


London Borough of Southwark
Energy mapping and masterplanning

Addendum - Appraisal of opportunities for heat offtake from public sewers

Final - May 2020

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Document Verification

Project Title	London Borough of Southwark - Energy mapping and masterplanning	Job Number	263349-00
Report Title	Addendum - Appraisal of opportunities for heat offtake from public sewers	File Reference	

Revision	Date		Prepared By	Checked By	Approved By
Draft Issue	**16/04/2020**	Name	Kirsty Smyth	Alban Leiper	Stephen Cook
		Signature			
Final Issue	**14/05/2020**	Name	Kirsty Smyth	Alban Leiper	Ben Smith
		Signature			
		Name			
		Signature			

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Appraisal of opportunities for heat offtake from public sewers

1. Introduction

Initial study

In 2019, Arup was appointed by the London Borough of Southwark to undertake a *Heat Mapping and Energy Masterplanning* study to support the Council in understanding opportunities for new district heating networks or to decarbonise their existing systems.

Part of this initial study explored the opportunity for Earl's Sluice combined river and sewer to provide heat to the nearby Wyndham Estate. The study showed no 40-year rate of return and negative 40-year Net Present Value (NPV) for the particular scheme. It was however identified that extracting heat from Thames Water (TWUL) public sewers may provide Southwark Council with valuable opportunities to transition the supply of heat to some of its largest residential properties to a lower carbon source.

Current addendum

Arup was then commissioned to undertake a further study to appraise opportunities for using heat offtake from public sewers to feed into large residential developments across Southwark. This addendum to the 2019 report identifies five of the most suitable "energy from sewer" opportunities for Southwark and compares these in terms of both cost and carbon.

Technology overview

Sewer source heat pumps (SSHPs) are an emerging technology which take low-grade heat from waste water pipework, through a heat exchanger either wrapped around pipework or placed within an area into which flow has been diverted. A SSHP uses electricity to turn this low-temperature heat into higher-temperature heat which can be supplied to buildings.

Overview of study

This study involved engagement with TWUL to understand where sewers are located in Southwark. Whilst TWUL were able to provide a map of existing sewers (see Figure 1), they do not have a way of monitoring flow in their network and can only do so for specific point locations.

Using the map and knowledge of the location/scale of Southwark's heat loads, five potential SSHP schemes were identified for further investigation (see Figure 1):

A. Barset Estate,
B. North Peckham Estate,
C. Aylesbury Proposed Development,
D. Brimmington Estate, and
E. Kingslake Estate.

This addendum report provides an overview of the methodology used to identify these five schemes as well as the techno-economic and carbon modelling used to compare the solutions. It provides an overview of the costs, revenues and key risks associated with the recommended scheme.

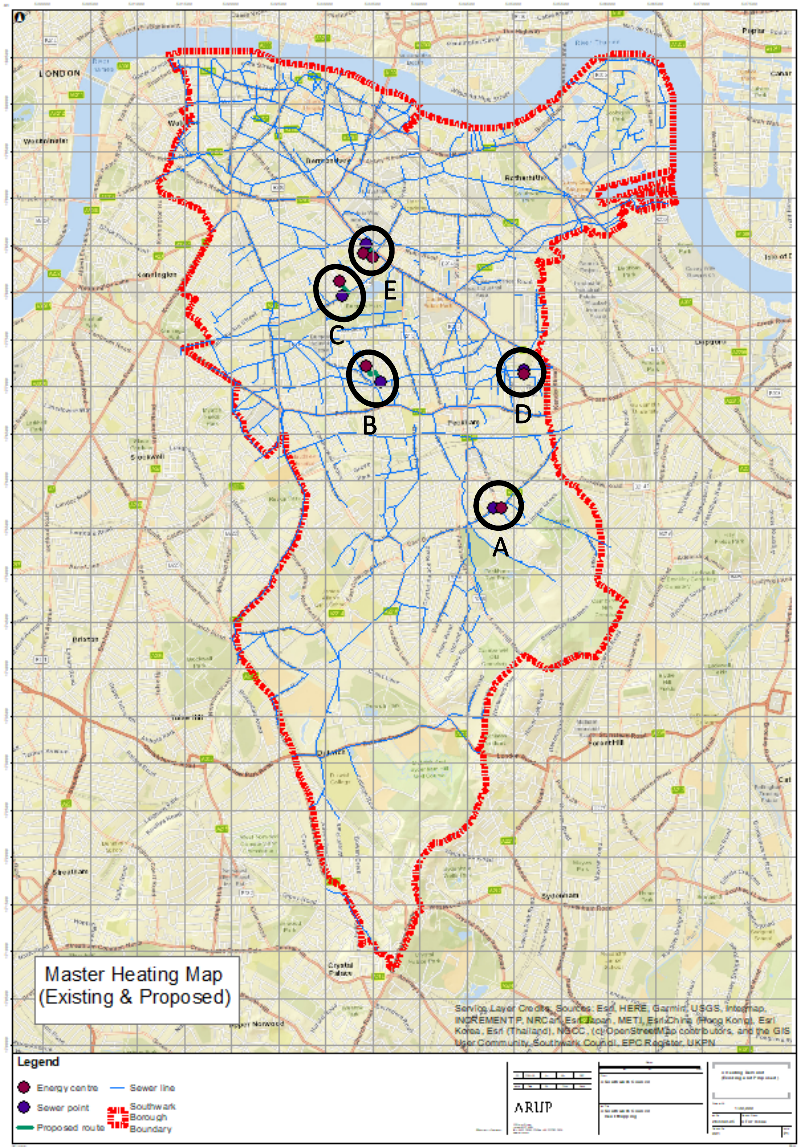

Figure 1: Overview of proposed scenarios

Appraisal of opportunities for heat offtake from public sewers

2. Supply options longlist

To identify potential points for heat offtake from TWUL public sewers, wastewater pipework maps were obtained and overlaid with heat consumption data for Southwark residential estates and proposed developments as shown in Figure 2.

Through discussion with Southwark Council, this map was used to initially identify 20 potential opportunities for further investigation, based on where a high-flow rate sewer may be located close to a heat load with high annual consumption (the top 10 of which are shown in Table 1). The 20 sewer points were therefore selected to include:

- Points on the wastewater network within close proximity to at least one of the borough's residential heat loads (highlighted red in Figure 2), and
- Points on trunk wastewater mains deemed likely to have a flow rate (highlighted amber in Figure 2).

The chosen sewer point co-ordinates were provided to TWUL who subsequently provided the following data for each point:

- Sewer diameter,
- Daytime peak flow rate, and
- Night time low flow rate.

	Name	Heat consumption (GWh/year)	Type
a	North Peckham Estate	21.1	Existing
b	Wyndham Estate	18.1	Existing
c	Brandon Estate	12.4	Existing
d	Brimmington Pomeroy	11.2	Existing
e	Consort Road Development	11.2	Existing
f	Aylesbury Estate	8.3	Proposed
g	Lettsom Street Development	8.3	Existing
h	D'Eynsford Road	7.6	Existing
i	Cossal Estate	7.5	Existing
j	New Kent Road	7.2	Proposed
k	Setchell Development	6.3	Existing
l	Newington Development	5.5	Existing
m	Barset Estate	5.1	Existing
n	Havil Street Estate	4.8	Existing

Table 1: Top Southwark residential heat loads

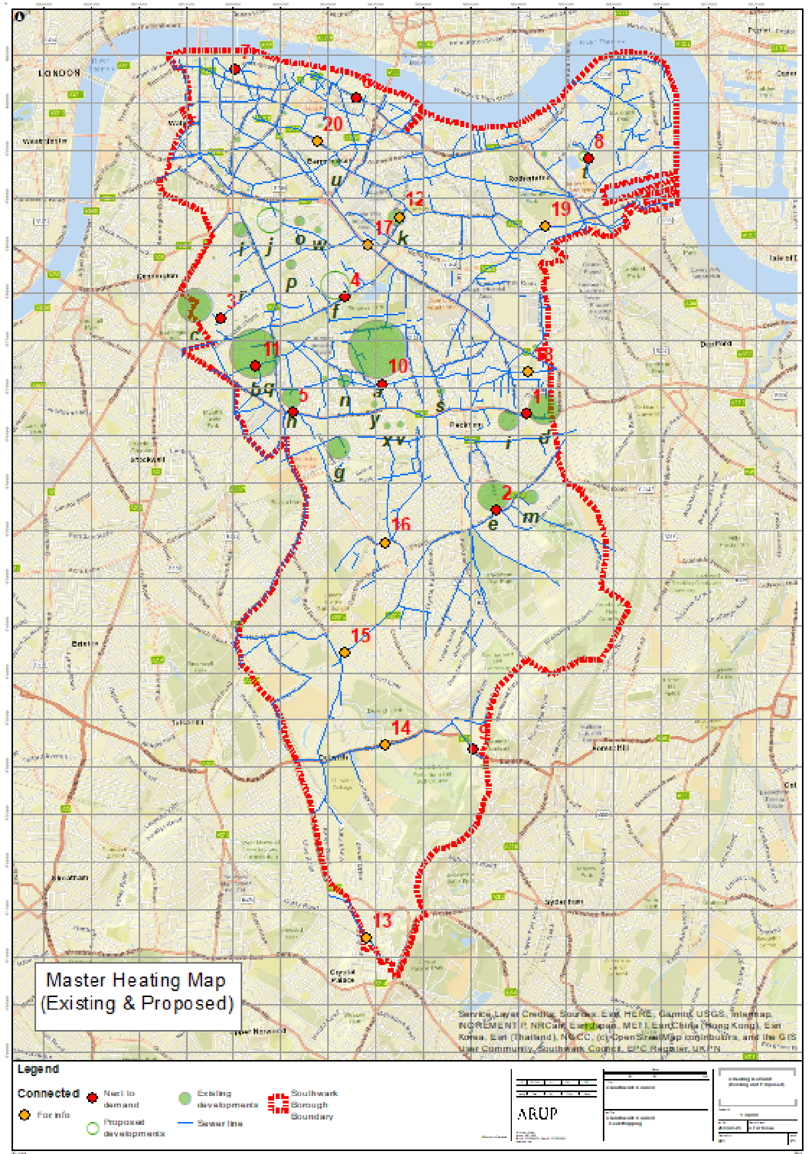

Figure 2: Southwark-owned residential estate heat loads, Thames Water sewer maps and sewer points for investigation

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Appraisal of opportunities for heat offtake from public sewers

2. Supply options longlist

For each of the identified sewer points, the heat recovery potential was estimated and used to identify the proportion of heat load of the closest Southwark residential development that it could meet.

Underpinning assumptions

The following assumptions were used to underpin this analysis:

- Calculations assume a sewer source heat pump (SSHP) technology that re-directs up to 50% of the sewer flow through a plate heat exchanger supplying low-grade heat. This is opposed to other SSHP technologies such as wrap-around systems and was assumed as Arup industry engagement shows this to be the most commonly available on the UK marketplace.
- An average temperature drop of 5ºC was assumed for the abstracted sewer water to inform the sewer heat output.
- For the initial assessment of available heat output, a network flow and return temperature of 90/70ºC has been assumed as a conservative estimate. This is later refined when more details of the specific schemes are understood.

Schemes shaded green and starred in Table 2 were identified as the most promising SSHP schemes and were explored further.

Sewer point	X	Y	Average flow rate	Heat available (GWh/year)	Purpose	Reference load	Percentage of load
1	535089	176730	2.7	0.4	Next to demand	Brimmington Estate	3%
2*	534783	175707	179.0	26.1	Next to demand	Barset Estate	233%
3	531882	177734	5.5	0.8	Next to demand	Brandon Estate	6%
4*	533178	177958	911.0	132.7	Next to demand	Aylesbury Estate	1598%
5	532642	176738	6.5	0.9	Next to demand	D'Eynsford Road	13%
6	533297	180055	Unavailable	-	Next to demand	Tooley Street Offices	-
7	532033	180353	Unavailable	-	Next to demand	Bankside House	-
8	535752	179414	9.5	1.4	Next to demand	Decathlon And What	44%
9	534532	173192	4.5	0.7	Next to demand	Sydenham Hill Estate	27%
10*	533584	177041	1361.0	198.2	Next to demand	North Peckham Estate	941%
11	532244	177225	4.5	0.7	Next to demand	Wyndham Estate	4%
12	533764	178800	2.0	0.3	For info		
13	533416	171203	7.0	1.0	For info		
14	533602	173238	19.5	2.8	For info		
15	533177	174208	101.0	14.7	For info		
16	533603	175369	21.5	3.1	For info		
17*	533428	178503	133.5	19.4	Next to demand	Kingslake	173%
18*	535211	177178	1420.0	206.8	Next to demand	Brimmington Estate	5712%
19	535296	178701	130.0	18.9	For info		
20	532891	179600	53.0	7.7	For info		

Table 2: Sewer points for investigation

Appraisal of opportunities for heat offtake from public sewers

3. Supply options shortlist

Figure 1 shows the location of each of the five most promising schemes for sewer heat take-off across Southwark. Key data associated with each scheme is captured in Table 3.

Plant capacity

Table 3 shows that each of the sewer points has sufficient flow rate to surpass the consumption of the associated development. To account for demand peaks and for periods of maintenance and plant servicing, it was assumed that 80% of site heat consumption would be met by SSHP with a capacity of 50% of the peak site heat demand.

Analysis is based on the assumption that there is sufficient space within existing energy centres to house the new heat pump and associated ancillaries in each instance. This study also assumes that there is sufficient space next to sewer offtake points to install heat exchangers and pipework.

Peaking and back-up supply

The remaining heat supply will be met by gas boilers in all instances. For comparative purposes, and because boilers are already installed in the majority of the energy centres, the cost associated with backup boiler plant has not been included in this study. However, the gas required to meet peaks and periods of SSHP downtime is included.

Pipework sizing

Each of the developments are either proposed to be, or are already, served from existing energy centres with existing distribution pipework to serve dwellings. Heat pumps are assumed to be located within existing energy centres. As such, connecting the sewer source supply would require low grade plastic pipework from the sewer to the energy centre but would not require new distribution level pipework to be installed. Flow and return pipework is assumed to be 80/70°C for existing schemes and 60/30°C for proposed developments. This assumption needs corroboration on site – schemes may require modification to enable these temperature regimes.

Pipework lengths for low-grade heat supply were calculated using ArcGIS and thermal losses of 10% were assumed on this primary system pipework. Given temperatures are closer to ambient in this low grade pipework, this assumption is considered to be conservative.

	Scheme	Flow / return (°C)	Installed SSHP capacity (kW)	Anticipated output from SSHP (kWh/year)	Development heat consumption (kWh/year)	Development heat demand (kW)	Low-grade heat pipework length (m)
A	Barset Estate	80/70	1,670	4,109,000	5,136,000	3,348	120
B	North Peckham Estate	80/70	4,740	16,848,000	21,060,000	9,490	284
C	Aylsebury Proposed Development	60/30	5,290	6,643,000	8,304,000	10,590	248
D	Brimmington Estate	80/70	3,000	8,969,000	11,211,000	6,010	77
E	Kingslake Estate	80/70	900	2,896,000	3,620,000	1,790	351

Table 3: Supply options shortlist

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Appraisal of opportunities for heat offtake from public sewers

4. Techno-economic modelling introduction

Methodology

A discounted cashflow economic modelling approach, following FAST standard principles, was used to compare the relative cost and carbon implications for each of the five SSHP opportunities presented above.

Key outputs from the techno-economic analysis include:

Lifetime CO_2 emissions:

Analysis compared carbon emissions of each scheme to a baseline for 15-years and 40-years using published carbon intensity factors such as BEIS, SAP 2012 and SAP 10 (see Table 4).

40-year net present value (NPV):

This is the cumulative sum of all the cash flows for the scheme at the present-day rate, taking account of the time value of money.

25, 30 and 40-year internal rates of return (IRR):

Considered alongside a given discount rate (DR), the IRR indicates whether the NPV of a given cashflow will be positive (IRR > DR), negative (IRR < DR) or 0 (IRR = DR). Current modelling assumes a 6% DR under the assumption that Southwark will fund, own and operate the scheme.

Levelized Cost of Heat (LCOH)

The LCOH (in pence per kWh) evaluates all the discounted costs associated with producing heat over a 40-year period on a per unit heat delivered basis.

Network revenues

Scenarios A, B, D and E are existing schemes, the annual revenues received from each was based on data collected from the Council under the previous study and is assumed to remain the same. To protect tenants from volatility in heat price, this study assumes that the heat tariff paid by residents is not affected by the change in supply technology. For the Aylesbury proposed development (Scenario C) a variable heat price of 0.044£/kWh and a fixed charge of 18£/kW/year is assumed. This would be subject to negotiation later.

The techno-economic analysis provides a comparison with the business as usual (BAU) use of gas boilers in each scenario. Therefore, for each of the existing schemes the cost of gas saved through installation of the development is included in the model as a revenue.

Commodity costs

Gas and electricity costs were calculated by averaging figures for the last 4 quarters using BEIS Table 3.4.1. This gives electricity costs of 10.61p/kWh and gas costs of 2.49p/kWh. No inflation has been applied to model.

As TWUL are not expected to contribute to the capital costs associated with the installation of the SSHP plant, it is assumed that there is no cost for the low-grade heat extracted from the sewer.

Capital costs

Costs associated with the heat extraction from the sewer were estimated through discussion with Landmark Waste Water solutions. The cost of the heat pump was taken from quotations given by the supplier Solid Energy. The techno-economic analysis includes costs for new pumps and controls to be installed however assumes that boilers for back up supply and thermal stores are already included in existing developments or accounted for in infrastructure cost plans for the proposed development.

Using a quote from Eneteq, a cost of 1,250£/m was identified for low-grade heat pipework and it was assumed that distribution level pipework is already installed, or else costed for, for each scheme.

Connection costs of £50/kW are assumed.

Carbon savings calculations

To compare the predicted carbon emissions for each scenario with the BAU use of gas, carbon intensity factors were taken from BEIS and Standard Assessment Procedure (SAP) 10. These values are summarised in Table 4. For each of the scenarios tested, guidance from HNDU Appendix D was used to calculate carbon savings using each supply technology.

SAP 10 values are representative of the 3-year average carbon factors published in 2019 and are likely to replace SAP 2012 values in Part L of the Building Regulations when next updated. SAP values are fixed for the life of the project. Meanwhile, HNDU factors change to reflect changes in grid composition but are not as up to date as SAP 10.

Input	HNDU	SAP 10
Gas factor (gCO_2e/kWh)	204	210
Electricity factor (gCO_2e/kWh)	Predicted figures used	233

Table 4. Carbon intensity factors

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Appraisal of opportunities for heat offtake from public sewers

5. Techno-economic results

Economic results

As shown in Table 5 and Figure 3, none of the five schemes has a positive NPV based on a 6% discount rate. This shows that the costs saved from not purchasing gas do not pay back for the capital costs of the plant. Similarly, none of the schemes have a positive IRR showing that they do not provide a return on investment.

Carbon results

All five schemes show significant carbon savings for Southwark Council. Installation of any one or combination of the schemes will result in operational carbon savings of approximately 70% compared to BAU using HNDU figures.

Recommended scheme

Figure 4 shows the costs of heat production per unit carbon savings associated with each scheme. North Peckham Estate and Brimmington Estate have the lowest costs per carbon saving. As Brimmington Estate has a higher IRR and NPV, it is recommended as the preferred option to Southwark Council. The Council may wish to pursue multiple sewer heat offtake opportunities in which case, North Peckham Estate may be considered as the second best option.

	Scenario	Average annual heat consumption (GWh/year)	CAPEX (£k)	40yr NPV (£k)	40yr IRR	LCOH (£/kWh)	BEIS lifetime carbon emissions		SAP 10 lifetime carbon emissions	
							BEIS savings (tCO_2e) 40 year	BEIS (%) 40 year	SAP 10 savings (tCO_2e) 40 year	SAP 10 (%) 40 year
A	Network 1 - Barset Estate	5.1	3,700	-4,000	None	0.10	39,800	72%	167,900	54%
B	Network 2 - North Peckham Estate	21.1	10,300	-14,400	None	0.08	162,100	71%	753,200	51%
C	Network 3 - Aylesbury Proposed Development	8.3	11,400	-8,000	-2.1%	0.15	60,500	72%	216,000	57%
D	Network 4 - Brimmington	11.2	6,400	-6,300	None	0.08	87,000	72%	366,500	54%
E	Network 5 - Kinglake	3.6	2,400	-2,900	None	0.09	28,100	72%	118,400	54%

Table 5. Summary of results

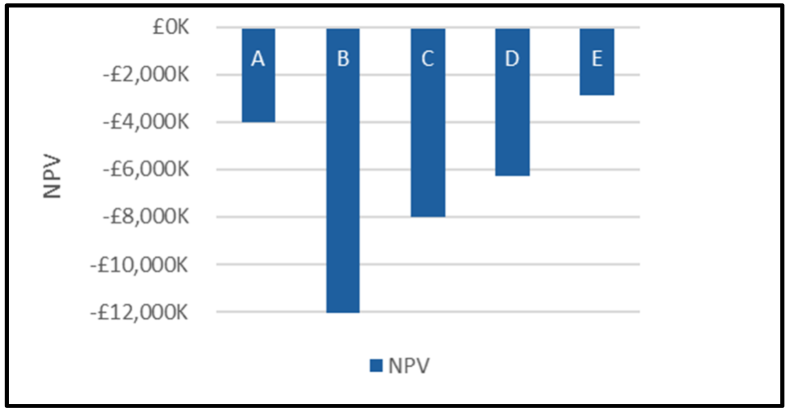

Figure 3: Key economic findings

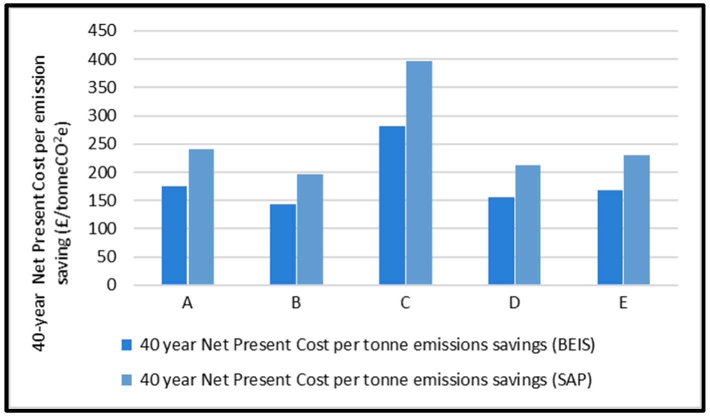

Figure 4: Cost and carbon comparison

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Appraisal of opportunities for heat offtake from public sewers
6. Results breakdown

Table 6, Figure 5 and Figure 6 show the breakdown of capital costs, operational costs and revenue respectively for each scenario.

The majority of capital costs are due to the installed plant. Although much of the backup supply and pumping equipment is already installed, plant capital costs remain high as SSHPs are a relatively young technology within the heat supply marketplace.

The majority of scheme operational costs are due to the purchase of electricity. At some point in the near future, policy requirements are likely to mean that Southwark properties will have to move away from a dependency on gas as the primary heating fuel. The coefficients of performance associated with heat pumps mean that the electricity required to supply the SSHP is approximately a third of that required if the heat supply is provided primarily from electric boilers.

Scenario 3 has no gas consumption as it is a new development where it is assumed no gas boiler back up is used on site due to the planning obligations imposed by the council.

As it can be seen, the new operational costs are mostly higher (or only very slightly lower) than the revenues of schemes (which are based on the assumption that revenues remain the same as they are today, i.e. no customer detriment).

In the case of Aylesbury, the scheme is profitable, but not to the extent that it is able to pay back the capital investment over the life time of the project. However, this development will need a heating system of some sort, and the sewer option should be compared with alternative solutions for that location.

A government extension to the Renewable Heat Incentive (RHI) scheme was announced after the completion of this study. There may therefore be opportunities for further revenue streams to be available to Southwark Council through installation of a SSHP scheme. This is captured as a risk in Table 7 overleaf. However, the scheme as it stands does not cover heat recovered from sewers. This may change with time.

	Network 1 – Barset Estate	Network 2 – North Peckham Estate	Network 3 – Aylesbury Proposed development	Network 4 – Brimmington	Network 5 – Kinglake
Building Connection Costs (£)	£167,425	£474,344	£529,494	£300,603	£89,722
Total EC Capital Costs (£)	£2,620,195	£7,423,479	£8,286,576	£4,704,433	£1,404,144
Network Pipe Costs (£)	£149,750	£355,000	£309,784	£96,125	£438,375
Project Costs (£)	£734,631	£2,057,442	£2,266,813	£1,259,397	£517,236
Total Capital costs (£)	**£3,672,001**	**£10,310,264**	**£11,392,666**	**£6,360,557**	**£2,449,477**
Gas costs (£)	£28,386	£116,390	-	£61,958	£20,007
Electricity costs	£154,839	£634,874	£250,324	£337,964	£109,130
Additional operational costs	£16,742	£47,434	£52,949	£30,060	£8,972
Total OPEX	**£199,968**	**£798,699**	**£303,273**	**£429,983**	**£138,108**
Total revenues	**£191,129**	**£548,430**	**£527,920**	**£433,365**	**£110,629**

Table 6: Scenarios costs breakdown

Appraisal of opportunities for heat offtake from public sewers

7. Key risks

Title	Risk description	Likelihood	Severity	Mitigation
Demand assessment risks				
D1 - Risk of lower heat consumption than expected	Incorrect assumptions related to building heat consumption could compromise the commercial viability of heat networks.	Low	Low	Real gas data used in majority of scenarios and therefore consumption data assumed to be broadly accurate. This risk is higher for the proposed Scenario C. Southwark Council to assess whether any large scale energy efficiency schemes have been rolled out before installing SSHP technology for a particular development.
Routing risks				
R1 - Existing Utilities	There is a risk of utilities or services bloacking or hindering the installation of low-grade heat pipework from the SSHP to the energy centre.	Medium	Medium	A Groundwise survey must be undertaken to fully understand utilities around a proposed sewer point before further development of any particular scheme goes ahead.
Supply risks				
S1 - SSHP immature technology	SSHPs are a relatively new technology and there is therefore a risk that there are unknown issues with the technology.	Low	Low	Landmark have installed solutions and the performance and challenges associated with these should be monitored and learning applied to this heat network if DCWW SSHP scenario is selected.
S2 - TWUL supply	There is a risk that TWUL could divert flows in future for unknown reasons or that pipework flow rates could change due to surface water management.	Low	Low	Early engagement with TWUL recommended.
S3 – Reduced/halted output from HP	The failure of heat pumps may result in the loss of heating for all buildings connected to the network.	Low	Low	Existing heat supply assumed as back up.
S4 - Gas grid	There is a risk that policy changes limit the availability of back-up gas supply to the site.	Low	Low	Installation of SSHPs reduces the gas consumed by Southwark and therefore reduces its vulnerability to changes in the gas market.
S5 - Space availability	The study assumes sufficient space is available within the existing plant rooms to house SSHPs. The study also assumes that there is sufficient space at sewer points to accommodate the required heat exchangers.	Medium	High	If Southwark council decide to persue any of the SSHP opportunities, a full assessment of the spatial requriements of proposed plant must be conducted.

Table 7: Key risks (continued overleaf)

Appraisal of opportunities for heat offtake from public sewers

7. Key risks

Title	Risk description	Likelihood	Severity	Mitigation
Techno-economic risks				
TE1 - CAPEX assumptions	Early stage assumptions have been made and there is a risk that CAPEX assumptions are too high or too low.	Medium	Medium	CAPEX assumptions taken from manufacturers' quotes where possible.
TE2 - Fuel prices risks	Changes to fuel prices (particularly electricity prices) could alter the economic performance of the scheme.	Medium	Low	Use of a heat pump reduces the electricity consumed compared to electric boilers meaning that Southwark Council will be less exposed to the effects of changes in commodity price. Dual fuel solution enables the council to optimise systems for cost if required.
TE3 - Heat tariffs	Southwark Council may decide that they wish to increase heat tariffs to make schemes more economically attractive. This may be unfavourable with tenants.	Medium	Medium	Early engagement with tenants recommended.
TE4 - Operational strategy	Techno-economic analysis is based on boilers within the site being used to back up heat pumps. There is a risk that if the heat network is not operated as following the operation strategy defined then emissions and running costs associated with the network will differ from those calculated.	Medium	High	Operation strategy to be defined for the site and future facilities team to be correctly trained to operate the installed technologies.
TE5 - RHI available for SSHPs	RHI funding has been extended for schemes installed before March 31 2022. If the proposed schemes are eligible the revenue received would be higher than anticipated for all scenarios.	Medium	Low	Current modelling is based on the assumption that no RHI funding is available and therefore, any changes to this would have positive economic implications for each scheme.
Commercial risks				
C1 - HNIP funding	HNIP funding may be considered for the supply options examined to a maximum of £5million as a grant fund. This can increase up to £10 million in the form of a loan.	Medium	Medium	Interested parties should consider the timescales of HNIP funding, along with the timescales of the phasing of the project to ensure that the funding can be obtained.
C2 - Commercial agreements with TWUL	Modelling assumes no capital contribution from TWUL and no cost of heat. TWUL may favour a different commercial model or expect payment for heat offtake.	Medium	High	Early engagement with TWUL recommended, they may consider a capital contribution in exchange for a payback due to revenues associated with low grade heat.

Table 7: Key risks (continued overleaf)

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Appraisal of opportunities for heat offtake from public sewers

8. Conclusions and next steps

Conclusions

The identification of the five locations explored in this study supports Southwark Council and TWUL in understanding the most appropriate developments for installation of SSHPs. Roll out of the technology in some or all of these sites will allow both the Council and TWUL to draw on learning from existing SSHP schemes and to play a part in demonstrating the use of heat take-off from public sewers in providing heat to residential properties in Southwark and more widely across London.

This study shows that all five of the explored scenarios will provide significant carbon emissions savings for Southwark Council. Any individual or combination of the schemes would reduce operational carbon emissions by approximately 70% using HNDU figures compared to the current use of gas boilers.

The study shows that none of the five schemes are economically favourable in comparison to the business-as-usual base-cases. Most of the schemes are not profitable when you calculate the new operational costs and compare them to the existing revenues.

For the Aylesbury development, the scheme is profitable, but at the highest capital cost it also does not pay back over the lifetime of the scheme. This solution should be compared to others for that location, since the development needs a heating system of some kind that meets the carbon emission reduction targets under the planning obligations.

Revenues from the recently extended RHI scheme could make the scheme more economically favourable.

Despite poor performance economically, the schemes have the potential to deliver strong additional social and environmental benefits such as improved local air quality through a reduction in gas combustion and lower carbon emissions. Whilst the monetary value of these benefits have not been included in the financial modelling, the council should consider them going forward – it may be that despite the lack of a return on investment, the council may still choose to invest as it deems these benefits to be worthy of the investment in themselves. This is particularly true when you consider that Southwark Council have declared a climate emergency and have set a target to be net zero carbon by 2030.

Next steps

Based on the outcomes of this study, it is recommended that Southwark Council follow the following next steps:

- Southwark Council to discuss their appetite for further exploration of SSHP opportunities within their residential developments.
- Energy centre drawings to be obtained for the plant rooms of the explored schemes and an assessment conducted to understand which of these sites have sufficient space for additional heat pump plant.
- Site visits should be made to each of the proposed sites and utility drawings obtained to understand potential barriers to installation of low-grade heat pipework.
- The Council should understand the scope for reducing heating supply temperatures at any of the sites listed here, as this would significantly improve heat pump efficiencies and therefore the economic performance of schemes.
- An assessment is required of the space available close to the sewer point for installation of heat exchangers.
- Data should be collected from each of the sewer points to verify temperature and flow rate assumptions.
- The Council should keep an eye on development of the potential new Government incentive scheme for the use of waste heat which would greatly improve financial performance of schemes.

There is an opportunity for a number of the steps outlined above to form part of a feasibility study and detailed project development funded by the Department for Business, Energy and Industrial Strategy (BEIS) through their Heat Network Delivery Unit (HNDU). Southwark Council should consider applying for HNDU funding to investigate the technical viability of the schemes.