	Event	US/CL (m)	Water Level (m)	Surcharged Depth (m)	Flooded Volume (m³)	Flow / Cap.	Overflow (l/s)	Pipe Flow (l/s)	Status
1.000	SW01	15 minute 100 year Sumn	2.874	1.772	-0.202	0.000	0.02		0.7	OK
2.000	SW02	15 minute 100 year Sumn	2.846	1.730	-0.216	0.000	0.01		0.5	OK
1.001	SW05	15 minute 100 year Sumn	2.844	1.480	-0.191	0.000	0.05		1.9	OK
1.002	SW06	15 minute 100 year Sumn	2.844	1.411	-0.190	0.000	0.06		2.1	OK
1.003	SW07	15 minute 100 year Winte	2.966	1.184	-0.187	0.000	0.07		2.4	OK
3.000	SW08	15 minute 100 year Sumn	3.350	2.452	-0.098	0.000	0.00		0.1	OK
1.004	SW09	15 minute 100 year Winte	3.272	1.145	-0.105	0.000	0.07		2.6	OK
4.000	SW10	15 minute 100 year Sumn	3.001	1.883	-0.217	0.000	0.01		0.8	OK
1.005	SW11	15 minute 100 year Winte	3.273	1.144	0.005	0.000	0.03		0.9	SURCHARGED
1.006	SW12	15 minute 100 year Winte	3.283	1.144	0.143	0.000	0.07		0.4	SURCHARGED

5.2.3. Gravesend Results (Tide Locked)

Pipe Number	US/MH Name	Event	US/CL (m)	Water Level (m)	Surcharged Depth (m)	Flooded Volume (m³)	Flow / Cap.	Overflow (l/s)	Pipe Flow (l/s)	Status
1.000	SW01	1440 minute 100 year Wi	2.874	2.328	0.354	0.000	0.00		0.0	SURCHARGED
2.000	SW02	1440 minute 100 year Wi	2.846	2.328	0.382	0.000	0.00		0.0	SURCHARGED
1.001	SW05	1440 minute 100 year Wi	2.844	2.328	0.657	0.000	0.00		0.0	SURCHARGED
1.002	SW06	1440 minute 100 year Wi	2.844	2.328	0.727	0.000	0.00		0.0	SURCHARGED
1.003	SW07	1440 minute 100 year Wi	2.966	2.328	0.957	0.000	0.00		0.0	SURCHARGED
3.000	SW08	15 minute 100 year Sumn	3.350	2.452	-0.098	0.000	0.00		0.1	OK
1.004	SW09	1440 minute 100 year Wi	3.272	2.328	1.078	0.000	0.00		0.1	SURCHARGED
4.000	SW10	1440 minute 100 year Wi	3.001	2.328	0.228	0.000	0.00		0.0	SURCHARGED
1.005	SW11	1440 minute 100 year Wi	3.273	2.328	1.189	0.000	0.00		0.1	SURCHARGED
1.006	SW12	1440 minute 100 year Wi	3.283	2.328	1.327	0.000	0.00		0.0	SURCHARGED

5.3. APPENDIX C

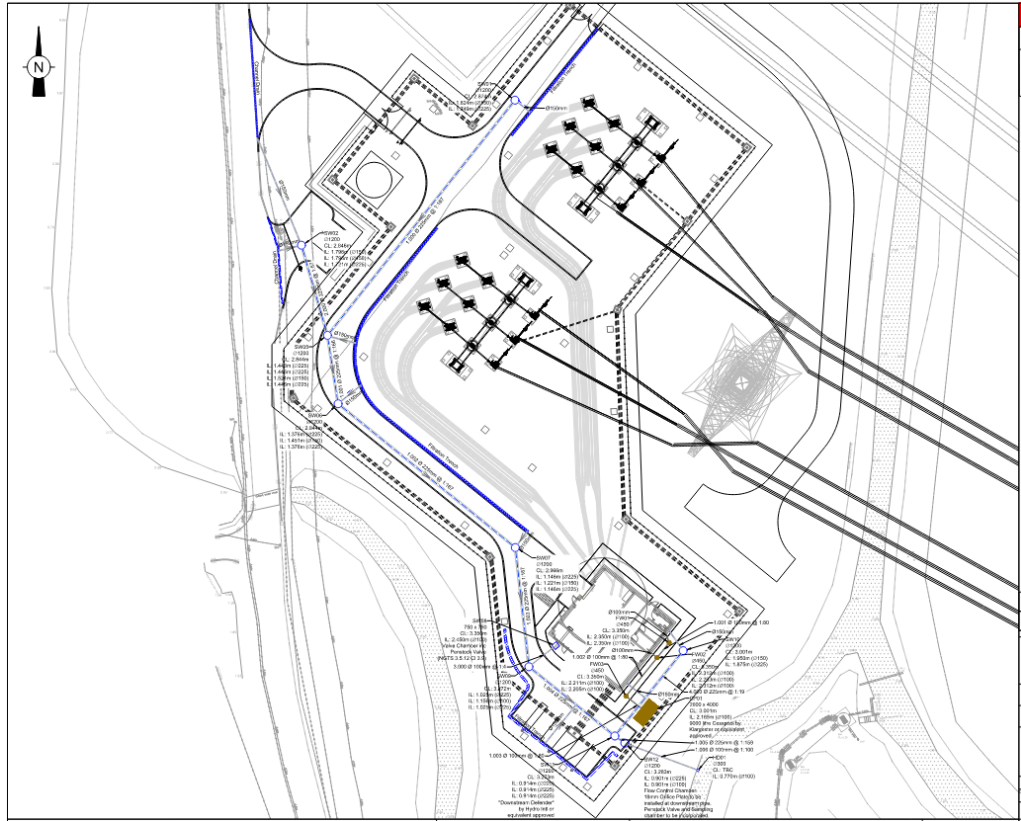
5.3.1. Tilbury Preliminary Surface Water Drainage Layout



For further Information refer to FEED stage drainage general arrangement drawing 30003364-BHK-XX-XX-DR-C-02039

5.4. APPENDIX D

5.4.1. Gravesend Preliminary Surface Water Drainage Layout



For further Information refer to FEED stage drainage general arrangement drawing 30003364-BHK-XX-XX-DR-C-02041



OUR OFFICES.

United Kingdom

- Motherwell (Eurocentral) +44 (0)1698 756100
- Manchester +44 (0)161 873 2500
- Derby +44 (0)1332 974398
- Warwick +44 (0)1926 567800
- London +44 (0)20 7549 1300

JOIN US (UK).

bakerhicks.com/careers

FOLLOW US.

Twitter [@BakerHicks_1957](#)

LinkedIn [BakerHicks](#)

bakerhicks.com