BUROHAPPOLD ENGINEERING

Hogsmill Heat Detailed Feasibility

Detailed Feasibility Report

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Glossary

Term	Definition
AD	Anaerobic Digestion
ASHP	Air Source Heat Pump
BEIS	Government department for Business Energy and Industrial Strategy
BoQ	Bill of Quantities
Capex	Capital Costs
CHP	Combined Heat and Power
COP	Coefficient of Performance
CRE	Cambridge Road Estate
DPD	Detailed Project Development
dT	Temperature difference
EC	Energy Centre
EMP	Energy Masterplan
FBO	Full Build Out
GLA	Greater London Authority
HIU	Heat Interface Unit
IRR	Internal Rate of Return
KH	Kingston Hospital
NPV	Net Present Value
O&M	Operation and Maintenance
Opex	Operational costs
PFS	Preliminary Feasibility Study
PHE	Plate Heat Exchanger
RBK	Royal Borough of Kingston upon Thames
Repex	Replacement costs
SAP	Standard Assessment Procedure
SOC	Strategic Outline Business Case
TEM	Techno-economic cashflow model
WSHP	Water Source Heat Pump
WWTP	Waste Water Treatment Plant

1 Executive Summary

Context to the Hogsmill Heat Network

The Hogsmill Heat network proposes to export low carbon resilient heat from multiple sources at the Thames Water Hogsmill Waste Water Treatment Plant (WWTP) to supply the Cambridge Road Estate development as a first stage of an expandable decarbonisation project. This will reduce gas consumption by ~50% vs. alternative CRE technology and provide up to ~95% of the heat with only 5% coming from onsite boiler plant.

The RBK commissioned detailed feasibility study finds that the ~£6.2m project could provide a commercially viable proposition for both RBK and Thames Water and would deliver long term low carbon heat and air quality improvements as well as a gateway for further decarbonisation across the borough through scheme expansion.

This report presents the findings from the detailed feasibility study and outlines the key risks and next steps for project implementation.

Benefits to RBK

In 2019 RBK declared a climate emergency, setting a target for the borough to be carbon neutral by 2038. This project could save an estimated 16,600tCO2e over 30 years compared to the CRE proposed solution and will likely be the single biggest intervention RBK can make to reduce carbon emissions in the borough.

Other benefits include:

- Potential **to create jobs** during construction phase and local upskilling for operation
- Alleviate fuel poverty and **improve air-quality** in the borough, with an estimated 80% reduction in carbon emissions at year 15 compared to the counterfactual
- Requires funding in the region of **£2-3m investment** and would qualify for the government backed £320m HNIP scheme.
- **Private sector investment:** The scheme could deliver returns within Thames Water hurdle rates and attract ~£3-4m of investment for Energy Centre operation and could attract further private sector investment on the heat network elements..

Heat demands and supply

The accelerated sense of urgency since the climate emergency declaration has led RBK to focus the scheme on the key anchor load of Cambridge Road Estate (CRE). CRE is a 2,170 residential unit social housing estate in Kingston. Its timely redevelopment and location near the Hogsmill WWTP presents an excellent opportunity to provide one of Kingston's most deprived areas with affordable, clean, low carbon heat.

WWTP final effluent and biogas CHP waste heat will supply the bulk of heat to the network. Gas boilers at CRE provide the peaking capacity.

The network route, key connections and heat supplies are shown in Figure 1-1. Along with CRE, the nearby Cambridge Gardens social housing and new Hampden Road residential development have been considered as additional heat loads.

Positive conversations held with Kingston Hospital have opened up the opportunity to integrate this large heat load as part of future network phases however this is not investigated in detail in the scope of this study.

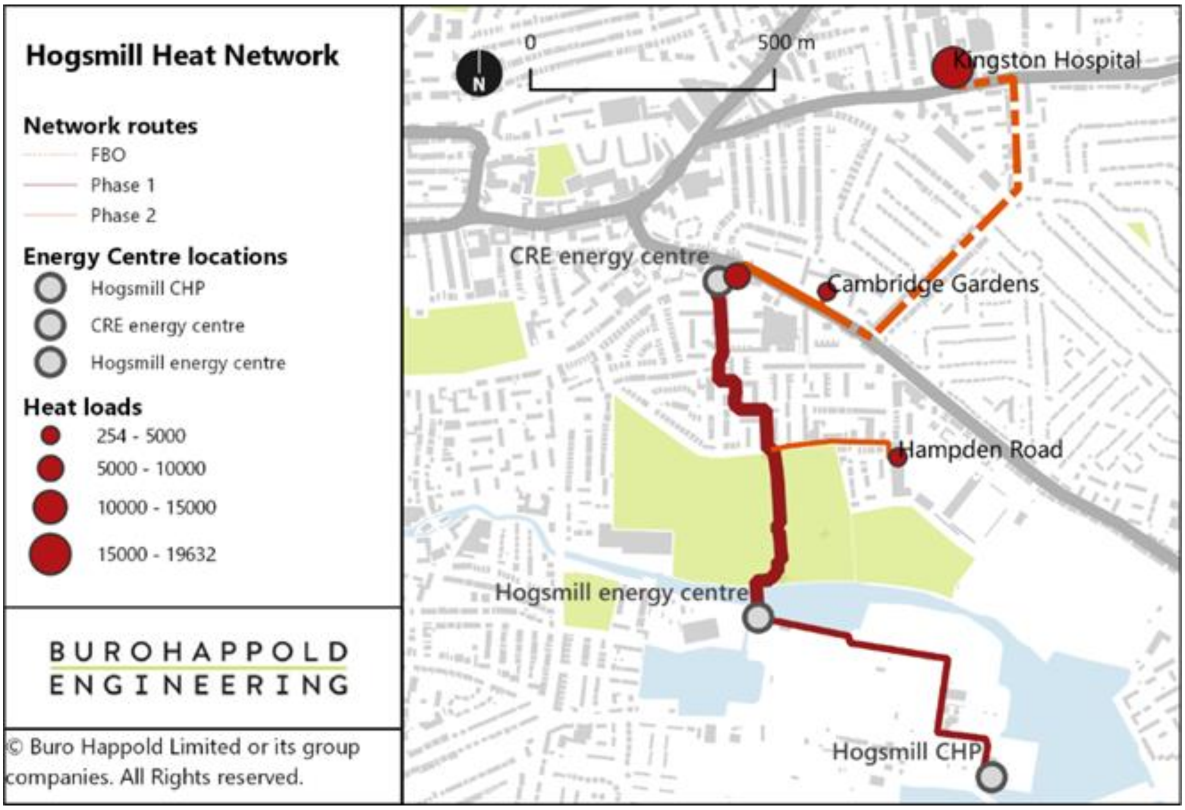


Figure 1-1 Hogsmill heat network

Effluent heat offtake and energy centre

BuroHappold have held monthly discussions with Thames Water, the operators of Hogsmill WWTP, to develop the technical requirements for heat offtake. The proposed solution is to extract heat from the effluent post tertiary treatment to minimise impact on WWTP operations.

It is proposed a new chamber is built with an offtake from the existing culvert. From here the effluent will be pumped to the Energy Centre (EC) where the low-grade heat will be compressed in a heat pump to the required 80°C for distribution in the network. Thames Water are currently undertaking further design and costing of the offtake solution.

Techno-economic performance

The capital costs of the proposed network total £6.2m (see Table 1—1). This includes £1.0m of additional interventions to the existing biogas CHPs to utilise the zero-carbon high grade heat currently being dumped. By reducing the reliance on peaking gas boilers at CRE, this intervention improves the carbon and economic performance of the network.

Modelling suggests the project can deliver a 4.8-9.2% IRR, depending on the level of funding that can be secured. This is well within the RBK internal hurdle rate of 4-6.5%, suggesting significant benefit to RBK and any 3rd party wanted to invest.

Table 1—1 CRE Scheme costs with heat pump and CHP

Capital costs breakdown	
Hogsmill offtake interventions and EC plant	£3.2m
Additional interventions to the existing Hogsmill biogas CHPs for heat injection into network	£1.0m
Network costs from Hogsmill EC to CRE	£2.0
Total	**£6.2m**

Operational considerations

Different operational options have been investigated to understand the sensitivity to Thames Water involvement and potential payment for services provided. E.g. operation of the Energy Centre and Heat Pumps on TW land. The assessment suggests that the returns when funded would be adequate to meet both RBK and TW hurdle rates.

Required actions

This project has the potential to provide RBK with a secure revenue stream which can be reinvested into the community. It is therefore recommended that the study is taken forward further to Detailed Project Development (DPD) stage.

The key next steps are to:

- Stakeholder engagement
  - Continue Thames Water engagement to work towards an agreeable delivery model.
  - CRE design team integration of proposals
- Develop scheme through DPD
  - Technical development
  - Costing
  - TEM update
  - Operational model
- Produce the Outline Business Case (OBC)
- Proceed with funding applications and procurement
- Further investigate the Kingston Hospital network extension
- Surveys recommended:
  - Desktop C2 utility record survey and identify locations for GPR surveys
  - Ground investigation surveys at Thames Water site

2 Key drivers for the Hogsmill Heat Network

2.1 Aims and focus

Since 2018 the Royal Borough of Kingston upon Thames (RBK) have been investigating the opportunity to utilise the large waste heat source available at the Hogsmill Waste Water Treatment Plant (WWTP) to provide low carbon heat and hot water to RBK residents.

RBK declared a climate emergency on 25th June 2019, with the goal of making the borough carbon neutral by 2038[1]. This decision has accelerated the council's interest in the Hogsmill heat network project as likely the single largest intervention they can make to reduce greenhouse gas emissions in the borough. It has attracted the interest of the former Energy Minister and MP for RBK, Ed Davey who says of the CRE redevelopment:

> *"We need locally, nationally and globally, to make climate change a top priority because it is so urgent… Councils have got to work hard on energy efficiency… with the new homes programme on the Cambridge Road Estate, sustainability is really a much bigger aspect than it was under the last council… we have to tackle it, we have to act far more quickly than some people think…* ***Local authorities have an important role to play****"*

Ed Davey, Surrey Comet 22nd March 2019

This accelerated sense of urgency has led RBK to focus the scheme on the key anchor load of Cambridge Road Estate (CRE). The CRE development is a 2,170 redevelopment of an existing social housing estate in Kingston. It's timely redevelopment and location near the Hogsmill WWTP presents an excellent opportunity to provide one of Kingston's most deprived areas with affordable, clean, low carbon heat.

BuroHappold Engineering have been appointed as the main consultancy to progress this from Energy Mapping and Masterplanning (EMP) to Preliminary Feasibility Study (PFS) and Strategic Outline Case (SOC) to the current stage Detailed Feasibility as presented herein.

In December 2019, RBK submitted an application for funding of the Detailed Project Development stage, for a heat network scheme serving the Cambridge Road Estate area and the Kingston Hospital, to the UK Government's Business, Energy and Industrial Strategy (BEIS) department. At the time of writing no decision has been made.

2.1.1 Key drivers

A DHN can contribute to The Royal Borough of Kingston upon Thames (RBK) drivers and targets:

- Utilising waste heat at Hogsmill makes this likely **the largest single impact project** that RBK could participate in
- Potential **to create jobs** during construction phase and local upskilling for operation
- Alleviate fuel poverty and **improve air-quality** in the borough, with an estimated 80% reduction in carbon emissions at year 15 compared to the counterfactual
- Could deliver in the region of **£2m investment into CRE** towards the required low carbon heating system from the private sector

[1] https://www.kingston.gov.uk/info/200284/energy_climate_change_and_sustainability/1635/climate_change_-_news_and_events

- **Private sector investment:** The scheme could deliver returns to any operator in the range of 5% IRR before funding, which could bring revenue to RBK and also attract private sector investment.

2.2 Strategic vision

The borough wide opportunities presented in the PFS have been consolidated to focus on connecting Cambridge Road Estate (CRE) cluster.

Effluent waste heat at Hogsmill WWTP and biogas CHP heat will supply the bulk of heat to the network.

Positive conversations with Kingston Hospital (KH) have opened up the opportunity to integrate this network extension in the future.

Figure 2-1 illustrates the strategic vision in three phases:

- **Phase 1:** Cambridge Road Estate only
- **Phase 2:** additional connections of Cambridge Gardens and Hampden Road
- **Full Build Out (FBO):** network extension to Kingston Hospital

It is the intention that the scheme can be extended into Kingston Town Centre in the medium/long term.

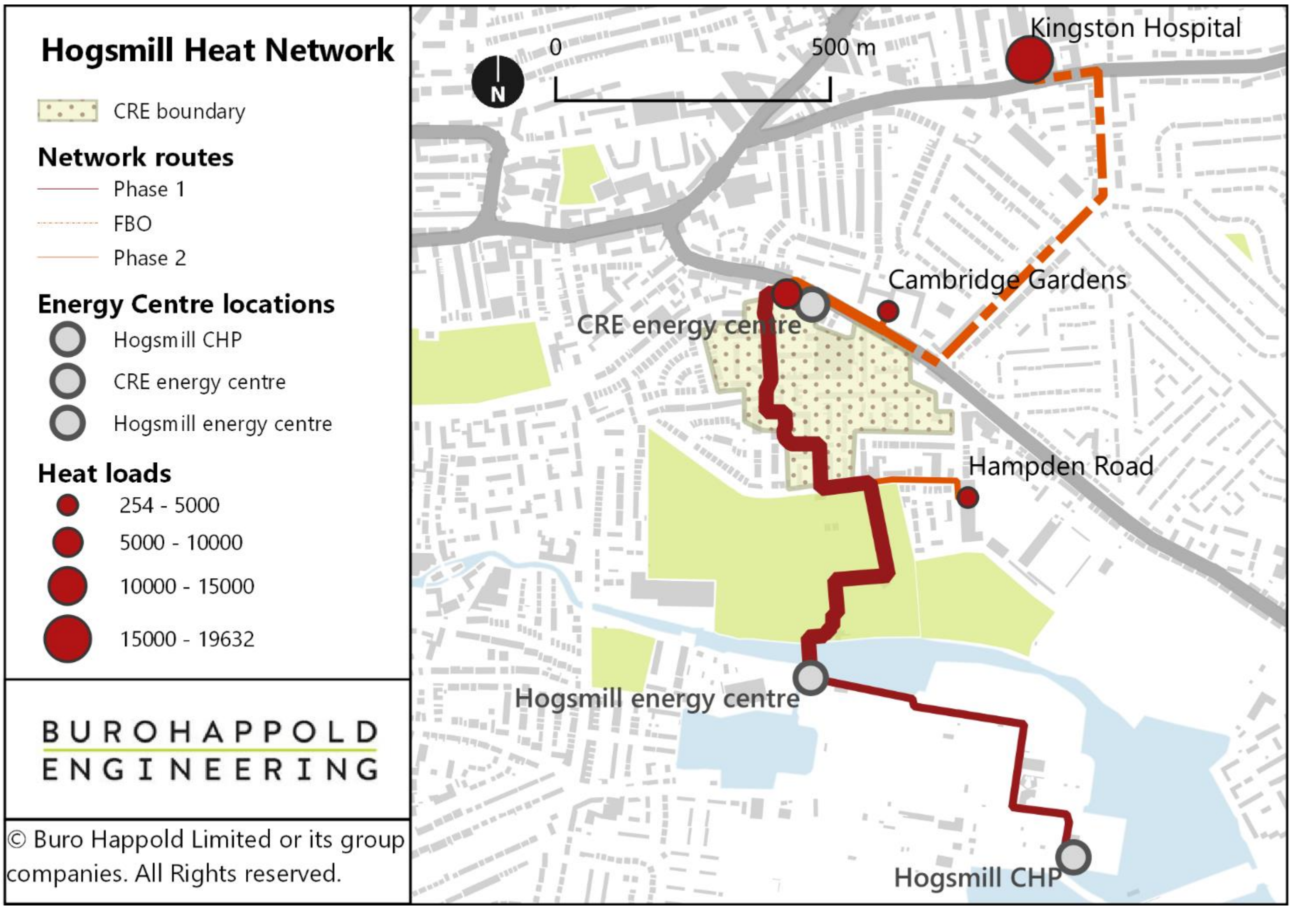


Figure 2-1 Strategic vision

2.3 Report structure

This report provides an update on the previous work BuroHappold have completed for RBK. Namely:

- The Energy Masterplan (2019)
- Strategic Outline Case (2019)
- RBK Heat Network Preliminary Feasibility Study (PFS) (2019)

As stated above, this report focusses on CRE and the surrounding connection opportunities. This is referred to as Phase 1 in the PFS.

The report is split into the following seven sections:

1. **Scheme update:** taking all lessons learnt from site visits and stakeholder engagement, this section detailed the proposed network
2. **Energy production:** summarises the available heat sources (including the final effluent, crematorium waste heat and onsite Thames Water Combined Heat and Power (CHP) heat)
3. **Energy Centre and plant:** provides the bill of quantities of all major plant on the network, along with the schematic and other drawings
4. **Network routing:** detailed the route and constraints as assessed by external consultant 3DTD. Network sizing and trenching specified is also specified in this section
5. **Carbon assessment:** Carbon dioxide equivalent (CO2e) modelling based on BEIS projections. The network's CO2e emissions is compared to the counterfactual CO2e emissions to assess potential savings
6. **Techno-economic modelling:** details of the capital and operation costs of the network, heat pricing, funding options and sensitivity testing
7. **Next steps and risk management:** the next steps for progression to Detailed Project Development (DPD) and beyond are detailed along with key risks.

3 Scheme update

Taking the learnings from the case studies and the stakeholder engagement (Appendix A), the proposed network design is detailed in the following section.

This report focusses on kick-starting the project through connection to Cambridge Road Estate. The extension to Kingston Hospital and the town centre (detailed in the PFS report) is not the focus of this study however, it is still considered a viable option for future phases of the network.

Due to positive engagement with the hospital, a high level review of the performance of the Kingston Hospital connection as a 'Plan B' for if the CRE ballot was rejected has been undertaken – this will be subject to further technical and commercial work at the next stage.

3.1 Load schedule

The load schedule for each connection is shown in Table 3—1. CRE consisted of 5 phases, built in 2-year intervals as per the phasing plan. All other key inputs and assumptions can be found in Appendix A.

Table 3—1 Load schedule

Connection name	Annual heat load	Peak heat load	No. resi units	Connection year	Option	Data source
	MWh/a	*MWth*	-	*Year*		
CRE phase 1	1,899	1.746	501	2024	Basecase	Annual and peak loads provided by Hodkinson. Estimated split over each phase based on phasing plan. Connection dates taken from phasing plan
CRE phase 2	1,579	1.453	417	2025	Basecase	
CRE phase 3	1,597	1.468	421	2027	Basecase	
CRE phase 4	1,555	1.430	410	2029	Basecase	
CRE phase 5	1,597	1.469	421	2031	Basecase	
Cambridge Gardens	2,155	0.754	164	2022	Sensitivity	Annual heat load estimated from EPC data (183kWh/m2). Peak load benchmarked
65 Hampden Road	254	0.424	79	2022	Sensitivity	Benchmarked based on info in planning documents
Kingston Hospital	19,632	5.751	n/a	2027	Sensitivity	Annual and peak loads provided by Kingston Hospital. Connection date assumed to align with new onsite EC from discussions with Kingston Hospital. Heat load includes the new residential development

3.2 Network schematic

The network schematic is shown in Figure 3-1. The following section details each heat supply and customer's connection requirements and configuration.

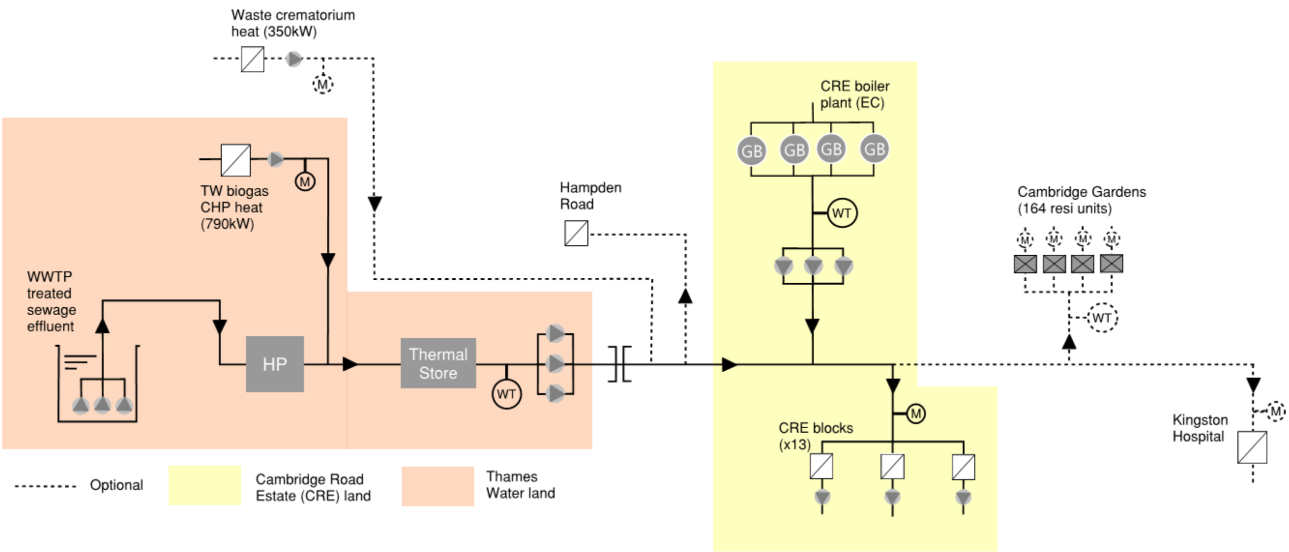


Figure 3-1 Network schematic

3.2.1 Heat customers

CRE

The key anchor load for the network is CRE. It's estimated annual heat load at the site EC of 8,227MWh/a and a peak of 7.6MW over the 2,170 resi unit development. Detailed plans of the redevelopment are yet to be seen. Based on the available information (see appendix) it has been assumed that at full build out there are 13 blocks, each requiring a Plate Heat Exchange (PHE) skid and pump set. These will supply residents through a direct Heat Interface Unit (HIU) at each flat as part of the secondary network.

It is assumed that Countryside will install the secondary network at CRE. Once connection is made, the network operator will take on the O&M and replacement costs of the PHE, pump sets, HIUs and all secondary network. Metering will be carried out at the HIU.

Hampden Road (sensitivity)

Hampden Road is a new 79-unit residential development. Identified in the EMP as a potential connection due to its proximity to CRE. Since the EMP, Hodkinson have written an energy addendum to the planning documents, stating the development will have an onsite heat network powered by ASHPs and top-up gas boilers. All dwellings to connect into a single plant room for ease of connection to the proposed heat network.

This is an considered an optional heat supply as it has a small heat load compared to CRE. It is proposed connection is made in the onsite plant room through installation of a PHE skid. Heat is supplied and metered at bulk point.

Cambridge Gardens (sensitivity)

As in the PFS report, it is proposed the existing 164-unit social housing at Cambridge Gardens is considered for connection to the network. The secondary system, currently individual gas boilers, will require retrofitting to become connection ready to the network.

Heat will be sold to the customer at HIU level. As none of the Cambridge Gardens blocks are high-rise indirect HIUs are considered appropriate, with no central thermal substation.

Kingston Hospital (optional – future phases)

Kingston Hospital's continued interest in connecting to the proposed heat network means it could act as an alternative heat customer should the CRE regeneration fall through due to the residential ballot. In this scenario is proposed that a single PHE skid is installed into the Hospital's EC to facilitate connection to the network. Low carbon heat will be metered at sold in bulk. It is assumed the Hospital will retain and operate its existing peaking plant as part of their secondary network.

4 Energy production

The sewage effluent heat offtake arrangement at Hogsmill WWTP is detailed in this section. Data on the available heat from the existing CHPs on the Hogsmill site is also summarised with indicative drawings and routing to connect into the new energy centre. Similarly, the indicative interventions required at Kingston Crematorium to connect into the network are shown in this section.

4.1 Heat supplies summary

Table 4—1 shows the peak and max annual heat supplies available from the three waste heat sources.

Gas boilers housed at the CRE EC will provide back-up and peak heat supply to the network. By locating the boilers here the network can make the most out of the existing plant space and reduce network losses. It is proposed that Countryside will provide boiler capacity to meet the peak load of the CRE. Once connection is made, the Operation and Maintenance (O&M) and replacement costs of these boilers and associated plant will be adopted by the network.

Table 4—1 Low carbon heat supplies summary

Heat supply	Peak heat (kWth)	Max. annual heat supply (MWhth)
Heat pump	1,523	12,000
Biogas CHPs	790	6,000
Crematorium	350	730

4.2 Hogsmill effluent offtake arrangement

The following section details the considerations made on location and design on the effluent offtake.

It is proposed the main energy centre, housing the heat pump(s), thermal stores, water treatment, distribution pumps and auxiliary plant is located on Thames Water land at the Hogsmill WWTP. Locating the heat near the final effluent abstraction will reduce pumping power and increase the overall efficiency of the network.

4.2.1 Basis of design

Investigation on the feasibility of each option is based on initial hydraulic considerations, ease of access and potential disruption to the site.

Table 4—2 shows the estimated water head in the culvert downstream of the tertiary treatment at different flow conditions, calculated with the Manning equation (subject to future investigation of roughness, slope etc.). The recommended minimum water depth in the pumping chamber for the abstraction pumps is 1m. Therefore intervention is required to ensure minimum depths in all flow scenarios.

Table 4—2 Water head at selected flow conditions

	Flow (l/s)	Normal Depth (m) Culvert
Minimum Flow	282	0.35
Average Flow	744	0.58
Maximum Flow	2258	1.13

4.2.2 Optioneering

Three options for effluent offtake were presented to Thames Water (locations shown in Figure 4-1). Detailed of the alternative options discussed with Thames Water can be found in Appendix D.

- **Option A:** existing chamber upstream the tertiary treatment
    - Disregarded as the temperature drop is thought to affect the tertiary treatment process
- **Option B:** existing chamber downstream the tertiary treatment
    - Disregarded at this stage as a sluice gate would be required to increase water head in low flow scenarios which could interfere with upstream tertiary treatment
- **Option C:** offtake on existing outfall/manhole before the outfall in the Hogsmill River
    - Taken forward as has no impact on WWTP operations and located away from key plant

Figure 4-1 Offtake options – locations (edited from GoogleMaps)

4.2.3 Preferred design

The design of the offtake (Option C - Figure 4-2) has been developed based on an iterative design process with feedback from Thames Water. The design minimises the risk to Thames Water operations while also providing a reliable flow of water to the heat pump.

The existing chamber is to be modified or replaced to divert flows to a new pumping chamber. A new sluice gate is suggested to facilitate maintenance and access to the pumps. This also ensures complete control of the discharge flow should Thames Water require it. The cold return can be placed inside the existing culvert, downstream of the new offtake chamber. This has the added benefit of the chamber's proximity to the proposed EC location (see Section 0). This means it may be possible to create a separate compound with private access from the RBK Recycling Centre.

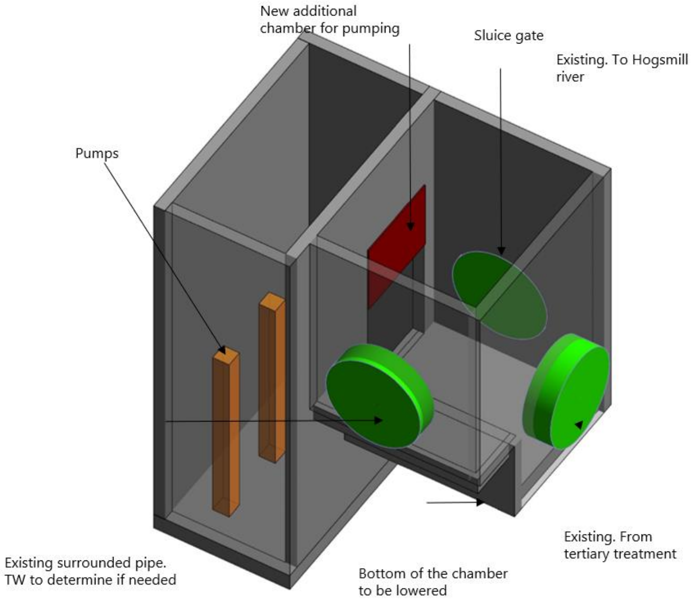


Figure 4-2 Option C Offtake drawing – BuroHappold initial proposal

Thames Water development of the design

Based on this work Thames Water have since taken forward their own design for costing of works onsite. This design is similar to that detailed here, however it uses hot tapping to the existing outfall to connect a pre-made cylinder to the existing culvert.

This option will likely reduce capital costs and construction tine on site compared to the solution detailed above. However, it is not possible to tell from the drawings if the existing culvert can maintain its water level at periods of low flow to ensure a constant flow into the heat pump.

Further development of the design and monitoring of flow conditions in the culvert is recommended before this design is taken forward.

4.3 Heat supply connection to network

See Appendix F for the schematic arrangement of the connections detailed below.

4.3.1 Hogsmill biogas CHPs

To utilise the waste heat from the CHP, it is proposed a plate heat exchanger (PHE) skid is installed before the existing heat-dump radiators in the South-East corner of the Hogsmill WWTP site (see Figure 4-3).

This PHE have been sized at 66% duty/assist to the combined peak thermal load of the three CHP units. This has been estimated at 1,547kWth based on data provided by Thames Water. It is assumed this is high-grade heat. This ensures that the maximum heat available from the CHPs can be utilised if not being used on site.

During normal operation, the average combined peak heat load from the three CHPs is 790kWth.

Assuming a 90/50degC flow and return from the CHP, the network size required to carry 1,547kW is DN125mm.

Figure 4-3 Indicative CHP routing across Hogsmill WWTP (image from GoogleMaps)

4.3.2 Kingston Crematorium

There is an estimated 350kW of available heat per cremation and Kingston Crematorium perform an average of 4 cremations per working day (Section 1). Assuming an average of two hours per cremation (i.e. the cremators are continually running over the 8-hour day) annual heat available with a 90% availability factor is ~730MWh/a.

Assuming a peak factor of 1.25, the peak power available is 460kW. The PHE required to connect this heat into the network is sized to this peak, with a 66% duty/assist configuration.

As a worse case estimate, it is assumed the heat is bought back to the Hogsmill EC (Figure 4-4). However, it is likely that the networks trunk pipe will pass directly adjacent to the Crematorium building and the heat can be injected directly into the network. The crematorium upgrades are also facilitating heat recovery for use in their buildings and therefore intervention should be straightforward, however mechanical drawings were not made available at this stage.

Assuming a 90/50degC flow and return from the Crematorium PHE, the network size required to carry 460kW is DN80mm.

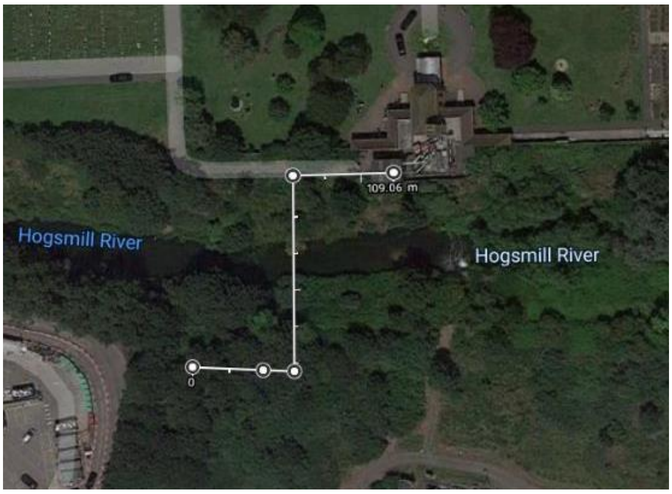


Figure 4-4 Crematorium network routing (image from GoogleMaps)

5 Energy Centre and plant

This section details the sizing and design of the main Energy Centre (EC) at Hogsmill WWTP. A bill of quantities is produced for all major plant along with EC layout, connection schematic, ventilation design and the electrical concept schematic.

5.1 EnergyPro modelling

Overview

The energy modelling software EnergyPro has been used to assess the annual heat flows of the network. Five scenarios have been modelled to determine plant sizing and heat fractions, as shown in Table 5—1.

This section outlines the methodology used for the modelling and presents the results with recommendations for heat pump and thermal store capacities at the energy centre.

Table 5—1 Scenarios modelled

Scenario	Heat supplies	Heat demands
1	Hogsmill final effluent heat	CRE
2	Hogsmill final effluent and CHP heat	CRE
3	Hogsmill final effluent and CHP heat	CRE and Cambridge Gardens
4	Hogsmill final effluent and CHP heat	CRE, Cambridge Gardens and Hampden Road
5	Hogsmill final effluent, CHP and Crematorium heat	CRE

5.1.2 Methodology and key inputs

Profiling

To build a model of the annual operating profile for the scheme, in order to size plant, a number of profiles were combined. The annual heat load of each connection was modelled. This data was distributed for each building across the year using a typical week hourly profile for a building of that typology. The profiles used are from a range of BuroHappold metered operational data and previous project experience.

These typical weekly profiles are then factored to the annual heat demand of each connection. The process for the core scheme connections is outlined in Figure 5-1. Figure 5-2 shows the hourly heat profile for the year for CRE, including 10% network losses applied as a flat profile across the year. The domestic hot water profile remains relatively constant throughout the year; the dip in the summer months is due to domestic hot water generation as minimal space heating is required in these periods.

Figure 5-1 Heat demand profiling method

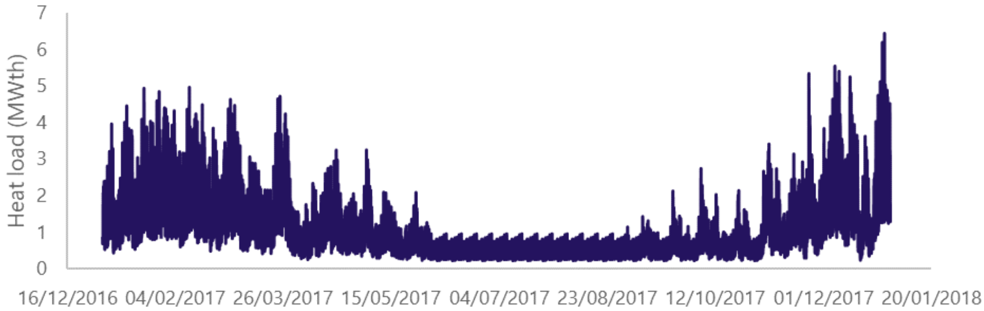


Figure 5-2 Combined annual hourly heat profile for CRE

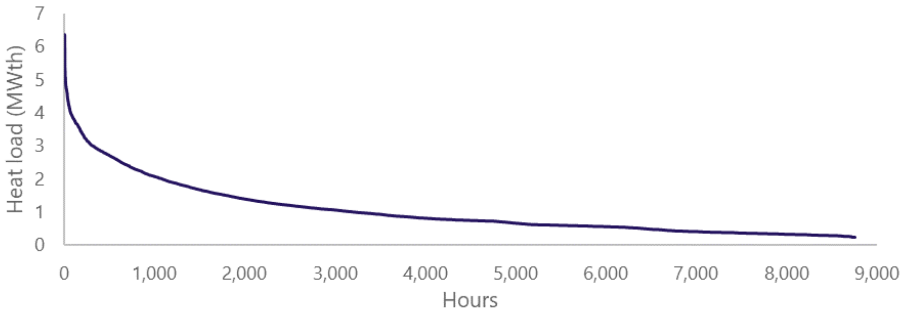


Figure 5-3 Combined heat duration curve for CRE

Heat pump modelling

The 1.5MWth heat pump has been set up to run at a minimal partial load of 50%, with a minimum run time of 1 hour (as per GEA specifications). The Coefficient of Performance (COP) varies with network temperature (assumed 80^{o}C flow and 50^{o}C return), effluent water temperature (using Thames Water data and assuming 7degC dT at 100% load) and load on the network. Partial load is achieved with constant flow rate and varying the dT and supply return temperatures. As can be seen from Figure 5-4, the COP varies from 3.5 to 4.1 depending on outfall temperature and load on the network.

Two days downtime per year for each heat pump unit for maintenance is assumed in the winter months, with an availability factor of 98% as per GEA guidance. Gas boilers are modelled at 89% efficiency and allow for part load.

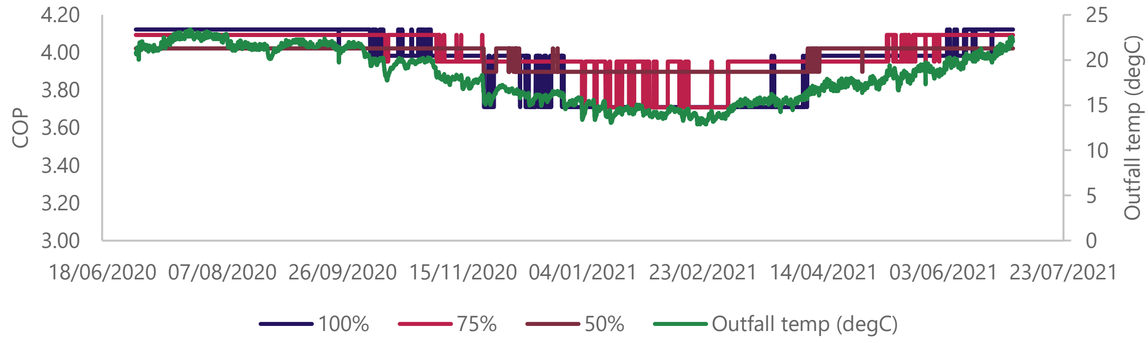


Figure 5-4 Heat pump COP and outfall temperatures over one year

CHP heat supply modelling

The waste heat supply from the three Hogsmill biogas CHPs has been modelled as three flat profiles totalling 790kW. Each CHP has an assumed 2 hours of downtime per day (estimated from data received from Thames Water).

The operational strategy has been set to prioritise heat from the CHPs before the heat pump. With the remaining heat supplied by the gas boilers (Figure 5-5). In this case both the heat pump and CHP heat are used to charge the thermal store.

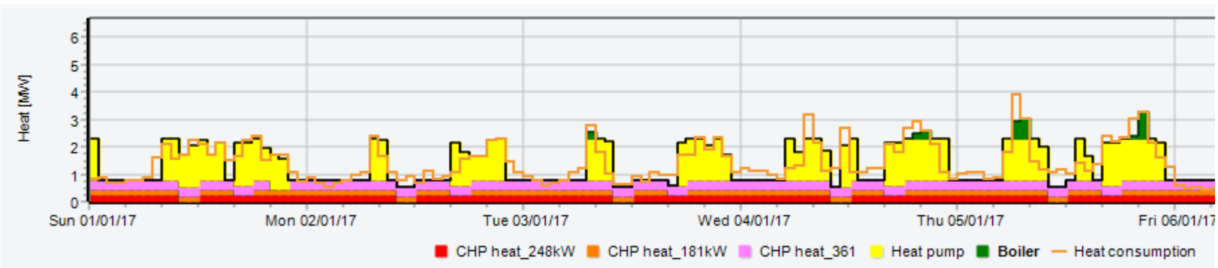


Figure 5-5 Typical winter week with CHP heat

Crematorium heat supply modelling

As with the CHP heat, the crematorium waste heat has been modelled as flat 350kW profile (see Section 4.3.2). It is assumed this heat is only available from 9am to 5:30pm Monday to Friday. At these times the crematorium heat is prioritised over the other heat sources

The resulting profile of a typical winter week is shown in Figure 5-6.

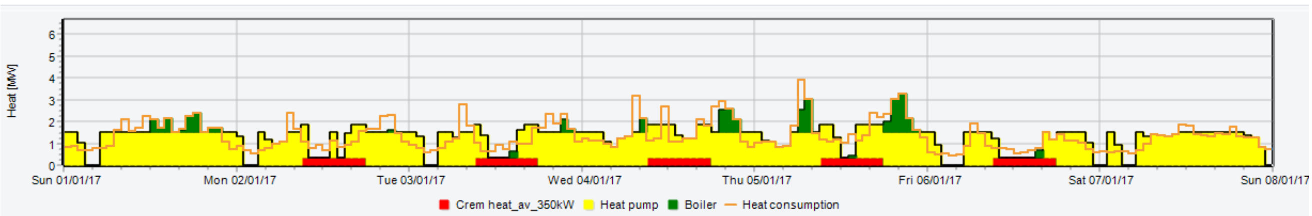


Figure 5-6 Typical winter week with Crematorium heat

Thermal store modelling

A thermal store, comprised of a large hot water tank, is used in order to maximise the operational hours of the heat pump unit to maximise carbon emission savings. Functions include:

- Smooths the daily variation in heat demand to reduce the use of peak boilers
- Enables plant to operate at full output for fewer hours rather than part load, which can be less efficient
- Reduces the number of starts of the low carbon plant.

The thermal store has been set up to allow charge from all heat supply except the gas boilers. Assumes a 90% utilisation factor and 20% minimum storage content.

Assessment of the thermal store capacity's impact on total heat load met by the heat pump with CRE heat load is shown in Figure 5-7. After approximately 50m^3 the percentage met by the heat pump is almost constant. A constant thermal store size of 100m3 has been incorporated to allow for the inclusion of CHP heat and will reduce load cycling on the heat pump in early phases and the summer months when load is low.

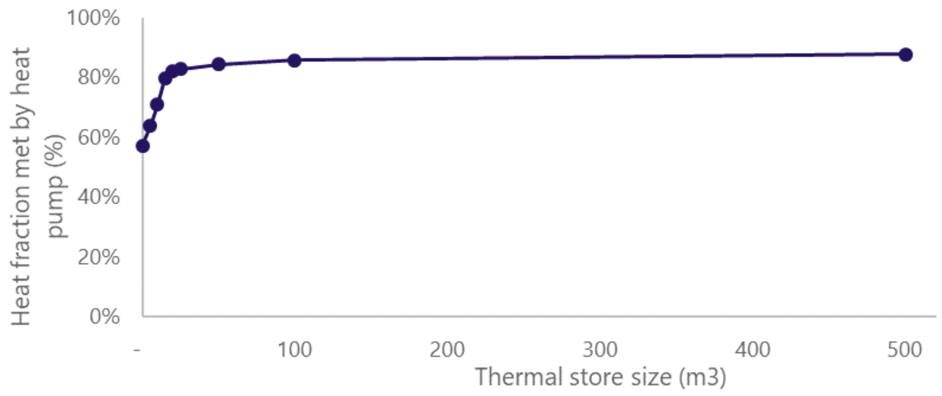


Figure 5-7 Thermal store sizing

5.1.3 Results

Table 5—2 details the results from the EnergyPro modelling for all five scenarios tested. The maximum percentage of annual heat demand met by the 1.5MW heat pump is 86%. Peaking gas boilers can provide the remaining 14% (Scenario 1).

The combined waste heat from the three biogas CHP engines at Hogsmill have the potential to provide over 60% of CRE's annual heat demand (Scenario 2). In this option the heat pump would provide the remaining 33% of heat load, with gas boilers operating during the top 5% of peak. As more heat load is added to the network (Scenarios 3 and 4), the percentage of heat delivered by the CHP reduces to around 50%, with the heat pump increasing its use to ~45%.

The modelling suggests the crematorium (Scenario 5) can provide approximately 8% of CRE's annual energy demand. Although this is a small amount, the heat is free and currently wasted. Techno-economic modelling will assess the financial viability of incorporating this heat source into the network.

Table 5—2 EnergyPro modelling results

Scenario	Annual heat load incl. losses (MWhth)	Peak heat load (kWth)	Annual heat demand met by… (% annual heat demand)			
			Heat pump	CHP	Crematorium	Gas boilers
1 – Effluent & CRE	9,050	6.4	86%	-	-	14%
2 – Effluent, CHP & CRE	9,050	6.4	33%	62%	-	5%
3 – Effluent, CHP, CRE & Cambridge Gardens	11,420	7.0	44%	51%	-	5%
4 – Effluent, CHP, CRE, Cambridge Gardens & Hampden Road	11,700	7.2	45%	50%	-	5%
5 – Effluent, CHP, Crematorium & CRE	9,050	6.4	30%	57%	8%	5%

5.2 Energy centre location

After discussions with Thames Water it is proposed that the EC is located on the large area of disused land near to the existing outfall and culvert (Figure 5-8). The western edge of the Hogsmill WWTP site borders an RBK Recycling Centre which is under ownership of RBK Environmental Services.

This location could provide access for external parties other than Thames Water, depending on who goes on to operate the scheme therefore avoid disruption to the Hogsmill WWTP operations and site entrances when the EC is being serviced. In this case it is recommended that a secure perimeter is built around the EC compound to separate it from existing Hogsmill operations. The other benefit of this location is reduced pumping losses as the heat pump is near the existing outfall where heat can be extracted. Its remote location (not near any housing) means disruption to the local area can be minimised both during construction and operation.

This location is also the opposite side of the WWTP to the CHP engines. Additional pipework must be laid to connect this heat into the EC; as explored in the techno-economic modelling section.

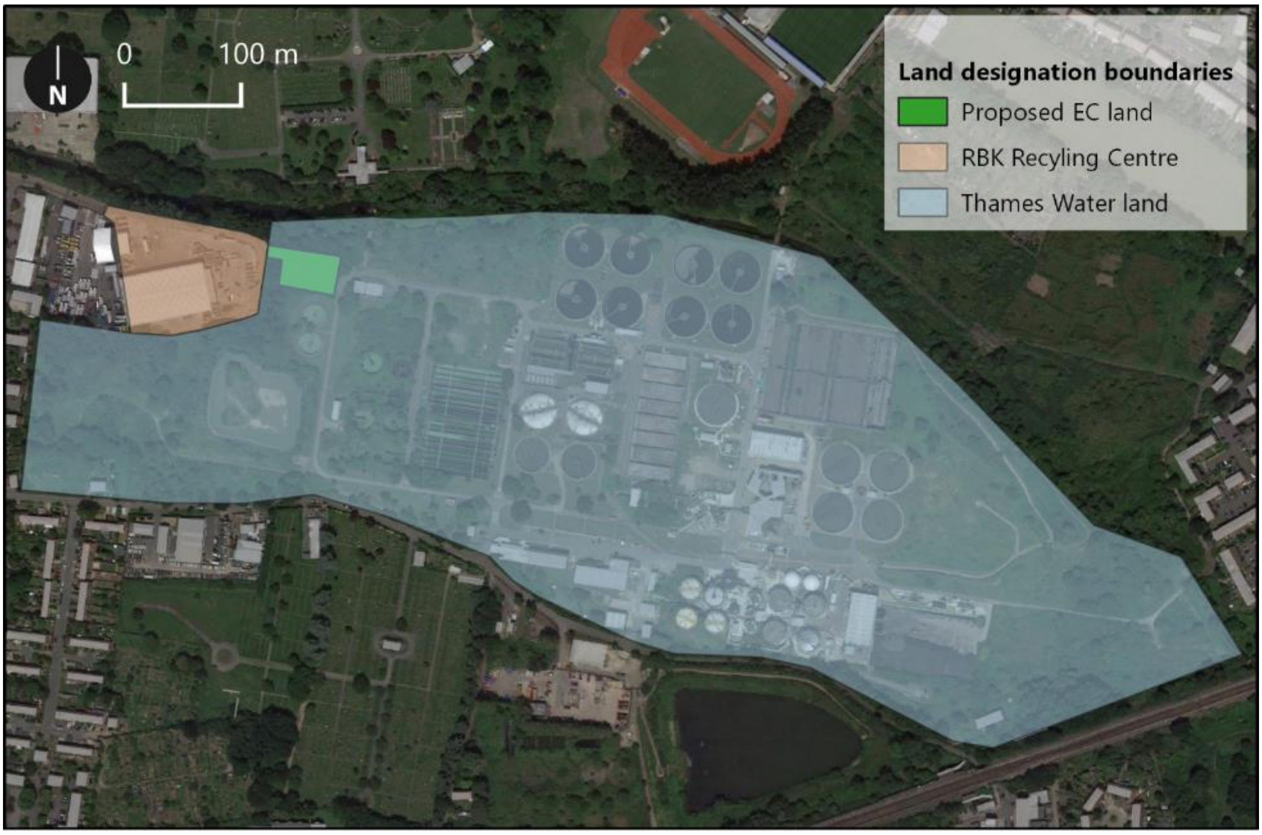


Figure 5-8 Energy Centre location

Earthworks and Flooding

Flood protection is likely to be a key consideration going forward, due to the proximity to the Hogsmill River. Although flooding maps suggest that this area is just outside of a flood zone area it is recommended that a flood protection survey is carried out as levelling of the existing abutment in this location will be required for access.

A site visit to Hogsmill WWTP in 2019 indicated the land proposed for EC development is mainly built up of excavated earth during the WWTP construction. The earth is covered in vegetation and shrubs.

In order to prepare the land for EC construction it is recommended the land is cleared of vegetation, with the excess earth excavated and disposed of. The earthworks can be disposed offsite using a tipper however Thames Water have suggested the earth could potentially be relocated to a disused area of the site.

The removal strategy and associated cost significantly depends on the make-up of the earth. Costs of disposal may increase due to the large amount of vegetation. If the organic carbon content high the cheapest option will be to relocate the earth to elsewhere onsite.

Similarly, if any contaminated land or invasive species are present costs of excavation will greatly increase.

Due to these risks, the following future surveys are recommended:

- Phase 1 desk study to provide details on site history and ground conditions
- Phase 1 ecological survey (required for planning): assessment of existing vegetation including invasive species (Japanese Knotweed, Giant Hogweed etc.) and any protected wildlife (bats, newts etc.)

- Flood risk assessment (required for planning) and air quality assessment
- Ground investigation: assessment of the physical and chemical nature of the ground. May include window samples, trial pits, boreholes and laboratory testing
- Topographical survey: a full 3D survey for setting out, plotting of constraints, establishing levels etc.

5.3 Air quality assessment

The overall air quality in the borough is likely to improve if this network is implemented as it will replace existing gas boilers at Cambridge Road Estate.

5.3.1 Hogsmill EC

The proposed location of the Hogsmill EC is on Thames Water land, far from any residential properties. The EC houses the heat pump with no gas boilers, making the impact on air quality minimal.

It is however important to consider leaking of the working fluid (ammonia) in the heat pump. Ammonia has a Global Warming Potential (GWP) rating of 0. This is significantly less harmful when compared to the common heat pump refrigerant R134a, which has a GWP of 1,430.

However, ammonia can be poisonous in high concentrations and an ammonia leak detection system should be installed. It is recommended by GEA, the heat pump manufacture that this is set at 450ppm for a low level alarm and 4,500ppm for a high level alarm.

At the high level alarm a signal would be sent out to a trip switch which would turn off power to the heat pump. The leak detection system would also be linked to the plantroom ventilation which would vent the plantroom away from personnel areas or to high level. It is recommended a DSEAR and plume dispersion model is carried out to assess the impact of any discharge to atmosphere.

5.3.2 CRE boiler plant

The boiler plant at CRE is being designed by Countryside. It is recommended that all plant comply with emissions standards as detailed in the GLA's Sustainable Design and Construction SPG. According to this document the two pollutants of specific concern in London are particulate matter (PM_{10} and PM_{25}) and nitrogen dioxide (NO_2). Nitric oxide easily converts into NO_2, therefore these are both generally referred to as NOx. NOx can be minimized by adhering to GLA NOX emission limits and use of effective abatement.

In order to ensure effective pollutant dispersion it is also necessary to consider the stack height and location. The energy centre stack should be as tall as possible, ideally at a level above all buildings in the vicinity of the site so as to minimise the building downwash effect (the increased vertical dispersion of plume emitted from stacks due to wind recirculation cavity areas created by buildings). It is also important to consider the proximity to sensitive receptors (particularly residential properties), which may be affected by pollutant emissions.

The use of thermal storage at the Hogsmill Energy Centre aims to maximise use of the heat pump and therefore the boilers are only anticipated to deliver around 15% of the annual heat demand at the CRE development.

5.4 Bill of quantities

The following section details the main plant and Bill of Quantities (BoQ) at Hogsmill and CRE as well as the possible additional network supply and demand connections.

The Energy Centre layout, detailed network schematic and electrical schematic can be found in Appendix F.

Table 5—3 Hogsmill energy centre BoQ

Hogsmill Energy Centre	
Effluent Abstraction	Grundfos submersible pumps (66% duty, assist, standby) SP 60-6 14A00006
	2no. 150m of DN225mm pipework and trenching to EC (uninsulated)
Energy Centre building	250m2 concrete slab. 80m2 office, new substation and storage facilities
Heat generation	1.5MWth GEA high temperature ammonia heat pump (externally housed)
	Taprogge ball heat exchanger cleaning system
Electrical substation	2MVA transformer (N+1 redundancy) 11/0.415kV, Dyn 11, 50Hz. Circuit breakers and batteries
	6.35/110kV 3 core 120mm and trenching 500m, looped cable (future proofed for FBO)
	HV Point of Connection (POC) for new 770kVA at LV (as per UKPN correspondence)
Distribution pumps	Grundfos CR 45-6 A-F-A-V-HQQV - 96122832 (66% duty, assist standby)
Water treatment	ENWA Water Treatment. EnwaMatic BS 300 and 1665 with associated break tank, dedicated circulation pump (Grundfos CRI 5-3)
Thermal stores	2no. Hartwell 50m3 (externally housed)
Other	CCTV, intruder alarm, fire protection, data, ammonia detection, ventilation and ductwork, fibre connection, cold water pipework, sewer, BMS, expansion and pressurisation units, LTHW pipework
Pipe bridge	Pipe bridge over the Hogsmill River (quote from Beaver Bridges)

Table 5—4 Cambridge Road Estate BoQ

Cambridge Road Estate	
CRE Energy Centre	

Boilers	3no. 500kW Hoval condensing boilers (steel heat exchangers). Sized to Cam Gardens and Hampden Rd peak with N+1 redundancy. Remaining CRE capacity provided by Countryside. Incl. heat meter and control valve
Gas upgrade	To allow for additional grid capacity to serve Cambridge Gardens and Hampden Rd
Other	All other plant provided by Countryside. Provision has been made for the distribution pumps (Grundfos NB 65-315/320 ASF2ABQQE (66% duty, 2x assist, standby)) to be included in the Opex and Repex payments of the network once connection is made. No thermal substation at CRE energy centre as assumed the boilers are rated to network pressure
CRE secondary network - for Opex and Repex only	
Block level Plate Heat Exchangers (PHE)	Armstrong PHE skid at each phasing block connection on CRE (assumed 13 in total) - sized to peak load 66% duty/assist.
Block level distribution pumps	Grundfos 66% duty/assist (13 in total)
Water treatment	EnwaMatic 1672
Heat Interface Units (HIUs)	Evinox ModuSAT XR Twin Plate 100A-10A (2,170 units)

Table 5—5 Optional connections BoQ

Optional connections	
CHP heat offtake	Armstrong PHE skid 1,547kW sized to 66% duty, assist (peak of all three biogas CHPs combined)
	Pumps: 66% duty, assist, jockey 10% pumps, Grundfos. 2no. Isolating valves, Logstor
	Logstor Series 2 795m DN125mm (hard dig) pipework and trenching from CHPs to EC
Crematorium heat offtake	Armstrong PHE skid 438kW sized to 66% duty, assist
	Pumps: 66% duty, assist, jockey 10% pumps, Grundfos. 2no. Isolating valves, Logstor
	Logstor Series 2 110m DN80mm (hard dig) pipework and trenching from Crematorium to EC
Cambridge Gardens	HIUs: Evinox ModuSAT XR Twin Plate 100A-10A (164 units)
	Secondary system retrofit from gas heating to DHN connection (see below)
	EnwaMatic 1260 water treatment and dosing
Hampden Road	Armstrong PHE skid 424kW sized to 66% duty/assist

6 Network route

3DTD, an external consultant specialising in district heat network routing, have performed a route assessment. Three options have been appraised from Hogsmill WWTP to CRE:

1. Over the Hogsmill River and through Kingston Crematorium
2. Along Chapel Mill Road, crossing the Hogsmill River at the existing road bridge. Reaching CRE along Villers Road
3. Through Hogsmill WWTP, crossing at the onsite bridge. Reaching CRE through Kingstonian Football Club Grounds

The preferred route is Option 1 and this has been taken forward for network design. The full route appraisal report and HAZIDs list can be found in Appendix E.

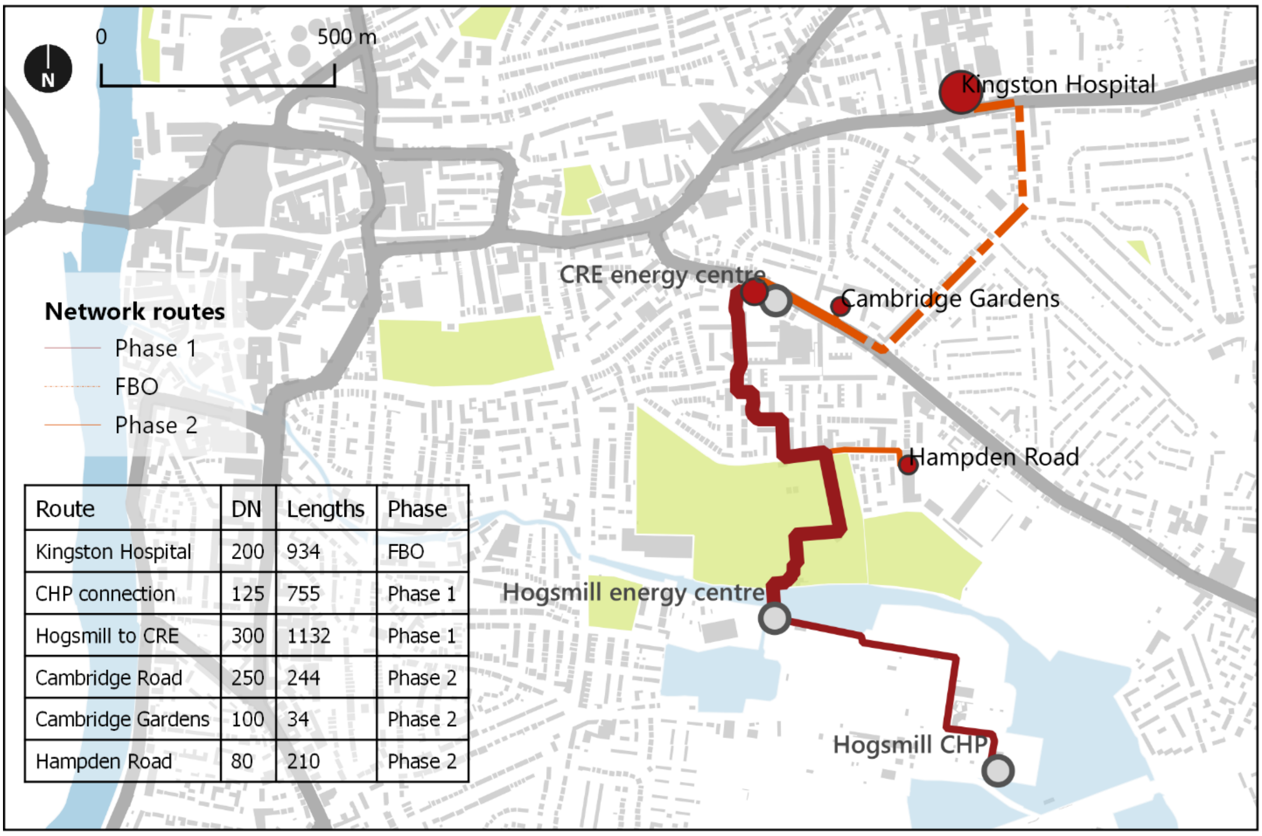
6.1 Network sizing

The network has been sized to allow for future expansion of the network to accommodation Kingston Hospital, Cambridge Gardens and Hampden Road. This provides a future proofed capacity of 14.5MW. A certain amount of oversizing is required to avoid having to replace pipework when the interconnection happens. Key inputs are shown in Table 6—1.

Table 6—1 Hydraulic modelling inputs

Input	Unit	Value
Delta T	^{o}C	30
Max allowable flow velocity	m/s	3
Water density	kg/m^3	1000
Max allowable pressure gradient	Pa/m	100
Kinematic viscosity	m^2/s	0.4091×10^{-6}
Specific heat capacity of water	kJ/kgK	4.181
Pipe roughness factor	mm	0.05

Total network length at FBO (i.e. including Kingston Hospital) is estimated at 2,545m. The Phase 1 network to CRE is approximately 857m. There is an assumed 550m of soft-dig trenching through Kingston Crematorium. Network sizing results are shown in Figure 6-1 and Figure 6-2.



Route	DN	Lengths	Phase
Kingston Hospital	200	934	FBO
CHP connection	125	755	Phase 1
Hogsmill to CRE	300	1132	Phase 1
Cambridge Road	250	244	Phase 2
Cambridge Gardens	100	34	Phase 2
Hampden Road	80	210	Phase 2

Figure 6-1 Network sizing

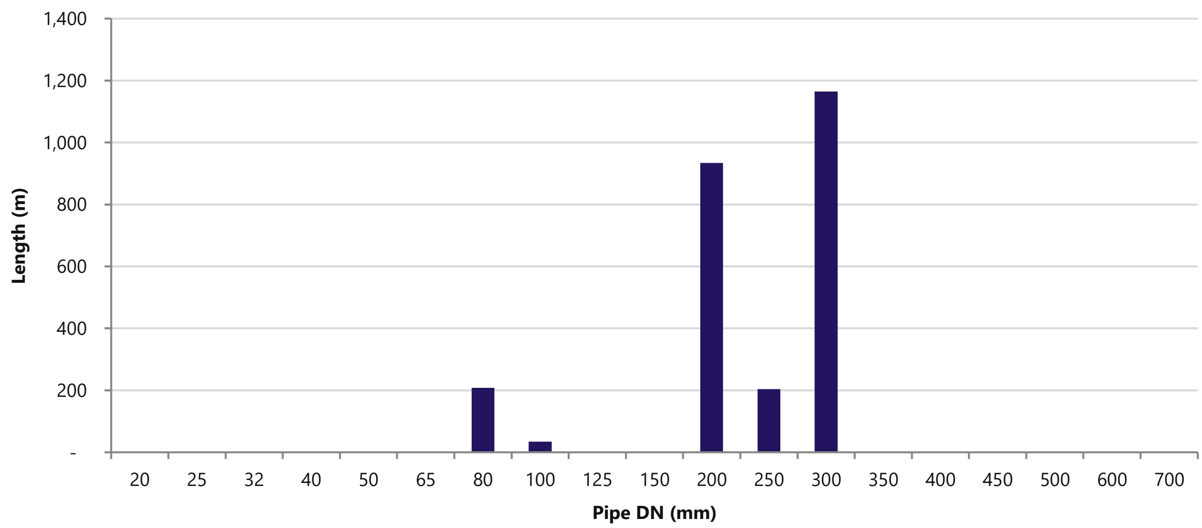


Figure 6-2 Network length by DN size (FBO)

7 Carbon assessment

The carbon emissions of the network have been calculated based on BEIS projections. The results are compared to the 'counterfactual' of not connecting CRE to the network. In this case this is assumed to be ASHPs with peaking gas boilers, housed at the CRE EC.

The heat fraction split for each scenario is as reported in Table 5—2 and assumes an average water-source heat pump COP of 3.8 (based on data provided by GEA) and gas boiler efficiency of 89%.

The biogas used in the CHP is being produced through onsite anaerobic digestion (AD). The Standard Assessment Procedure version 10.1[11] (SAP10.1) states a carbon factor of 0.011tCO2e/kWh for heat from biogas CHP (landfill or sewage). It is thought that the small associated carbon emissions reported in SAP10.1 derive from the biogas fuel stock transportation to the AD plant. Therefore, as the fuel stock for the Hogsmill biogas AD plant is produced onsite the associated carbon emissions are considered negligible and the carbon factor of the CHP heat has been modelled as zero.

Carbon emission factors for natural gas and electricity are based on the BEIS 2019 carbon factors of fuel[12]. The electricity grid carbon factor varies over time as predicted by BEIS.

7.1 Network carbon emissions

7.1.1 CRE counterfactual heat supply

Countryside have confirmed their counterfactual heat source if connection to the network is not secured will be ASHP led. While the exact annual heat fraction the ASHP will supply is not known, Countryside have indicated it will be between 50% and 75%.

The modelling presented below summarises the impact this has on the carbon emissions savings CRE can achieve by connecting the scheme. For this a 60% heat fraction ASHP counterfactual is assumed, with gas boilers providing the remaining annual demand.

7.1.2 Results

Table 7—1 Carbon results summary

Scenario	Unit	CRE (heat pump only)	CRE with CHP heat	CRE + Cam Gardens + Hampden Rd with CHP heat	CRE + Cam Gardens with CHP heat	CRE + CHP + Crematorium (heat pump only)
DH emissions saving @ year 15	%	52%	81%	79%	80%	81%

[11] https://www.bregroup.com/wp-content/uploads/2019/10/SAP-10.1-10-10-2019.pdf
[12] https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2018

DH emissions saving @ year 30	%	55%	83%	81%	82%	83%
DH emissions saving (15yr total)	*tCO2e*	4,586	7,493	9,988	9,727	7,544
DH emissions saving (30yr total)	*tCO2e*	10,592	16,627	21,621	21,096	16,712
Energy centre emissions (30yr total)	*tCO2e*	10,071	4,036	5,877	5,681	3,951

The key results are shown in Table 7—1. The heat pump only CRE network achieves an emissions saving of 10,590tCO2e over the projects 30 year lifetime. This represents a 55% saving at CRE compared to the alternative of ASHPs. This increases to an 83% saving if the waste heat from the biogas CHPs can be utilised on the network.

As the additional heat loads of Cambridge Gardens and Hampden Road are connected, the emissions savings continue to increase to a maximum of 21,620tCO2e over the 30-year lifetime.

Figure 7-1 shows the variation in carbon savings over the project lifetime. It clearly illustrates the CRE five stage phasing strategy. Once all heat loads are connected (in 2032) the annual carbon savings remain relatively constant, varying slightly with the BEIS electricity grid carbon intensity predictions.

The connection of Kingston Hospital in the future would see more significant savings as the counterfactual is currently CHP and gas boilers.

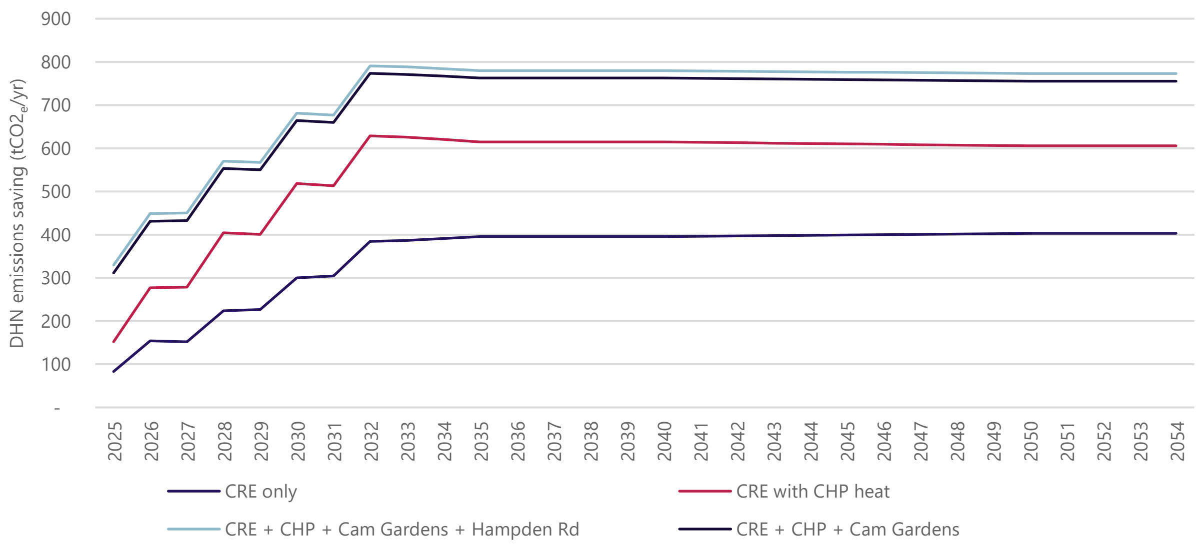


Figure 7-1 Carbon emissions saving across network lifetime

7.2 Carbon boundaries

The carbon savings detailed above can be attributed to the connected buildings. As the heat extraction at Hogsmill does not change the water treatment process, it is felt that this saving cannot directly be claimed by Thames Water (see Figure 7-2).

By enabling the network, Thames Water are providing low carbon heat to the surrounding community in exchange for revenue from the heat used on site. This revenue can then be used to fund carbon offsetting schemes either onsite or offsite to contribute to Thames Water's net zero by 2030 carbon target.

Discussions should be held between Ofwat and Ofgem to establish whether, once Cambridge Road Estate has planning based on a carbon factor for the heat network, then the carbon savings could be credited to the Thames Water site.

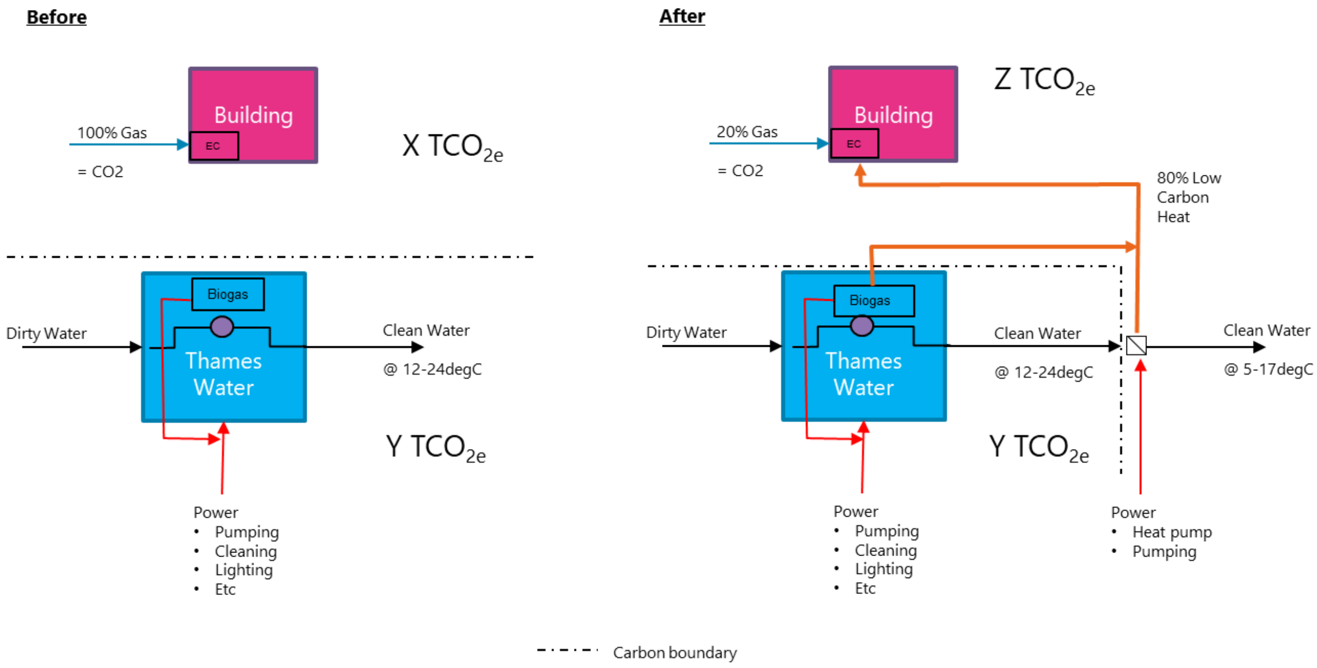


Figure 7-2 Thames Water carbon boundary

8 Techno-economic modelling

A techno-economic cashflow model (TEM) has been built to assess the possible return on investment the network can achieve over a 30-year time period. The model allows for key sensitivities to be tested, such as heat price, heat load, fuel prices and capital costs.

Multiple scenarios have been assessed including connections to Cambridge Gardens and Hampden Road, utilising the alternative heat sources of the Crematorium and Hogsmill CHPs and possible funding streams.

8.1 Methodology

A techno-economic cash flow model (TEM) was built in MS Excel combining the technical details of the scheme (capital and operational) with appropriate cost/price inputs to generate an annual cash flow. This enabled an assessment of viability (pre-tax) using Net Present Value (NPV) and Internal Rate of Return (IRR) as key indicators.

Key assumptions are detail in Appendix C and include:

- At Cambridge Road Estate it is assumed that Countryside pay for own energy centre, boiler capacity, network and HIU Capex and installation (as they would for own on-site solution). Provision is made within the energy centre for the DHN operator to install additional boiler capacity. The DHN operator will adopt the CRE plant and be responsible for OPEX and REPEX costs. Residents pay non-bulk rate for heat price
- Cambridge Gardens: building heat supply retrofit paid for by DHN project, including HIUs etc. Heat is supplied to each residential unit (i.e. non-bulk) with new peaking boiler capacity housed at the CRE plant room
- Hampden Road: a PHE interface is installed in the existing central plant room. Heat is sold at a bulk rate to whole development
- Crematorium heat is supplied to the network free of charge through a PHE skid and pump set integrated into the Crematorium by the DHN operator
- The price paid to Thames Water for the effluent and CHP waste heat is used as a key sensitivity in the model
- 5.4% parasitic electrical pumping power as a percentage of network heat load. 2% of which is attributed to distribution pumping (as per CP1). The remaining 3.4% is attributed to effluent abstraction pumps (as calculated by BuroHappold)
- 10% network losses (as per CP1)
- First heat load connected in 2024. CRE is assumed built out in five phases as per phasing plan provided. All other loads connected in year one.

The modelling boundary and key costing inputs are summarised in Figure 8-1.

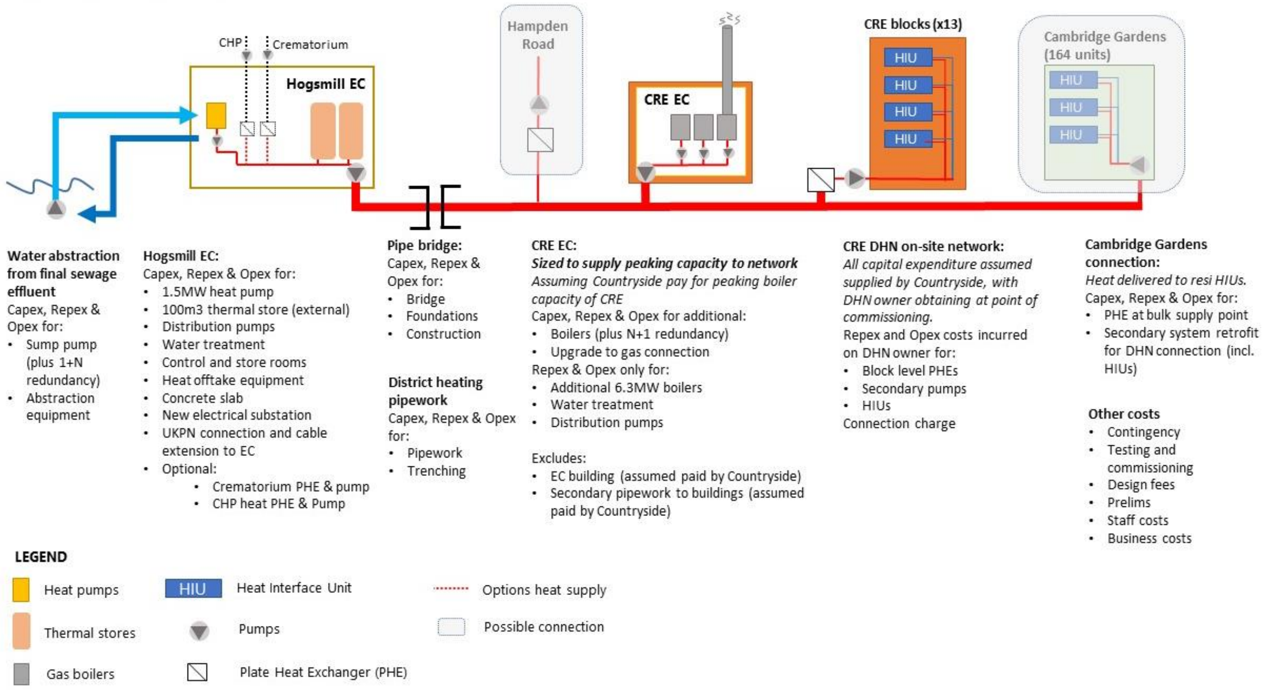


Figure 8-1 Modelling boundary and costing summary

8.2 Inputs

8.2.1 Capital costs

Industry quotes have been obtained for key plant including heat pump units, boiler, thermal stores, package substations at buildings and network pumps. Network costs have been determined using linear metre costs based on inner London pricing, as described in Appendix C.

The effluent abstraction has been costed for as described in Section 4.2.3. Additional costs have been included for expected earthworks (see Section 0.0.1662080896.34) on the assumption that no contaminated land or invasive species are found.

15% contingency has been applied to all cost estimates, with an additional 5% for installation and delivery and 16% for prelims, design fees, testing and commissioning applied where not included in manufacturer quotes. The costs are subject change and future site investigation is recommended. A full cost breakdown can be found in Appendix C.

CRE connection charge

A connection charge of £552,680 is applied to CRE to take into account the avoided cost of installing the counterfactual ASHPs. This has been estimated based on an assumed sizing to meet 60% heat fraction, using a quote for a 890kW ASHP from Solid Energy, a supplier of heat pumps.

A summary of capital costs is shown in Table 8—1.

Table 8—1 Capital cost summary

	Network	Energy centre and ancillary equipment	Total Capex	Total Capex after connection charge
Details	*All pipework and trenching infrastructure connecting heat supply to heat loads*	*All EC plant, abstraction equipment, PHE skids, pumps, UKPN and SGN upgrades, ancillary equipment etc.*	*Excludes CRE replacement costs*	*Connection charge £552,680 from CRE*
CRE	1,995,500	3,175,900	**5,171,400**	4,618,700
CRE and CHP	2,988,300	3,249,500	**6,237,800**	5,685,100
CRE, CHP and Cambridge Gardens	3,373,600	4,268,500	**7,642,100**	7,089,400
CRE, CHP, Cambridge Gardens and Hampden Road	3,567,600	4,317,100	**7,884,800**	7,332,100
CRE, CHP and Crematorium	3,093,900	3,310,100	**6,404,000**	5,851,400

8.2.2 Operational costs

Table 8—2 presents the commercial assumptions made regarding the operation of the scheme. Gas, heat and electricity prices have been indexed over the project lifetime using BEIS projections. Opex costs have been included in the model based on a number of manufacturer quotes and other references.

For the purposes of this study, a discount rate of 3.5% has been applied to pre-debt cash flows. All other assumptions are detailed in Appendix C.

Table 8—2 Opex assumptions

	FBO	Unit	Reference and notes
Heat pumps and Taprogge ball cleaning	0.42	p/kWh	Heat pump O&M based on information GEA – applied to annual heat load of heat pumps
Top-up gas boilers	0.13	p/kWh	Boilers and PHX costs at CRE based on manufacture quotes – applied to annual heat load of boilers

Network ancillary equipment (TES, distribution pumps, water treatment, sump pumps)	0.048	p/kWh	Based on manufacture quotes and BuroHappold experience – applied to total annual heat load[13]
Pumps	0.03	p/kWh	Distribution and abstraction (sump) pumps – applied to total annual heat load. Grundfos
HIUs at Cambridge Gardens	0.90	p/kWh	Applied to the annual heat load of only residential connections where applicable[14]
CRE HIUs and PHEs	85,000	£ / yr	Operational cost of all HIUs, water treatment and block level PHEs at CRE
Metering and billing – bulk	1.1	p/kWh	
Metering and billing – non-bulk	65	£ / unit	
Staff costs	16,000	£ / yr	EC manned 2 days per week at £40k FTE
Business costs	0.60	p/kWh	Applied to total annual heat load[15]
Fuel charges			
Gas price at energy centre	2.37	p/kWh	BEIS UK gas and electricity prices in the non-domestic sector 2018[16] - medium consumer (incl. climate change levy)
Electricity price at energy centre	11.5	p/kWh	

8.2.3 Replacement costs

Replacement costs (Repex) are included for all pumps, heat pumps, thermal stores, boilers, PHXs, water treatment, HIUs, heat meters and associated components. As shown in the modelling boundary schematic (Figure 8-1), the TEM assumes that CRE pay for the initial Capex of their peaking boiler plant and HIUs. The DHN operator then takes over the O&M of the scheme up to each residential unit (i.e. including HIUs). This equates to a total capital expenditure of £4,541k to be added to the sinking fund.

An annual sinking fund is built up across the equipment lifetime to account for the Repex costs for 80% of the total energy centre capex in the TEM model.

Pipework replacement is excluded from the model as these typically last longer than the lifetime of the project.

[13] Department of Energy & Climate Change (DECC), 2015. *Assessment of the Costs, Performance, and Characteristics of UK Heat Networks*

[14] Department of Energy & Climate Change (DECC), 2015. *Assessment of the Costs, Performance, and Characteristics of UK Heat Networks*

[15] Sandvall, A. F. et al., 2017. Cost-efficiency of urban heat strategies – Modelling scale effects of low-energy building heat supply. *Energy Strategy Reviews,* Vol. 18, p. 212-223. Available at: https://www.sciencedirect.com/science/article/pii/S2211467X17300615

[16] https://www.gov.uk/government/statistical-data-sets/gas-and-electricity-prices-in-the-non-domestic-sector

8.2.4 Heat pricing

The assumed heat prices for residential bulk and non-bulk connections are shown in Table 8—3, split into standing charge and variable rate. Both rates are based on an average of several Heat Trust registered operational projects and quotes for schemes in London obtained by BuroHappold.

- The standing charge is a flat rate paid to the DHN operator for connection to the network. For heat network pricings, this is usually based on the avoided costs of connecting into the DHN compared to the counterfactual of gas boilers.
- The variable rate is the price paid per unit of heat consumed by each customer – again usually based on the fuel cost to deliver a kWh of heat compared to the counterfactual. E.g. cost of gas per kWh divided by the boiler efficiency.

The heat price at this stage is indicative and subject to change. There is currently no regulatory body for the supply of heat from DHNs however the heat pricing strategy will need to comply with the Heat Network (Metering and Billing) Regulations 2014[17]. All schemes BuroHappold have based the heat price are based on are Heat Trust compliant[18] - in-lieu of official regulation for heat networks the Heat Trust is a not for profit company focussed on customer protection for the district heating sector.

Table 8—3 Heat price – variable and standing charge

	Variable rate (p/kWh)	Standing charge
Non-bulk	5.6	£328/yr per resi flat
Bulk	4.2	£24/kW

8.2.5 Thames Water waste heat pricing

The TEM allows for sensitivity testing around the heat price paid to Thames Water for their two waste heat sources:

- WWTP effluent: low-grade heat
- Biogas CHP: high-grade heat.

As the proposed scheme will be the first to capture waste heat from a Thames Water outfall, the rate charged for this resource greatly depend on the level of funding obtained and negotiations with Thames Water.

8.2.6 Funding

A summary of the available funding sources and potential Council funding sources is listed below:

- **Zero Carbon Homes and S106 /CIL –** Zero Carbon Homes (ZCH) is now being enforced in Kingston. Contributions are set at £1,800 per tonne of carbon
- **Connection charges –** It is assumed that developers of new buildings connecting to the scheme will pay a connection charge. This is to be treated as an offset against the capital costs of the scheme.

[17] http://www.legislation.gov.uk/uksi/2014/3120/pdfs/uksi_20143120_en.pdf

[18] Heat Trust, 2018. *Heat Cost Calculator: Further information and background assumptions*. Available at: <http://www.heattrust.org/images/docs/HCC_Further_information_and_assumptions_Jan2019_update__v1.pdf>

- **Heat Network Investment Project (HNIP) –** HNIP funds are specifically offered as 'gap funding' through a combination of grants and loans and will be offered to eligible projects up till March 2022. This can be used for capital costs of energy centre, network and connections and will also cover some commercialization funding
- **Renewable Heat Incentive (RHI)** – Eligible installations receive quarterly payments over 20 years, with payments are made on a £/kWh of renewable heat generated basis. Available until March 2021.
- **The Mayor's Energy Efficiency Fund (MEEF)** – The fund will invest in capital funding of energy conversion measures and renewables, fabric improvements to buildings and innovation. The current interest rate is 1.2%, with the fund open to receive applications until March 2023.

8.3 Results

Results are presented for the CRE only 'core network' both with and without utilisation of the waste CHP heat at Hogsmill (Section 8.3.1). The performance of the network if 40% capital grant funding is secured through the Government's HNIP is also presented here.

In Section 8.3.2 sensitivity testing has been carried out to assess the key modelling risks to the scheme. The key sensitivity is the annual payment to Thames Water, which is discussed in this section.

Scenario testing on the additional heat loads, crematorium heat and RHI is shown in Section 8.3.3.

Disclaimer: Prospective information for revenue, capital expenditure and operating costs have been derived from information provided by different sources. BuroHappold does not accept responsibility for such information. BuroHappold emphasises that the realisation of the prospective financial information is dependent upon the continued validity of the assumptions on which it is based. BuroHappold accepts no responsibility for the realisation of the prospective financial information; actual results are likely to be different from those shown in the prospective financial information because events and circumstances frequently do not occur as expected, and the difference may be material.

8.3.1 Core network

Table 8—4 shows the core network's performance if supplied by:

1. Heat pump and gas boilers at CRE
2. Heat pump, CHPs and gas boilers at CRE

The results are shown for an unfunded network and a 40% grant funded scheme. These are the results if no payment is made to Thames Water for the waste heat sources.

- Table 8—4 shows that without any grant funding the network returns a positive IRR (1.9%) with heat pump and gas boiler only. With 40% capital funding this increases to a 5.6% IRR; within the internal RBK hurdle rate of 4-6.5%
- If CHP heat can be secured to supply around 60% of the heat network annual demand the scheme with no funding could see IRRs of 4.8%, increasing to 9.2% with capital funding.

- Figure 8-2 and Figure 8-3 shows the 30-year unfunded cashflow for both these options. It is clear that securing the CHP heat would not only greatly improve the network's carbon savings (see Section 7) but also improve its economic viability.

Table 8—4 Core scheme performance (over 30 years)

Scenario	**Unfunded**			**Funded – 40% Capex funding HNIP / other**		
Core network	NPV @3.5% £m	IRR %	Funding £m	NPV @3.5% £m	IRR %	Funding £m
Heat pump and gas boilers	[- 1.08]	1.9%	-	0.99	5.6%	2.07
Heat pump, CHP and gas boilers	1.24	4.8%	-	3.74	9.2%	2.50

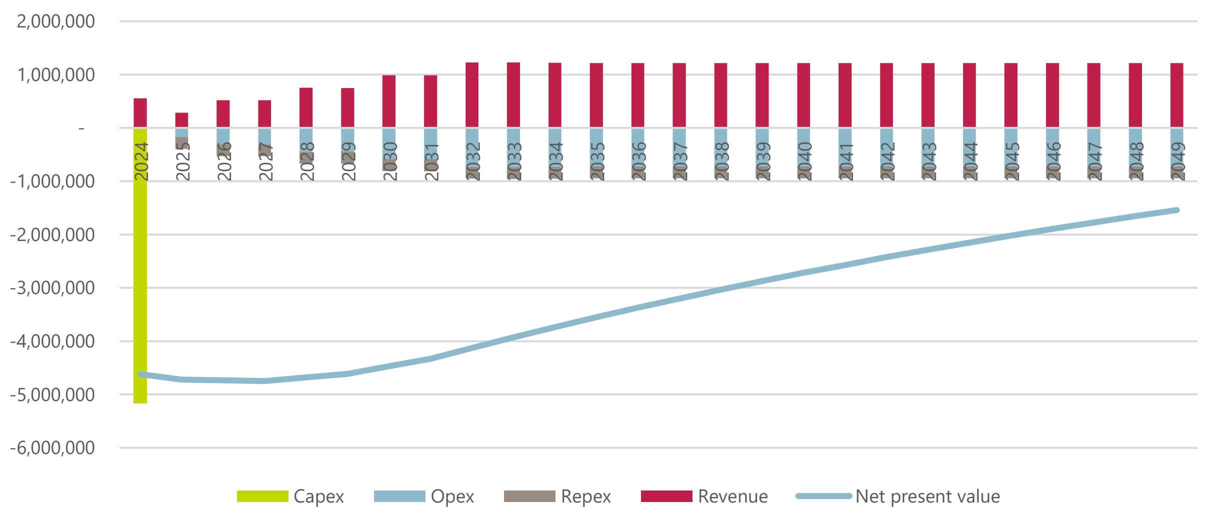


Figure 8-2 Core scheme 30-year cash flow – heat pump and gas boilers only

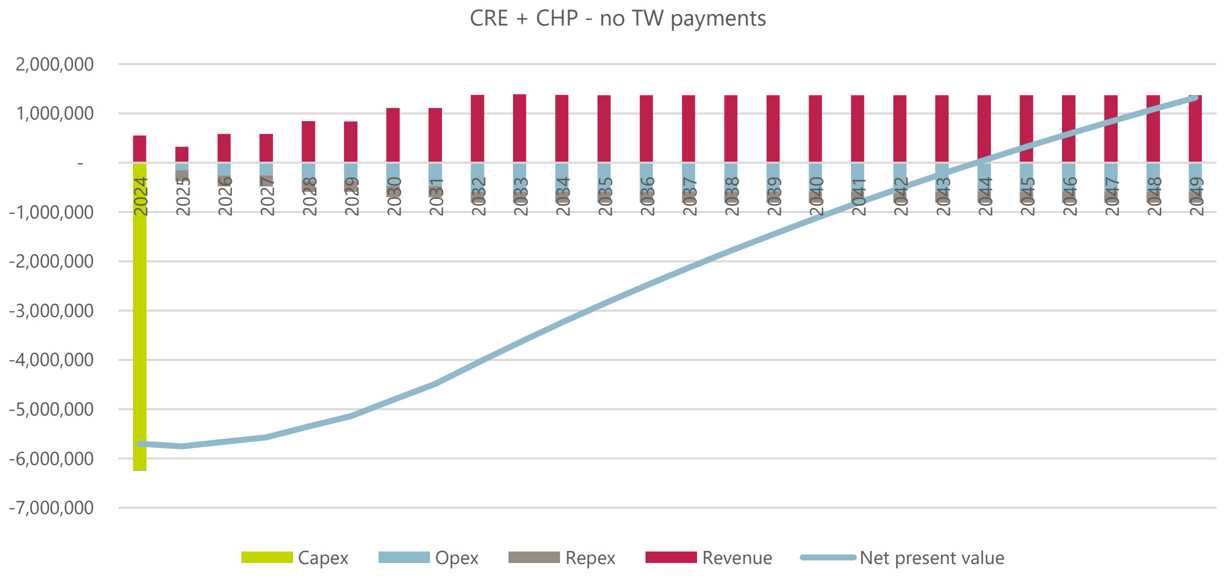


Figure 8-3 Core scheme 30-year cashflow – heat pump, CHP and gas boilers

8.3.2 Sensitivity testing

Tornado graphs

The sensitivity of the model to key inputs has been tested by changing each input in turn and assessing the impact on NPV. Figure 8-4 and Figure 8-4 show the impact of a ±10%, 20% and 30% change in the key variables noted on the vertical axis.

The purpose of undertaking this analysis is to establish which variables are key to project performance and therefore which need particular management focus in order to reduce and mitigate risk.

The standing charge is the most sensitivity variable tested for both the core network with and without CHP. This is followed by the variable heat sales price. As stated in DM2 of the Kingston Core Strategy[19], the CRE falls in one of the most deprived areas in the borough and it is anticipated that a significant proportion of the residential heat load connected may currently be in fuel poverty. This result highlights the importance of setting a heat price that will create a suitable return on investment as well as ensure affordable heat is delivered to those that need it.

Figure 8-4 indicates a variation it annual heat load has minimal impact on the networks NPV. This is due to the proportional increase in revenue through variable heat sales and Opex costs increasing by p/kWh. This effect is reduced in the CHP option (Figure 8-4) because the majority of the heat is considered 'free' (see following section); reducing the fuel import cost.

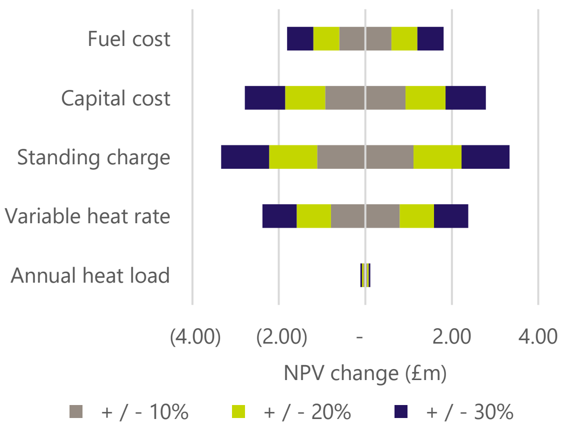


Figure 8-4 Tornado – heat pump and boilers only

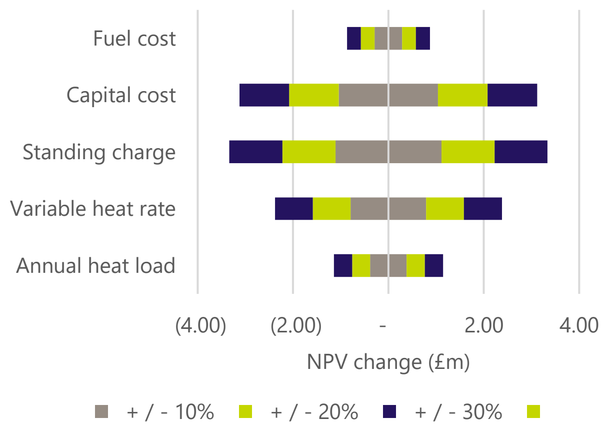


Figure 8-5 Tornado – heat pump, CHP and boilers

Thames Water waste heat pricing

The results presented above have assumed no payments to Thames Water. Discussions with Thames Water suggest that they will expect something in return for enabling the network. Figure 8-6 and Figure 8-7 show how the networks IRR will vary with annual payment to Thames Water for the use of both the low-grade effluent waste heat and high-grade CHP waste heat.

[19] https://www.kingston.gov.uk/downloads/file/1901/core_strategy

A price per p/kWh of heat used has been applied in the model and sensitivity applied to assess the network's resilience to such additional costs. This is then represented as the annual payment made to Thames Water (at year 15 – once the CRE development is fully built out). This means that if the network extends beyond CRE (e.g. to Kingston Hospital and Cambridge Gardens) revenue to Thames Water will increase.

From Figure 8-6 it is clear that without HNIP funding, the network cannot reach RBK hurdle rates even if no payment is made to Thames Water.

Figure 8-7 indicates that with 40% capital funding, the IRRs achieved reach RBK hurdle rates. If CHP heat at Thames Water can be utilised, then Thames Water could receive over £80k per year for supplying heat to the network.

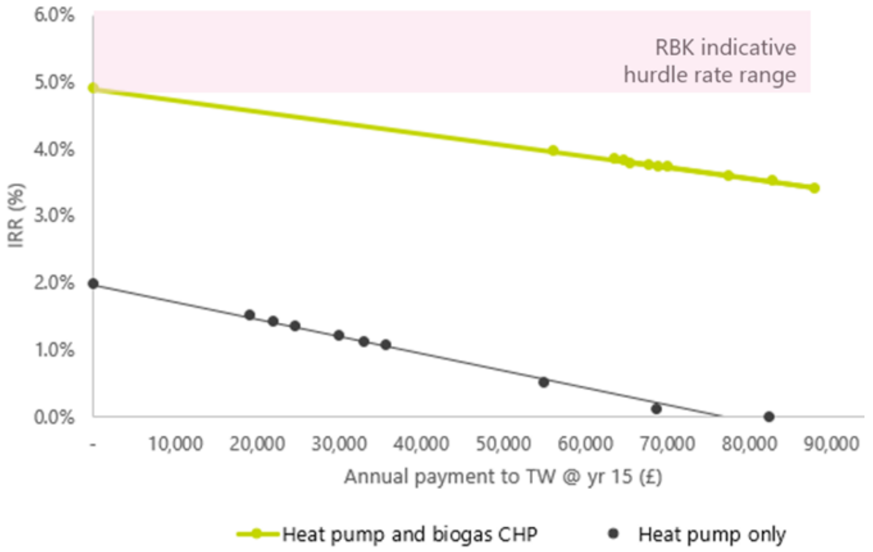


Figure 8-6 Thames Water pricing sensitivity – no HNIP funding

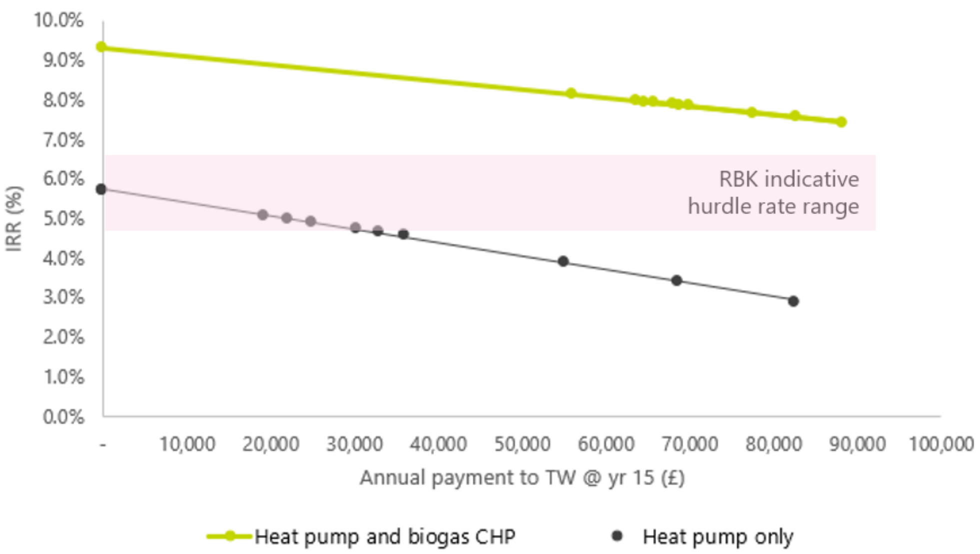


Figure 8-7 Thames Water pricing sensitivity – 40% capital grant HNIP funding

8.3.3 Scenario testing

As the network's economic performance improves significantly with CHP heat, the following sensitivities are for the core scheme with CHP heat and no payment to Thames Water.

Table 8—5 shows that with RHI funding the IRR increases to 5.8%, within RBK's hurdle rate. As applications to the RHI scheme are closing in March 2021 and it is currently unknown if or what will replace it. It is therefore only included as a sensitivity in the model. If both RHI and 40% HNIP funding is secured, then IRR reaches 10.5%.

If Cambridge Gardens can be connected the core scheme's IRR decreases from 4.8% to 4.2%. It is likely this is due to the high cost of retrofitting the existing individual gas boiler heating supply in each flat. The addition of Hampden Road will improve this IRR by another 0.2%. This highlights the importance of future network phasing and ensuring suitable low capital cost connections. There may be separate funds available to contribute towards the retrofit of Cambridge Gardens (e.g. RBK replacement funds for gas boilers in the individual dwellings) – these could help improve performance.

This also appears to be the case for the crematorium heat, which sees a slight drop in IRR to 4.7%. The additional network cost to transport the heat from Kingston Crematorium to the EC is too large to warrant the small increase in waste heat. However, if the network is routed through Kingston Crematorium (as in Section 6), then networks costs can reduce and capturing this heat becomes more viable.

Table 8—5 Scenario testing results

Scenario	**Unfunded and no TW payment**	
Includes CHP heat	NPV @3.5% £m	IRR %
Core network (for comparison)	1.24	4.8%
Core network with Cambridge Gardens	0.74	4.2%
Core network with Cambridge Gardens and Hampden Road	1.01	4.4%
Core network with Crematorium heat	1.19	4.7%
Core network with RHI	2.15	5.8%

9 Next steps

The section details the key next steps, risks and proposed timeline for project delivery.

9.1 Next steps

The study suggests that the scheme is able to achieve a positive IRR and meet RBK hurdle rates with grant funding. It is therefore recommended that the study is taken forward further to Detailed Project Development (DPD) stage.

Key next steps are therefore:

- Develop scheme through DPD
- Produce the Outline Business Case (OBC)
- Proceed with funding applications and procurement
- Further investigate the Kingston Hospital network extension

This will further develop the technical scheme but also develop the commercial case and develop a full financial model, plus obtain early legal involvement to ensure regulatory / policy / State Aid compliance of proposals.

Surveys recommended

- Desktop C2 utility record survey and identify locations for GPR surveys
- Ground investigation surveys at Thames Water site

Key Stakeholder engagement

- Thames Water
    - Continue development of offtake option and energy centre location
    - Agree commercial structure with Thames Water
- Kingston Hospital
    - Obtain technical data to inform the development of a scheme serving the Hospital and future demand forecasting
- CRE
    - Engagement with Hodkinson/Countryside for EC peak output and pipework configuration for DH adoption.
    - Performance specification for Energy centre requirements e.g. peak outputs, utility connection and pipework arrangements
- Recycling Centre
    - to review possible energy centre access from existing access road

- Cemetery / Crematorium
  - Review bridge and pipework routing options with cemetery operators and crematorium
- Environment Agency / South East Rivers Trust
  - Gain necessary approvals for the scheme
  - Look for coordination opportunities with renaturalisation of river
- Retain engagement with key connections outside of Phase 1 to ensure that investment decisions are not made in energy infrastructure that may impact ability to connect to the strategic heat network
- Engagement with RBK members including Highways, Housing and Planning.

9.2 Key risks

- CRE residential ballot: residents rejecting the CRE ballot. Mitigation for this can be made through securing the Kingston Hospital connection and retrofitting the existing CRE estate blocks to facilitate DHN connection
- No contaminated land or invasive species at Hogsmill: if these are found at Hogsmill, the land clearing costs for the Hogsmill EC will significantly increase. It is recommended a Phase 1 Habitat Survey is conducted to mitigate against this risk
- Flood protection at Hogsmill: a flood risk survey is recommended to ensure the proposed EC location is not at risk of flooding
- UKPN capacity is not secured: there is a risk of load being taken up by a different a user, increasing cost of supply. The mitigation for this is to pay to secure grid capacity once confident the project is going ahead
- Cambridge Gardens heat load: no data has been provided for heat load over the year and this has been estimated based on a review of EPCs. It is recommended half-hourly metered data is sought to verify heat load.

See Appendix B for full risk register.

Appendix A Stakeholder engagement

This section details the information gleaned from engagement BuroHappold have conducted with the key stakeholders of the project. This section aims to update the reader on progress since the PFS and highlight any key changes.

A.1 Countryside and Hodkinson

BuroHappold have continued engagement with Countryside Ltd., the 50:50 joint venture partner to the Cambridge Road Estate (CRE) development, and Hodkinson, the energy consultant for the CRE development. They have confirmed intention to connect to the DHN as their main option, if the DHN project is realised.

The residents at CRE are waiting to participate in a residential ballot. The result of this vote will determine if the regeneration plans go ahead or not. If the result of the ballot is 'Yes', the next step will be to submit a planning application to RBK's planning team. This ballot is currently scheduled for early 2020. This unknown presents a key a key risk to the heat network proposal detailed in this report which assumes the CRE regeneration will go ahead.

To mitigate this risk, BuroHappold have reviewed an energy study of the CRE that was carried out by Hodkinson. The study found that the average energy use of the redeveloped dwellings is expected to be 60% less than the existing dwellings on the estate due to improved efficiency measures. From this it is likely that although the existing estate has fewer homes than the planned redevelopment, the overall annual heat demand of the estate may be similar before and after regeneration. Suggesting that if the full regeneration does not go ahead, CRE could still benefit from the low carbon that can be delivered by this heat network, subject to further site studies and assuming funding for the additional secondary system retrofit costs can be sourced.

Key points to note from information provided by Countryside and Hodkinson are:

- There are no major changes to the phasing plan since the PFS
- Target number of homes for the whole site is 2,170
- Estimated peak heat load at Energy Centre (EC) of 6,810kW
- Estimated end use (i.e. excluding network losses) demand of 7,835MWh/a
- The CRE development are proceeding with the principle to not do anything that reduces the viability of connection to the proposed network. With this in mind, the intent is to install only gas boilers, sized to peak load, until connection to the network is made
    - Once connected, this study assumes that the boilers will be operated and maintained by the network operator to provide back-up and peaking capacity to the network, with the connection point located at the CRE EC to not disrupt the secondary network
- Should the network not go ahead, Countryside will install Air Source Heat Pumps (ASHP), sized to 50-75% of peak demand. This is used as the 'counterfactual' in the carbon assessment (Section 7)
    - Hodkinson suggest that this alternative ASHP option would not itself achieve the 35% CO_2 reduction target required for planning permission

- The CR EC is currently proposed to be located in the basement of one of the residential blocks to the North-West of site

A.2 Thames Water

CONFIDENTIAL DATA UNDER NDA. DO NOT SHARE REPORT PUBLICLY BEFORE EDITING

Figure 9-1 shows the location of key plant on the Hogsmill site. Key points to note from engagement with Thames Water are as follows.

A.2.1 Existing infrastructure

- 2no. 13,050m3 biogas storage
- 3no. biogas CHP engines (2x470kWe & 1x400kWe)
- 2no. biogas boilers
- Large area of disused land to the west of the site that could be used for energy centre. Well located adjacent to the final effluent culvert
- Sludge dewatering only (no drying process)
- UKPN agreed electricity import capacity 2,200kVA
    - 2 MPANs - 1900060421100 and 1900090353153
    - Last 12-month site max demand was 2,227KVA. Monthly max regularly exceeds 1,900KVA
- Electricity export: 100kW nominal export capacity
- Natural gas: no natural gas supply to site (all heat required generated through biogas)

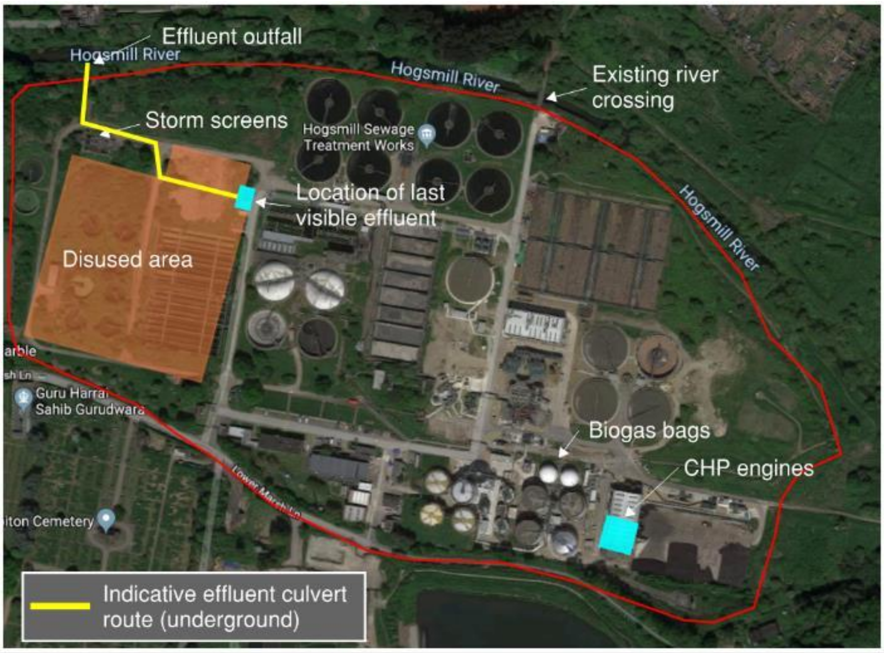


Figure 9-1 Annotated Hogsmill WWTP site map

A.2.2 Final effluent

Hourly temperature and flowrate data at the Hogsmill outfall are shown in Figure 9-2.

There are no minimum temperature restrictions on effluent entering Hogsmill. If effluent drops below 5oC, an 'abnormal weather conditions' report has to be sent to EA as at these temperatures the sewage treatment process is less effective.

Effluent flowrate rarely drops below 200l/s, with an average annual flowrate of 740kg/s. Assuming a 7K dT on a heat pump solution to lift the heat, an average of 25MW of heat is available.

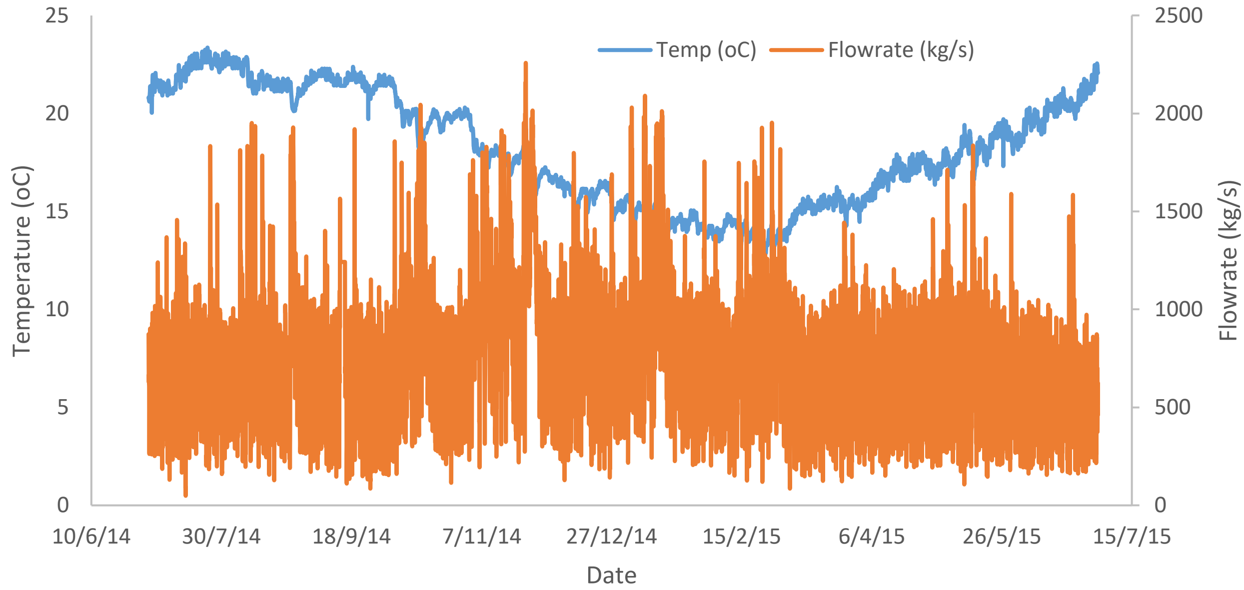


Figure 9-2 Hogsmill Hourly temperature & flowrate profile 2014/15

A.2.3 CHP and biogas

Hogsmill WWTP currently has three biogas Combined Heat and Power (CHP) engines to utilise the biogas produced in the onsite Anaerobic Digestion (AD) plant. Around half of the heat produced is used onsite for the sewage treatment process. Most of the electricity produced is also used on site, with a small amount (100kW max) exported to the grid. The electricity export is restricted here due to grid constraints in the area.

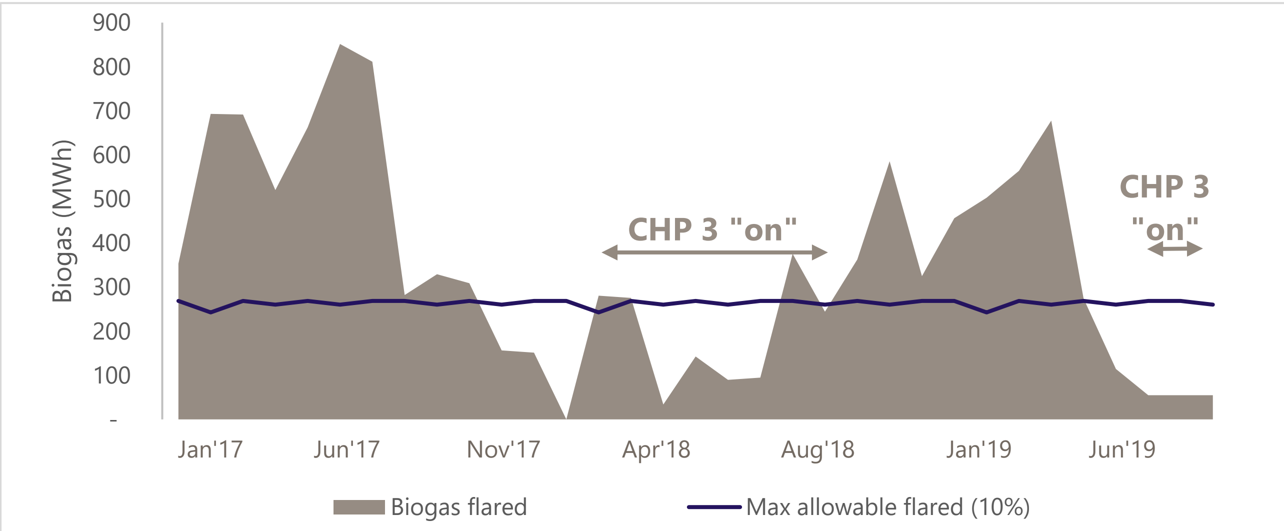
Biogas

The restricted electricity grid export means that the CHP engines cannot run when there is low electricity demand on site. This results in excess biogas being flared off; varying between 0.7 to 4 GWh/a.

Around 13,000m3 of biogas is produced per day with an average of 4GWh/a biogas flared in the last couple of years (~13% of total estimated production). This has reduced to an extrapolated average of 0.66GWh/a since CHP3 has come online. However, only 3 months of data available (see Figure 9-3).

Thames Water have a license to flare a maximum of 10% of annual biogas production. If this is exceeded, a fine is paid. shows this level was exceeded 64% of the 2.5 years of data provided (assuming 13,000m3 biogas produced per day)

Figure 9-3 Biogas flaring



CHP

As the three CHP engines are sized to the sites electrical demand, a large amount of excess heat is produced that is currently being dumped into atmosphere. This is assumed to be high grade heat.

Although there is a reduction in biogas flared when CHP 3 in running, the heat dumped from CHP increases (see Figure 9-4). The average monthly heat dump when CHP 3 is running is 507MWh. Using this, total CHP heat dumped averages at approximately 6.0GWh/a. This heat could likely be considered zero carbon heat if recovered onto the heat network and represents the equivalent of around 1,500 homes annual heat demand.

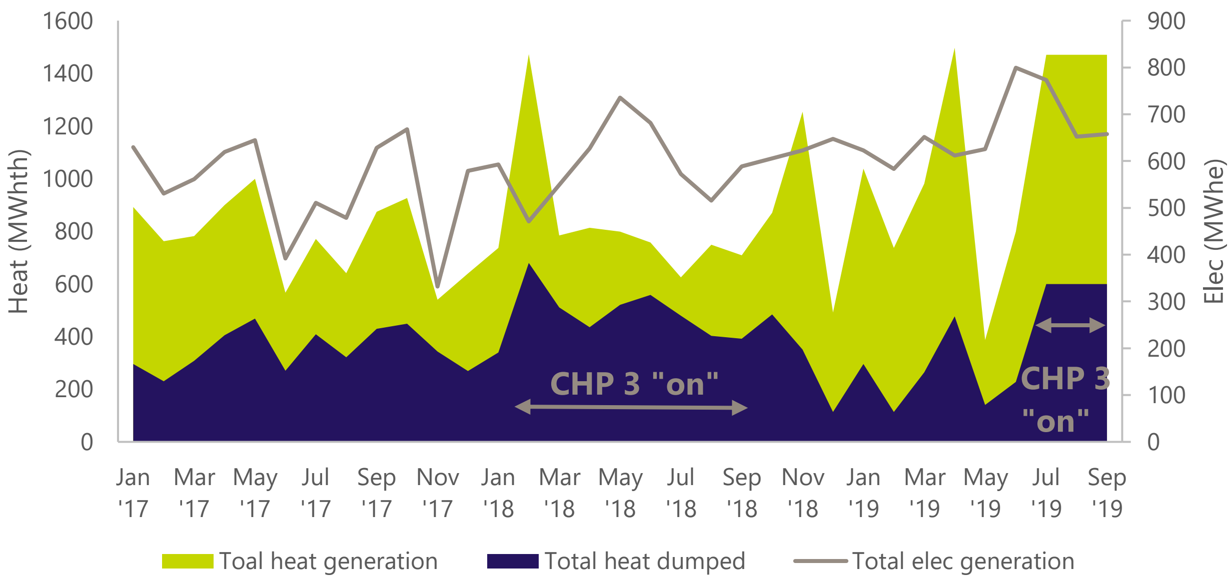


Figure 9-4 monthly heat and electricity generation

Table 9—1 CHP heat summary

	CHP (with all three units running)
Details:	3no. biogas CHP engines (2x470kWe & 1x400kWe)
Av. generated (MWh/a)	11,474
Av. dumped (MWh/a)	6,087
% dumped	53%

Private wire opportunity

Average daily electricity generation profile from CHP generation provided from 2017 – 2019. The average profile is relatively flat throughout the day, with peak load of ~800kWe. This can be compared to the diurnal electricity import profile (Figure 9-5). Daily peak electricity demand on site is ~1,600kWe.

From this it is assumed that on a typical day Thames Water use all electricity produced by the CHPs. It is therefore assumed there is no private wire potential on the site.

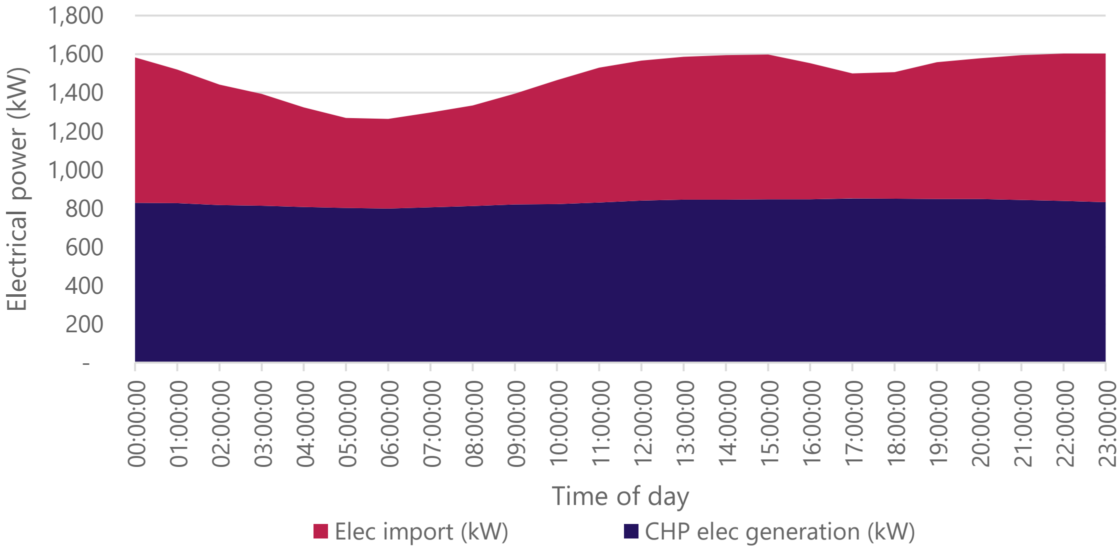


Figure 9-5 Hogsmill CHP electrical generation and import

A.2.4 Future plans at Hogsmill

- Thames Water have advised that in 3-5 years two of the three CHP engines will likely need replacing
- Installation of fourth CHP likely to be delayed to 2025-2030
- The Hogsmill WWTP is 50 years old. Thames Water are planning a capacity increase in line with upstream population increase of an estimated 12%. The increased capacity is likely to be an additional settlement bed. It is believed the additional plant will be located to the east of the site and not on the currently disused land to the west
- Thames Water innovation funding may become available in the next AMP funding cycle starting 2020, which could be used to develop this scheme

A.3 South East Rivers Trust (SERT)

Thames Water have been leading discussions with SERT and have shared the following information:

- The South East Rivers Trust are seeking the demolition of the existing river crossing and want to re-naturalise the river by removing the concrete river banks
- SERT have agreement from TW to look at the feasibility of de-canalising a section of the Hogsmill river channel at the WWTP and demolishing the existing bridge. Currently there are no outputs, however they have received funding from the EA to produce the feasibility
- SERT do not currently have funding to carry out the actual work but hope the EA and other funders will do so once the detail feasibility has been produced
- SERT are not concerned whether the bridge is demolished or not they thought retaining it may increase the cost of the project as additional reinforcement may be needed if the canalised section is removed
- Removing the weir would remove one of the last barriers to fish on the Hogsmill river which would be a major environmental benefit. They are keen on the heat recovery project as cooling effluent from Hogsmill would be beneficial not only to the dissolved oxygen concentration in the river but would be a better environment for the fish in the river which may lead to increased fish numbers.

A.4 Environment Agency

The Environmental Regulation Team at Thames Water have contacted the EA and they are aware of the project. At present we have not been able to secure a meeting with the design team.

A.5 RBK

Since issuing the PFS report, the dedicated project manager for the heat network project Ian Manders has been having monthly meetings with Thames Water to report on progress and explore offtake solutions. A submission to BEIS for Detailed Project Development (DPD) funding was submitted in December 2019 by RBK.

The council has established a cross-directorate working ground to lead on the response to the Climate Emergency (declared June 2019). The group will develop and monitor the short, medium and long term deliverables and targets and lobby Government and the Mayor of London (GLA) for support and funding. Another key aim of this group is to ensure an appropriately trained workforce to deliver carbon reduction across all Council activities. As part of this RBK also conducted a citizen's assembly on air-quality in November 2019.

Titled 'Making Kingston Better Together', RBK's new Corporate Plan[20] sets out vision, ambitions and priorities for the borough over the next four years (2019-23). This focuses on three strategic outcomes:

1. A sustainable approach to new homes, development and infrastructure which benefits our communities
2. A safe borough which celebrates the diverse and vibrant communities
3. Healthy, independent and resilient residents

[20] https://www.kingston.gov.uk/corporateplan

The heat network can help meet these outcomes through reducing carbon emissions at CRE, as well as reducing the reliance on gas boilers. This in turn will improve air quality and the heath of local residents. New homes in the vicinity of the heat network are provided with an easy route to meeting RBK's planning carbon targets. This helps promote sustainable growth within the community and enable RBK to meet their target on 1,000 new homes by 2022.

A.6 Kingston Hospital

Further talks with facilities staff Charles Hanford (Director of Facilities and Capital Development) and Paul Graham (Energy and Waste manager) have provided the following:

- **Existing on-site steam heat network:** A cost study carried out by Ameresco concluded that de-steaming would lead to similar lifetime costs but would require significant upfront capital. As part of the planned development, KH are looking to outsource their cleaning facilities, meaning steam will no longer be needed. They also intend to extend the on-site network to serve a larger proportion of the site as well as new buildings
- **On-site Energy Centre:** The existing Energy Centre (EC) is contracted until 2022, however they are likely to extend this for a few years, with the new EC planned to be fully commissioned between 2024 and 2029. If no alternative heat source is available, the existing 1.4MWe CHP engine is likely to be replaced by 1.2MWe unit, as CHP is still seen as the most economical source of electricity for the hospital. As this will be a new energy centre building, the hospital may struggle to get planning for a new CHP engine
- **Connection to wider RBK heat network:** KH expressed strong interest to connect to the proposed network and acknowledged it is likely the largest impact project to achieve carbon savings on-site, as it significantly reduces carbon emissions compared to the counterfactual of CHP. The EU ETS scheme is thought to be costing KH £200k per year and therefore there is a financial incentive for reducing on-site emissions. Their energy reduction on the site has also "flatlined" i.e. the low hanging fruit has already been carried out. KH are currently considering the best time to de-steam network and connection to the DHN provides clear incentive.
- KH have cooling on the site and there could be opportunity for heat recovery for the site / DHN network.
- KH agreed to share studies carried out to-date as well as other information and commission a study to assess the interconnection to the DHN. They have signed a Memorandum of Understanding in exploring connection further

A.7 Kingston Crematorium

Kingston Crematorium is currently being refurbished, with two new cremators being installed. They have confirmed that exporting the waste heat from the cremators is not issue and will not affect their design. Based on data provided it is estimated that there are 4 cremations per working day, each allows for 350kW heat recovery on average.

Post refurbishment, the crematorium is considering the option to expand the use of the two cremators beyond the 9-5 working day. This gives the potential to increase the recoverable heat at the site.

A.8 WWTP heat recovery precedents

A.8.1 Stirling, Scotland

In October 2019, BuroHappold went to the Stirling WWTP heat recovery site (see Figure 9-6, Figure A–7 and **Error! Reference source not found.**). This scheme is operated by Scottish Water Horizons and supplies heat to a mixture of local heat loads, including new residential housing, a school and a leisure centre. Key notes:

- 2no. 350kWth heat pumps + 800 kWth CHP + gas boilers
- Effluent offtake in existing well, mid-way through WWTP process. Suction pumps. Not taken from outflow due to topology of the site. Takes 1/10th of flow
- Heat pumps and CHP currently serve two different temperature networks, with a closed off interconnection for the future when temperatures on the CHP loop are reduced
- ~10 month build and commission
- Main complications – lots of existing utilities on the site made pipe routing and energy centre location difficult, negotiations, lead times for plant
- Total cost = £6m, ~50% funded by Low Carbon Infrastructure Transition Programme, rest from Scottish Water Horizons (£2m) and Stirling Council (£1m)
- Unlikely that the project was going to be profitable without CHP electricity sales

Effluent offtake | *Energy centre and thermal stores* | *Macerator and SHARC system* | *Heat pump*

Figure 9-6 Images from Stirling site visit

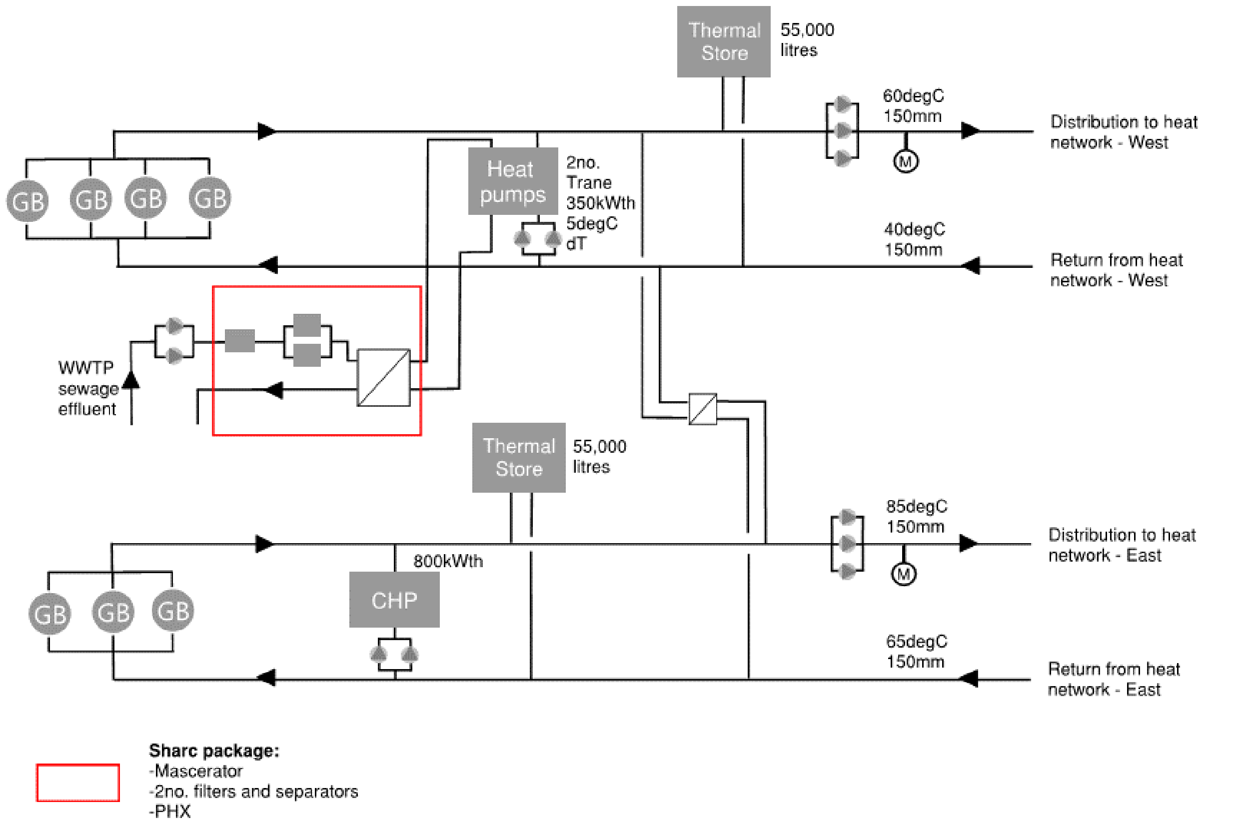


Figure 9-7 Stirling WWTP indicative schematic

A.8.2 Malmo, Sweden

Key information gathered from the Malmo network:

- The WWTP effluent is taken after the tertiary treatment process. The water is extracted from a pump pit using submersible pumps
  - The pit has a 60m^3 capacity and water is pumped at 1m^3/s. There is a level transmitter in the pump pit which stops a sewage water pump (and one heat pump) if the level decreases to fast
- Nominal flow/return temperatures of 14/8degC
- Inlet temperatures vary from 10-22degC depending on the time of year
- Nominal heat pump network temperatures of 66/47 flow/return (with additional high-grade heat supplied by nearby incinerator)
- The heat pump plant is small in comparison to the entire DH-system. Peak load in the system is 750 MW and the plant delivers ca 40 MW. Final heating of the DH-water (from 66C to 80/90C) is done in a waste incineration plant located next to the heat pump plant
- Heat pumps provide ca 8% of annual energy. Waste ca 60%

- The sewage pumps have a constant flow of 300 kg/s per heat pump. There is frequency drive, but it is primarily used to get a smooth start of the pumps and the water flow. The DH-flow is 250 kg/s per heat pump. Constant flow and frequency converter are used here as well
- The Taprogge ball cleaning system functions very well. There is one Taprogge system for four heat pumps. It cleans each HP for about 2 hours, then the next one
- E.ON owns the DH-grid and all production plants, including the heat pump plant. E.ON has a land lease agreement with the sewage water treatment plant (which is a publicly owned company). E.ON also pays for the right to take the heat from the sewage water
- There are no temperature limitations in their permit on return to the WWTP. E.ON just cools the water 6 degrees colder than before, which brings the temperature of the effluent closer the sea water temperature
- The Heat Pump building is approx. 25m x 48m x 6m high

Taprogge ball cleaning system

GEA heat pump

Figure 9-8 Malmo site photos

A.8.3 Uppsala, Sweden

Vattenfall AB is a local supplier in Uppsala of heat, electricity, steam and cooling. Almost 95% of all properties in Uppsala are supplied with heat from the DHN.

Overview:

- The network is supplied with heat from CHP plant, waste incineration and heat pumps.
- The network is 460km long and the district cooling network is 14km long. There is also a 7km steam network.
- A big thermal store serves the whole network, located near the heat pumps.
- Vattenfall AB has a central control room with 4 people there 24/7.

- Since 1982 heat pumps recover heat from the treated wastewater in the WWTP. The energy from wastewater is used to pre-heat the return from the network from 45degC to 55degc, with a SCOP of 4. The hot water is then topped up by other sources like woodchip or incinerator heat.

Key points to note:

- 3no. 15MW heating and 3no. 8MW cooling
- 2 out of 3 heat pumps use wastewater as heat source, the other uses the cooling network
- Each heat pump enclosure is 5m high, 9m wide and 22m long
- Wastewater temperatures range from 10-18degC with a volume of around 52,000m3/day
- 3,500m3 of thermal store
- Refrigerant used is HFC R134a (GWP 1,200). However, this is becoming expensive and looking at the potential to use R1234 (GWP 1) in future. 11 tonnes of refrigerant per heat pump
- One person onsite, one shift per day (applies to WWTP heat pumps only, not the whole network)

Commercial:

- Vattenfall pays an annual fixed fee to the sewage plant for the offtake
- No flowmeter monitoring wastewater
- Vattenfall has ownership of the offtake, generation, distribution and secondary building system

Maintenance:

- First motor changed in 2019 since installation (37 years)
- Every 3 years a major overhaul of the compressor is performed
- There are no problems with algal growth on the heat exchangers because clean water is used
- dT between refrigerant at evaporator and cold side of wastewater is monitored to know if dirt is building up in the evaporator

Appendix B Risk Register

Item ref.	Risk description	Pre-mitigation			Mitigation measure	Lead by	Post-mitigation		
		Impact (I) 1-5	Probability (P) (1-5)	Risk level (I*P)			Impact (I) 1-5	Probability (P) (1-5)	Risk level (I*P)
1	**Technical**								
1.1	Heat consumption estimates vary vs actual consumption. If heat loads do not materialise (e.g. Cambridge Gardens) the scheme may become difficult to operate economically	4	3	12	No data has been provided for heat load of Cambridge Gardens over the year and this has been estimated based on a review of EPCs. It is recommended half-hourly metered data is sought to verify heat load.	BH / RBK	3	2	6
1.2	Heat load insufficient to justify running of LZC plant during the summer	4	3	12	Obtain hourly heat profiles where possible. Current sizing based on typical hourly heat loads profiles for clusters to ensure sufficient base load. Measure heat loads over long period of time for best possible design information. Provide large thermal store or heat pump modulation for lower summer loads	RBK	3	2	6
1.3	LZC technology availability - if the plant does not achieve the required availability it may impact running costs and carbon emissions. Significant plant failure may leave customers without heat	5	3	15	Transfer risk to operation and maintenance contractor via guaranteed minimum availability contract provisions and penalties. Back-up boilers (or alternative) provided for resilience and fuel flexibility	RBK	2	2	4
1.4	Large heat network distribution losses may lead to substantial loss in value if heat network is not adequately designed or insulated	3	2	6	Transfer risk to O&M contractor - specify high performance as per CP1 guidance and ensure detailed approval, inspection, testing and acceptance process including penalties for under performance. Minimise route lengths where possible in route proving process at detailed feasibility	RBK	3	1	3
1.5	UKPN capacity is not secured	5	3	15	There is a risk of load being taken up by a different a user, increasing cost of supply. The mitigation for this is to pay to secure grid capacity once confident the project is going ahead	BH / RBK	3	3	9
2	**Business case**								
2.1	**Funding**								

2.1.1	Failure to identify funding sources adequate to meet the capital costs of the scheme. Scheme performance reliant on grant funding	5	3	15	Continuous engagement with the GLA to ensure schemes meet requirements for HNIP funding. CP1 and HNDU checklists will be carried out to ensure scheme compliance. Do not proceed if adequate funding cannot be secured	RBK	2	2	4
2.1.2	Lack of interest from commercial developers	5	3	15	Establish what IRR/ NPV values would attract commercial investment through soft market testing	BH	4	2	8
2.2	**Capital costs**								
2.2.1	Budget overspend due to poor cost controls	4	2	8	Undertake design reviews with relevant stakeholders. Consider procurement via a contractors to cover energy centre and networks	RBK	2	2	4
2.2.2	Budget underestimated due to unforeseen issues	5	3	15	15% contingency added to cost estimates	RBK	4	2	8
2.3	**Revenues**								
2.3.1	Resulting cost of heat too high for residents	5	2	10	RBK required to provide additional capital funding over and above loan value in order to reduce heat cost. However, this will affect the schemes revenue performance. Tight control on scheme costs is required through detailed development	RBK	4	1	4
2.3.2	Uncertainty around access to the Renewable Heat Incentive (RHI) after March 2021	4	3	12	Access to RHI funding is ending in March 2021. It is not currently known if this will be replaced by a similar funding stream. Ensure schemes are viable without RHI funding – current base modelling excludes RHI	RBK	1	3	3
2.3.4	Changes to energy taxes could impose costs on the energy business	3	2	6	Any increase in tax will be transferred to customer - include change of law provision in heat contracts that adjusts charges to reflect new taxes	RBK	2	2	4
2.3.5	Heat sales price	3	5	15	As identified in the TEM, the agreed heat sales price has a high impact on the projects economic performance. As with all LA lead DHN projects, there is a trade off in benefits sought through increasing revenue to the council and providing value for money to customers and ensuring fuel poverty is minimised. A market study of typical energy prices should be conducted to ensure both residents and DHN owner/operator receives value for money	RBK	2	4	8
3	**Stakeholders**								
3.1	CRE residential ballot rejected	5	3	15	RBK to manage TFL interface through normal channels with assistance from RBK Highways	RBK	3	2	6
3.2	TFL oppose street-works or propose onerous requirements	4	2	8	RBK to manage TFL interface through normal channels with assistance from RBK Highways	RBK	3	2	6

3.3	Failure to gain resident support for the scheme	4	2	8	Structure proposal to make it attractive to residents and ensure a communications plan is enacted for local residents. Ensure residents are no worse off and bring savings where possible through the cost of heat	RBK	4	1	4
3.4	RBK lack of expertise to carry project forward	4	3	12	External project manager recommended to lead the scheme. Operation and maintenance can be contracted out	RBK	3	1	3
3.5	Low support from within RBK council	5	3	15	Identify a "champion" from within council to take project forward and increase awareness. RBK to manage ongoing discussions with BH input.	RBK	4	2	8
3.6	Thames Water do not agree to sell heat from Hogsmill Sewage Treatment Works at suitable price	4	3	12	TW have expressed interest in the scheme. Detailed financial modelling carried out to ensure best price is agreed during negotiations with Thames Water. Continued engagement at all stages of DHN development is required. CRE team already in contact with TW as adjacent land owners.	RBK	4	2	8
3.7	RBK's ability to invest in the 'leg work' in setting up a DHN	4	2	8	Involve relevant RBK internal departments from project outset to raise awareness of project. Apply for funding/support from GLA/BEIS	RBK	2	2	4
3.8	Third party negotiations (Thames Water, Crematorium)	4	3	12	Early stakeholder involvement in proposed schemes once identified. Discussions with third parties as to acceptable IRRs	RBK	3	2	6
4	**Planning consents, permitting and environment**								
4.2	High noise levels from energy centre	4	3	12	Acoustic impact managed through using proven compliant heat pumps and noise insulating casing	RBK	3	2	6
4.3	Flood protection at Hogsmill	4	3	12	A flood risk survey is recommended to ensure the proposed EC location is not at risk of flooding	BH / RBK	3	2	6
4.4	Planning permission required for heat network	3	2	6	RBK to confirm whether permitted development rights cover installation of heating pipework in the public highways	RBK	2	2	4
4.5	Air quality issues increase cost or result in restriction on operation of energy centre	4	2	8	Air quality impact managed by ensuring flues extend to a higher level than the surrounding buildings. Early consultation with planning team advised. De-risk by installing high efficiency gas boilers	RBK	3	2	6
4.6	Failure to negotiate use of Thames Water land for CRE energy centre	4	3	12	Continue engagement with Thames Water and continue to pursue a memorandum of understanding for use of land for energy centre and waste heat off-take. If land is not available, EC could possibly be located on the CRE	RBK	2	2	4
4.7	Kingston Hospital contracts for power/gas. Existing service contracts may limit options for extending heat supply to wider network	3	3	9	Early engagement with the hospital NHS Trusts. Get key dates of planned heating system refurbishments and ensure stakeholders are aware of plans for DHN in the area. Ensure planned site network is compatible with wider DHN connection	RBK	3	2	6

4.8	Failure to obtain planning permission for WSHP at HSTW due to environmental issues	5	3	15	Early engagement with the Environment Agency (EA) on acceptable discharge temperatures and flow rates. Not currently aware of a minimum discharge temperature into rivers set by the EA	RBK	5	1	5
5	**Construction and procurement**								
5.1	Contract choice inappropriate and prevents project aims from being delivered	5	3	15	Residents rejecting the CRE ballot. Mitigation for this can be made through securing the Kingston Hospital connection and retrofitting the existing CRE estate blocks to facilitate DHN connection	RBK	4	2	8
5.2	Redevelopment time windows missed	4	4	16	Early and continued engagement with all major stakeholders identified (e.g. Cambridge Road Estate, Kingston Hospital) to ensure they are aware of the project and potential to connect into a DHN. Promotion of work from within RBK and across the borough so that future developers are aware of proposed scheme	RBK	4	3	12
5.3	Contaminated land or invasive species at Hogsmill	4	2	8	If these are found at Hogsmill, the land clearing costs for the Hogsmill EC will significantly increase. It is recommended a Phase 1 Habitat Survey is conducted to mitigate against this risk	RBK	3	2	6
5.4	Level of intervention required at Hogsmill	3	4	12	If construction works are not fully costed and planned it will lead to overspending. Recommended that detailed schematics of existing infrastructure at HSTW is obtained at early stage of detailed development. 15% contingency included in the Capex schedule	RBK	2	4	8
6	**Operation and maintenance**								
6.1	Heat delivery failure	5	4	20	Design resilience into system including redundancy for pumping, boilers etc. Make plans and procedures for emergency boiler hire for connection at building level.	RBK	3	1	3
6.2	Lack of clarity over the department with RBK who is responsible for operation and maintenance	3	2	6	RBK to make a clear statement of responsibility as part of internal business case. Particularly important if energy is being supplied by third party (Thames Water)	RBK	2	2	4
6.3	High losses in primary or secondary network negate cost savings and create inefficient system	4	3	12	Commissioning and ongoing monitoring conducted to ensure performance is achieved	RBK	3	2	6

Appendix C TEM Inputs

C.1 TEM inputs

	Input / assumption	Value	Unit	Reference
Plant: Low-carbon technologies				
	Heat pump capacity	1,500	kW	Energy modelling
	Heat pump thermal efficiency	350%	%	GEA
	Heat pump fraction as a % of total generation	33-85%	%	Energy modelling – depending of if CHP/Crem heat incl.
	CHP peak thermal output to network	789	kW	Energy modelling
	CHP heat fraction as a % of total generation	0-62%	kW	Energy modelling – depending of if CHP heat incl.
	Crematorium peak thermal output to network	350	kW	Energy modelling
	Crematorium fraction as a % of total generation	0-3%	kW	Energy modelling – depending of if Crematorium heat incl.
Plant: Back-up boilers				
	Natural gas boiler capacity	9,049	MWth	Energy modelling
	Natural gas boiler efficiency	89%	%	Assumed
	Boiler heat fraction as a % of total generation	5-15%	kW	Energy modelling – depending of if CHP heat incl.
Equipment life expectancy				
	Heat pump	20	yrs	[21]
	Top-up technology	15	yrs	[22]
	DHN connections	20	yrs	[23]
	Cambridge Road Estate HIUs	20	yrs	[24]
	Abstraction and distribution pumps	20	yrs	[25]
	DHN network	longer than scheme life	yrs	Assumed
Network losses				
	Parasitic pumping power	5.4%	%	2% network losses (CP1) and calculated 3.4% abstraction pumping at HSTW
	District heating standing losses	10%	%	CP1
REPEX sinking fund				
	% of replacement expenditure incurred	80%	%	Assumed
Other				
	Discount rate	3.5%	%	Green Book
	Start year	2024		Assumed
	Modelling lifetime	30	yrs	Assumed
	Discount rate	3.5%	%	[26]

[21] Department of Energy & Climate Change (DECC), 2015. *Assessment of the Costs, Performance, and Characteristics of UK Heat Networks*
[22] Department of Energy & Climate Change (DECC), 2015. *Assessment of the Costs, Performance, and Characteristics of UK Heat Networks*
[23] Department of Energy & Climate Change (DECC), 2015. *Assessment of the Costs, Performance, and Characteristics of UK Heat Networks*
[24] Department of Energy & Climate Change (DECC), 2015. *Assessment of the Costs, Performance, and Characteristics of UK Heat Networks*
[25] Department of Energy & Climate Change (DECC), 2015. *Assessment of the Costs, Performance, and Characteristics of UK Heat Networks*
[26] HM Treasury, 2018. *The Green Book, Central Government Guidance on Appraisal and Evaluation*

C.2 Network costs

The following appendix details the assumption made in network costing. Logstor Series 2 2016 prices, with trenching adjusted to reflect London area as per Logstor values. Final costs adjusted in line with RPI to reflect 2020 prices[27].

Pipe size	DN	Pipe unit cost	Trench unit cost (hard dig)	Trench unit cost (soft dig)
	mm	*£/m*	*£/m*	*£/m*
DN25	25	225	302	156
DN32	32	243	328	182
DN40	40	273	339	208
DN50	50	287	351	214
DN65	65	313	377	224
DN80	80	330	423	234
DN100	100	386	488	245
DN125	125	432	547	252
DN150	150	481	618	261
DN 200	200	516	716	287
DN 250	250	661	719	307
DN 300	300	705	724	313
DN 350	350	839	745	365
DN400	400	928	802	417
DN450	450	993	834	469
DN500	500	1,444	886	521
DN600	600	2,167	912	573
DN700	700	2,928	1,011	625
DN800	800	3,390	1,110	834

		Basecase	Phase 2	Phase 3
		CRE only	**Cam Gardens**	**Cam Gardens & Hampden Rd**
Pipe and trench total costs	*£*	£ 1,548,907	£ 1,883,959	£ 2,052,708
Length	*m*	1,165	1,403	1,611
£/m	*£/m*	1,330	1,343	1,274

[27] https://www.ons.gov.uk/economy/inflationandpriceindices/timeseries/l55o/mm23

C.3 Capital costs

Item	Description	Total Capex (£) Including prelims, design fees, testing, commissioning, installation, delivery, 15% contingency
Heat Offtake at HSTW		
Civils		
New chambers (x2)		104,800
Over pumping during construction	Temporary generators, pumps etc. 7-week construction	190,400
Surveys, design etc.	Assumption	34,500
Offtake equipment		
Sump pumps	Grundfos submersible pumps (duty, assist, standby) SP 60-6 14A00006	25,976
Pipework & trenching	To EC assuming MDPE 2xDN225mm, 150m of pipework. Uninsulated	227,036
HSTW Energy Centre		
Civils		
Concrete slab	250m2 EC area for FBO	50,592
Building	Office, substation, storage (assumed 80m2)	27,064
Land clearing	Vegetation clearing, excavation and disposal, site investigation, assumes no contaminated land	218,597
Heat generation equipment		
Taprogge ball cleaning system	Quote from Taprogge	232,424
Heat pumps	1.5 MW GEA units (high temp ammonia)	816,000
Electrical		
Substation	N+1 redundancy. 2MVA transformer. 11/0.415kV, Dyn 11, 50Hz.	46,104
Switchgear	Circuit breakers and tripping batteries/ battery chargers	88,128
Cabling extension	6.35/110kV 3 core 120mm and trenching 500m, looped cable (future proofed for FBO)	209,440
UKPN upgrades	HV POC for new 770kVA at LV (as per UKPN quote, including VAT)	138,000
Distribution		
Pumps	Grundfos CR 45-6 A-F-A-V-HQQV - 96122832 (duty, assist standby)	48,266
Water treatment	ENWA water treatment and dosing	80,837
Thermal stores	Previous project experience	154,700
Other		
CCTV/ Intruder alarm	Estimate	10,200
Fire protection and alarm	Estimate	15,232
Voice/data	Estimate	6,800
Ammonia detection (incl. internal ductwork and ventilation system)	GEA quote	27,200

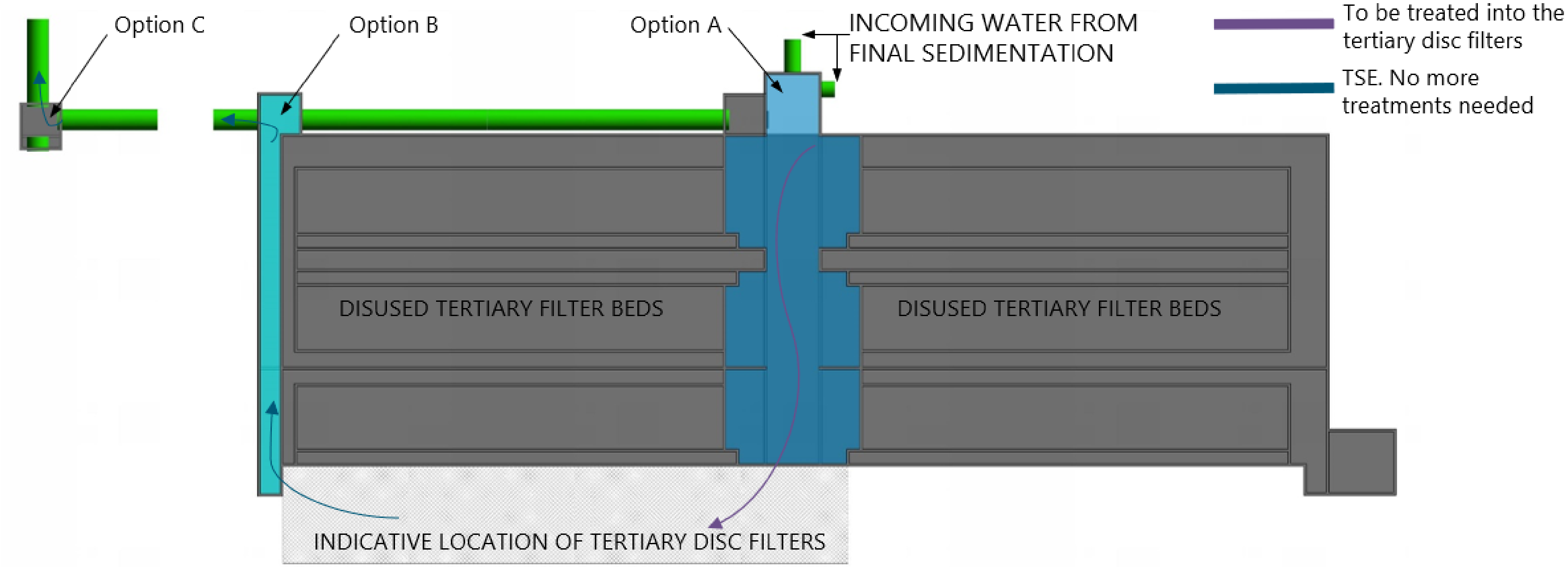
		Ventilation and ductwork in office space	Estimate	13,600
		Fibre connection	Estimate	30,600
		Cold water pipework	Estimate	13,600
		Sewer	Estimate	13,600
		BMS system	Estimate	136,000
		Expansion and pressurisation units	Estimate	145,748
		LTHW pipework	Estimate	68,000
CRE Energy Centre				
	Heat generation equipment			
		Boilers	3no. 500kW Hoval condensing boilers (steel HEX). Sized to meet peak load of Cam Gardens and Hampden Rd (1.177MWth) with N+1 redundancy. Remaining 14 boilers (N+1) for CRE peak assumed paid for by Countryside. Network pay for repex	70,828
		Flues	Assume paid by Countryside	-
		Gas connection upgrade	Assumption to allow for additional capacity to serve Cambridge Gardens / others	68,000
Network and connection equipment				
	Connection costs			
		Heat meter and control valve at CRE	Wolfson quote, 3 heat meters (CRE, CRE EC, HSTW EC)	2,448
	Network costs			
		Pipework & trenching	Logstor Series 2, 1,165m, soft dig through cemetery. Sized to Hospital, Cam Gardens and Hampden Rd peak. Max DN300. Rates allow for supply, delivery, offloading, installation, hydraulic testing, 10% N.D.T	1,781,235
		Pipe bridge	Beaver Bridges quote	214,245
Optional - sensitivities				
	Cambridge Gardens			
		HIUs	Cambridge Gardens only - Evinox quote (ModuSAT XR Twin Plate 100A-10A)	369,104
		Secondary system retrofit	Cambridge Gardens only - gas heating low rise flat conversion. Incls installation, DH pipework, overheads, prelims and labour	488,060
		Water treatment at Cambridge Gardens	ENWA 1260 water treatment and dosing at Cambridge Gardens	23,060
		Pipework and trenching extension from CRE	Logstor Series 2. Rates allow for supply, delivery, offloading, installation, hydraulic testing, 10% N.D.T	385,310
	CHP heat offtake			
		PHE	Duty/assist 66% sized to thermal peak of 3 CHPs at HSTW (1,547kW). Costs quote from Armstrong	56,364
		Pumps and valve to EC connection	Duty/assist jockey 66% 10% pumps, Grundfos. 2no. Isolating valves, Logstor.	17,215

		Pipework and trenching to EC	Logstor series 2 795m DN125mm. Hard dig. Rates allow for supply, delivery, offloading, installation, hydraulic testing, 10% N.D.T	992,795
	Crematorium heat offtake			
		PHE	Duty/assist 66% sized 438kW peak. Costs quote from Armstrong	45,988
		Pumps and valve to EC connection	Duty/assist jockey 66% 10% pumps, Grundfos. 2no. Isolating valves, Logstor.	14,639
		Pipework and trenching to EC	Logstor series 2, 110m DN80mm. Hard dig. Rates allow for supply, delivery, offloading, installation, hydraulic testing, 10% N.D.T	105,662
	Hampden Road			
		Pipework and trenching extension from CRE to Hampden Rd	Logstor Series 2 - DN80. Rates allow for supply, delivery, offloading, installation, hydraulic testing, 10% N.D.T	194,061
		PHE at Hampden Rd	Sized to peak	48,613

Appendix D Hogsmill offtake options

3 options were considered:

Site Layout
3D Revit Model

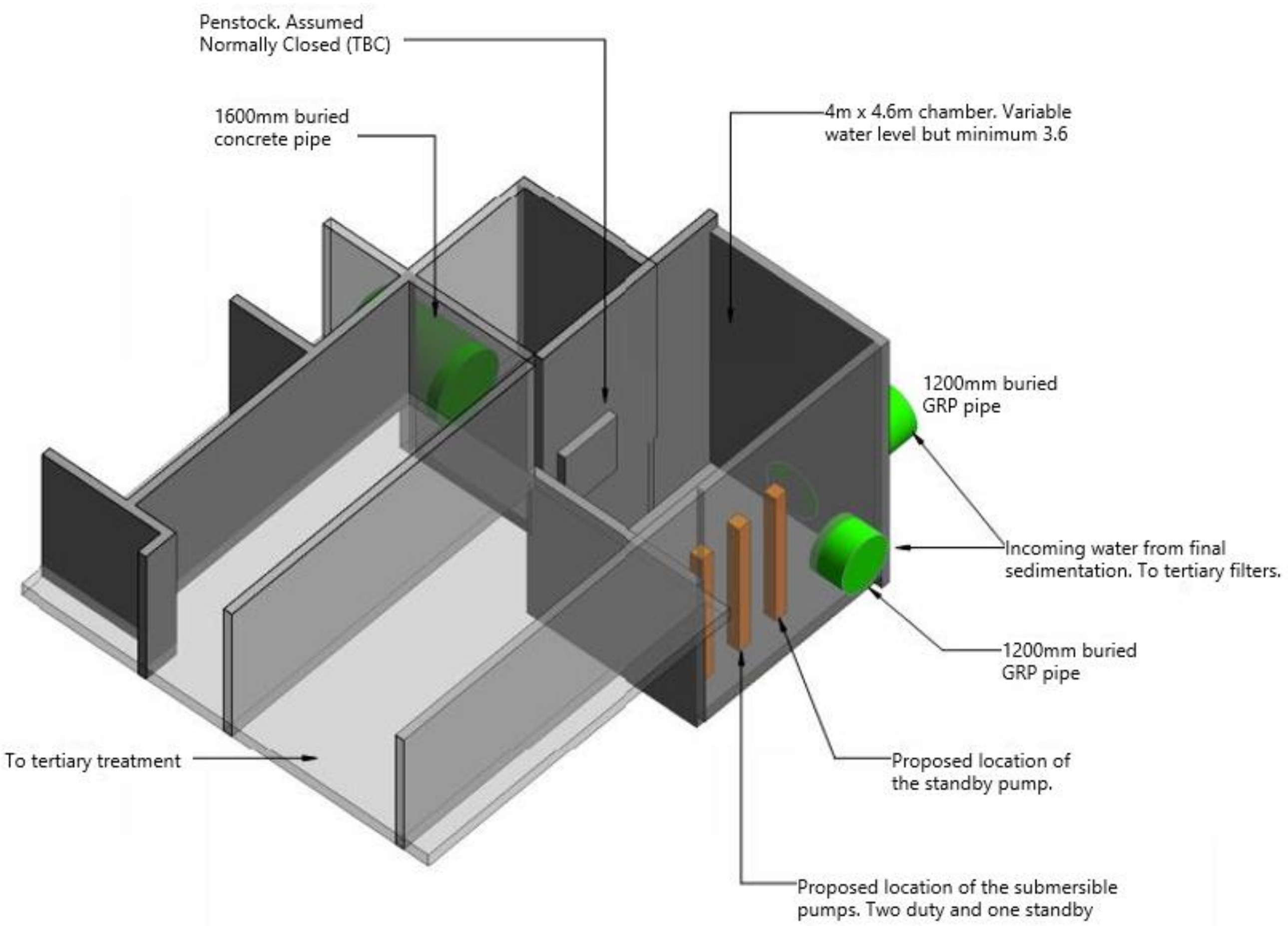


- 3D model based on technical drawings found during site visit
- Further investigation on hydraulic parameters (roughness, slope etc) shall be carried out.

Offtake options
Option A

- **Option A – Pre-tertiary treatment:**
  - *PRO:*
    1. Minimal civil works required for the offtake pumping station as a 60m^3 sump is already existing.
    2. No significant further investigations are needed to assess pumps operations and locations
    3. Cold return can be done downstream
  - *CONS:*
    1. Access requires agreements with TW.
    2. Located before tertiary treatment. Lowering temperature may impact polymer efficiency in removal of solids.

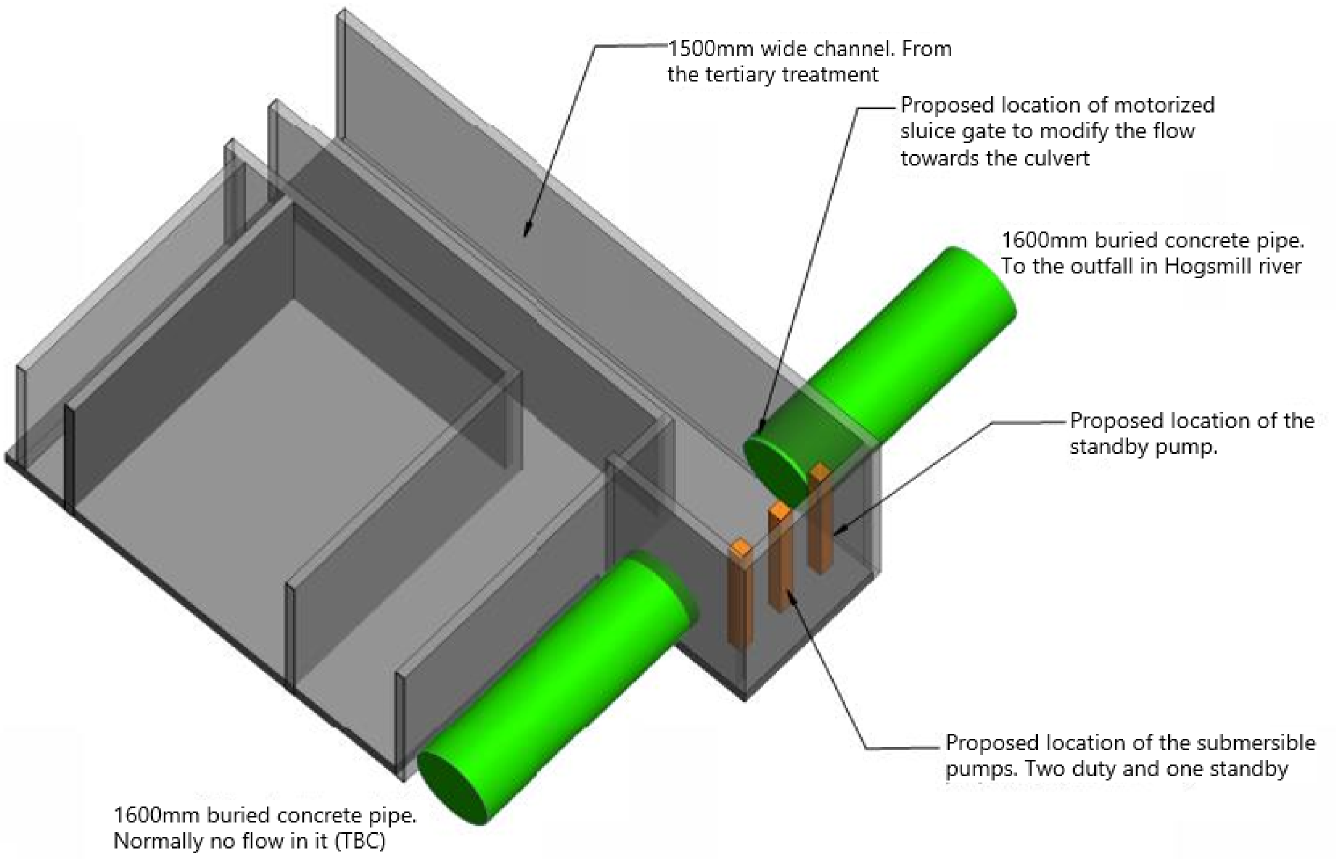
<u>Option A is discarded for the time being, until effect of temperature on polymers has been established.</u>



Further information on the hydraulic consideration can be found in the technical note

Offtake options
Option B

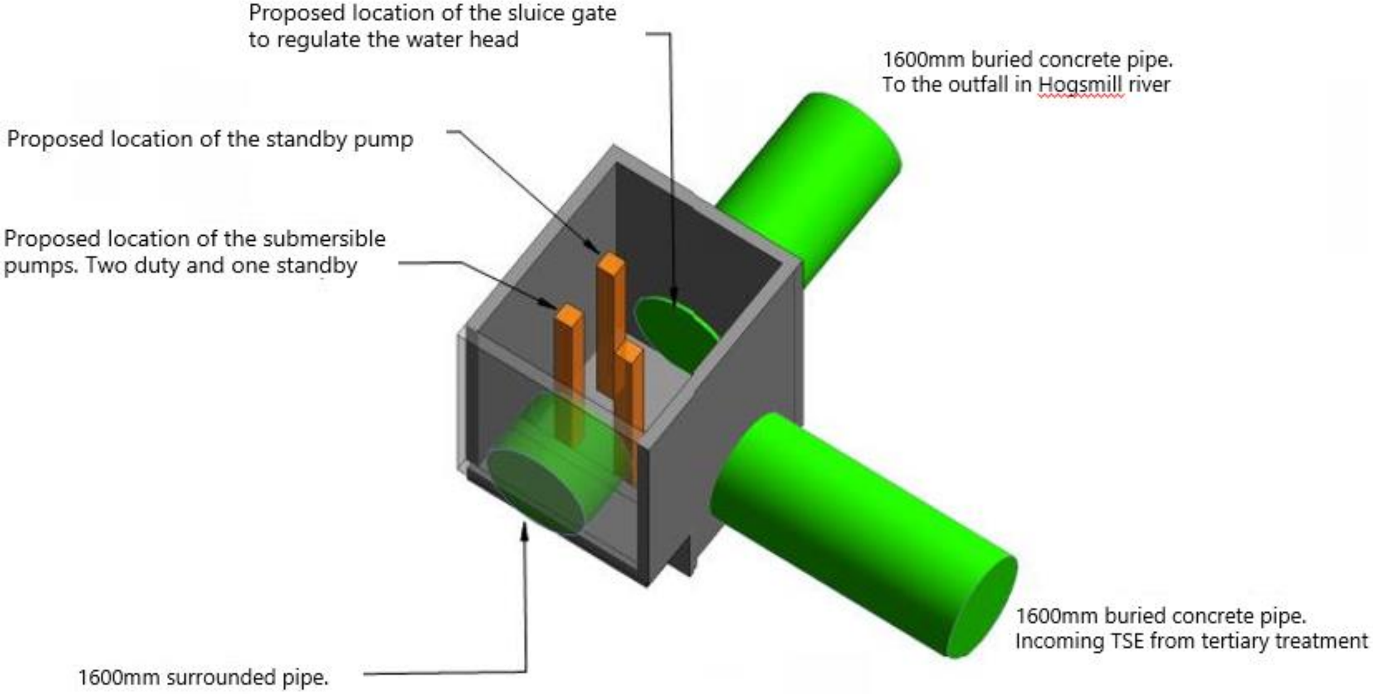
- **Option B– Before the flow kiosk and after tertiary treatment**
  - *PRO:*
    1. Depending on location of EC, pipework length is reduced.
    2. No impact on TW operations – pending review of sluice gate impact
    3. Cold return can be done in the flow meter kiosk
  - *CONS:*
    1. Access requires agreements with TW.
    2. Water head is not enough for pumps operations. A sluice gate it is proposed to increase the water head to 1m.
    3. Geometry and hydraulic parameters to be validated. Therefore, surveys and further investigations are needed.



Further information on the hydraulic consideration can be found in the technical note

Offtake options
Option C

- **Option C – Before Outfall**
  - *PRO:*
    1. Access to offtake might be possible from the recycling centre.
    2. Depending on location of EC, pipework length is reduced.
    3. No impact on TW operations
  - *CONS:*
    1. Configuration of the chamber/manhole is not clear from technical drawing. Therefore, surveys and further investigations are needed.
    2. Water head is not enough for pumps operations. A sluice gate it is proposed to increase the water head to 1m.
    3. Due to uncertainties, civil works might be significant (additional chamber and flow diversion may be required)
    4. Cold return will require civil works i.e. return pipe has to enter the culvert.



Further information on the hydraulic consideration can be found in the technical note

Appendix E 3DTD network report

Route Option Appraisal Report

London Borough of Kingston upon Thames

6384-3DTD-00-ZZ-RP-10001

Contact Information

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Companies House No. 02683933

1. Project – Route Option Appraisal and Desktop Study.

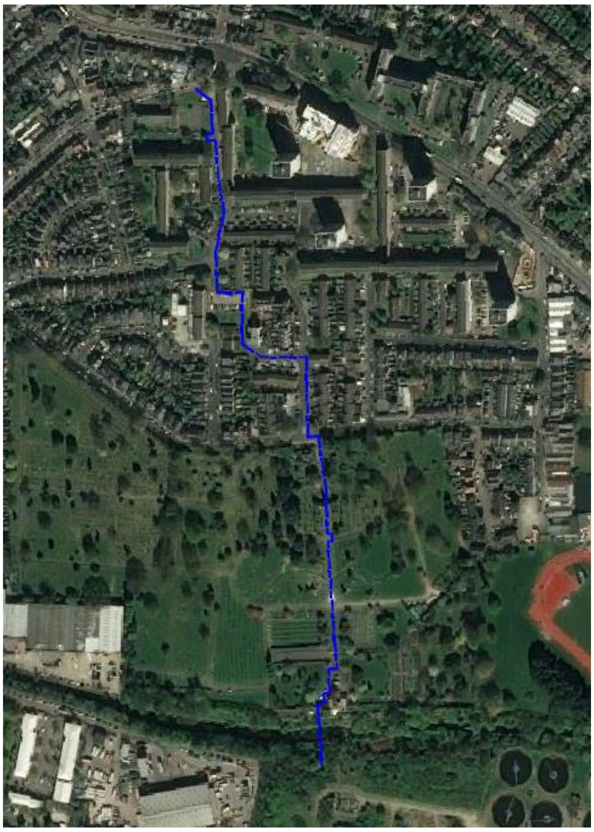
Prepared for: Buro Happold
Project Name: Kingston upon Thames OBC
Lead Consultant: David Underwood
Job Reference: 6384
Date: 19th January 2020

Detail	Rev	Author	Date Reviewed	Reviewed By	Next Review
Original Draft	1	DJU	Jan 19	Craig Grobety	As Required

2. Contents

3. Executive Summary

3D Technical Design were instructed to carry out a Route Option Appraisal for the London Borough of Kingston upon Thames, to identify major infrastructure crossings and highway routes, identify the HAZIDs and control measures to reduce the design and commercial risks.



After the desk top review and site visit, it is 3D Technical Design Ltd.'s opinion that the preferred route is technically feasible, with several commercial risks to be resolved, such as approval to access and install in non-highways land.

In the highways, it is envisaged that, due to the size of the trench and pipe, utility diversions will be required to provide a suitable district heating network route.

The assets which will require diversion will be identified in the proposed next steps.

The preferred route and dimensions are shown in drawing 6345-3DTD-00-ZZ-DR-Y-1001. The preferred route has been designed to leave the Thames Water Sewage works via a pipe bridge crossing the Hogsmill River, landing on the Kingston Cemetery embankment.

It is understood that approval in principle has been obtained from Kingston Cemetery and the scope of this study did not call for consultation with Kingston Cemetery.

The route crosses Bonner Hill Road, along Willingham Road, before turning into Franklin Close, leaving Franklin close at the end of the cul-de-sac. The route crosses the grassed area and car park adjacent to Piper Hall before proceeding north along Washington road to the substation.

The optional routes and associated dimensions are shown in red within drawing 6345-3DTD-00-ZZ-DR-Y-1001. These routes are technically feasible but have more commercial risks than the preferred route which would need to be resolved, such as approval to access and install district heating pipe in non-highways land.

As all routes require different land access and approvals, it is recommended that two routes, the primary and one optional route, should be explored in unison, if the delivery programme is critical. If the delivery programme is not critical one route could be developed.

The current pipe size requires a trench excavation of 2m wide to allow for pipe install and anticipated temporary works, this will therefore require a working zone of at least 7.5m to excavate and install the network through the Cemetery.

In the highways a trench of this size often requires some utility diversion to allow a clear route to install the network, the extent of these diversions will be identified in the next stage of the design process. There is a high risk utilities will need to be moved to allow the installation of the District Network, it is recommended consultation with the utility providers is started as soon as possible.

During the study all HAZIDs identified for the river crossings and network routes were recorded in the HAZID register and drawing/s to enable the reader to understand the residual risks outside the selected preferred and optional routes, and to understand which crossings have been reviewed.

To develop this project design towards the next phase of delivery 3D Technical Design would recommend the following next steps:

1. Client to agree preferred and optional route,
2. Start consultations with all stakeholders,
3. Produce utility survey area drawing for preferred route, once preferred route agreed,
4. Carry out underground utility survey to PAS128,
5. General Arrangement and Detailed Design from utility survey to confirm network route, potential asset diversions and traffic management requirements,
6. Production of design and commercial risks with associated costs,
7. Support in costing preferred route.

4. Introduction and Scope of Works

3D Technical Design Ltd (3DTD) were instructed by Buro Happold (BH) to complete a Route Option Appraisal & Feasibility Study in relation to a district heating network (DHN) route from Thames Water Sewage Works crossing Hogsmill River to Cambridge Road Estate.

BH requested that any potential routes should be technically assessed to install a DHN across the Hogsmill River to ensure all options have been explored.

3DTD were asked to review utility information provided by BH from SGN, UKPN and Thames Water and carry out a site survey of the area in the attached image.

All findings have been detailed in a HAZID Report with annotated drawings.

3DTD have produced the following drawings:

- District Heating Route Option Appraisal - Preferred and Optional Routes
- District Heating Route Option Appraisal - Preferred and Optional Route with Identified HAZID's

Other Key documents included in this report:

- HAZID Report

5. Methodology and Information

5.1. Desk Top Study

An initial desk top study was carried out using Google maps to provide route familiarisation, and to identify possible crossing locations of the Hogsmill River, and highways routes prior the site visit.

5.2. Site Visits/RFI

A site visit was carried out by 3DTD to review the three optional routes and identify visual HAZIDs.

To maximise the opportunity of identifying HAZID's a further review of Google Maps was carried out by a different 3DTD team member. The aim of both reviews being the identification of major HAZIDs which may affect the viability of any potential route options proposed and included within this report.

HAZIDs were identified from the site visit and google review separately, then jointly reviewed by the two operatives to combine the findings.

A site visit was not carried out to Kingston Cemetery as 3D TD were advised by Buro Happold in previous discussions that approval had been obtained in principle to install pipes through the cemetery. As no specific route was provided, 3DTD selected the most direct route dimension calculation. This may vary and increase as the route within the cemetery develops.

5.3. AutoCAD Design

All work has been carried out in Autodesk Civil CAD 2020 and is currently saved in 2013 format. If different formats are required please advise.

All design is carried in meter format and to OSGB36 coordinate system.

5.4. Strategy for Reader

The Route Option Appraisal Report combines information from all the documents delivered as part of this study. All documents should be reviewed in conjunction with all other documents issued with this report.

During the study all HAZIDs identified for the river crossings and network routes were recorded in the HAZID register and drawing/s to enable the reader to understand the residual risks outside the selected preferred and optional routes, and to understand which crossings have been reviewed.

For this study and review, a DN350 Series 2 pipe is used which requires a clear excavated trench of 1.8m, including temporary works a total trench width of 2m has been assumed.

If the reader has any questions, they should contact the report writer for clarification.

6. Route Option Review

3DTD route design policy is to take the shortest possible route from the sewage works to Cambridge Road Estate, which was the same route provided by BH. It is important that all routes and major infrastructure crossings are reviewed with the HAZIDs identified and an optional route should be developed in tandem with the preferred route until all HAZIDs are resolved or approvals obtained. As reliance on the preferred route may be detrimental to the delivery programme of the scheme if approval is not obtained.

The identified risks are detailed in the HAZID Report and drawing 6384-3DTD-UU-DH-DR-Y-1002, District Heating Route Option Appraisal - Preferred and Optional Route with Identified HAZID's.

6.1. Preferred Route A to E

6.1.1. HAZID 110 – Thames Water Sewage Works

It is anticipated approval will be obtained from Thames Water, though a confirmed area and extent of the energy centre and river crossing was not available at the time of the study.

6.1.2. HAZID 126 – Kingston Cemetery and Crematorium

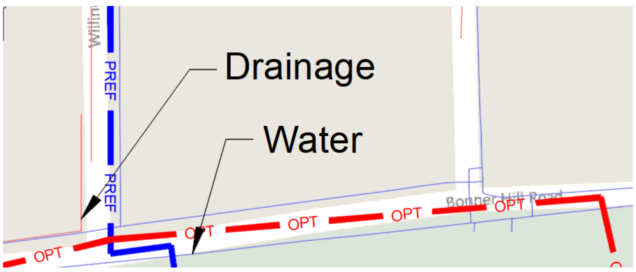
3DTD were informed, prior to this study, that agreement in principle had been obtained from the stakeholder. Meeting with the stakeholder was not part of our scope of works, and as a route would need to be agreed with the stakeholder prior to Route Option Appraisal, a site visit to the cemetery was not carried out.

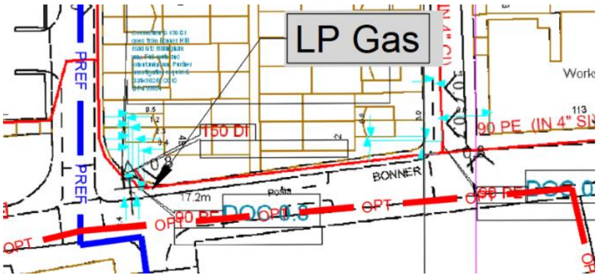
Section 8.2.1 details the soft dig civil requirements for installing the DHN.

6.1.3. HAZID 101 – Bonner Hill Road

Bonner Hill Road, whether using the preferred or optional route, has HV and LV electric to the north side of the road which will require crossing when turning into Willingham Way.

Drainage is clear within Bonner Hill Road until the junction with Willingham way.





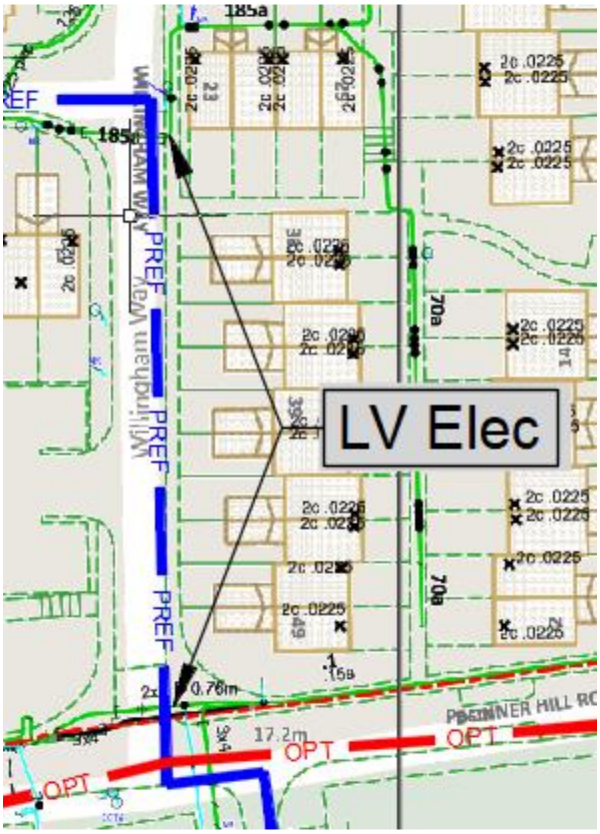
LP gas in a 150mm ductile iron runs in the northern footpath.

Recommendation

A full schedule of assets has not been provided for this study. With the current asset information, 3DTD would expect the DHN to be installed to the southern side of the road without any asset diversion. It is recommended all assets are assessed at the next stage of design.

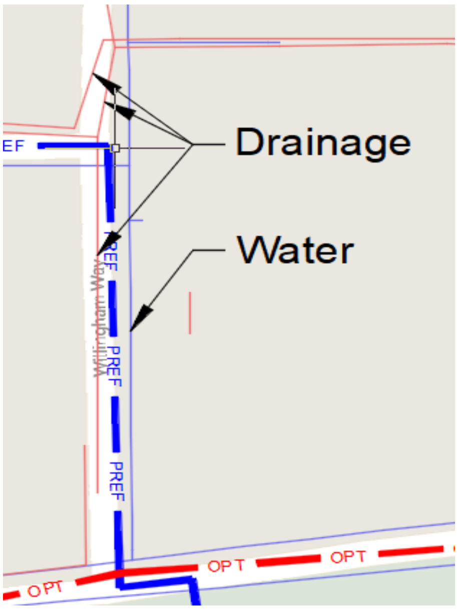
6.1.4. HAZID 142 – Willingham Way

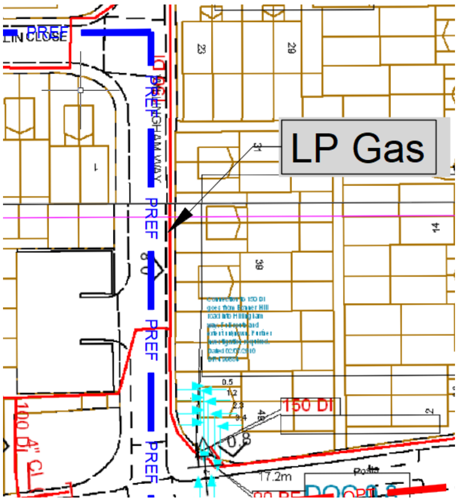
Willingham Way is a two-way cul-de-sac road with designated resident parking. A TTRO may be required to suspend parking in this area. As there is currently no other access from the north, detailed design and traffic management planning is required to be carried out before tender to understand the known restrictions to be issued to the civil contractor.



Willingham Way has only LV electric identified at the north and south sections. As the DHN is crossing both services, diversions would not be expected.

A Drainage chamber is identified in the north bound carriage which will require the DHN to be installed in the opposite carriage. Currently water is located in this carriage or footpath and may require diverting and/or a build over approval obtained to install the DHN above the drainage. If the water is installed in the footpath a diversion would not be anticipated.





The LP gas is also shown in the footpath, with a comms chamber and network in the same eastern footpath.

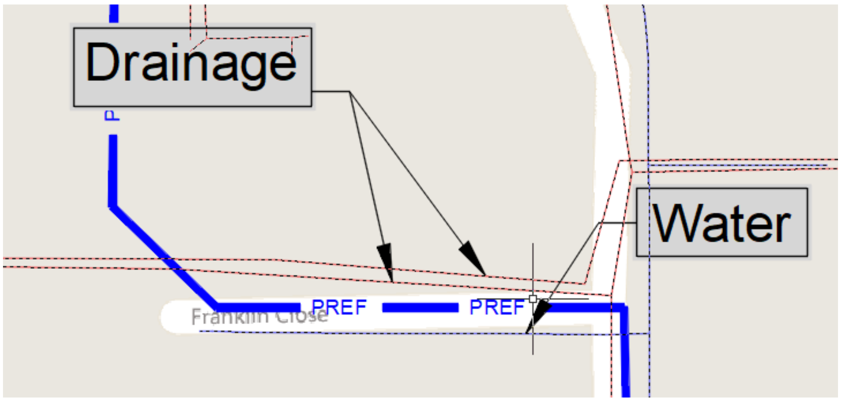
Recommendation

A full schedule of assets has not been provided for this study. With the current asset information, 3DTD would expect the DHN to be installed to the south bound carriage. It is recommended all assets are assessed at the next stage of design with a utility survey and General Arrangement (GA) design carried out to confirm if a route is possible or if asset diversions are required.

6.1.5. HAZID 143 – Franklin Close

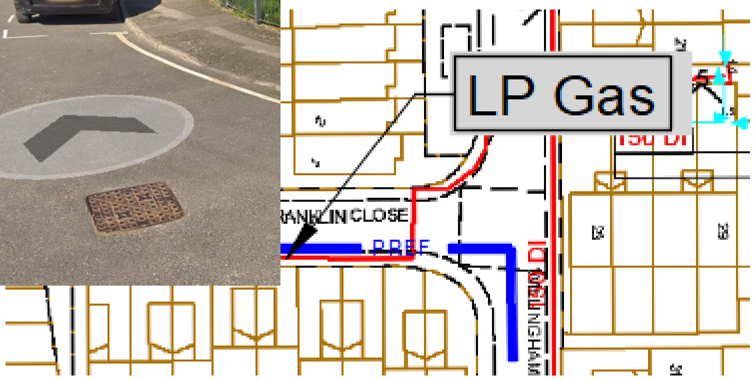
Franklin Close is a two-way cul-de-sac road with designated resident parking, a TTRO may be required to suspend parking in this area. As there is currently no other access from the north, detailed design and traffic management planning is required to be carried out before tender to understand the known restrictions to be issued to the civil contractor.

LV cables are shown in the southern footpath and require crossing on entry into Franklin Close. A lamp post, (HAZID 146) at the eastern end will require removal to allow safe excavation.



The two drainage runs are identified to the north and pass under the resident parking bays (see image xxx). The water is to the south of the proposed network and may restrict the route of the network turning into Franklin Close and crossing the drainage. Crossing above the drainage with DN350 pipe will be subject to the size and depth of the drainage. Passing below will entail deeper excavations and temporary work design.

As the gas is to the south along with the water main, it is highly likely one of these assets will require diversion.

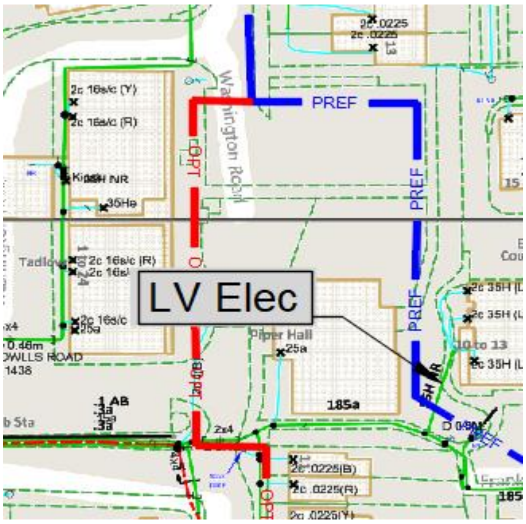


Recommendation

A full schedule of assets has not been provided for this study. With the current asset information, 3DTD would expect the DHN to be installed to the southern side of the road. It is recommended all assets are assessed at the next stage of design with a utility survey and General Arrangement (GA) design carried out to confirm if a route is possible or asset diversions are required.

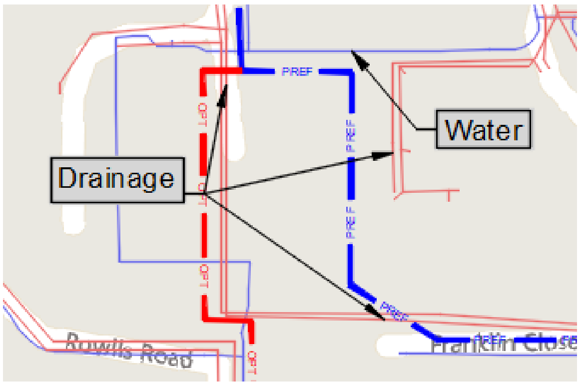
6.1.6. HAZID 144 – Piper Hall Grass and Car Park

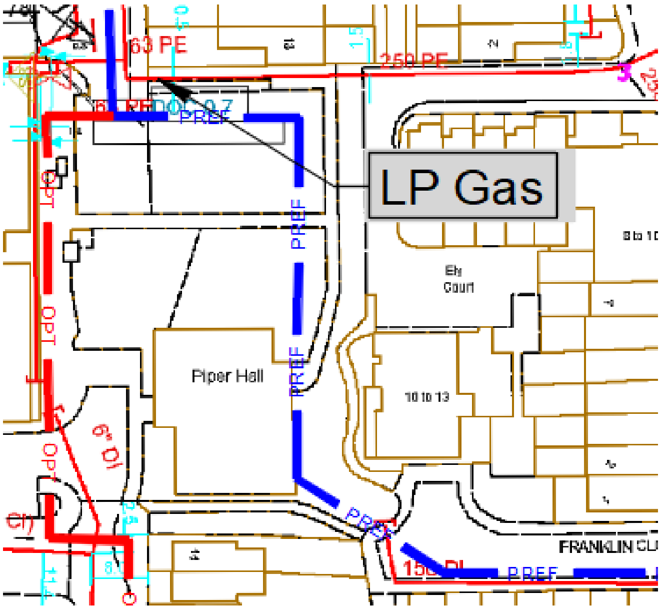
Ownership and access of Piper Hall grassed, and carpark area is unknown and requires confirmation.



LV electric is identified to the south west of the network route and crossed when turning in from Franklin Close to the grassed area during the installation, this would not be expected to affect the network installation.

Crossing above the drainage with DN350 pipe will be subject to the size and depth of the drainage. Passing below will entail deeper excavations and temporary work design.





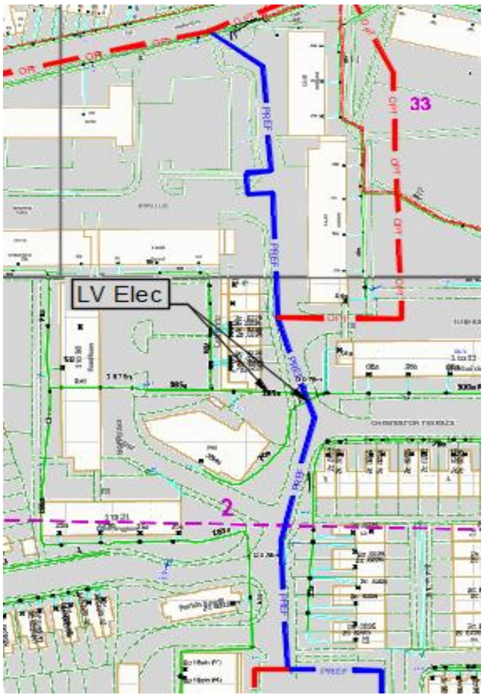
LP gas is clear of the car park and grassed area, after leaving Franklin Close and the network passing into Washington Road.

Recommendation

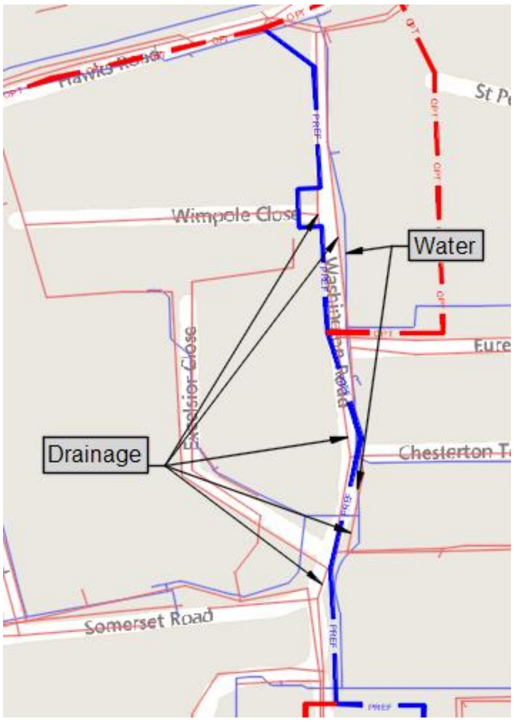
A full schedule of assets has not been provided for this study. With the current asset information, 3DTD would expect the DHN to be installed to the east of Piper Hall proceeding north to the northern parking bays before turning west towards Washington Road. It is recommended all assets are assessed at the next stage of design to ensure they do not affect the network route.

6.1.7. HAZID 145 – Washington Road

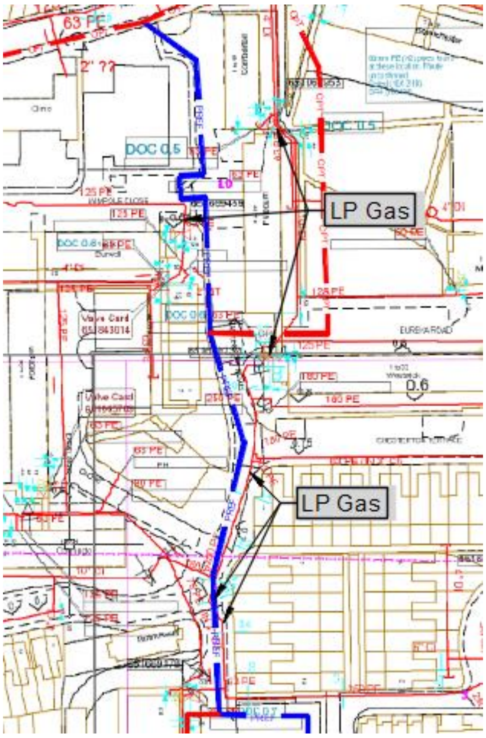
Washington Road is a two-way cul-de-sac and leads to Wimpole Close, Excelsior Close, Eureka Road and Chesterton Terrace which are also cul-de-sacs with unrestricted parking. A TTRO may be required to suspend parking in this area. As there is currently no other access from the north, detailed design and traffic management planning is required to be carried out before tender to understand the known restrictions to be issued to the civil contractor.



LV electrics are only showing at the junction of Chesterton Terrace which need to be crossed. There are no HV cables in Washington Road



Drainage records show assets in either side, crossing the road at several locations, with expected chambers at branches. These will provide the most significant challenge to find a suitable route for the DHN.



LP gas runs parallel with the proposed network and may require some diversions dependant on the network route that can be selected due to the drainage, crossing from either side of the road through sections of Washington Road.(explain the issue with drainage to be clear?),

<u>Recommendation</u>

A full schedule of assets has not been provided for this study. With the current asset information 3DTD are unable to provide a possible position for the network due to the complexity of the drainage and how this will interface with the LP gas. It is recommended all assets are assessed at the next stage of design with a utility and detailed drainage survey carried out with a GA design to determine is a route is possible or if assets require to be diverted.

7. Reinstatement and Commercial Rights

Local Highways reinstatement and commercial rights have not been reviewed in detail as part of this study and are recommended to be discussed during stakeholder liaison.

8. Structures and Excavations

8.1. Building Connection – Localised Controls and Commercial Considerations

Building connections have not been assessed within this study, it is anticipated this will form part of the general arrangement and detailed design phase.

8.2. Soft Dig.

8.2.1. Kingston Cemetery – HAZID 117

There are areas of soft dig expected through the cemetery which will need to be coordinated and planned with the stakeholder. A trench width of 2m is required with a working zone of approx. 1.5m to one side and 4m to the other, if full shoring is used to allow surcharging of the trench sides. In total a continuous working zone of 7.5m wide would be required.

If a battered trench is to be utilised a wider working area will be required.

The approach to the cemetery from Thames Water preferred sewage works crossing will require early coordination to ensure the network can pass into and through the cemetery.

8.2.2. Thames Water Sewage Works – HAZID 110

Following a review of the information provided by Thames Water, the area proposed for the energy centre within the sewage works is expected to be soft dig with no utilities. This should be confirmed with Thames Water with a survey carried out at the detailed design stage.

8.2.3. Hogsmill River Crossing – HAZID 126

Hogsmill River will provide significant challenges for the installation of a pipe bridge due to the gradient of the banks to both sides of the river. As this is the shortest and preferred route, early ground investigation should be carried out to confirm the pipe bridge design requirements.

8.3. Hard Dig

The remainder of the preferred route is anticipated to be in highways and installed under a section 50.

With a trench width of 2m it is expected utility diversions will be required to install the DHN in highways. This should be considered in all highways forecasted installation costs.

It is recommended early utility surveys and general arrangement design is carried out to identify potential utilities that may require diversion.

9. Typical design measures used to account for buried environment:

Provisional examples of loops and offsets have been included within the route recommendations, where applicable to demonstrate methods commonly applied in designing away from high risk utilities and chambers whilst accounting for the Heat Network's thermal expansion forces. It should be noted that due to utility congestion, there would be a risk of additional u-loops/dog legs being required in all highways to navigate past chambers.

In general, Heat Network routes which clash with unidentified buried services, or unearth fragile infrastructure, often suffer considerable disruption and installation delays / re-designs.

Therefore, early and accurate utility identification/GPR surveying, achieves significantly improved design accuracy, together with identifying opportunities for multi-utility collaboration.

It is therefore recommended that during the GA and Detailed Design stage of the project, a utility survey is carried out to PAS128 using GPR (Ground Penetrating Radar) and other methods to identify and model buried utilities.

10. Cost Assumptions/Procurement Advice.

10.1. Civil and Mechanical Installation Rates

There are various approaches to establishing and budgeting Civil and Mechanical Installation rates. Network installation costs vary significantly from project to project and informing a project's Financial Model with accurate benchmarks early is key to its success.

Methods for developing budgets include; general estimates per meter installed, obtaining typical schedules of rates for depth of excavation/welds and applying sensible assumptions based on these and project risks, and undertaking soft market testing.

By undertaking soft market testing Clients can;

- Properly appraise/justify the economic case for the Heat Network.
- Make informed routing decisions.
- Request estimates/guidelines on high risk infrastructure crossings.
- Gather further local data and input.

There are two main forms of soft market testing at this stage:

- Redline Dimensioned GA
- Detailed Schedule of rates:
    - Costs per weld and sleeves
    - Civil rates at an estimated depth
        - Schedule of rates for varying depths.
    - Target Production Rates – This is key to assessing how any contractor perceives project risk and is an excellent measure of their assessment of project risk and local factors.

10.2. Underground Utility Survey

A key further process which is recommended to obtain early cost estimates for an underground utility survey incorporating GPR (Ground Penetrating Radar) and other methods to identify assets, as well as a drainage chamber survey. An underground utility survey together with a detailed 3D design enables improved design accuracy, installation quality, and delivers significant Capital Cost reductions through shallow excavation/installation, minimised disruption and risk of redesign, and therefore vastly improved production rates.

The cost/benefit of both Underground Utility Survey and detailed 3D design should be measured against the overall Capital costs of a Heat Network project.

10.3. Other matters to establish costs early.

It is also prudent to budget for:

- Suitable locations for project compounds at an early stage:
    - the storage of pipe, spoil, working cabins and welfare, requires large expanses of land which need to be close to the working areas and easily accessed.
- Third Party Consent approval processes and costs
- Structural design and calculation costs
- Project Management
- Independent Quality/Governance
- Traffic Marshals (where required), and Local Stakeholder Management
- Project Marketing

11. Key Stakeholders Identified

The following Stakeholders are considered Key at this Stage:

- London Borough of Kingston upon Thames
- Hogsmill River Owner
- Environmental Agency
- Kingston Cemetery
- Highways
- Arboriculture Officer
- SGN
- UKPN
- Thames Water
- Local Residents
- Local Retailers

12. Key Project Risk Documents

Appendix 2 sets out the HAZIDs contained within this report.

When installing Heat Networks across the UK's dense City Centres, the greatest risks are those which are unknown. Working in a civil environment carries far greater risks above where a working environment is established, visible and can be fully investigated and surveyed beforehand.

Those projects which are delivered successfully, identify and prove key commercial consent risks also, such as wayleaves and infrastructure crossings, at an early stage. Mitigating and identifying risks prior to tender; reduces installation costs, enables a quality design to be formulated prior to delivery, and ensures a less disruptive programme.

13. Next Steps

Following the presentation of this report, the following are recommended as the key next steps required in developing the project further towards construction tender:

Next Steps

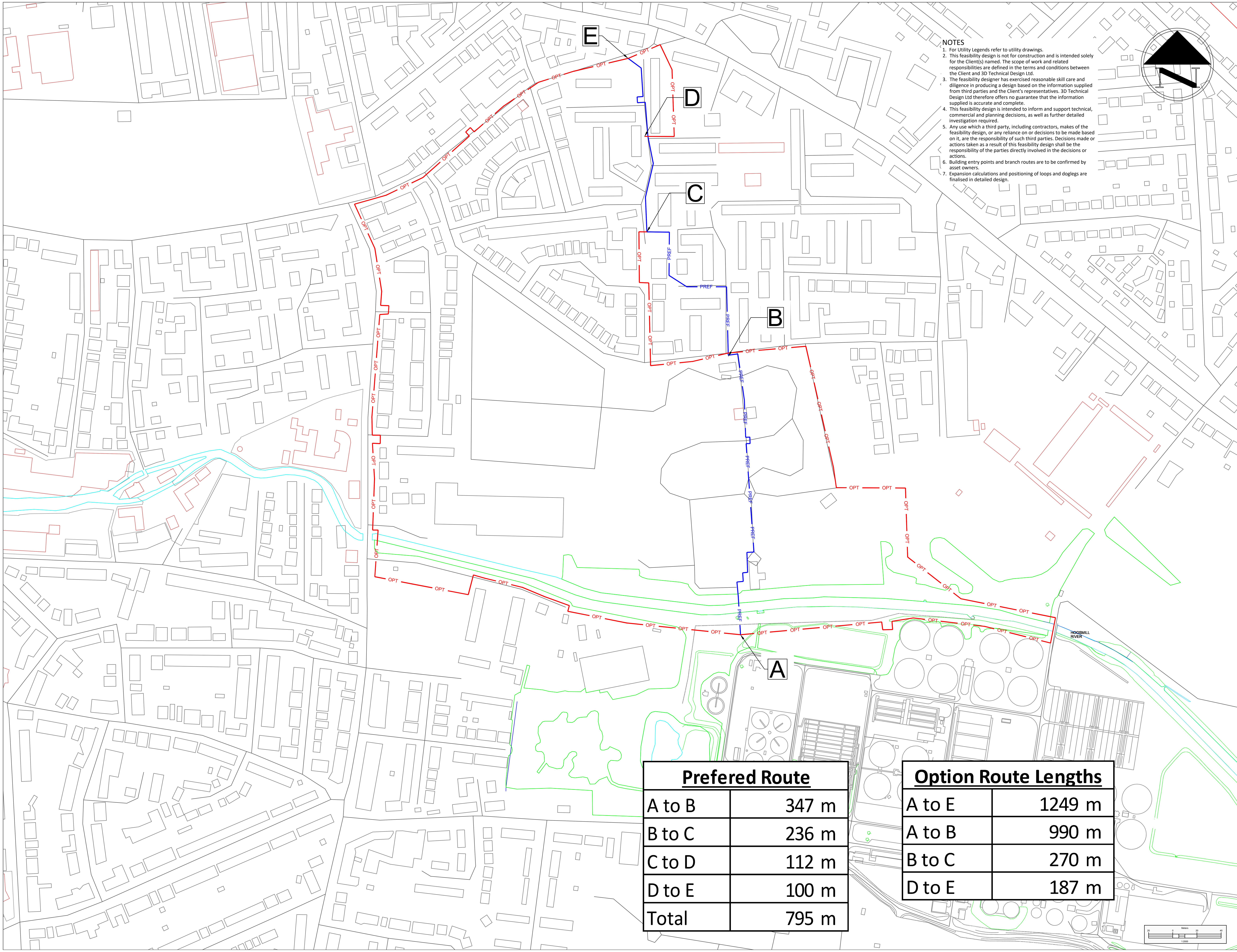
8. Client to agree preferred and optional route,
9. Start consultations with all stakeholders,
10. Produce utility survey area drawing for preferred route, once preferred route agreed,
11. Carry out underground utility survey to PAS128,
12. General Arrangement and Detailed Design from utility survey to confirm network route, potential asset diversions and traffic management requirements,
13. Production of design and commercial risks with associated costs,
14. Support in costing preferred route.

14. Appendix 1 – Drawings Produced

6384-3DTD-UU-DH-DR-Y-1001	District Heating Route Option Appraisal - Preferred and Optional Routes
6384-3DTD-UU-DH-DR-Y-1002	District Heating Route Option Appraisal - Preferred and Optional Route with Identified HAZID's

15. Appendix 2 – HAZID Report

See Document 6384-3DTD-OP-DH-HA-Y-10001



NOTES
1. For Utility Legends refer to utility drawings.
2. This feasibility design is not for construction and is intended solely for the Client(s) named. The scope of work and related responsibilities are defined in the terms and conditions between the Client and 3D Technical Design Ltd.
3. The feasibility designer has exercised reasonable skill care and diligence in producing a design based on the information supplied from third parties and the Client's representatives. 3D Technical Design Ltd therefore offers no guarantee that the information supplied is accurate and complete.
4. This feasibility design is intended to inform and support technical, commercial and planning decisions, as well as further detailed investigation required.
5. Any use which a third party, including contractors, makes of the feasibility design, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Decisions made or actions taken as a result of this feasibility design shall be the responsibility of the parties directly involved in the decisions or actions.
6. Building entry points and branch routes are to be confirmed by asset owners.
7. Expansion calculations and positioning of loops and doglegs are finalised in detailed design.

Prefered Route	
A to B	347 m
B to C	236 m
C to D	112 m
D to E	100 m
Total	795 m

Option Route Lengths	
A to E	1249 m
A to B	990 m
B to C	270 m
D to E	187 m

Legend

Proposed Routes

PREF — Proposed Main Spine

OPT — Optional Routes

Outline position of expansion dogleg - Located to account for buried structure/utility risk

Outline position of expansion loop - Located to account for buried structure/utility risk

Misc Text Symbols

11, Hazid, Potential Risk — HAZID reference number

HAZID area identified

User Legend Notes

1. This drawing has been produced by overlaying existing utility drawings with the heat network route option developed by 3D-TD.
2. In some instances the utility company may have used the same colour as 3D-TD heat network route where clarity required please refer to relevant utility drawing and the separate dimension route drawing.
3. The quality of third party utility drawings varies.

Revision Details

Rev	Description	By	Date	Chk'd	Auth
P01	Original Issue	DJU	18/01/2020	KP	DJU

Work In Progress

THE ROYAL BOROUGH OF KINGSTON UPON THAMES

Client
Kingston upon Thames

Project
Kingston upon Thames OBC

Title
District Heating Route
Option Appraisal
Preferred and Optional Routes

Paper Size A1
Suitability S0
Scale 1:2000
Drawn JS 05.12.2019
Checked KP 05.12.2019
Authorised DJU 05.12.2019

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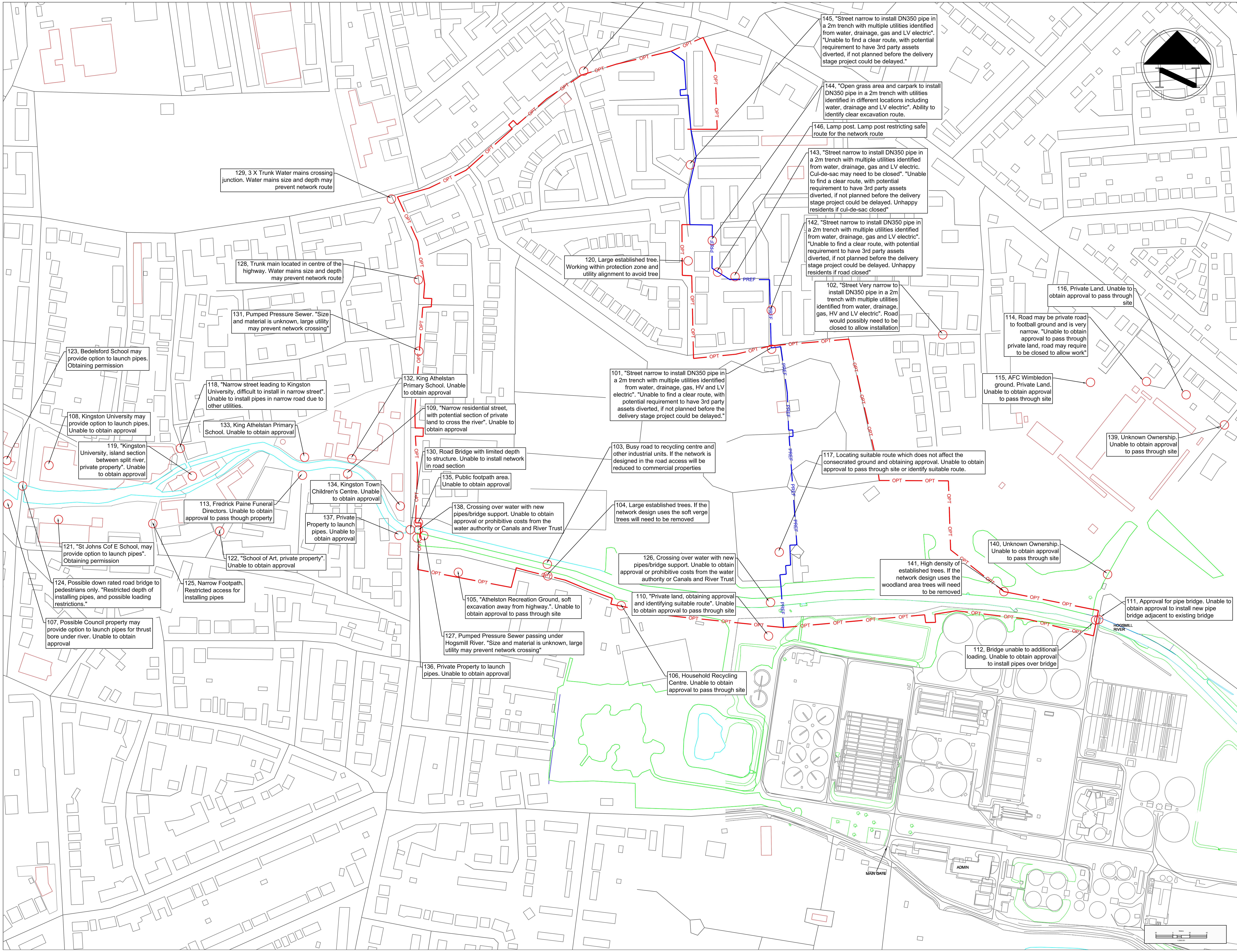
Tel: 07825 108940

Drawing Number
6384-3DTD-UU-DH-DR-Y-1001



Legend

Proposed Routes

PREF — Proposed Main Spine

OPT — Optional Routes

Outline position of expansion dogleg - Located to account for buried structure/utility risk

Outline position of expansion loop - Located to account for buried structure/utility risk

Misc Text Symbols

11, Hazid, Potential Risk — HAZID reference number

HAZID area identified

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Revision Details

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P01	Original Issue	DJU	18/01/2020	KP	DJU

Work In Progress

THE ROYAL BOROUGH OF KINGSTON UPON THAMES

Client: Kingston upon Thames

Project: Kingston upon Thames OBC

Title: District Heating Route Option Appraisal Preferred and Optional Routes with Identified HAZID's

Paper Size: A1

Suitability: S0

Scale: 1:2000

Drawn: JS 05.12.2019

Checked: KP 05.12.2019

Authorised: DJU 05.12.2019

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Drawing Number: 6384-3DTD-UU-DH-DR-Y-1002

Appendix 2 - HAZID Register

PROJECT	Kingston upon Thames OBC	Client:	London Borough of Kingston upon Thames	Document No:	6364-3DTD-OP-DH-HA-Y-10001
		Principle Contractor:	TBA	Suitability:	S1
		Lead Underground Designer	Buro Happhold	Revision:	P01

ID	Area of Hazard	Hazard Identified	Potential Risk	Control Measures	Response: Eliminate	Response: Detailed Design	Response: General Design	Response: Client Management	Client Stakeholder Notes
101	Bonner Hill Road	Street narrow to install DN350 pipe in a 2m trench with multiple utilities identified from water, drainage, gas, HV and LV electric	Unable to find a clear route, with potential requirement to have 3rd party assets diverted, if not planned before the delivery stage project could be delayed.	GA design at the early stage to assess restrictions to network route. If asset diversion is required start early consultation.	N/A	Yes	N/A	N/A	
102	Bonner Hill Road	Street Very narrow to install DN350 pipe in a 2m trench with multiple utilities identified from water, drainage, gas, HV and LV electric	Road would possibly need to be closed to allow installation	GA and detailed design required to prove route. If asset diversion is required start early consultation.	Not on Current Route	N/A	N/A	N/A	
103	Chapel Mill Road	Busy road to recycling centre and other industrial units	If the network is designed in the road access will be reduced to commercial properties	GA design at the early stage to assess restrictions to vehicle movement, early consultation with stake holders.	N/A	N/A	Yes	N/A	
104	Chapel Mill Road	Large established trees	If the network design uses the soft verge trees will need to be removed	Start consultation with the Arboriculture officer	N/A	N/A	Yes	N/A	
105	Chapel Mill Road	Athelston Recreation Ground, soft excavation away from highway.	Unable to obtain approval to pass through site	Start consultations as soon as possible and design	N/A	N/A	Yes	Yes	
106	Chapel Mill Road	Household Recycling Centre	Unable to obtain approval to pass through site	Start consultations as soon as possible and design	N/A	N/A	Yes	Yes	
107	Denmark Road	Possible Council property may provide option to launch pipes for thrust bore under river	Unable to obtain approval	Start consultations as soon as possible	Not on Current Route	N/A	N/A	N/A	
108	Grange Road	Kingston University may provide option to launch pipes	Unable to obtain approval	Start consultations as soon as possible	Not on Current Route	N/A	N/A	N/A	
109	Herbert Road	Narrow residential street, with potential section of private land to cross the river	Unable to obtain approval	Start consultations as soon as possible	Not on Current Route	N/A	N/A	N/A	
110	Hoggsmill Sewage Treatment Works	Private land, obtaining approval and identifying suitable route	Unable to obtain approval to pass through site	Start consultations as soon as possible	N/A	N/A	Yes	Yes	
111	Hoggsmill Sewage Treatment Works Bridge	Approval for pipe bridge	Unable to obtain approval to install new pipe bridge adjacent to existing bridge	Start consultations as soon as possible	N/A	Yes	N/A	Yes	
112	Hoggsmill Sewage Treatment Works Bridge	Bridge unable to additional loading	Unable to obtain approval to install pipes over bridge	Start consultations as soon as possible and investigate if bridge can take additional loading.	N/A	Yes	N/A	Yes	
113	Horace Road	Fredrick Paine Funeral Directors	Unable to obtain approval to pass though property	Start consultations as soon as possible	Not on Current Route	N/A	N/A	N/A	
114	Jack Goodchild Way	Road may be private road to football ground and is very narrow	Unable to obtain approval to pass through private land, road may require to be closed to allow work	Start consultations as soon as possible, GA design at the early stage to confirm if the road does not require to be closed.	Not on Current Route	N/A	N/A	N/A	
115	Jack Goodchild Way	AFC Wimbledon ground. Private Land	Unable to obtain approval to pass through site	Start consultations as soon as possible	Not on Current Route	N/A	N/A	N/A	
116	Jack Goodchild Way	Private Land	Unable to obtain approval to pass through site	Start consultations as soon as possible	Not on Current Route	N/A	N/A	N/A	

Appendix 2 - HAZID Register

ID	Area of Hazard	Hazard Identified	Potential Risk	Control Measures	Response: Eliminate	Response: Detailed Design	Response: General Design	Response: Client Management	Client Stakeholder Notes
117	Kingstone Cemetery & Crematorium	Locating suitable route which does not affect the consecrated ground and obtaining approval	Unable to obtain approval to pass through site or identify suitable route.	Start consultations as soon as possible	N/A	N/A	Yes	Yes	
118	Mill Street	Narrow street leading to Kingston University, difficult to install in narrow street	Unable to install pipes in narrow road due to other utilities.	Utility survey and GA design required to confirm section of the route.	Not on Current Route	N/A	N/A	N/A	
119	Mill Street	Kingston University, island section between split river, private property	Unable to obtain approval	Start consultations as soon as possible	Not on Current Route	N/A	N/A	N/A	
120	Piper Road	Large established tree	Working within protection zone and utility alignment to avoid tree	GA design at the early stage to assess restrictions to tree and utilities.	Not on Current Route	N/A	N/A	N/A	
121	Portland Road	St Johns Cof E School, may provide option to launch pipes	Obtaining permission	Start consultation to see if feasible	Not on Current Route	N/A	N/A	N/A	
122	Portland Road	School of Art, private property	Unable to obtain approval	Start consultations as soon as possible	Not on Current Route	N/A	N/A	N/A	
123	Springfield Road	Bedelsford School may provide option to launch pipes	Obtaining permission	Start consultation to see if feasible	Not on Current Route	N/A	N/A	N/A	
124	Springfield Road	Possible down rated road bridge to pedestrians only	Restricted depth of installing pipes, and possible loading restrictions.	Avoid if possible, if selected for route obtain structural information or have structural survey carried out.	Not on Current Route	N/A	N/A	N/A	
125	Three Bridges Path	Narrow Footpath	Restricted access for installing pipes	Use different route, not suitable to install large pipes	Not on Current Route	N/A	N/A	N/A	
126	Thames Water/Cemetery Crossing	Crossing over water with new pipes/bridge support	Unable to obtain approval or prohibitive costs from the water authority or Canals and River Trust	Start consultations as soon as possible	N/A	Yes	N/A	Yes	
127	Villiers Road	Pumped Pressure Sewer passing under Hogsmill River	Size and material is unknown, large utility may prevent network crossing	Utility survey and GA design required to confirm section of the route.	N/A	N/A	Yes	N/A	
128	Villiers Road	Trunk main located in centre of the highway	Water mains size and depth may prevent network route	Utility survey and GA design required to confirm section of the route.	N/A	N/A	Yes	N/A	
129	Villiers Road	3 X Trunk Water mains crossing junction	Water mains size and depth may prevent network route	Utility survey and GA design required to confirm section of the route.	N/A	N/A	Yes	N/A	
130	Villiers Road	Road Bridge with limited depth to structure	Unable to install network in road section	Obtain structural information from highways or others and assess structure for the ability to install network.	Not on Current Route	N/A	N/A	N/A	
131	Villiers Road	Pumped Pressure Sewer	Size and material is unknown, large utility may prevent network crossing	Utility survey and GA design required to confirm section of the route.	N/A	N/A	Yes	N/A	
132	Villiers Road	King Athelstan Primary School	Unable to obtain approval	Start consultations as soon as possible	Not on Current Route	N/A	N/A	N/A	
133	Villiers Road	King Athelstan Primary School	Unable to obtain approval	Start consultations as soon as possible	Not on Current Route	N/A	N/A	N/A	
134	Villiers Road	Kingston Town Children's Centre	Unable to obtain approval	Start consultations as soon as possible	Not on Current Route	N/A	N/A	N/A	
135	Villiers Road	Public footpath area	Unable to obtain approval	Start consultations as soon as possible	N/A	N/A	Yes	Yes	
136	Villiers Road	Private Property to launch pipes	Unable to obtain approval	Start consultations as soon as possible	N/A	N/A	Yes	Yes	
137	Villiers Road	Private Property to launch pipes	Unable to obtain approval	Start consultations as soon as possible	Not on Current Route	N/A	N/A	N/A	
138	Villiers Road Bridge	Crossing over water with new pipes/bridge support	Unable to obtain approval or prohibitive costs from the water authority or Canals and River Trust	Start consultations as soon as possible, and outline design requirements	N/A	Yes	N/A	Yes	

Appendix 2 - HAZID Register

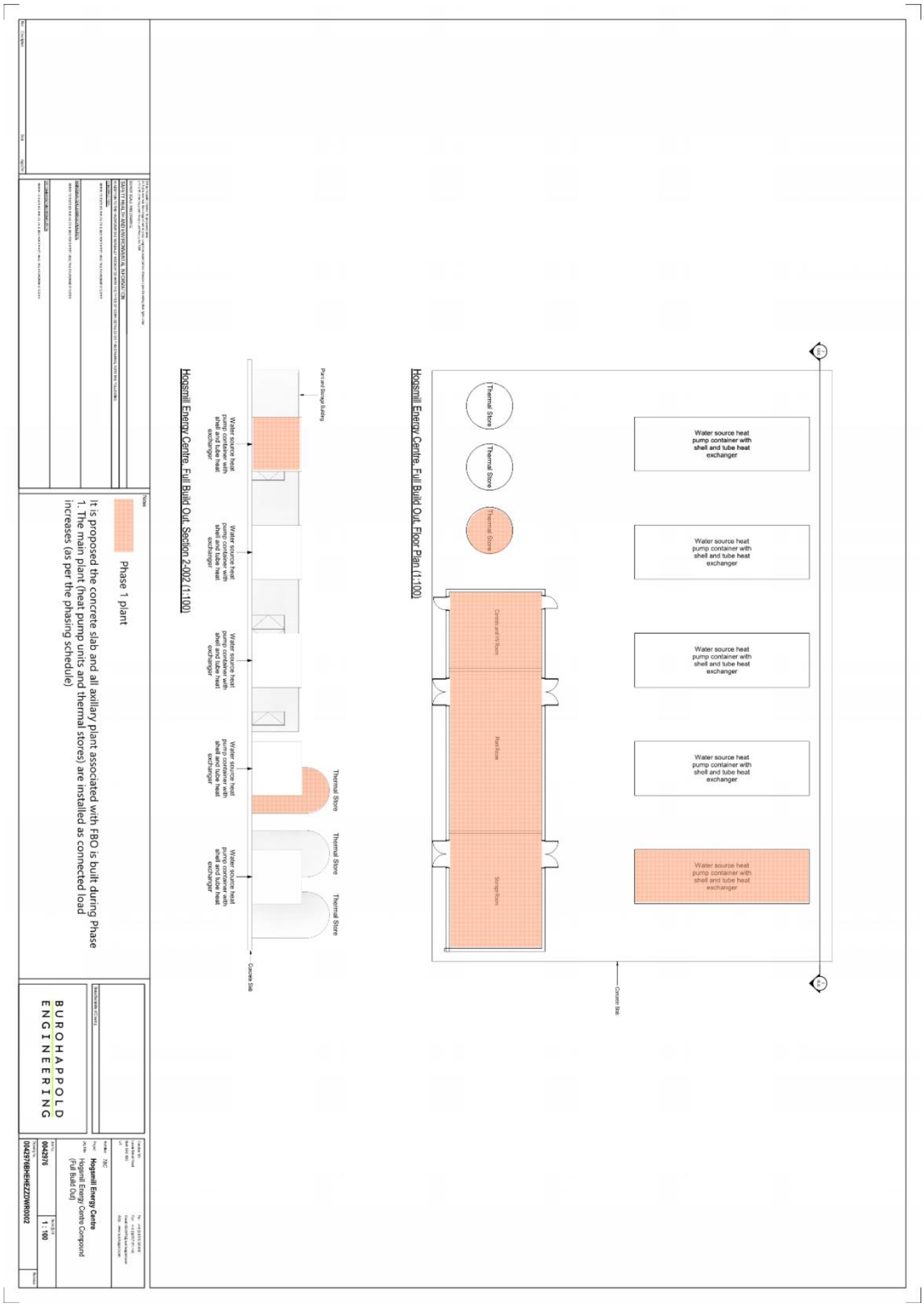
ID	Area of Hazard	Hazard Identified	Potential Risk	Control Measures	Response				Client Stakeholder Notes
					Eliminate	Detailed Design	General Design	Client Management	
139	Waste Land	Unknown Ownership	Unable to obtain approval to pass through site	Start consultations as soon as possible	Not on Current Route	N/A	N/A	N/A	
140	Waste Land	Unknown Ownership	Unable to obtain approval to pass through site	Start consultations as soon as possible	Not on Current Route	N/A	N/A	N/A	
141	Woodland	High density of established trees	If the network design uses the woodland area trees will need to be removed	Start consultation with the Arboriculture officer	N/A	N/A	Yes	Yes	
142	Willingham Way	Street narrow to install DN350 pipe in a 2m trench with multiple utilities identified from water, drainage, gas and LV electric	Unable to find a clear route, with potential requirement to have 3rd party assets diverted, if not planned before the delivery stage project could be delayed. Unhappy residents if road closed	GA and detailed design at the early stage to assess restrictions to network route, plan road closure and early consultation with residents. If asset diversion is required start early consultation	N/A	Yes	Yes	N/A	
143	Franklin Close	Street narrow to install DN350 pipe in a 2m trench with multiple utilities identified from water, drainage, gas and LV electric. Cul-de-sac may need to be closed	Unable to find a clear route, with potential requirement to have 3rd party assets diverted, if not planned before the delivery stage project could be delayed. Unhappy residents if cul-de-sac closed	GA and detailed design at the early stage to assess restrictions to network route, plan road closure and early consultation with residents. If asset diversion is required start early consultation	N/A	Yes	Yes	N/A	
144	Pipe Hall Grass and Carpark Area	Open grass area and carpark to install DN350 pipe in a 2m trench with utilities identified in different locations including water, drainage and LV electric	Ability to identify clear excavation route.	GA design at the early stage to assess restrictions to network route.	N/A	N/A	Yes	N/A	
145	Washington Road	Street narrow to install DN350 pipe in a 2m trench with multiple utilities identified from water, drainage, gas and LV electric	Unable to find a clear route, with potential requirement to have 3rd party assets diverted, if not planned before the delivery stage project could be delayed.	GA and detailed design at the early stage to assess restrictions to network route. If asset diversion is required start early consultation.	N/A	Yes	Yes	N/A	
146	Franklin Close	Lamp post	Lamp post restricting safe route for the network route	Allow for removal and replacing during construction	N/A	N/A	N/A	Yes	
147	Hawks Road	Busy two way road to install DN350 pipe in a 2m trench with multiple utilities identified from water, drainage, gas, HV and LV electric"	Unable to find a clear route, with potential requirement to have 3rd party assets diverted, if not planned before the delivery stage project could be delayed.	GA design at the early stage to assess restrictions to network route. If asset diversion is required start early consultation. There is significant soft area to the south of Hawks Road which may belong to a government department, land ownership should be identified.	N/A	N/A	Yes	N/A	

Library File Number -1000_3DTD_TE_0013_HAZID DTS

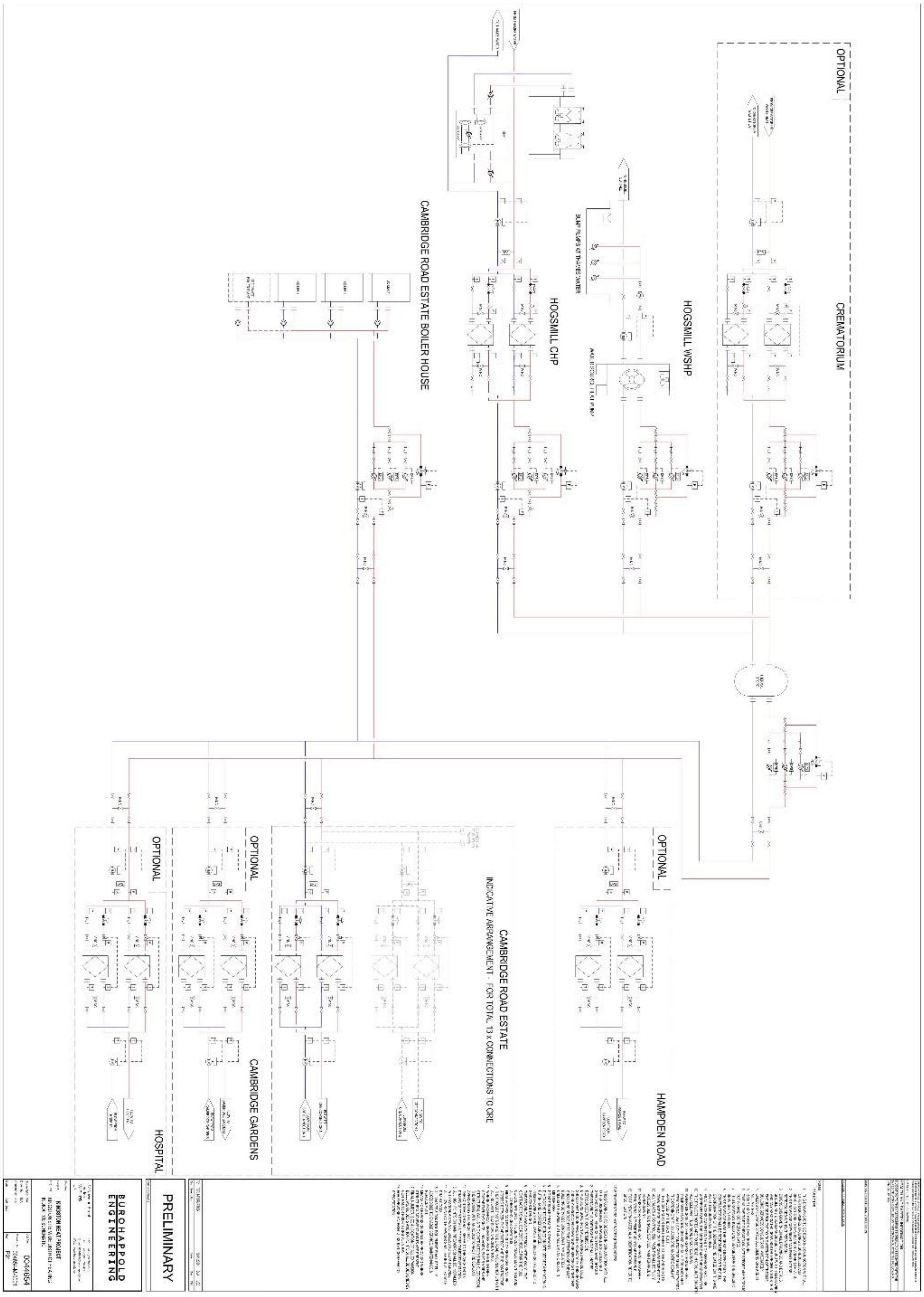
Detail	Rev	Date Reviewed	Reviewed By	Date Checked	Checked By	Next Review
Original	1	17/05/2017	C Grobety			May-18
Revision	2	06/07/2017	N Grobety			Jul-18
Re-format and order of columns	3	07/11/2018	DJU	07/11/2018	KP	Nov-19

Appendix F Drawings

F.1 Energy Centre layout



F.2 Network schematic



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