ST JOHN THE DIVINE, SELSDON

Heating options study

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INTRODUCTION

The church was built in 1935-6 to the designs of Newberry and Fowler. The chancel and Lady Chapel were destroyed by bomb damage during the Second World War and were rebuilt to their original design in 1944.

The church is straightforward in plan with narrow projecting aisles. Although not nationally listed, the church is locally listed and has a plain but elegant interior with exposed timber roof trusses. All walls are solid brick, and the windows are single glazed with metal framing and stone mouldings.Vestries and tower are located at the north east corner and a Lady Chapel at the south east corner. There are porches at the north-west and south-west corners. There is a secondary entrance on the east side of the tower and a further porch at the east end of the north aisle.

A highly insulated garden room has been built on the south-west end of the nave, and is used extensively for community activities and meetings. The garden room is heated by on-peak electricity. A nearby church hall with air-source heat pumps is available for larger events.

The church heating system, which uses a gas-fired central boiler, suffered a major leak recently and although it proved possible to repair, it is likely that the remainder of the distribution pipework has a limited life. This report considers options for renewing the heating system.

Future plans need to take into account the effect of carbon emissions on global warming and the Church of England's aspirations for net zero carbon emissions. A target date of 2035 is the aim to achieve net zero within the Diocese of Southwark.

EXISTING HEATING

The present heating system is a Low Temperature Hot Water (LTHW) heating installation comprising a gas boiler within the basement boiler room, distribution pipework and a mixture of surface radiators and convectors built into the fabric of the walls.

The boiler is a 275kW gas-fired Clyde Combustion 505-8 boiler coupled with a Buderus burner manufactured in 1993. The boiler is therefore around 30 years old, and is at the end of its normal economic life. The boiler is a conventional type, and therefore will have a lower efficiency than a modern condensing boiler.

Even though the church is large, it is a large boiler and so would have provided ample capacity for heating

Boiler in basement boiler room

Heat emitters are a mixture of flat panel radiators, metal-encased convectors and convectors built into the walls of the nave. Built-in convectors are located below windows, with an air inlet grille at low level and an outlet grille in the window sill.

Double panel steel radiator

Radiator between two convector grilles

Encased convector behind grille. Valve and connection to radiator to right

Location of leak under floor

An estimate has been made of the heat from the radiators and the metal-encased convectors. Radiators have a similar configuration to current equivalents so the heat output can be determined accurately. Assumptions have been made as to the internal construction of the encased convectors to allow the heating capacity to be assessed.

It has not been possible to calculate the heating effect of the convectors built into the walls of the church due to lack of access, but it is unlikely that their heat output is much more than that of the other heat emitters.

The total heat output of the system has therefore been estimated as around 45kW.

This is considerably less than the boiler output, and less than the calculated heat loss. The existing heating system will not be capable of providing modern comfort conditions within the church during cold days.
A leak recently occurred in the older buried pipework. Extensive efforts were made to trace the leak and it was eventually repaired, but it is almost inevitable that other parts of the pipework will start to leak in the near and medium term.

A complete new heating system including energy source, heat distribution and heat emitters is required.

The existing system is illustrated in Appendix A.

HEAT LOSS CALCULATIONS

Heat loss calculations based on the existing fabric of the church have been carried out.

The church is traditionally constructed with solid walls and no additional insulation anywhere, so the heat loss is very high. It is difficult to see how insulation could be added without substantially changing the interior.
Opportunities for adding insulation are limited but should be considered when the opportunity arises.

Roof:
The worship spaces have a pitched ceiling with timber boarded lining and exposed timber trusses. Any insulation will need to be added externally when the roof is being replaced in the future.

Walls:
Walls are exposed brickwork, any additional insulation would have a major effect on the appearance of the church, so may well be thought unacceptable. Insulating plaster on the walls of the smaller rooms may be possible if these are ever refurbished.

Windows:
Windows are single glazed but plain glass. Secondary glazing should be possible, although likely to be expensive.

The total heat loss of the church has been estimated as 160kW, including a warm-up margin. Small-scale upgrades to the building fabric will help, but will not change the overall heat loss by much.

HEATING OPTIONS

A number of heating options have been considered. Bearing in mind the Church of England target of zero net carbon emissions by 2030, energy use and carbon emissions should be reduced as much as possible.

Insulation will reduce carbon emissions, but the biggest effect will from upgrading the heating system.

Some heating options can be discounted at an early stage.

- Ground source heat pumps are significantly more expensive than any other system and they are not possible to justify for a church which is only infrequently used more than once a week. Underfloor heating has many advantages, especially in connection with heat pumps, but the same considerations apply. Digging up the floor to give sufficient depth for heating pipework and insulation would be expensive, and a system laid on top would require work to ensure level access throughout the church.
- Individual gas heaters with flues on outside walls, such as Vulcana, are a cheap option, but are visually intrusive, require cutting the fabric for multiple flues, have multiple gas service requirements and cannot be upgraded to avoid fossil fuels
- Solar panels do not help with the heating in winter, and so may be considered as a stand-alone option for reducing carbon emissions but not as part of the heating system.
- Hydrogen may become important in the future but not within the Church of England's target timescale.
- Ceiling-mounted de-stratification fans are of uncertain effectiveness.

Three options are considered in more detail. In all three options, some kind of zoning is recommended, so that the smaller rooms can be used independently from the main worship space.

OPTION 1 - CONDENSING GAS BOILER AND RADIATORS.

The system would be similar to the existing but certain points need to be highlighted.

The existing boiler is non-condensing, so provision must be made for disposal of condensate. More importantly, the existing flue will not be acceptable, and either must be lined, or an alternative location found.

The existing heat emitters are undersized. Even if large radiators are mounted along the length of the nave, the heat output will not be sufficient, so a mixture of radiators and fan convectors will be needed.

The system would be more efficient than the present one, but still relies on fossil fuels. Ideally, radiators and fan convectors would be sized to allow a straight swap of heat sources when the new boiler is decommissioned, with heat pumps being located in the same positions as in Option 2. In practice, a mixed system, with heat pumps supplying only part of the load, may prove most suitable in the future.

OPTION 2 - AIR-SOURCE HEAT PUMPS

These can be simple comfort cooling units used in reverse, with internal and external units connected by refrigerant pipework, similar to the present system in the hall. Internal units should be encased in a timber enclosure if possible, as they can be felt to be visually unattractive.

Alternative heat pump systems produce hot water, and can be connected to radiators and fan convectors as in a boiler system. The heat output of a radiator will be less if used with the current generation of heat pumps as the temperature of the water will be less, so larger radiators or a greater number of them will be needed.

The former system of heat pumps will be less expensive, so further consideration has been given to this type. A concept design for a possible scheme has been produced and is illustrated in Appendix B.

External units can be placed against the north and possibly the south wall of the Nave. Pipework would be simplified if both locations are used, although the north side has the advantage that the nearest residential properties are shielded from noise by the church.

Noise would need to be considered both for the internal and the external units. Internal units will need to be selected on low-speed. External units will probably need to be selected for low noise, and the planning consent which will may be required for a new heat pump installation would need to show noise compliance

OPTION 3 - DIRECT ELECTRIC HEATING

Convectors or Radiant Heaters

CONVECTORS (Ecomiser).

These act like hot water radiators but are significantly more costly to run. The Ecomiser system, for which the church have obtained a quotation, is this kind of heating. If used to heat the whole of the church the present electrical supply would need to be upgraded. Even a 200A TPN supply would not be sufficient, so it is highly likely that a new transformer would be necessary, with associated supply upgrade costs.

RADIANT ELECTRIC HEATERS (Tansun)

High-level radiant heaters in a variety of configurations are available from different manufacturers. Tansun are manufacturers of typical units. Although expensive to run, they do not require a long warm-up period, so can be cost-effective for churches which are not in regular daily use.

They need careful positioning to avoid parts of the congregation being either too hot or too cold. They are very visible and people would need to be convinced that they are suitable for a church which may become nationally listed. There is a case which could be made for using them to heat the Lady Chapel for small services without partitioning it off. As with convector heaters, an electrical supply greater than the present 100A TPN would be needed to heat the whole church, although the capital cost of the heating system itself would be less than that of either of the other two systems

COSTS

CAPITAL COSTS

Quotations have been obtained by the church for various systems. The quotes to install Vulcana individual gas heaters have been discounted. EngDesign have made estimates for a gas boiler system and an ASHP system using data within this report. Costs are summarised below.

	NEW BOILER	NEW BOILER	ECOMISER	GAS BOILER	HEAT PUMP
Source	Argonaut quote	Thermoserv quote	CD quote	EngD estimate	EngD estimate
Cost	£120,000	£60,558	£57,160	£100-120,000	£200,000

The Thermoserv quote is very competitive and further analysis of exactly what is included would be necessary. If a gas boiler system is installed, it will be important to ensure that the heat emitters are suitably sized, and not replaced on a like-for-like basis.

All figures are given ex VAT and exclude professional fees.

RUNNING COSTS

Two estimates have been made for annual energy use.

A degree day calculation has been done to estimate the equivalent full load hours per year assuming the church were in use daily. Using the calculated heat loss of 160kW in the worship space and typical annual use of 1500 hours, the annual kWh figures for each system are the first set in the table below.

The existing boiler and heating system has a typical consumption of 67,000 kWh pa, using figures from previous invoices. Based on this, the equivalent energy use of each different system based is given in the second set of annual energy figures in the table below.

It can be seen that the actual consumption is far less than the predicted daily consumption. There are two reasons. Firstly, the church is typically used for one day a week. Secondly, the actual output of the heating system is less than the calculated heat loss.

	EXISTING SYSTEM	NEW BOILER	ECOMISER	HEAT PUMP	TANSUN	Units
Heat loss	160	160	160	160	160	kW
Electrical	-	-	232	77	232	TPN A
Efficiency	70%	85%	100%	300%	100%	
Annual energy (degree day)	342,857	282,353	240,000	80,000	204,000	kWh pa
Annual energy (Invoice)	67,000	55,176	46,900	15,633	39,865	kWh pa
Gas Tariff	10	10	10	10	10	p per kWh
Electrical Tariff	32	32	32	32	32	p per kWh
Annual Running cost	£6,700	£5,518	£15,008	£5,003	£12,757	£ per year

The running cost above for the various systems is based on the actual invoiced use.

While tariffs may alter in the future, values approximately similar to the quotation which the church has received from Octopus have been used in the assessment.

It can be seen that the running costs of the electric Ecomiser system will be extremely high, and more than outweigh any saving in the capital costs. The electric Tansun radiant heaters are more reasonable, although still likely to be more than a heat pump system.

CARBON EMISSIONS

TARGETs

At its February 2020 meeting, the General Synod of the Church of England set a new target for reducing emissions of carbon dioxide, aiming to reduce to net zero by 2030. Even coming close to meeting the target will inevitably incur capital expenditure which may not be recovered. Conventional economic justifications have led to the global warming crisis in the first place, and this report therefore has not looked at financial payback of different systems.

This report does not provide a full energy audit. The heating is the largest single source of carbon emissions, either directly or indirectly, and therefore attention is focused on this in the section below.

CARBON DIOXIDE BALANCE

	EXISTING SYSTEM	NEW BOILER	ECOMISER	HEAT PUMP	TANSUN	
Heat loss	160	160	160	160	160	kW
Electrical	-	-	232	77	232	TPN A
Annual energy	67,000	55,176	46,900	15,633	39,865	kWh pa
Carbon factor	0.185	0.185	0.181	0.181	0.181	kg/kWh
Carbon dioxide emissions	12,395	10,208	8,489	2,830	7,216	kg per year

There are a few main points to note:

- The carbon factor, or the amount of carbon released by the production of 1 kWh of energy, is about the same for gas and for electricity at the moment, but will drop significantly for electricity in the coming years as the grid increasingly is supplied by renewable sources of energy.
- A new condensing boiler would save 2.2 tonnes of carbon emissions per year
- On-peak electric heating is slightly better, but only heat pumps would make a very significant difference.
- Because the church is not heated a lot, the overall level of carbon emissions is quite low, and is equivalent to that produced annually by the central heating in two or three homes.

SUMMARY

- The existing gas boiler, radiators and distribution pipework should be replaced.
- Further measures to reduce carbon emissions should also be undertaken if possible.
- In the long term, fossil fuels such a natural gas will be phased out, and it is likely that electricity will be the main energy source.
- In the shorter term, the price of electricity is unlikely to reduce below the 2021 level.
- An air source heat pump system could provide suitable heating but would be a significantly higher cost than alternatives. Given the restricted use of the church itself, high capital costs may not be justifiable.
- On-peak electric systems will have high running costs.
- Options exist for replacing the boiler system with a LTHW boiler and radiators and fan convectors, and this is believed to be the most cost effective, while still reducing carbon emissions.

- If a gas boiler system is to be installed, the possibility of retrofitting heat pumps in due course should be considered, making use of the new distribution system.
- A scope of work for the proposed new heating system should be drawn up.

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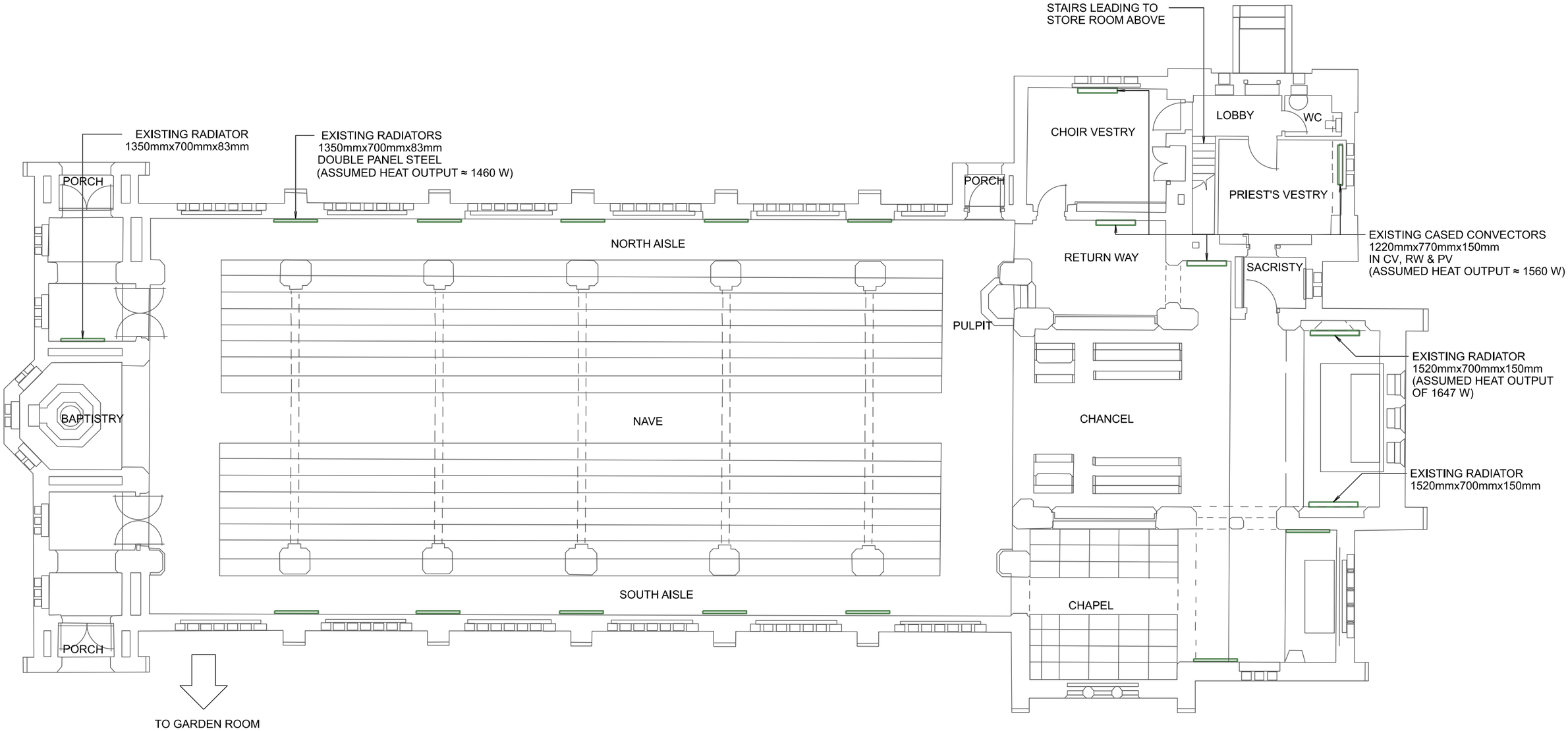
APPENDIX A EXISTING HEATING



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TITLE: EXISTING HEATING

PROJECT: ST JOHN DIVINE SELSDON

ARCHITECT: N/A

SCALE AT A3: 1:125

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CHECKED: MRD

DATE: APR 23

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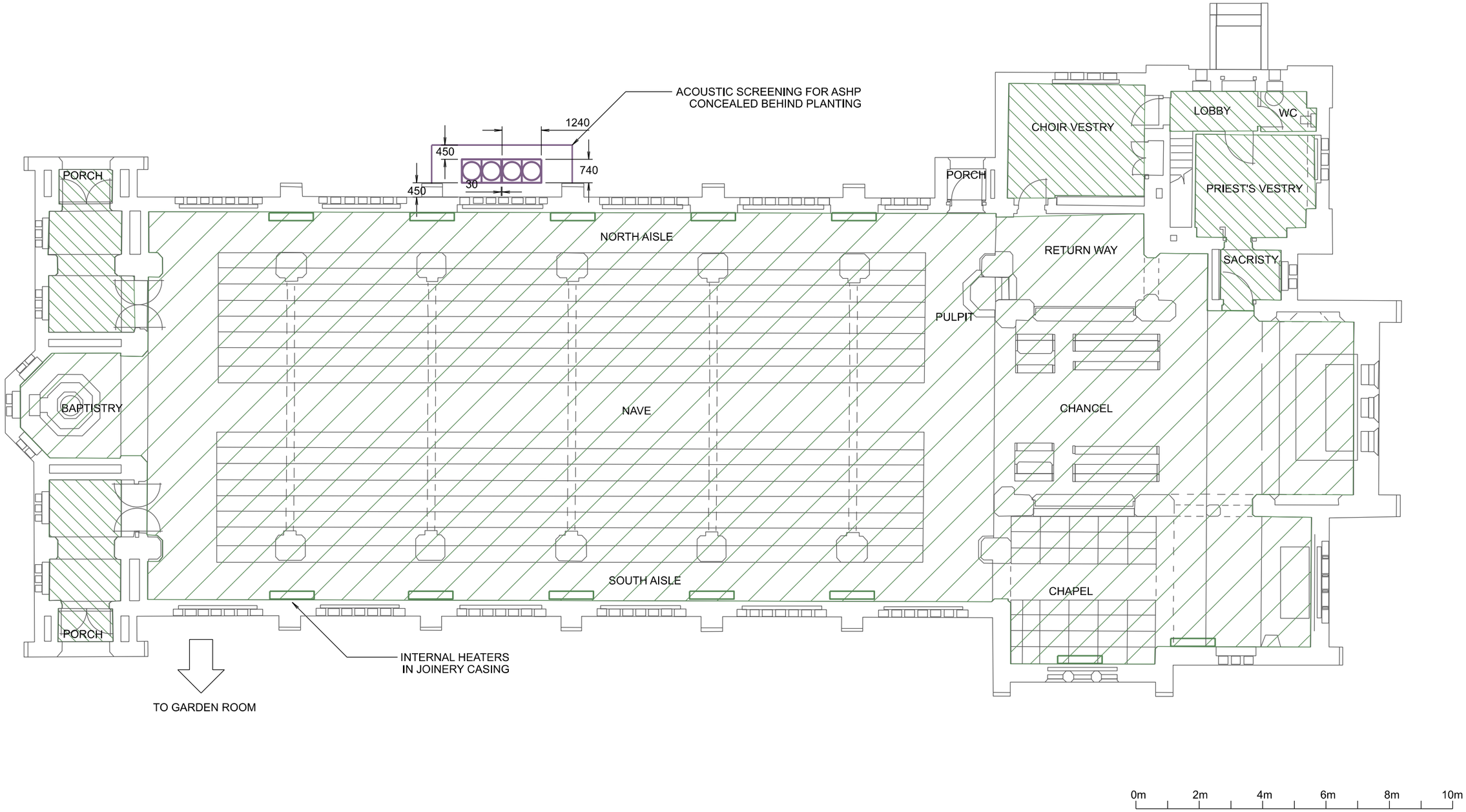
APPENDIX B PROPOSED AIR-SOURCE HEAT PUMPS



MAIN ZONE

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TITLE PROPOSED HEATING
AIR SOURCE HEAT PUMPS

PROJECT ST JOHN DIVINE SELSDON

ARCHITECT N/A

SCALE AT A3 1:125

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