REPORT

'Geothermal Installation Design and Costing:

Sligo Regional Sports Centre &

TUD Grangegorman'

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To

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ABBREVIATIONS

AHU	Air Handling Unit
CAPEX	Capital Expenditure
CAT	Cable Avoidance Tool
CO2	Carbon Dioxide
DCC	Dublin City Council
DECC	Department of the Environment, Climate and Communications
DHN	District Heating Network
DTS	Distributed Temperature Sensor
E	East
EED	Earth Energy Designer
GDA	Gragegorman Development Authority
GPR	Ground Probing Radar
GSHP	Ground Source Heat Pump
GSI	Geological Survey Ireland
GW	Gigawatt
GWh	Gigawatt hour
HE	Heat Exchanger
HP	Heat Pump
HVAC	Heating Ventilation and Cooling
I.D.	Internal diameter
IoT	Internet of Things
kW	kilowatt
kWh	kilowatt hour
LCOH	Levellised Cost of Heat
LPG	Liquid Petroleum Gas
LPHW	Low Pressure Hot Water
m.a.O.D.	metres above Ordinance Datum
m.b.G.L	metres below ground level
MW	Megawatt
MWh	Megawatt hour
NE	North East
NW	North West
O.D.	Outer Diameter
OPEX	Operational Expenditure
PE100RC	Polyethylene Type 100 Crack Resistant
PN	Nominal Pressure
S	South
SCC	Sligo County Council
SDR	Standard Dimension Ratio

SE	South East
SEAI	Sustainable Energy Authority of Ireland
SRSC	Sligo Regional Sports Centre
SW	South West
SWOT	Strengths, Weaknesses, Opportunities and Threats
TUD	Technical University of Dublin
WBM	Water Based Mud

1 INTRODUCTION:

The Department of the Environment, Climate and Communications and Geological Survey Ireland are focussing on development of the geothermal sector in Ireland and to promote the development of geothermal energy as a heat source. As part of the objectives outlined in the Climate Action Plan for Ireland, geothermal energy has been identified as a renewable energy source that can facilitate the decarbonisation of the heating and cooling sector in Ireland.

As part of these objectives, geothermal energy has the potential to be implemented in public sector buildings that are currently using fossil fuel fired technologies to address their current energy demand needs. Public sector agencies and County Councils are currently focused on developing new Local Authority Climate Action Plans and identifying opportunities to develop renewable energy technology solutions to facilitate decarbonisation.

The development of geothermal energy resources in Ireland is still dominated by the deployment of small scale, residential ground source heat pump solutions, with limited deployment of large scale systems exceeding a few hundred kW [12].

A consortium of public agencies is seeking to deliver geothermal heating solutions for two public developments at Technological University Dublin (Grangegorman Campus) and Sligo Regional Sports Centre with the aim of displacing existing fossil fuel heat sources. An initial feasibility study to identify possible ground source heat pump solutions and establish a design and cost for the implementation of 2 No. suitable systems for both sites is required to facilitate the development of two GSHP systems that will act as demonstrator in Ireland of the potential for deployment of geothermal energy.

2 BACKGROUND TO THE PROJECT

A detailed design and cost two geothermal GSHP installations is required to develop:

1. a large “intermediate-depth” (>500m) GSHP array at TUD Grangegorman Campus; and
2. a shallow GSHP solution for Sligo Regional Sports Centre, Sligo.

The energy demand at both locations is currently met through gas fired generation. In the case of TUD, a central energy centre with gas fired boilers delivers heating and DHW to a number of buildings connected to a DHN. The expansion of the DHN and additional building connections is planned during 2023 and 2024. Future plans for decarbonisation of the campus are being considered in the context of the development of a city wide district heating network planned by DCC by 2030.

Sligo Regional Sports Centre is characterised by 1990s building that houses a swimming pool, gym and fitness rooms, where the heating demand is met by LPG fired boilers. A cooling demand is also present at the site and currently met by independent electrical air handling units.

The scope of this report is to provide a preliminary design and plan for the installations along with a detailed cost breakdown for the chosen designs of 2 No. GSHP solutions that would integrate to the existing building infrastructure at both sites without the need for further interventions (building retrofit or upgrades). The design solutions identified provide budget-level estimates, consider different geothermal and heat pump technology options suitable for the sites as well as providing a detailed risk assessment and gap analysis for early stage planning of the geothermal projects at both sites. The results of this design report will support securing funding to fully implement the geothermal projects at both locations and will provide guidance as to the work requirements for the early phases of development.

The report has been structures in two separate parts:

- Part A – Sligo Regional Sports Centre
- Part B – Technical University of Dublin, Grangegorman

Both sections apply a detailed workflow to both sites which is focussed on energy demand assessment, technology overview and selection (GHSPs and geothermal collector) as well as providing detailed design and implementation methodologies for both sites in line with existing best practice and standards.

The individual sections review the capital investment cost requirements for the design solutions proposed as well considering the operational costs of the new GSHP solutions proposed. A detailed risk assessment for both systems and recommendations are made to facilitate progressing the projects to the next phases.

Part A – Sligo Regional Sports Centre

3 INTRODUCTION TO SLIGO REGIONAL SPORTS CENTRE

Sligo Regional Sports Centre (SRSC) is located in south east of Sligo town along Cleveragh Drive east of Sligo race course. The SRSC building comprises a leisure facility that includes a 25 metre indoor heated pool, a kids pool, jacuzzi, sauna and steam room. The centre also comprises indoor sports facilities that include an internal gym and a spin studio.

The centre is currently using a combination of LPG fired central heating boilers and roof mounted air handling units to supply heating and cooling to the facilities. As part of the GSI *Geothermal Installation Design and Costing* project, SRSC has been selected as one of two sites for the development of a preliminary GSHP solution design to help decarbonise the sport centre and offer alternative heating and cooling solutions using ground source heat pumps.

This report provides an initial assessment of the existing heating and cooling infrastructure at the SRSC site and outlines a design and CAPEX budget for an alternative GSHP system to meet the centre's energy needs. The assessment focuses on three key aspects to deliver a geothermal solution for the site:

- Energy demand requirements for heating and cooling and building fabric;
- Subsurface geological conditions and opportunities to deliver a geothermal solution;
- Geothermal collector technology design and heat pump selection.

4 SUBSURFACE DATA REVIEW

Sligo Regional Sports Centre is located to the south east of Sligo town. The bedrock geology is characterised by Carboniferous limestones of the Dartry Limestone Formation (figure A.1 – refer to appendix A) described as a fine grained, massive and thickly bedded limestone locally rich in microfauna. The limestones are medium- to thick-bedded, cherty, dark grey and bituminous. The site is located on the south-eastern flank of the Sligo Syncline, where the Dartry Formation comes into contact with Lower Palaezoic formations along the plane of the Ox Mountains-Pettigoe Fault [1].

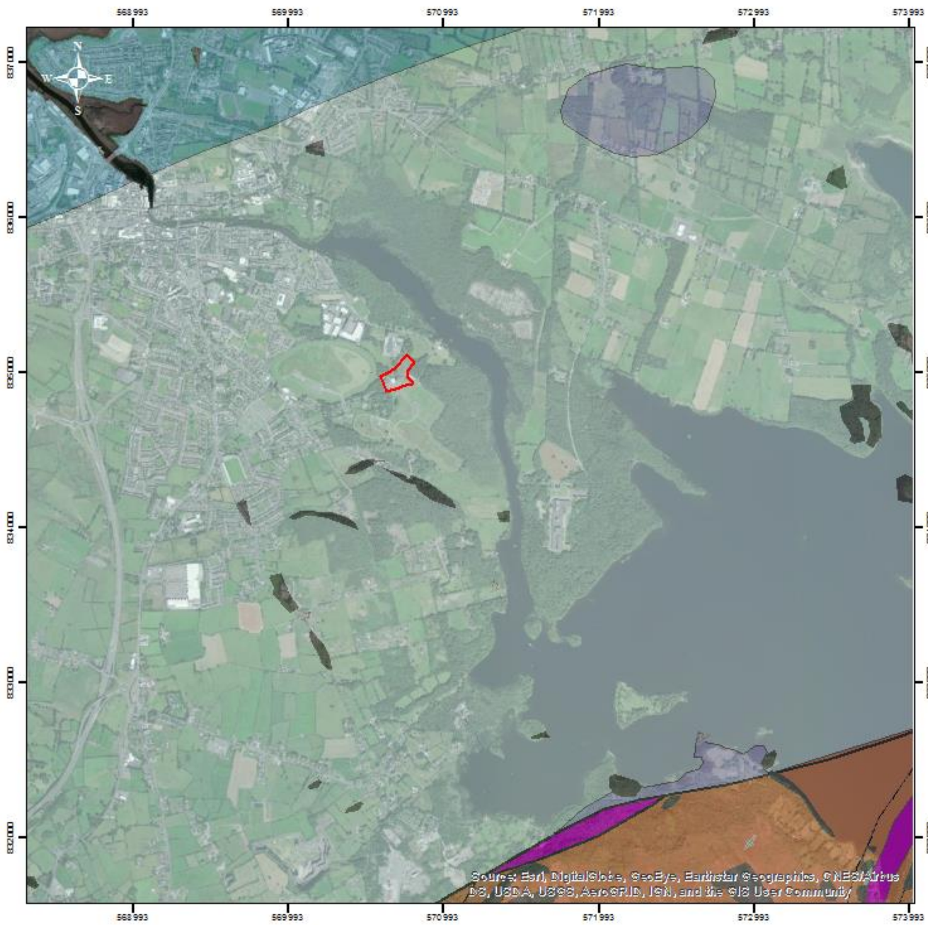


Figure A.1. Sligo Regional Sports Centre shown in red outline and solid bedrock geology of the area.

The Dartry Formation is characterised as a regionally important aquifer with karst conduits by GSI. Several karst features are present in close proximity to the site (figure A.2). Four springs at Toberanalt (2km SSE), Poulconaperry (4km SW), Carrowmore (3.5km WSW), Tobernaveen (4km WNW) are located in close proximity to the site (approximate distances shown in brackets). The springs at Poulconaperry, Carrowmore and Tobernaveen are interconnected by a traced karst conduit (Tonafortes sink) to the Tonaforte sinkhole. Foxes Den cave is also located approximately 850m south west of the site on higher ground. The spring at Toberanalt is described as having a yield of 5,000 m^3/day and a recorded temperature of between 9^o and 15^oC.

Several historical groundwater exploration boreholes located to the north and east of the site, encountered collapsing ground conditions and in many cases were abandoned with little or no groundwater yields proven.

The above data suggests that groundwater is dominated by localise karst features and by localised fault structures acting as conduits for groundwater flow. The description of dry and abandoned groundwater exploration boreholes would suggest that permeability in the main matrix of the Dartry Formation is limited.

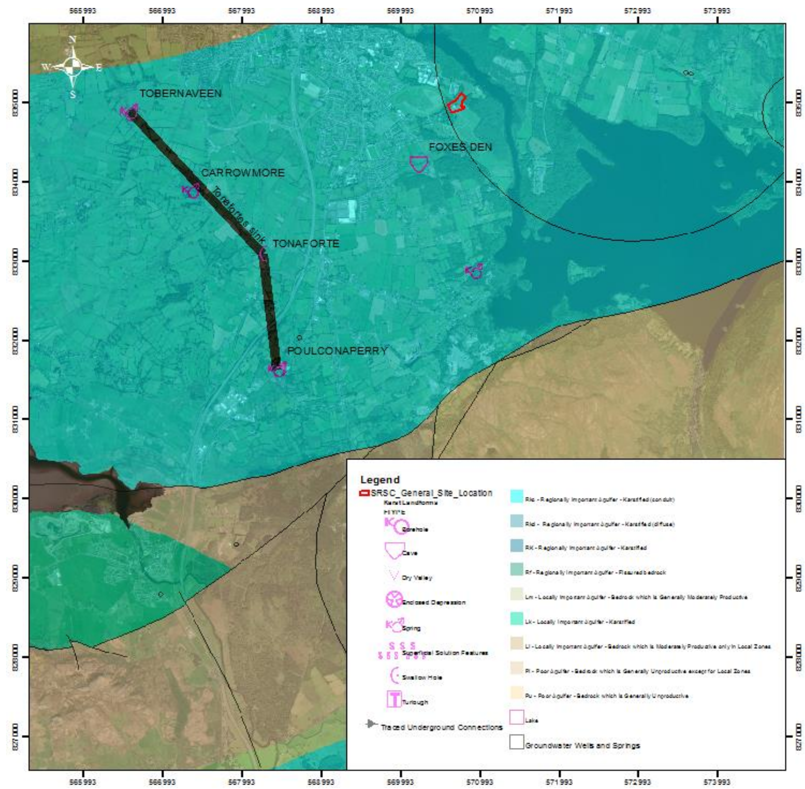


Figure A.2. Sligo Regional Sports Centre – Hydrogeological Setting

5 ENERGY DEMAND & EXISTING INFRASTRUCTURE ASSESSMENT

The initial phase of the GSHP feasibility study has focussed on an assessment of the existing building fabric, the plant room infrastructure and an analysis of the current energy demand of the centre. An site visit was undertaken to the centre on the 25th of October 2022, where the plant room, the HVAC systems and site constraints were assessed and mapped.

5.1 SRSC Energy Demand Data

The energy consumption of the sports centre is individually metered through a central system and estimates of the energy demand have been based on the review of existing LPG consumption data from the boilers present on site. A summary of the LPG consumption for 2020 and 2021 was provided by Sligo County Council to facilitate in the in the energy demand assessment. The data for the two years is summarised in table A.1.

To derive the energy demand data the following assumptions were made:

- Litres of LPG to kWh conversion factor: 7.09 kWh per litres [2]
- Boiler Efficiency: 80% (assumption)

Table A.1. Energy Demand Data at Sligo Regional Sports Centre

	Litres of LPG			Energy Demand	
Year	**2020**	**2021**		**2021 (kWh)**	**2021 (MWh)**
January		15,001		85,085	85.1
February	24,626	5,000		28,360	28.4
March	10,200	5,000		28,360	28.4
April	18,291	5,000		28,360	28.4
May		5,000		28,360	28.4
June		7,001		39,709	39.7
July		7,000		39,704	39.7
August	7,001	7,001		39,709	39.7
September	10,000	7,002		39,715	39.7
October	10,001	14,002		79,419	79.4
November	10,000	19,000		107,768	107.8
December	8,803	10,149		57,565	57.6
Litres	***98,922***	***106,156***		***602,116***	***602.12***

The LPG data provided as input to the assessment demonstrates a reduced consumption during the course of 2020 as a result of the closure of the sports centre due to the COVID-19 pandemic over a period of four months. The LPG consumption data from 2021 was therefore deemed to be more presentative and used to estimate the energy demand data of the centre (table A.1).

It is important to note that the gas consumption data considered is based on the time of purchase of the fuel rather than the actual measured consumption at the boilers throughout the year. The energy demand (and associated consumption) is higher during the winter months, however consumption in the shoulder months (March, April, May and September) may not be a true reflection of the actual energy consumption. Figure A.3 shows the distribution of the demand over a year.

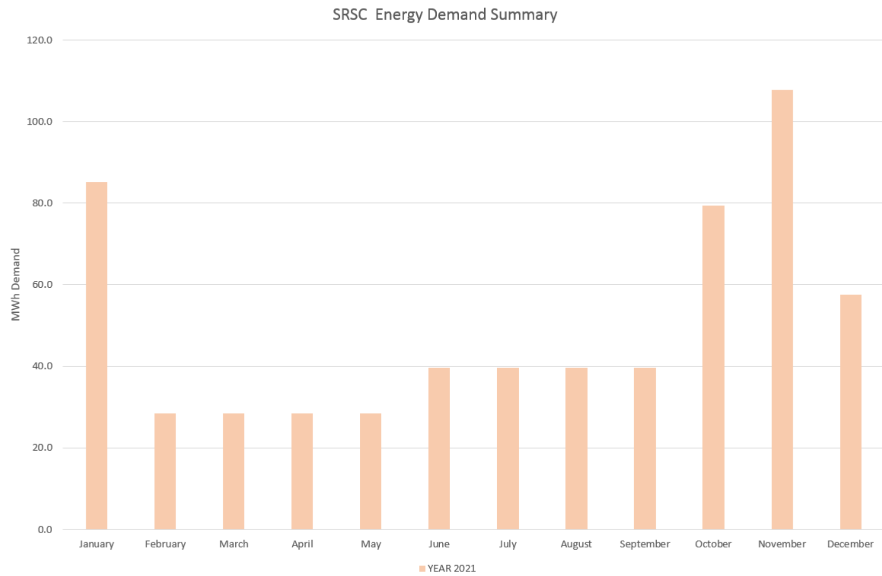


Figure A.3. Sligo Regional Sports Centre – 2021 Energy Demand Summary

5.2 Building Characteristics and Site Layout

The main sports centre building comprises a 1990s, single storey building with of block and cavity wall construction with a south facing entrance (figure A.4).

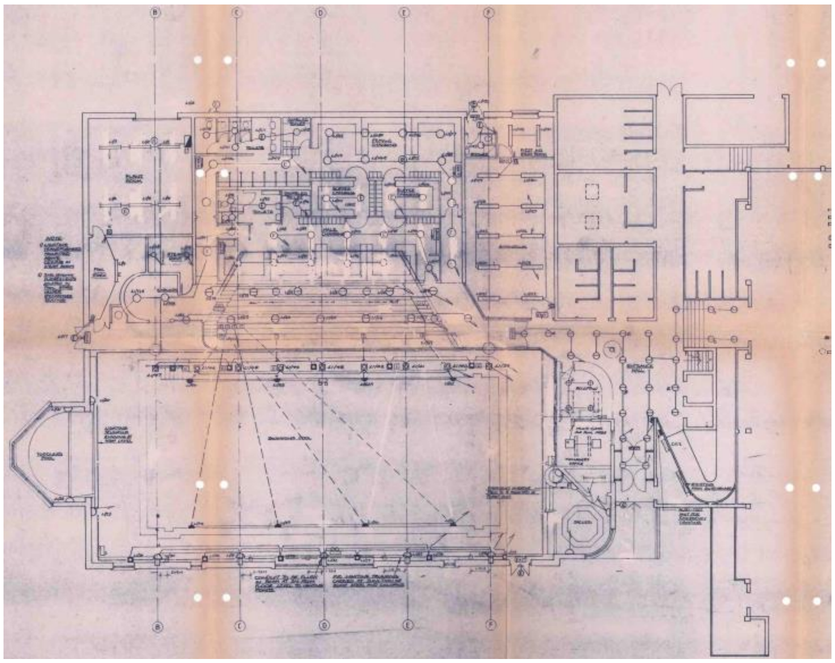


Figure A.4. Sligo Regional Sports Centre – Building Layout (source SCC & JV Tierney)

The main fabric of the building was not thoroughly inspected and no information of the building stratigraphy or heat loss with respect building material U-values was available at the time of the study.

5.3 Plant Room and Existing HVAC System

The current central heating system uses Low Pressure Hot Water (LPHW) to provide heating to different areas of the building. The heating terminals are a mix of radiators, a simple fan heater (for the indoor arena) and an Air Handling Unit serving the pool.

The boiler room is located in the north-western corner of the building, which also contains the pool water treatment, water heat exchangers, and Domestic Hot Water Calorifier.

The heating is provided by a 500 kW, Rendamax 132 HR, natural gas fired primary boiler (B1) with an integrated atmospheric burner and modulating control system. The year of manufacturing of the B1 boiler is 2006.

An older Buderus boiler (B2), originally oil fired but converted to natural gas via a forced air Riello Burner, supports the primary boiler during peak demand and as backup unit. Both boilers are obsolete and not energy efficient.

According to the operators, as the second boiler is rarely needed (currently disabled), it can be assumed that the peak demand of the building is close to 500 kW, with a current water set point of 70ºC.

Figure A.5. SRSC – Internal plant room condition

A detailed survey of the plant room was undertaken during the initial site visit and a detailed 3D scan (available here) was completed. Figure A.5 shows a view of the plant room with the two boilers.

Based on the results of the mapping and scanning of the plant room, a detailed schematic of the plant room in its current state was developed (figure A.6). This shows the boilers, primary manifold and secondary pumps and separately highlights the Dantherm AHU units used for cooling.

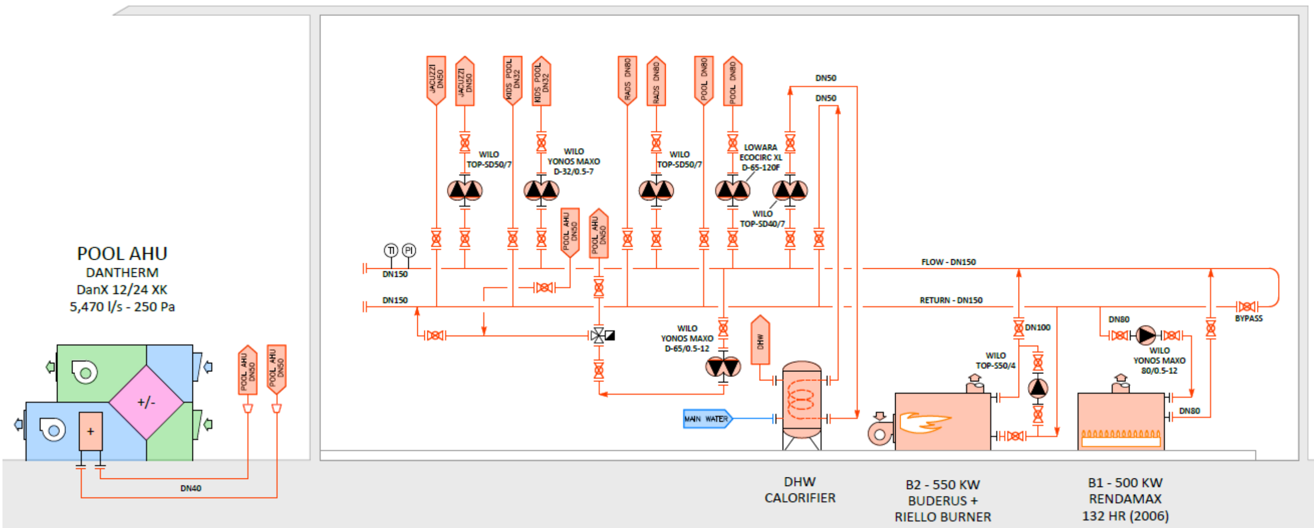


Figure A.6. SRSC – Existing plant room schematic

The main flow and return headers are connected with a by-pass valve (low loss header not installed). Secondary twin pumps sets supply water to 6 different circuits (figure A.7), respectively:

- Jacuzzi Pool Heat Exchanger
- Kids Pool Heat Exchanger
- Main Pool Heat Exchanger
- Radiators Circuit (and Arena fan heater)
- Domestic Hot Water Calorifier
- Pool Air Handing Unit (located outside)

Figure A.7. SRSC – LPHW pipework

According to operators the Pool AHU heating coil doesn't receive the right amount of water. The system would benefit of re-balancing and the installation of a low loss header.

A layout of the existing plant room with respect to the main building structure and service yard located on the norther part of the site is shown in figure A.8

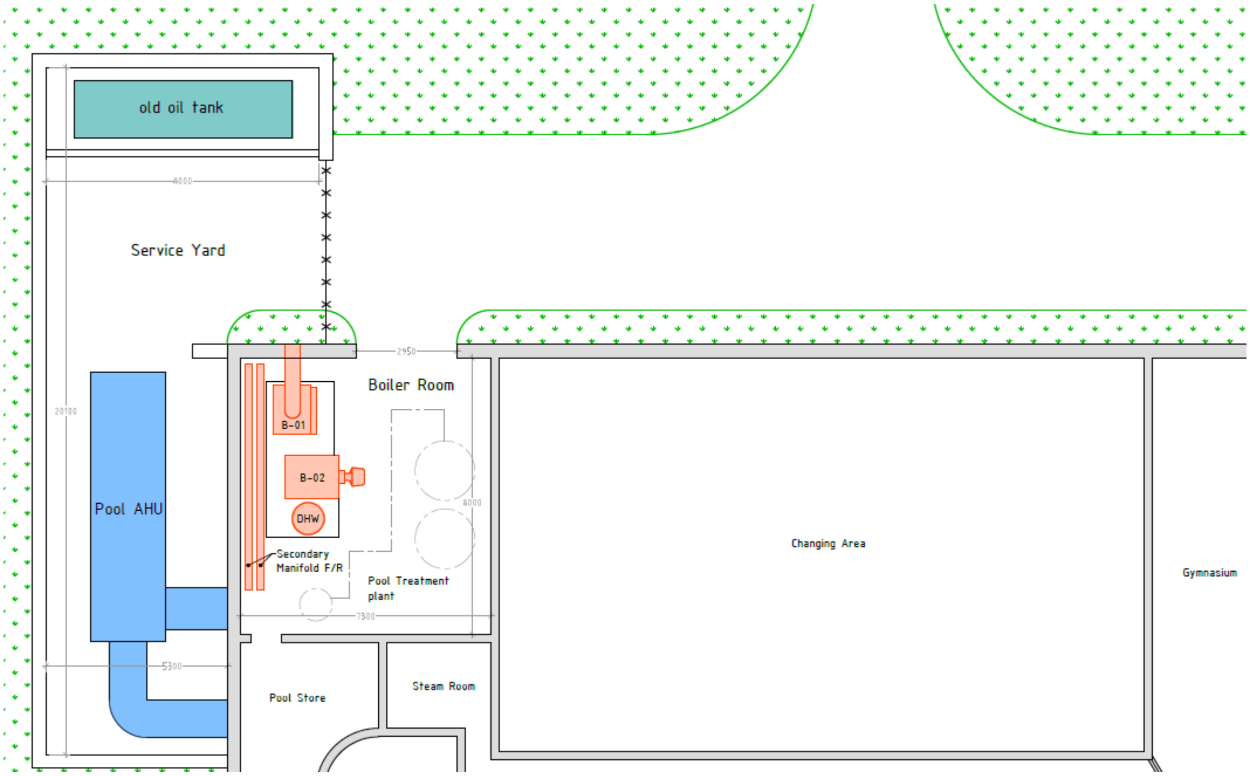


Figure A.8. Existing Plant Room location with respect to the main SRSC building

5.3.1 Swimming Pool

The pool area is served by a Dantherm DanX 12/24 XK AHU (figure A.8), providing a design airflow of 5,470 l/s distributed by circular exposed ductwork.

The AHU is equipped with a Cross Heat Recovery Exchanger, but there is no cooling at the moment, precluding dehumidification of the pool room.

AHU is in poor conditions and would require significant maintenance.

Ductwork distribution was not included in the scope of the inspection but it seems well designed and sized and in acceptable conditions.

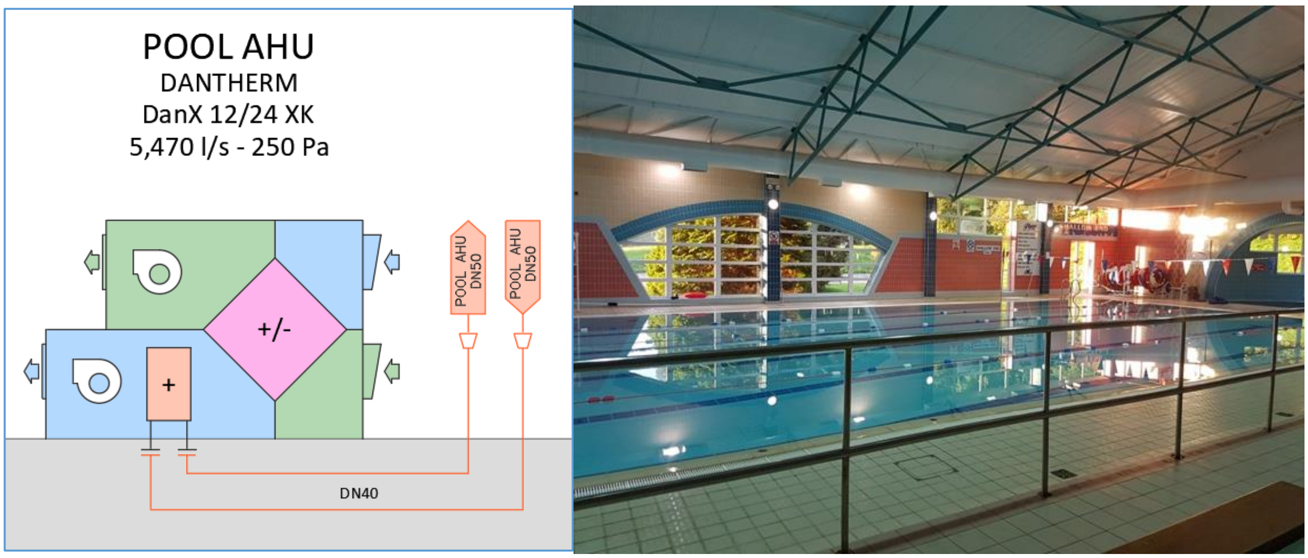


Figure A.9. SRSC – Swimming Pool AHU. (a) Schematic. (b) photograph showing pipework in the Pool area

5.3.2 Gym Area

The gym area (figure A.10a), located on the first floor, is served by radiators and a Split Air conditioning system for cooling (the only cooling present in the building at the moment).

Condensing units are located on the roof, and at the time of the site visit access was not available.

According to operators the air conditioning system is not fully operational, and it would require significant maintenance.

5.3.3 Indoor Arena

The split air conditioning system should be replaced, while ductwork distribution (in yellow pipework in figure A.10b) seems well sized and maintained and should be retained.

a)

b)

Figure A.10. a) Gym Area – b) Indoor Arena

6 GSHP TECHNOLOGY SELECTION AND SYSTEM DESIGN

To address the challenge of decarbonising SRSC, the use of heat pumps to deliver heating, hot water and cooling using a geothermal source represents a unique opportunity to upgrade the existing technologies and significantly reducing the carbon emissions of the centre. As part of the project, the use of a water-cooled heat pump using a geothermal closed loop collector (or if deemed viable a groundwater) source similar to units used for industrial processes, offers an innovative, reliable solution to SRSC and Sligo County Council to deliver a combination of low carbon heat and cooling to the centre.

Based on the energy demand identified, the temperature requirements of the building areas for LPHW as part of the project and the analysis of the plant room infrastructure, the sections below propose a technology solution aimed at substituting the existing LPG fired generation heating system with a heat pump capable of delivering similar water temperatures. Critically, this design focusses on the opportunity to use the existing HVAC infrastructure as much as possible, whilst making recommendations only for additional interventions where these are deemed necessary.

6.1 GSHP Technology Selection

The heat pump selection has focussed on available units rated between 400-500 kW (depending on working conditions) and the ability of these to provide water temperatures of up to >65ºC at the condenser. Three different refrigerants were considered as part of the selection. These include, an A2L, low-GWP refrigerant R-1234ze (GWP <1) as well as the highly efficient A1 safety refrigerants R-515B (GWP 299) and R-513A (GWP 573). Following an initial review, the Engie Spectrum SPH-W0500H, with R-513A refrigerant was deemed the most appropriate and selected to cover the entire heating demand of the systems (appendix C).

Due to the innovative magnetic bearings of the compressor shaft, the selected heat pump requires no lubricants in its refrigerant circuit – in contrast to the standard compressor technologies on the market.

The new oil-free turbo compressors with magnetic bearings technology combined with flooded shell and tube condensers, as well as the integrated open-flash economizer were selected to guarantee maximum seasonal efficiency and performance with a minimal footprint.

The oil free configuration ensures stable performance and efficiency throughout the machine's service life, as no oil deposits can develop in the heat exchangers or in the refrigerant circuit (referred to as 'oil fouling'). It also makes for a simple, low-maintenance and reliable machine design, as no fault-prone oil management peripherals are required.

In addition, the magnetic bearings of the compressor shaft achieve noise and vibration levels that are unparalleled in the field of large heat pumps; the values for this kind of machine are in the range of 94-102 dB(A). In noise-sensitive environments, the noise level can be further reduced by means of optional compressor enclosures.

6.2 System Design

The system design has focussed on delivering two possible options for the new GSHP system to be installed at SRSC. Both options are established on the basis that the new heat pump will be the primary source of heating as it will be the greenest and most efficient solution and will have the capacity to meet the heating demand throughout most of the year, by supplying water at 65°C. During peak demand times (extreme winter conditions) the design makes provision for backup or top up gas boilers that will act as a secondary source to increase LPHW flow temperature up to 75°C if required.

In order to integrate heat pump and the proposed gas boilers, the heat pump will be connected in series upstream of the gas fired boiler, so as to preheat the return water and decrease or remove demand for the boiler to engage.

Only when the return temperature will drop below a set point temperature (>65ºC when the heat pump is not capable of heating water any further) the boiler will be started to top the temperature further.

A low loss header should be installed between the primary and secondary pipework in order to equalise pressures and water flows independently. This will be controlled and achieved speed setting and switching of the secondary pumps (figure A.11).

The preferred design solution would be to decommission both of the old boilers, allowing for more efficient, wall mounted condensing gas units to be installed. The decommissioning of the old units would also free up additional space in the plant room to accommodate the heat pump footprint.

6.2.1 Option 1 – Heating only operation

The first design option (figure A.11) presents a solution where the GSHP system is designed to deliver a heating only solution for the LPHW in the building. This solution effectively substitutes the existing gas fired technology using the GSHP as the main heat source with a minor top up and gas back up boiler component. As part of this design, the cooling demand in the building is not considered and the therefore assumes that the existing cooling solution is either retained or upgraded independently to the GHSP system.

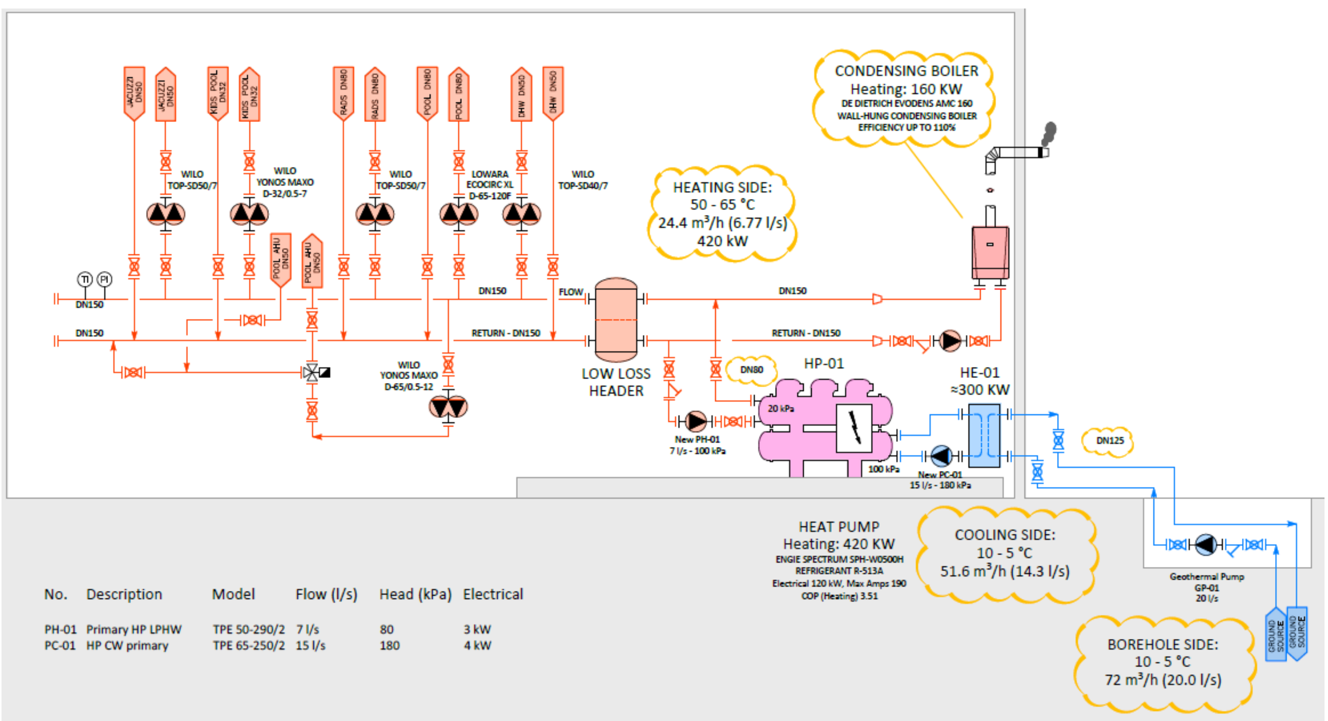


Figure A.11. SRSC GSHP Option 1 – heating only schematic

6.2.2 Option 2 – Heating & Cooling Design

In addition to heating only, a second design options is proposed and is deemed to be preferred for the sports centre. Hydraulic switching allows the heat pump to be deployed as a water-cooled comfort cooler producing up to 300 kW of chilled water. This would allow the building's cooling requirements in summer and heating requirements in winter to be met with just one machine (figure A.12).

Furthermore, with a double heat exchanger arrangement, the Heat pump can produce simultaneously hot and cold water to be used for pool dehumidification, gym air conditioning and summer cooling in other areas.

Despite a more complex design and delivery solutions, option 2 allows both heating and cooling to be delivered simultaneously, especially when dehumidification in the pool area is required all year around. Although it was not possible to quantify the cooling demand of the centre at the time of the initial assessment, the benefits of using one single unit to deliver both heating and cooling, considerably increased efficiencies compared to the existing infrastructure as well as providing a further opportunity to decarbonise the energy requirements of SRSC. The cooling element included as part of option 2, would also ensure increased performance of the geothermal collector (although not modelled in the following sections due to lack data) by returning warmer temperature to the ground and overall improving the long term temperature profile of the ground.

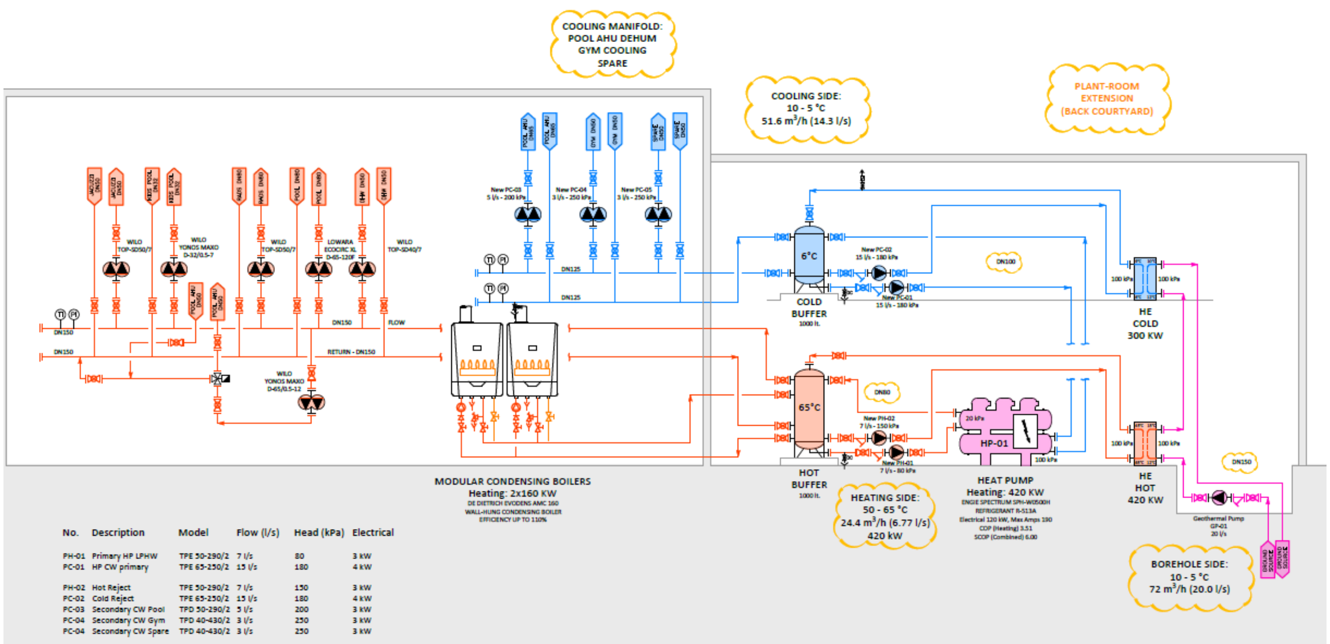


Figure A.12. SRSC Plant room schematic showing integration of heat pump and back up modulating gas boiler.

Due to the current lack of space inside the existing plant room, the design and proposed upgrade works make provision for an extension of the current plant room to the back service yard, where the Pool AHU is currently located. The currently space comprises a masonry wall structure that can be used to complete an extension to the existing building and create an additional enclosed, roofed area to house the new heat pump and ancillary plant (figure A.13). The existing oil tank should be safely decommissioned and removed and the area cleared from spills, before creating a new concrete floor.

The new plant room will accommodate the new heat pump, the heat exchangers, the new circulation pumps, as well as the existing AHU and all new electric and control panels and switchboards.

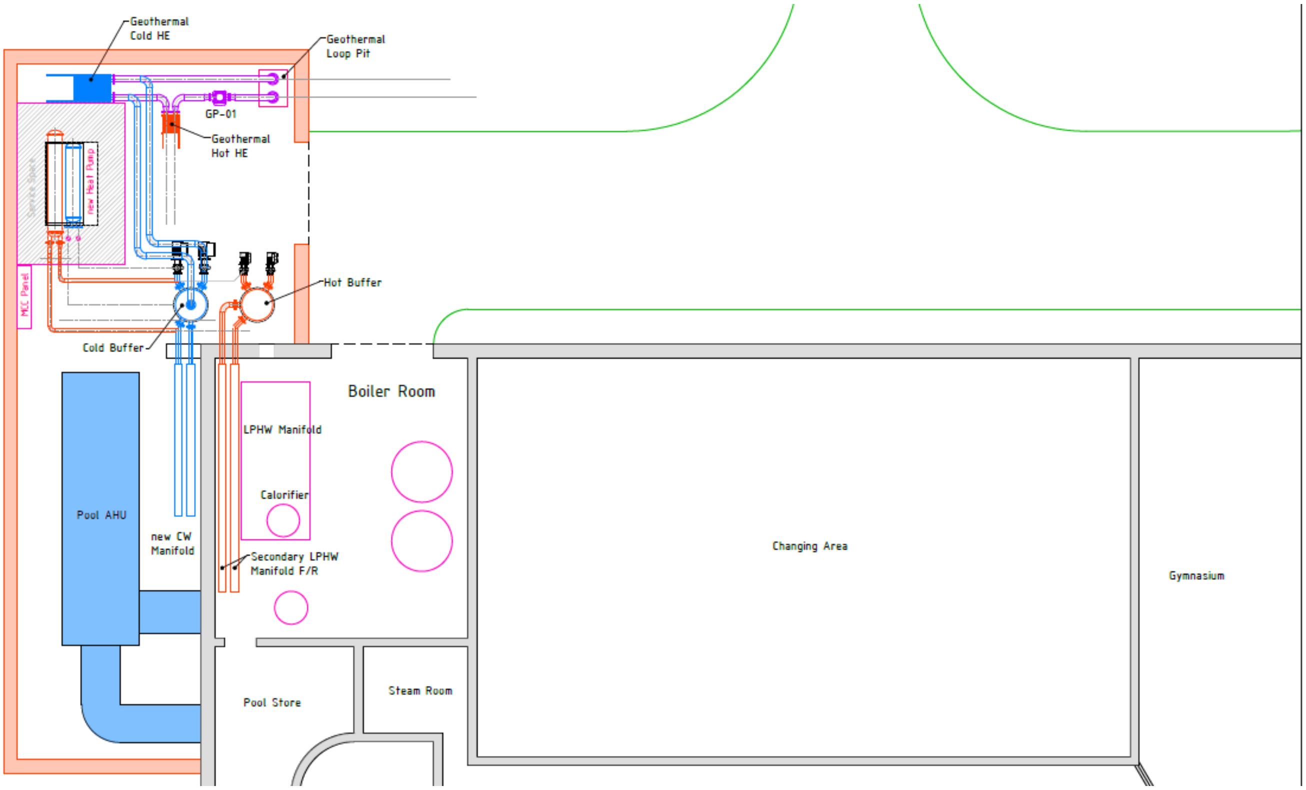


Figure A.13. SRSC Plant room extension schematic showing location of the heat pump and ancillary equipment.

7 GEOTHERMAL COLLECTOR DESIGN

The geothermal collector model integrates the energy demand data and ground conditions at the site, to solve the total collector length required to satisfy the demand from the heat pumps. This section describes the initial collector selection process, reviews the consideration of possible collector solutions in the context of the heat pump selection and system design outlined in section 6, as well as illustrating the detailed modelling methodology and results for the final collector.

7.1 Collector Types

A ground source heat pump system uses the ground to deliver constant temperatures to the evaporator side of a heat pump allowing heating and cooling to be generated efficiently. There are different types of geothermal collector systems commonly deployed in Ireland and these can be broadly classified into 2 main types: open loop and closed loop (figure A.14). Open loop collectors are focussed on using ground or surface water to deliver the energy source to the heat pump. Closed loop collectors are characterised by the installation of sealed, flow and return pipework where the working fluid does not interact with the surrounding environment. In the case of closed loop systems, the energy to the heat pump is provided solely by thermal exchange of the pipework surface with the surrounding ground.

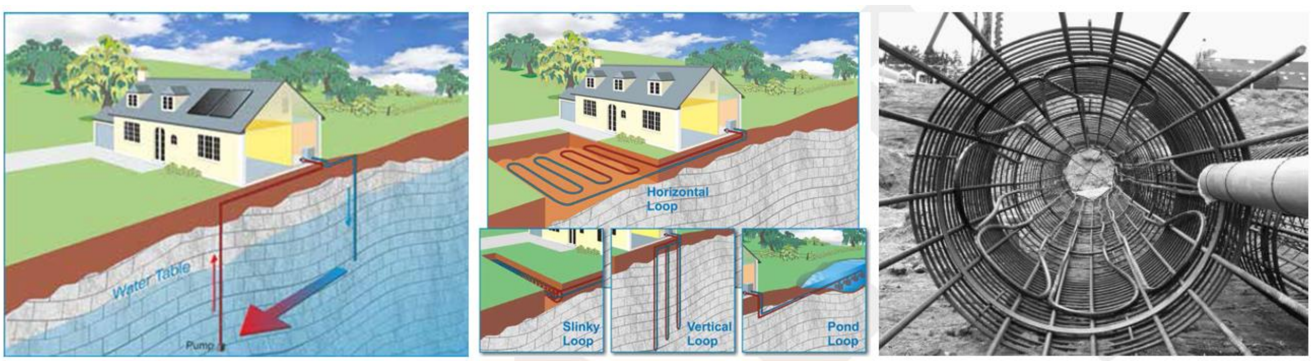


Figure A.14. Ground source heat pump geothermal collector types (source Geological Survey Ireland – Designing & Building, 2018 showing the installation of a closed loop energy pile).

Table A.2 provides a summary of the basic characteristics of the two different types of geothermal collectors. As part of the initial design considerations for SRSC, open loop vertical and closed loop vertical collectors were considered to be the most suited as these have the opportunity to deliver the heat pump energy requirement most efficiently and with the lowest risk of success. The site location was considered in the context of the horizontal closed loop collectors, however, their deployment is deemed not feasible at the site due to overall low energy exchange potential compared to other collector solutions and the requirement for significant disruption or excavation of the existing car park infrastructure. The use of energy piles was deemed not applicable given the lack of any construction planned as part of the project.

Table A.3 outlines the main pros and cons associated with each of these collector technology solutions that require consideration at early project design stage.

Table A.2. Summary of Geothermal Collector Types

Collector Type	Characteristics
Closed Loop Vertical	• **Sealed** Flow and return pipework • **Vertical** Configuration or Energy Piles • **Brine to water** (Water/Glycol brine)
Open Loop	• **Direct Use of Groundwater** • **Water to Water**

Table A.3. General Pros and Cons associated with different collector types

Collector Type	PROs	CONs

Closed Loop Vertical	• **Almost everywhere** (subject to site conditions assessment)
	• **Free Cooling potential**
	• Integrated **to planned building design (energy piles) or boreholes below basement slab**
	• **>50 Year life cycle**
	• **Lower Risk**
	• **Low Maintenance**
	• **No permitting required**
		• **Design Critical** – the total collector design and length to consider:
		  • Thermal properties of the ground – site specific
		  • Heating and cooling loads (base and peak)
		  • Potential layout (spacing boreholes/piles)
		• **Space** – Site space availability
		• **Surface pipework** – design critical
		• **Sizing** - heating and cooling loads

Open Loop	• **Higher Efficiency**
	• '**Free' Cooling** Potential
	• Coupled with **grey water usage**
	• **Lower Footprint**
		• **Productive aquifer required** – Dartry Limestone Formation
		• **Sustained Yield for Operational lifetime** –only determined by exploratory well & pumping test
		• **Higher maintenance** –water quality & screen/ pump cleaning needed every 2 to 5 years
		• **Abstraction License** – pumping >25m^3/d
		• **Water Disposal considerations**:
		  • re-injection of groundwater (often difficult)
		  • Sewer/storm network or IPCC require permits
		  • Discharge Operational Cost

7.2 Initial Collector Screening and SWOT Analysis

Based on the geological and hydrogeological information at the site presented in section 4, a SWOT analysis was performed to determine the best possible collector option for the proposed GSHP design presented in section 6.

The SWOT analysis provides a qualitative methodology to assess the viability of the collector options for the project which are not only focussed on the more technical aspects of the delivery and completion, but also allows consideration of the broader objectives set out by GSI to deliver demonstrator GSHP systems in Ireland with a potential for replicability in the area. The SWOT analysis for SRSC has focussed on a number of key aspects of geothermal collector options and considered these against the following key factors:

- Availability of resource to match the energy demand and GSHP requirements;
- Requirements for further testing and confirmation of final system design;
- Construction phase and supply chain aspects;
- Potential for replication of both solutions to nearby areas and end users;
- System Efficiency and potential for decarbonising the heating and cooling solutions.

Table A.4 below summarises the categories considered as part of the strengths, weaknesses, opportunities and threats for each of the two collector solutions considered. The categories were provided an individual weighting out of 100 and the applicability of the closed loop and open loop solutions scored based on the available information at site from the initial site assessment.

Table A.4. SWOT Analysis Categories and Weighting

	Weaknesses	Weight		STRENGTHS	Weight
1	Risk of Resource	20	1	Higher Efficiency than Fossil fuel Option	30
2	Complexity of Design	10	2	CO2 emission reduction	20
3	CAPEX per installed capacity	25	3	Heating and Cooling Solution / Energy Storage	10
4	Potential for Expansion of Geothermal Solutions	10	4	Maintenance Cost	20
5	Site Preparation requirements	10	5	Permitting requirements	20
6	Construction Phase Length	15			
7	Resource Matching demand	10			
	OPPORTUNITIES			**THREATS**	**Weight**
1	Deployment of solution to other areas - interference	30	1	Operational Costs	20
2	Efficiency with reduced demand temperatures	10	2	Incompatible infrastructure	15
3	Initial Testing and Viability	20	3	Limited Capacity with Increasing Demand	10
4	Supply Chain Availability	10	4	Retrofit Building to suit temperature requirement	15
5	Potential for expansion at the site	15	5	Space Requirement	20
6	Successful Demonstrator for Ireland	15	6	Construction Timeline (slippage)	10
			7	Rig Availability	10

The SWOT analysis provides a means of assessing the suitability of the geothermal collector solution being considered by identifying potential matches with respect to the project related categories considered and to identify the most suitable option for delivering the required energy to the proposed GSHP project.

The outcome of the analysis is shown as a line chart (figure A.15) which demonstrated the most advantageous geothermal solution for the project being a closed loop collector. Whilst the analysis demonstrates that both open loop and closed collector offer a match in terms of delivering the required energy to the GSHP system, the open loop solution presents an increased risk to delivery in the context of the uncertainty of intersecting water bearing structures with sufficient, sustainable flow rate that match the GSHP design and the increased requirements around permitting and long term maintenance of an open loop system. The open loop solution also offers limited potential for possible redeployment in the area to address similar energy loads, given the lack of more detailed knowledge of the local hydrogeological conditions at the time of writing. The closed loop solution on the other hand, offers a lower risk completion in that whilst being more disruptive at the construction stage and having higher capex, a closed loop collector can be more readily designed and tested with existing borehole infrastructure on site and a guaranteed delivery of the energy requirements of the system achieved. Similarly, the closed loop solution provides lower permitting and completion risks with lower operational and maintenance costs throughout the lifetime of operation.

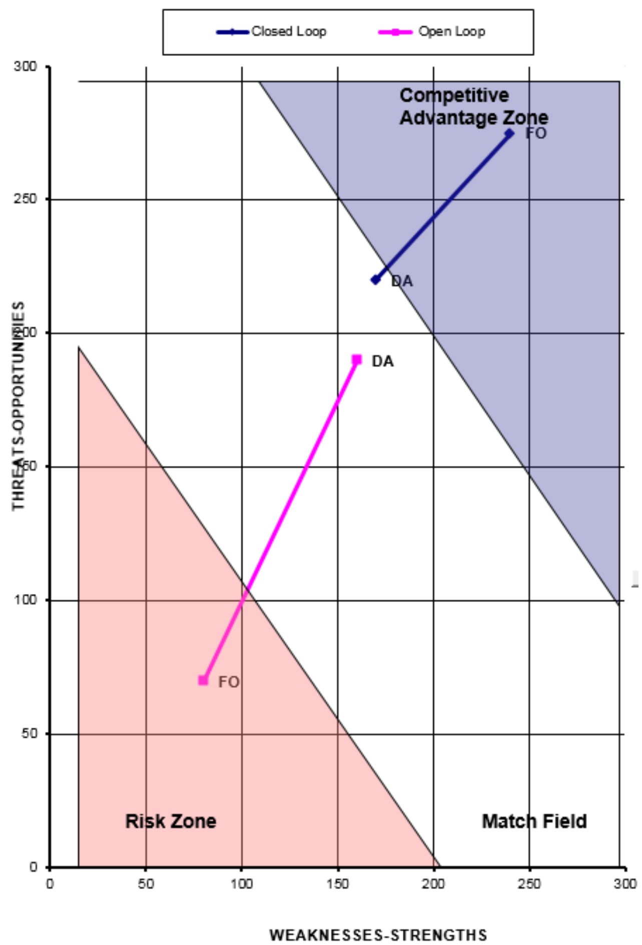


Figure A.15. SRSC SWOT Analysis Outcome.

7.3 Geothermal Collector Design

The geothermal collector model integrates the energy demand data and ground conditions at the site, to solve the total collector length required to satisfy the demand from the selected heat pump. This section describes the modelling methodology.

Specialist ground collector design software (EED) has been used to solve the total collector length required to satisfy the energy demand at SRSC and ensure the operational performance of the GSHP by delivering the required source side temperatures throughout the operational life of the system. The modelling integrates the heating demand derived from the consumption data at SRSC, the knowledge of the ground conditions and the analogue thermal properties of the bedrock where the collector is to be installed.

The objective of the model is to assess the ground temperature evolution over an operational period of 50 years and demonstrate that sustainable ground temperatures can be achieved ensuring efficient operation and maintained COP of the heat pump throughout the operational life.

The current standard documentation applicable for geothermal collector systems is Ireland is covered by the following:

- **NSAI (S.R.) 50-4:2021 - Building Services – Part 4: Heat pump systems for dwellings [6]**
- **prEN17522:2022 Design and completion of grouted borehole heat exchangers [4]**

Best practice in collector design requires that ground temperatures in heating mode do not reach below 5ºC at maximum peak load operation of the system during the heating season in the final year of assessment. This is to verify that the COP of the HP can be maintained based on brine 10-5ºC conditions as benchmarked against the manufacturer selection specification requirements.

It is important to note that the models only considers heat extraction in the context of a collector installed in saturated bedrock but with no contribution to heat exchange from groundwater flow across the vertical pipework.

For the purpose of modelling the collector at SRSC, the designer sought to:

- **Solve the required total collector length and configuration to meet NSAI (S.R.) 50-4:2021 specification for a system a lifetime of 50 years of operation;**
- **Ensure that the ground temperatures during the 50 year of operational life of the system can guarantee the COP of the heat pumps.**

7.4 Collector Model Results

This section outlines the main outputs of the collector model design process.

7.4.1 Thermal Model

The collector thermal model outlines the final collector specification and demonstrates the basis for the design of the geothermal collector array parameters.

7.4.1.1 Energy Demand Model Data

Based on the energy demand data presented in section 5, the following assumptions are made for the thermal model:

- A base load annual heating and domestic hot water demand of 602.12 MWh per annum
- Peak Load 420 kW
- Nominal Flow Rate of 72 m^3/hr across the collector
- COP/SPF of 3.47 in heating mode

A summary of the monthly profile base load including the domestic hot water demand apportioned to the above demand is summarised in table A.5. Given the lack of specific peak load data for the proposed system, the entire energy demand has been modelled as base load. It is therefore assumed that peak load requirements from the system are covered under the base load profile.

Table A.5. Space Heating Base Load Monthly Profile

Month	Heating & DHW Demand (MWh)	Ground Demand (MWh)
JAN	71.5	51.3
FEB	23.82	17.09
MAR	23.82	17.09
APR	23.82	17.09
MAY	23.82	17.09
JUN	33.60	23.94
JUL	33.60	23.94
AUG	33.60	23.94
SEP	33.60	23.94
OCT	66.71	47.87
NOV	90.53	64.96
DEC	49.35	34.70
Total	**602.12**	**362.92**

7.4.1.2 Geothermal Collector Thermal Model

Based on the subsurface information described at the site, a collector model was completed using the following assumptions:

- Layout based on space available around the car park area at the site
- Thermal conductivity properties of the Dartry Limestone Formation 2.75 [9]
- Temperature boundary conditions: 10ºC to 4ºC (as per Spectrum heat pump requirement)
- Borehole characteristics: Maximum depth: 200m, diameter 152mm
- Annual space backfill material: Thermally Enhanced Grout – 2W/mK^{-1}
- Geothermal Probe: Double 40mm with sacrificial grout tube
- Geothermal Collector Fluid: 30% monoethylene Glycol solution
- Parallel circuit design for all boreholes connected to a central manifold chamber

EED was used to solve the required borehole length for the energy demand profile and a series of collector layouts and spacing analysed as part of the model in ‘optimisation’ mode.

Table A.6 below summarises the geothermal collector design data for the new SRSC GSHP system.

Table A.6. SRSC - Summary Ground and Collector Design Data

DESIGN DATA		
SOLVED GEOTHERMAL COLLECTOR SPECIFICATION		
Number of boreholes	48	
Borehole depth	200	m
Total borehole length	9600	m
GROUND CONDITIONS		
Ground thermal conductivity	2.75	W/(m·K)
Ground heat capacity	2.3	MJ/(m³·K)
Ground surface temperature	8	°C
Geothermal heat flux	0.06	W/m²
FINAL BOREHOLE SPECIFICATION		
Borehole depth	200	m
Borehole spacing	10	m
Probe Type Installed	Double - U	
Borehole diameter	152	mm
U-pipe diameter	40	mm – SDR11 PE100RC Only
U-pipe thickness	3.7	mm
U-pipe thermal conductivity	0.42	W/mK^{-1}
U-pipe shank spacing	70	mm
Filling thermal conductivity	2	W/mK^{-1} (Thermally Enhanced Grout)
FLUID		
Fluid Thermal conductivity	0.48	W/mK^{-1}
Specific heat capacity	3795	J/(Kg·K)
Density	1052	Kg/m³
Viscosity	0.0052	Kg/(m·s)
Freezing point	-14	°C
Flow rate per borehole	0.63	(l/s)

The outputs of the model demonstrates that 48 No. closed loop geothermal boreholes with a minimum depth of 200m, resulting in a total drilled depth of 9,600m of collector are required to satisfy the demand load at the SRSC building.

7.4.1.3 Thermal Model Results

In order to contribute to reduced thermal resistance and improved long term ground temperatures, the 48 No. 200m borehole design makes provision for the use of Double-U, OD 40mm probes. The outputs of the SRSC collector thermal model are included in appendix B.

The long term ground temperature profiles resulting from the operation of the system in heating mode using the demand outlined in sections 5 are discussed below based on the results of the model.

The base load energy demand and peak load operation outlined, result in a profile of specific heat extraction rates from the ground based on monthly operation. Table A.7 summarises these rates.

Table A.7. Calculated Average Heat Extraction rates from the Ground based on 48 No. boreholes at 200m collector design

SPECIFIC HEAT EXTRACTION RATE [W/m]		
Month	**Base load**	**Peak heating**
JAN	10.93	31.98
FEB	10.84	23.1
MAR	11.18	21.32
APR	11.46	19.55
MAY	7.78	15.99
JUN	6.28	14.22
JUL	4.08	12.44
AUG	4.65	13.33
SEP	6.26	16.88
OCT	7.72	17.77
NOV	10.37	23.1
DEC	11.89	31.98

The heat extraction rates for the energy demand requirements remain modest based on the use of the 48 No. ground heat exchanger probes.

The effects of the above heat extraction are modelled by the software over a 50 year period of operation. Figure A.16 shows the temperature profile of the proposed collector over this period. Detailed temperature values are included in appendix B where the complete modelling results are reported.

The minimum temperatures achieved in heating mode when energy is extracted from the ground are shown in red and blue for peak load and base load operation respectively.

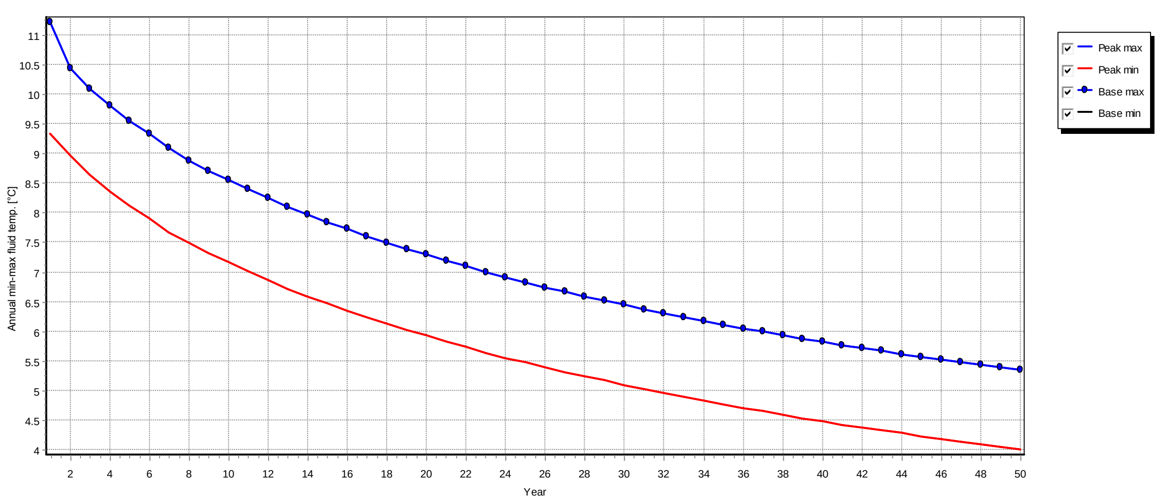


Figure A.16. SRSC - Annual Ground Temperature Data calculated based on base load demand on the collector (red line peak demand – blue line base load)

The temperature of the circulating geothermal collector fluid at year 50 of operation is shown in figure A.17. Both figure A.16 and figure A.17 show that the long term operation of the system ensures that ground temperatures are within the Engie Spectrum Heat Pump evaporator temperature specifications for the majority of the lifecycle of the system and only reaching 4ºC at their extreme lowest for two very short peak periods in January and November in the 50th year of operation.

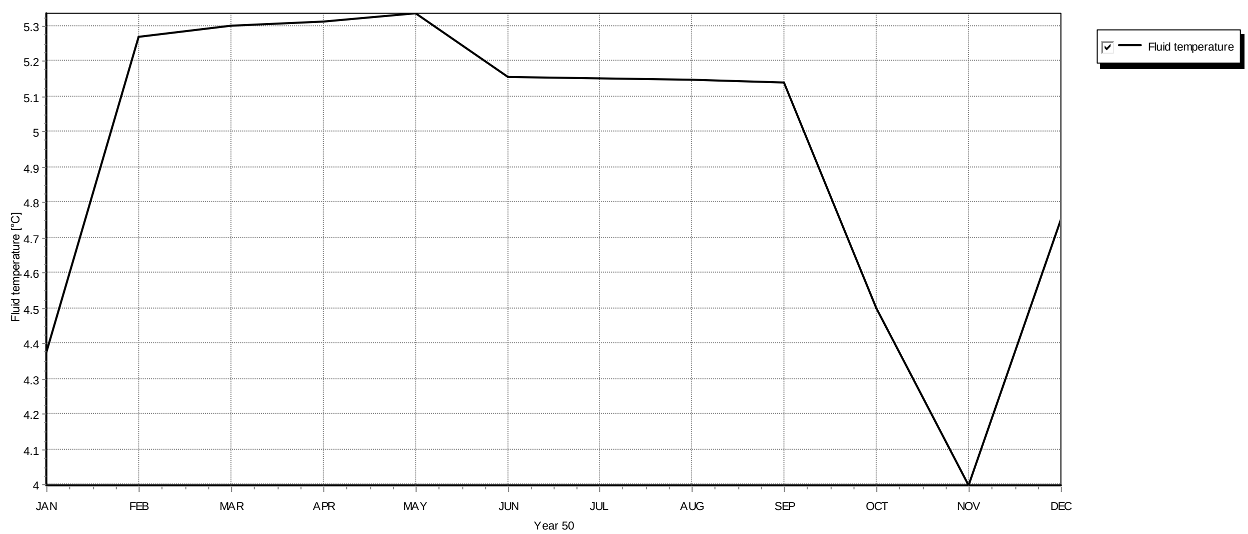


Figure A.17. Minimum Fluid Temperature Data based on base and peak demand at Year 50.

The solved long term collector temperatures are summarised in Table A.8.

Table A.8. Summary of expected collector fluid temperatures at year 50

MODEL SUMMARY RESULTS	
BASE LOAD OPERATION	
Minimum mean fluid temperature (°C at end of DEC – Year 50)	4
Maximum mean fluid temperature (°C at end of JUL – Year 50)	5.33

7.4.2 Hydraulic Model

The hydraulic performance of the geothermal collector has been considered based on the thermal collector assessment outputs outlined in section 7.4.2. A hydraulic verification based on the *MIS 3005 Microgeneration certification scheme Guidance for GSHP Hydraulic assessment* [5] was undertaken. A detailed hydraulic design using fluid flow modelling software was completed.

7.4.2.1 <u>The objectives of the model</u>

The objectives of the hydraulic model are to verify that the proposed collector design and layout configuration comply with the expected heat pump design and nominal operational parameters. The key criteria considered are as follows in order of importance:

- Pressure drop conditions are within the maximum values permissible for the HP;
- Minimal and Nominal HP operational brine flow rates can be met;

- Turbulent flow can be achieved in all the collector elements;
- Pipe sizing is selected to meet the above criteria;
- Brine circulation pumps can adequately meet the HP specifications;
- The proposed collector layout can satisfy the above criteria.

7.4.2.2 Model Assumptions

The following fixed inputs to the hydraulic model were applied:

- Heat Pump Elements – the heat pump element requirements are summarised in table A.9 below
    - Set maximum pressure drop of 0.37 bar at the Brine heat exchanger
    - Nominal design flow rate for the entire system of 51.6 m^3/h at the heat pump & ground loop heat exchanger
    - Brine Circulation pump (Ground loop side of the heat exchanger) – GRUNDFOS TPE 125-190 to achieve the flow rates required as per the heat pump manufacturer's specification
    - Heat Pump source circuit connection in parallel on a common header
- Active Elements – Double-U 40mm SDR11 PN16 ground heat exchangers in the layout discussed above;
- Double probe flows and return pipework connected using a Y-piece transition 40/40-50mm;
- Borehole Header to central manifold chamber – 50mm SDR17 PN10;
- Heat Pump header flow and return pipework elements comprising 160mm SDR17 PN10 with a maximum length of 140 m;
- Use of prefabricated chamber with headers including, full bore balancing valves (5-42 l/min rating) on the return flow header on each borehole circuit. Full bore ball valves on the borehole return headers;
- Requirement to achieve turbulent flow (Reynolds No. >2500) throughout the collector during operation;
- A pressure boundary of 2 bar at the brine HE;
- A fluid comprising a mixture of 30% ethylene glycol (-14°C rating) at a brine temperature of 0°C throughout the system.

The input assumptions for the completion of the assessment were taken from the Engie technical heat pump selection completed for the project (appendix D) and table A.9 below summarises the applicable parameters for the selected heat pump.

Table A.9. Heat Pump Pressure Drop Specification (Engie, 2023)

HEAT PUMP SPECIFICATION PER UNIT		
Make/Model	ENGIE – Spectrum SPH-W0500	
Heating Capacity	420	kW
Nominal Evaporator flow rate	51.6	m^3/h
Brine Heat Exchanger – Nominal Flow Rate Pressure Drop P_{hp}	0.37	bar
Brine Circulation Pump selected for ground loop heat exchanger	GRUNDFOS	TP 125-190_4

7.4.2.3 Geothermal Collector Layout

The results of the thermal mode, the hydraulic verification and the assessment undertaken as part of the initial site visit at the site, a geothermal collector layout is proposed. The collector layout has considered the existing conditions and the requirements for the construction phase of the project. The following key factors have been considered as part of the design of the proposed layout:

- Maximising the use of the existing green spaces and areas at the site location;
- Minimising construction stage disruption of the existing infrastructure in the car park and plant room areas;
- Requirement for the sport centre to remain open and operational during the completion of the proposed works;
- Potential presence of services and infrastructure affecting the installation of ground and connecting pipework from the boreholes to the plant room;
- The need for integration of the existing geothermal probe at the site as part of the new collector.

A collector focussed on the installation of a central manifold chamber to connect the 48 No. boreholes at 10m spacing (as required by the thermal model) is proposed in figure A.18.

Figure A.18. SRSC geothermal collector layout

The proposed layout allows the boreholes to be connected in a parallel arrangement, reduces the potential pressure drop from the system and provides greatest redundancy to the collector. An extract of the layout showing the location of the boreholes and the surface pipework connecting these to the manifold chamber is shown in figure A.18.a (appendix A).

7.4.3 Hydraulic Model Results

Figure A.19 shows the hydraulic model schematic based on the proposed collector layout above. The objectives of the hydraulic model and the performance of the layout and pipe specification comprising the connection in parallel of all 48 No. double-U probe circuits to a central chamber are shown in table A.10. Full schematics and details are available in appendix D.

The model demonstrates that a flow rate to the heat pump exceeds the nominal flow rate requirement, as well as offering a low, combined pressure drop of 0.3 bar (refer to header pipe ID 536 and 576) which is within the allowable value from the HP manufacturer.

Table A.10. SRSC Model Results - Summary

HEAT PUMP SPECIFICATION PER UNIT			
Objective	**Unit**	**Manufacturer Limit per HP**	**Model outcome**
Nominal Brine flow rate	m³/h	51.6	102.7
Brine Heat Exchanger – Nominal Flow Rate Pressure Drop P_{hp}	bar	0.37	0.38
Reynolds No. at furthest collector circuit (Lowest at pipe ID -1663)		>16,000	>22,000

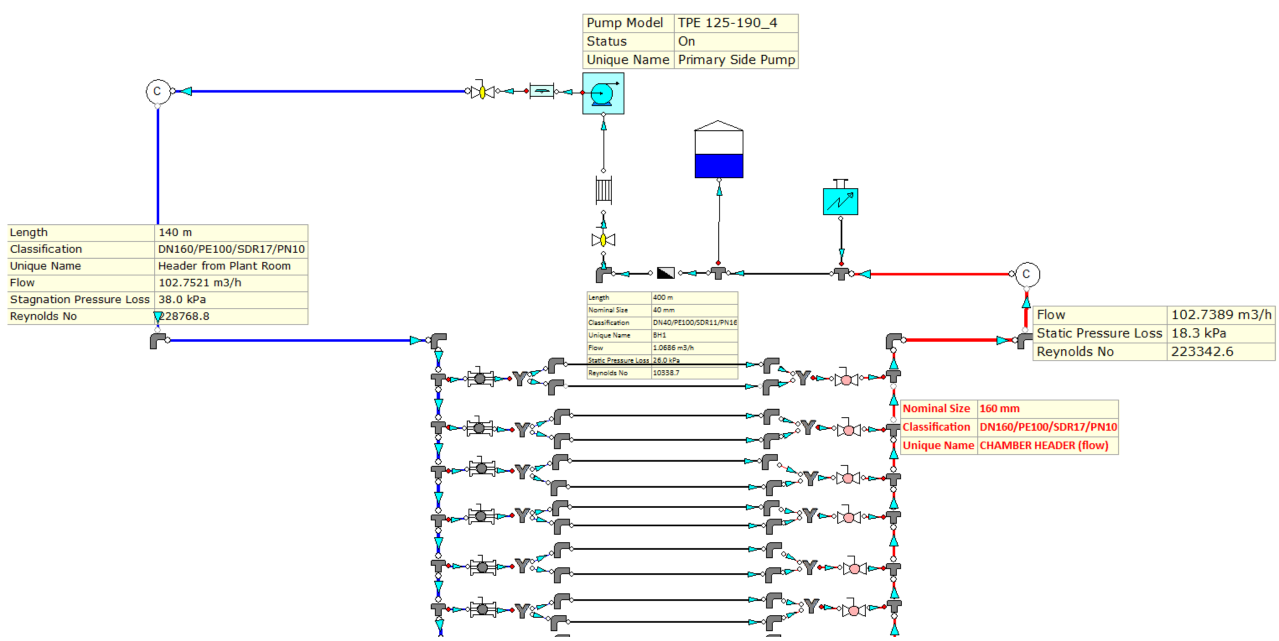


Figure A.19. Hydraulic results at nominal flow rate

8 WELL DESIGN & DRILLING SPECIFICATION

The section below provides an outline review of the proposed well design for the borehole heat exchangers, an outline methodology for the implementation of the enabling works required for facilitating the drilling operations and an outline assessment of drilling equipment and drilling methodologies to be used to implement the geothermal collector solution.

8.1 Well Design

The thermal model completed for the project based on the energy demand data and the heat pump selection, requires the completion of 48 No. 200m boreholes for the proposed collectors. A recommendation on the use of double geothermal probe comprising two flow and two return circuits of D40mm SDR11 PE100RC pipe (any reduced wall thickness will not be acceptable) per borehole are recommended to increase the energy exchange surface in each borehole. The well design for each of the boreholes is outlined in figure A.20 (refer to appendix C for detailed drawing).

The well design comprises the completion of a cased upper section to stabilise the overburden above the bedrock using 168mm casing (or larger diameter) set into the top of the bedrock section below any weathered horizons. The estimated depth of this is c. 8m.bG.L, however this is subject to confirmation from existing well records on site or through the completion of an initial test hole to verify the ground conditions.

The drilling should be completed at a diameter no wider than 152mm (smaller diameter of up to 147mm would be preferred) open hole in the bedrock section of the Dartry Limestone Formation to a depth of 200m. The drilling shall allow for a minimum of 2m of additional depth to accommodate the installation of weight (minimum of 140kg required) for the installation of the double-U probe in each hole.

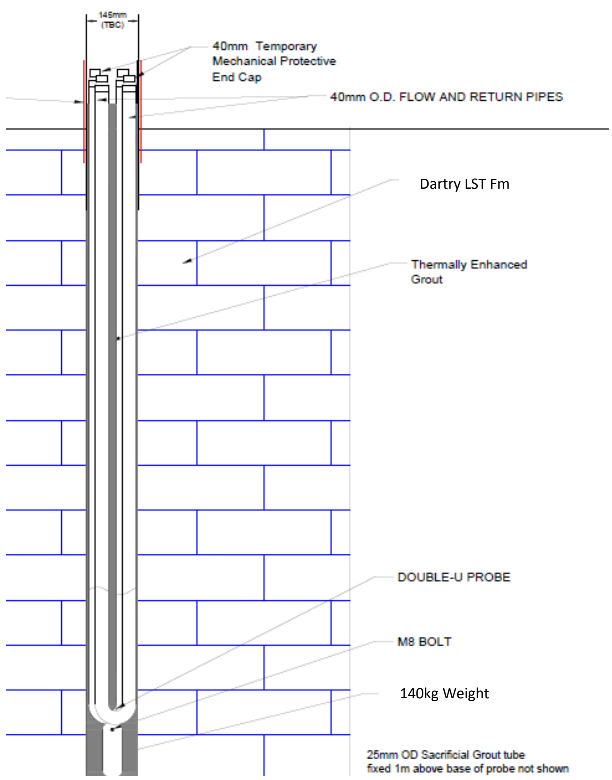


Figure A.20. SRSC – Geothermal Collector Well Design

The probe shall be filled with water on the surface and circulated to remove any air from the pipework, valves off or capped prior to the installation. A sacrificial grout tube (either 25mm of 32mm SDR11 pipework) shall be installed to the geothermal probe minimum 1m above the base of the probe. The probe shall be installed using a hydraulic decoiler with the ability hold the geothermal probe and withdraw the pipework during installation. The installation process shall ensure that the probe is installed slowly to the full depth of the borehole. Where the diameter of the hole permits (diameter greater than 147mm), spacers on the probe may be used to achieve and adequate shank spacing between to the flow and return pipework and to promote contact of the pipe with the borehole wall.

The annular space in the geothermal borehole shall be backfilled with thermally enhanced grout as per the requirement of prEN17522 and NSAI SR 50-4: 2021. The grouting process shall ensure that the grout is mixed to the manufacturer's specifications to achieve a minimum thermal conductivity of 2 W/mK^{-1}. Grout injection shall be performed using and paddle mixer and screw pump by injecting from the base of the borehole (injection from the surface will not be acceptable). The injection process will displace and groundwater present in the borehole and will remain continuous until such time that the grout overflows from the top of steel casing. The geothermal probe shall remain capped throughout the grouting process and for the duration of the grout setting period to prevent any pipework collapse.

8.2 Drill Pad Specification

The drilling operations will require preparation of the site to include the setting of a hard-core, level piling mat in order to set up the drilling equipment and facilitate completion of the drilling operations. An outline design of the piling mat area will require to be complete in detail prior to the commencement of the drilling operations. To achieve a level area for the proposed boreholes, the enabling works should include:

- Detailed topographic survey of the site;
- GPR/CAT scanner survey to identify presence of all existing services with respect to proposed borehole positions and surface pipework trenches;
- Stripping back of existing turf in grassed area;
- Cutting and removal of tarmac surface in areas where existing parking spaces are present;
- Excavation 100mm below existing ground level;
- Installation of temporary hard core (804) to accommodate piling mat working area;
- Excavation of each borehole position using either hand digging or vac-ex in areas where services are detected;
- Installation of protection 300mm PVC plastic casing prior to drilling where adjacent services are encountered.

A detailed design specification for approval should completed by a main contractor or specialist ground contractor prior to the commencement of the collector installation works.

The completion of the trenching works for connection the geothermal boreholes to the central manifold and to install the main header pipework from the central manifold chamber is further described in section 9 below. The installation of the collector makes provision for restoration works to take place after the completion of the collector in order to limit the visual impact from the proposed system. Upon completion of all the connections from the boreholes, surface pipework, manifold chamber and main headers, the collector area shall be re-instated to its original grassed status and any area of the car park returned to its original state.

8.3 Drilling Rig and Methodology

The completion of the geothermal boreholes for the proposed collector will require a drilling methodology to be implemented that considers the following aspects:

- Casing and stabilisation of any unstable overburden section above the bedrock – this may require the use of a casing while drilling system (ODEX or similar) where the presence of shallow gravels and potential for borehole collapse conditions are expected;
- Drilling and completion in competent limestone formation with the potential for intersecting water bearing fault structures;
- Presence of potential cavities and karst conduits leading to the requirement for well control measures to ensure the completion to the target depth required for each probe.

The expected ground conditions would allow the drilling operations to the completed using the following drilling methodologies:

- Down The Hole Hammer with air flush – this may require the use of a dual rotary rig to facilitate the installation of near surface casing. The use of compressed air in the bedrock will require a water management system to be put in place to collect, treat and dispose of groundwater intersected during the drilling operations. A discharge license for this method will be required to complete the works.
- Down the Hole Hammer with water flush – this will be similar to above but the re-circulation system used with a water hammer will reduce groundwater production from the formation during drilling, resulting in a reduced water management requirement which may limited to occasional disposal of filtrate from the re-circulated water;
- Rotary mud/water flush – this methodology would favour reduction in water management and disposal requirements, the reduction of CO_2 emissions from the drilling process but will require more time for borehole completion due to reduced penetration rates.

The drilling methodology chosen will require a detailed risk assessment to be implemented as part of the final project delivery phase that will require consideration of the site specific geological conditions and the observations made above in terms of waste and water management for the completion of the collector.

The report has considered the current supply chain of drilling equipment and contractors in Ireland, which have adequate equipment for completing the geothermal collector works. The majority of the specialist contractors and drilling equipment in Ireland is based on the use of diesel-hydraulic drilling plant equipment, with different contractors and rigs available to complete the drilling scope of works for this collector.

In addition, to the use of the more conventional equipment described in table A.11 below, the use of electric drilling rig was considered. Electric drilling rigs are currently not available on the market in Ireland, with contractors with such equipment only available in the UK or continental Europe. A limited number of manufacturers are currently offering electric drilling rig solutions, drilling rigs such as the EPIROC SmartROC T35 E battery-electric drilling rig would be suitable for completing the geothermal collector at SRSC. The use of electric drilling equipment will require further detailed investigation prior to the construction phase to ensure that an adequate power supply can be provided at the site.

Table A.11. Drilling Technology Comparison (**cost of MGO -16/03/2023 0.925 €c/l & electricity cost based on 0.21 €/kWh – SEAI, 2023. ***electricity Grid CO_2 emission, 2021. * SEAI - https://www.seai.ie/data-and-insights/seai-statistics/conversion-factors/)***

Drilling Method	DTH – Air Flush	DTH – Water Flush	Rotary – Water/Mud Flush	Electric (assumes Rotary)
Solid Waste (m^3 per borehole)	3.63 (152mm)	3.63 (152mm)	3.39 (147mm)	3.39 (147mm)
Water Disposal	**High** – for discharge license, treatment and disposal to foul of produced formation water	**Low** – shale shacker treatment & licensed disposal of recirculated water	**Low** – shale shacker treatment & licensed disposal of recirculated water	**Low** – shale shacker treatment & licensed disposal of recirculated water
Carbon Footprint – Drilling Rig Only (g CO_2/unit of fuel/)	10,591	10,591	7,092	10,259
Fuel CO2 content in g CO_2/kWh of fuel (source https://www.seai.ie/data-and-insights/seai-statistics/conversion-factors/)	263.9	263.9	263.9	347.8
Estimated Drilling Cost **(€/m) – drilling rig only	3.453	3.453	2.3125	5.575

9 COLLECTOR DESIGN SPECIFICATION

The outcomes of the thermal and hydraulic modelling of the proposed collector, the final specification of the collector layout as part of the feasibility design is presented in this section.

The final collector layout incorporates 48 No. boreholes to be installed in the southern and eastern part of the Sports Centre site. The layout proposed makes provision for integration of the 1 No. initial test borehole previously completed at the site.

Careful consideration has been given to the location of the collector elements with respect to the 10m spacing required between the boreholes, the length of the main flow and return headers from manifold chamber proposed and the heat pump in the plant room.

As part of the objectives of the final design, the importance in minimising any visual impact on the existing site infrastructure and parking area that the collector might have. In addition, the design takes into consideration such impact with respect any maintenance and future servicing requirements.

The final design and installation includes the following main key elements:

- A total of 48 No. geothermal probes using double-U 40mm O.D. borehole heat exchangers at a 10m spacing shall be installed to satisfy the energy demand. The boreholes shall be installed in accordance with EN and NSAI standards and shall comprise the use of cementicious thermally enhanced grout with a thermal conductivity of 2 W/mK (Drawing 0119A);

- Following completion of the drilling operations, each individual geothermal probe should be pressure and flow tested in accordance with the UKGSHPA methodology, the BS EN 805 modified method, EN17628:2015 and prEN17522. A field and digital record of each individual test shall be provided to the client in advance of the commencement of the next phase of works. Note that where pressure and flow testing is not deemed to be practical with respect to a finalised construction programme, it is possible to undertake this phase of work upon completion of the surface pipework connections from the boreholes prior to these being connected at the central manifold chamber.
- Once the individual geothermal probes are pressure and flow tested, the excavation of the trenches along the collector and at each borehole to facilitate the installation of the pre-insulated surface pipework. The layout of such trenches is shown in figure A.18.a (appendix A). This configuration allows trenches to be completed so that the pre-insulated pipework can share individual trenches without thermal interference between the individual boreholes header flow and return pipework. The depth of the trenches shall be no less than 1000mm from the top of the existing ground surface in the case of the boreholes and no less than 1600mm at the manifold chamber and area facing the collector (Figure A.18.a– appendix A).
- Drawing 0119B (appendix A) demonstrates that the depth of excavation required around each borehole and the need for an area 1200mm by 1200mm to be overdug by 200mm around each borehole below the excavated piling mat surface. This is to facilitate the cutting back of the casing and allowing for the connection of the surface pipework to base of the grouped surface pipework trenches;
- The Double 40mm probes in each borehole shall be connected using electrofusion 'Y' pieces to 50mm SDR17 headers with EF 90^o elbows and couplers (refer to Drawing 0119B – appendix C). Detailed welding records (including operator, fitting barcode, welding time, cooling time and a photographic record) shall be kept of each weld;
- Adjacent borehole pre-insulated flow headers and return headers shall be grouped into the same trench to minimise the surface footprint of the excavation (refer to Drawing 0119C – appendix A);
- A central manifold chamber comprising 160mm SDR11 headers shall be used to accommodate the individual borehole circuits. Drawing 0119D shows the proposed Frank Gmbh H-1500 model proposed for the design. The chamber configuration shall include a total of 48 individual circuits. The chamber will be equipped with flow balancing valves (5-42 l/min) on the individual flow manifold circuits and isolation ball valves on the return manifold. The prefabricated chamber shall include OD. 50mm stubs to facilitate the EF welding of the individual circuits as well as OD 160mm main flow and return header stubs for connection of the surface pipework. The flow and return headers will be internally equipped with butterfly valves.

  The chamber will facilitate reduced visual impact potential and the possibility using additional landscaping measures such as restoration of the original grassed area or re-instatement of the car park surface to reduce this further by including a trafficable D400 rated steel lid above the manifold chamber (such measures will require further discussion with the main contractor);
- Individual 50mm SDR17 headers from each borehole shall be connected to a central manifold chamber using EF couplers, 45^o, 22.5^o and 90^o elbows as required. Detailed welding records (including operator, fitting barcode, welding time, cooling time and a photographic record) shall be kept of each weld;
- The surface pipework including both the borehole and manifold headers, shall comprise a minimum bedding of 150mm below the pipework and 150mm above the pipework (total 300mm)

of washed rounded (10mm to 14mm) pea gravel or sand (refer to Drawing 0119C and 0119B – appendix A) to be supplied and installed by the specialist grounds contractor completing the excavation and re-instatement works;

- Following the connection of all the borehole header pipework, the collector shall be circulated and flushed though the central manifold and the individual surface pipework sections pressure and flow tested in accordance with the above specifications. At the end of the flow testing phase, each individual borehole header circuit shall be set a flow rate of 1.3 m^3/h.
- Following the surface pipework pressure testing phase, the pipework shall be left pressurised to 2 bar prior to the burial and backfilling of the trenches. In the event of any test failures, the pipework shall be pressurised again and visually inspected to identify any potential defects or leaks. Any necessary repairs shall be implemented using EF welding and a record of each weld kept.
- 160mm PE100 SDR17 main header flow and return pipe will be run from the manifold chamber to the plant room for connection to the heat pump. The manifold header pipe work shall be supplied in straight lengths and connected to the chamber using EF couplers and 45°/90° elbows as shown in Drawing 0119E.
- The pre-insulated header pipework shall not exceed a length of 140m. The bedding detail shall be similar to that of the borehole header pipework (Drawing 0119B).
- The entry point of the pipework to the plant room building shall be completed through a dedicated pipe entry point in the new basement slab to be completed for the plant room extension, or where entry to the building shall be through an existing or plant room extension wall, the entry points shall be equipped with 160mm heavy duty, EPDM sealing rings. Casing tubes shall be provided and cast by the contractor completing the plant room as part of the main plant room construction. Any further sealing or waterproofing measures shall be provided by the contractor.
- The header pipework finish in the plant room shall include the installation of a temporary cap to the flow and return headers (either using and EF welded end cap or a mechanical fitting). The ends of the surface pipework shall be fitted with a welded transition EF 160mm to 5” Male BSP threaded brass adaptors. The remainder of the plant room pipework connections shall be completed by a specialist M&E contractor responsible for the installation of the plant room equipment and the heat pump. The following will be required to complete the brine header connections to the plant room:
    - 1 No. Y In-line Strainer Brass - 5" BSP PF on each header
    - 1 No. 1 ¼” male BSP filler port with isolation valve on each header
    - Isolation ball valves on each side of the strainer/filler port section
    - 1 No. air bleed valve on each of the main headers and individual HP source headers
    - 1 No. brine expansion vessel in accordance with the manufacturer’s specification (final calculation to be provided prior to technical submittal approval at construction phase)
    - 1 No. pressure gauge on each on the source entry pipework to the ground loop heat exchanger.

10 COST ANALYSIS

This section reviews the CAPEX and OPEX of the proposed new GSHP systems for SRSC based on the technology selection and the expected operation of the system to meet the energy demand of the building. Table A.12 present a summary CAPEX for the purchase of the equipment including the heat pump and all ancillary equipment required for the installation of the new GSHP system, the installation of the geothermal collector and the completion of the plant room extension based on construction of a new extension to include the electrical and mechanical fit out.

Table A.12. Capex for proposed GSHP System at SRSC – 2 design options provided

Task Description	Unit	Comments	Total Budget (€ ex VAT)
Geothermal Drilling, Probe Supply & Installation			
Drilling & Casing to 200m - DoubleU probes, Grouting S&I		48 No. 200m BHLs - 155mm	588,288.00
Waste Management & Disposal	PC SUM	Estimate (subject to review)	33,000.00
Site Preparation, Welfare, Security	PC SUM	Estimate only	39,000.00
Geothermal Surface Materials			
Manifold chamber, Insulated Headers (Borehole & Plant room)	Supply	All pre-insulated HDPE pipework	87,200.00
EF Fittings for entire System	Supply		7,700.00
Glycol - 30% volume	Supply		34,500.00
Installation and Testing			
Borehole Head works - EF welding of all pipework	days		23,280.00
Pressure & Flow Testing + Certification	days		13,200.00
Collector Flushing - Glycol Mixing, Filling & Commissioning	days		6,850.00
Drilling Supervision	days		49,000.00
PM - Contingency, H&S, Freight (9%)			79,381.62
Total Turnkey Collector (ex VAT)			*961,399.62*
Geothermal Heat Pump & Plant Room			
Heating Only - OPTION 1			
New Plant room in back yard incl. mechanical fit out	PC SUM	Estimate only	189,000.00
Heat Pump (300kW)			180,000.00
Pipework Valves & Insulation			50,000.00
Materials (pumps, heat exchangers, buffer tanks, controls & BMS)			47,000.00
Electrical Supply and distribution	PC SUM	Estimate only	30,000.00
Design Stages (IFT, IFC, as-built)			10,000.00
Site balancing and commissioning			5,000.00
Preliminaries, PM, H&S (8%)			30,000.00
Unforeseen Mechanical Costs (3%)			15,000.00
Total Plant Room Option 1 (ex VAT)			*556,000.00*

Heating & Cooling - OPTION 2			
New Plant room in back yard incl. mechanical fit out	PC SUM	Estimate only	189,000.00
Heat Pump (300kW)			180,000.00
Pipework Valves & Insulation			150,000.00
Materials (pumps, heat exchangers, buffer tanks, controls & BMS)			80,000.00
New Cold Water Loop & Gym Cooling			30,000.00
Electrical Supply and distribution	PC SUM	Estimate only	60,000.00
Design Stages (IFT, IFC, as-built)			10,000.00
Site balancing and commissioning			5,000.00
Preliminaries, PM, H&S (8%)			40,000.00
Unforeseen Mechanical Costs (3%)			20,000.00
Total Plant Room Option 2 (ex VAT)			*764,000.00*
		OPTION 1	
		Sub-Total (ex-VAT)	1,517,400
		OPTION 2	
		Sub-Total (ex-VAT)	1,725,400

Based on the energy demand data provided an estimate comparison of the running costs of the system against the existing LPG fired technology used to deliver the energy demand of the building is presented shown in table A.13 below. The analysis has been completed to demonstrate the upfront capex and operational costs of the system. The following assumptions have been made for the assessment:

- CAPEX based on delivery of plant room Option 2 – heating & cooling solution;
- Assumed OPEX based on heating only scenario. No cooling has been considered due to lack of demand data;
- No Capital investment cost or financing;
- Fuel costs based on the SEAI Commercial Fuel costs – January 2023;
- No cost of inflation, increase in fossil fuel costs or reduction of electricity cost included;
- Fuel conversion factors based on SEAI Commercial Fuel tables;
- System efficiency based on the GSHP manufacturer data sheet;
- LPG gas boiler efficiency assumed based on age of the equipment surveyed;
- CO_2 emissions based on published SEAI CO_2 emissions per fuel.
- Additional saving for Option 2 based on inclusion of 15,000 kWh of free cooling (currently from AHU units
- Current LPG for spend aligned with SEAI, SSEA – January 2023 Energy Audit report

Table A.13. Capex for proposed GSHP System at SRSC – 2 design options provided

Name	Fuel Cost (c€/kWh)	Conversion Factor (*) Unit of fuel to kWh	COP	Geothermal Collector Cost (€)	Heating Installed Capacity (kWth)	GSHP & Plant Room Upgrade Cost (€)	Energy Produced (kWhth) Per annum	OPEX € Per annum	Plant Life Years	Delivered Energy Cost of Heat (€/kWh)	LCOH (€ per kWh) - 7% Discount Rate (excl GT collector)	Installed Capacity Cost (€ / kWth)	Annual Saving (€)	Annual tonnes CO_2 emissions (**)	Annual tonnes CO_2 saved	Simple Payback excluding geothermal collector
GHSP - Option 1	0.238	1	3.47	€ 961'400	420	€ 556'000	602'000	€ 41'290	25	0.0686	0.5670	3'613	47'137	60.34	188	12
GHSP - Option 2	0.238	1	3.47	€ 961'400	420	€ 764'000	602'000	€ 41'290	25	0.0686	0.7644	4'108	50'707	60.34	188	15
LPG Fired Boiler	0.86	10.55	0.73		500		786'456	€ 88'426	25	0.1124	0.0642	0	0	248.74	0	

* SEAI Commercial - Comparison of Energy Costs - Quarterly, January 2023

** gCO_2 emissions per kWh - https://www.seai.ie/data-and-insights/seai-statistics/conversion-factors/

(blue) figure includes additional annual saving from free cooling replacing 15,000 kWh of AHU cooling

(pink) figure aligned with SEAI SSEA Energy Audit 2023 post completion of the feasibility report

The outcome of the economic assessment demonstrated the potential in operational savings of over 47,000 euro associated with installing either option 1 (heating only) or 50,000 euro with option 2 which provides free cooling to the facility compared to the cost of operating the existing LPG boilers. The economic assessment is limited only to the generation of heat and does not consider the operational costs associated with the cooling demand at SRSC. In the case of Option 2 outlined above, the cooling is deemed free for the purpose of this model with an increased installed capacity cost compared to Option 1. A saving equivalent to estimated equivalent electricity usage of the AHU units is included in this scenario

The implementation of a GSHP heating solution at SRSC will also provide a significant CO_2 emission reduction to meet the energy demand based on the current technology used.

The analysis has assumed a plant life of 25 years to demonstrate a LCOH (excluding the capital investment cost of the collector) in order to compare the proposed heat pump and plant room technology solutions with that of the cost of replacing the existing LPG boiler with a modern condensing gas boiler.

A simple payback based on the operational cost savings against the capital expenditure (excluding the cost of the geothermal collector which is deemed to have a longer life cycle than the plant room equipment) shows a payback periods of 18 and 25 years respectively for options 1 and 2.

11 RISK ASSESSMENT & DATA GAP ANALYSIS

The risk assessment phase of the study has focussed four key aspects of the project related to the design, implementation and operation of GSHP system at SRSC. These areas include:

- The validation and completion of the geothermal collector (refer to section 11.2);
- The availability of the GSHP solution and collector elements for the construction phase;
- The integration of the new plant room to the existing building;
- The operational risks associated with the operation and maintenance of the system.

A risk assessment methodology (figure A.21) has been applied to the above aspects and used to identify suitable mitigation measures that would allow to reduce the level of risk and likelihood of occurrence of given hazards or gaps. A risk assessment matrix is summarised in table A.14.

HAZARD:	Is taken to mean anything that can cause disruption to the project delivery or operation.
RISK:	Is the chance, great or small, that some activity is likely to cause a hazard.
SEVERITY:	Is the possible outcome of a hazard occurring
LIKELIHOOD:	Is the possibility of the occurrence of a hazard

SEVERITY		LIKELIHOOD	
High	Major Project disruption (design, construction or operation)	**High**	Certain, near certain.
Medium	Disruption to project delivery, construction timeline & operation of solution	**Medium**	Reasonably likely to occur
Low	Minor Disruption to project delivery.	**Low**	Very seldom or never.

SEVERITY

LIKELIHOOD	LOW 1	MED 2	HIGH 3
LOW 1	LOW 1	MED 2	MED 3
MED 2	MED 2	MED 2	HIGH 6
HIGH 3	MED 3	HIGH 6	HIGH 9

Figure A.21. SRSC – Project Risk Assessment Methodology

Table A.14. SRSC Project Risk Assessment

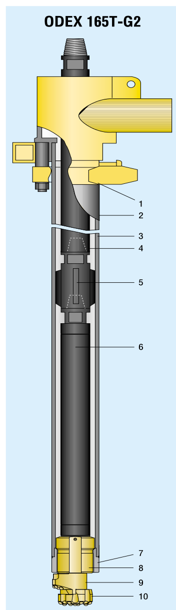
Activity	Hazard identified	Degree of risk			Control measures to be implemented to reduce level of risk	Residual Degree of Risk		
		L (1-3)	S (1-3)	R (1-9)		L (1-3)	S (1-3)	R (1-9)
Geothermal Collector Design	Thermal Properties & Sub- surface conditions not as expected. Collector design specification affected	2	3	6	Secure well log data from existing neighbouring boreholes to determine site specific conditions. Information from boreholes and geothermal collector installation at the site to be obtained. Undertake an undisturbed temperature profile of geothermal collector probes installed on site and complete a thermal response test to determine site specific thermal properties. Use results of the test to validate the thermal collector model design and layout.	1	2	2
GSHP system solution and Geothermal collector design	Inaccurate energy demand profile leading to incorrect sizing of HP and collector	3	3	6	Implement non-invasive monitoring solution for a heating period of the existing plant room and building infrastructure to monitor temperature and energy demand profiles on a min. ½ hourly basis for a period of no less than 1 year prior to commencement of installation. The monitoring data should include all heating, cooling and dehumidification requirements for the building. The demand data should be used to verify the GSHP selection and design (likely to remain unchanged) and to verify the geothermal collector model completed. The inclusion of a cooling load to the energy demand profile is likely to have a positive effect of long term collector temperatures and COP/SPF of the GSHP.	1	1	1
Geothermal Collector & GSHP Materials & Equipment	Delay in project implementation. Supply chain delay	2	2	4	Ensure geothermal collector and GSHP system specifications are finalised at early project stage. Consider pre-order and payment of materials to ensure delivery timelines and allow for project development timeline not to be compromised. Supply chain lead times estimated to 6 to 10 weeks from the point of order.	2	1	2

Drilling Operations & Contractor Selection	Availability of drilling rig and suitable contractor	2	2	4	The availability of drilling contractors with suitable equipment to complete the geothermal collector should be scoped at early project development stages. The completion of the geothermal collector and surface pipework would require a contractor with specialist experience in completion and installing geothermal systems to achieve the required specifications. Experienced contractors in Ireland are limited and early engagement with potential service providers essential.	2	1	2
Project Completion	Drilling and completion of geothermal collector – completion of plant room works delay and slippage	2	3	6	The selection process for contractors to deliver the GSHP solution and the geothermal collector to SRSC will require the engagement of specialist contractors (geothermal – turnkey service, design and build; main contractor/construction – surface excavation works and plant room construction; M&E – specialist plant room delivery for all mechanical and electrical installations). Early engagement through the form of a pre-qualification system allowing specific project timelines and deliveries to be outlined is critical to ensuring that a project delivery timeline is defined at early stage and that this is in line with any potential grant funding requirements that the project may be subject to.	2	1	2
Ground Works and Plant Room Structure	Excavation in the presence of existing services	3	3	9	A design risk assessment and detail survey of existing service infrastructure should be completed prior to finalising all construction drawings to map and identify all existing services and infrastructure in the proposed excavation areas for the geothermal collector surface pipework and the plant room. The results of the survey should allow for a completed final collector surface pipework design drawing to be completed, a definition of the excavation requirements (vac-ex or other) and any re-instatement measures to be implemented as part of the completion of the project. Given the limited space in the plant room, an extension needs to be completed in back yard to the NW and W of the existing plant room. A detailed design for the proposed extension should be implemented at early project development stage to by a competent engineering consultant.	2	1	2

Obsolete Plant Room Equipment & Decommissioning	Environmental risk with decommissioned infrastructure	3	3	9	Old Oil tank will need to be decommissioned and removed. Specialist services to assess risks and costing of to implement environmental mitigation measures that may be needed. Existing boilers are both obsolete, if LPG backup is maintained, they would need to be decommissioned and disposed of by a specialist contractor.	2	2	4
Cooling & AHU Infrastructure	Obsolete cooling and AHU infrastructure – inefficient operation	3	2	6	Cooling will be beneficial to the building for the Pool Dehumidification and for the Gym. Adding cooling secondary system will represent an additional cost. The pool AHU is currently in poor conditions, and it will need extra ordinary maintenance (condensate drain not working, the floor is flooded and corroded). Consider replacement of all cooling and AHU infrastructure as part of the HVAC system upgrade (outside scope of the project)	1	1	1
GSHP System Operation	Elevated cost of operation compared to expected OPEX	2	2	4	A final system design verification based on monitoring data should be implemented at the early stages of the development phase following initial monitoring measures and the completion of testing of subsurface conditions (refer to above). The long term operational costs and the efficiency of the system will depend on ensuring that load profiles and ground conditions of the collector are guaranteed. This can only be implemented through ensuring that all demand is carefully identified and that no additional demand arises through expansion, poor use of HVAC facilities or other. Engagement with electricity suppliers to secure the most economical tariffs for the operation of the GHSP should be sought and reviewed on a yearly basis to maximise cost savings.	1	2	2

11.1 Drilling Risk Assessment

The key risk will be low penetration rates, adding additional time to the programme, but this is considered to be of low concern. Geological risks, will be quickly identified during the drilling of the first well, with contingencies planned (but not implemented). A shallow casing, installed with a bottom driven casing system e.g. ODEX (figure A.22), will ensure stability of the wellbore near surface and ensure that the probes can be installed more efficiently. The completion of an initial test well or the review of existing borehole information from the site (table A.14) is recommended prior to the completion of a detailed drilling programme for the main collector works.



Type of hammer

	Description	Specifications
1	**Discharge/ Diverter head**	Complete, O.D. 254 mm For 102 mm hose (not incl.) Spare parts and hoses, see below
2	**Adapter sleeve**	Used with discharge head
3a	**Start casing tube**	One piece per bore hole Length 2980 mm excl. thread Incl. Casing shoe 8393 8179-54
3b	**Casing tube**	L.H. thread, O.D. 193.7 mm Wall thickness 6.3 mm ★ Lenght 3000 mm
4a	**Start drill pipe**	One piece per drill string (see page 32)
4b	**Drill pipe**	3 1/2 API Reg. diameter 114 mm (4 1/2) Wall thickness 6.3 mm, wrench flats 95 mm ★ Length 3000 mm
5	**Guide sleeve** Wrench flats 95 mm	3 1/2 API Reg. effective length 250 mm
6	**DTH-hammer**	Thread 3 1/2 API Reg.
7	**Casing shoe**	Surface hardened Included in Start casing tube (3a)
8	**Guide device** **- Foot valve** **- Locking kit**	 Plastic See page 32-33
9	**Reamer**	★★ Reaming diameter 209 mm (8 7/32)
10	**Pilot bit**	★★ Diameter 165 mm (6 1/2)

★ Below alternatives of casings and pipes, are available as standard

Length (in mm)	Casing tube Part Number	Drill pipe Ø 114 Part Number
1000 mm	8393 8179-55	8484 0141-90
1500 mm	8393 8179-63	8484 0201-08
2000 mm	8393 8179-71	8484 0141-91

★★ Buttons

	No. x size mm Gauge	Front
Reamer	5 x 16	1 x 16
Pilot bit	8 x 16	9 x 16

12

Figure A.22. SRSC – Example of bottom drive casing system

12 POTENTIAL FOR GEOTHERMAL SOLUTION EXPANSION

As part of the initial assessment of the SRSC site, GeoServ has also given consideration to other areas of Sligo town where shallow geothermal and deep geothermal technologies could be replicated to facilitate in decarbonising local heating and cooling loads. Key areas of Sligo town identified during initial consultation with GSI and SCC have been considered in the context of potential development of shallow and deep geothermal solutions. These areas were selected on the basis of potential energy demand and space availability to replicate the geothermal collector technologies presented in this report. These areas were also considered in the context of the potential development of future district heating in the town and the role the geothermal infrastructure could play in decarbonising existing and future energy demand as well as acting as interseasonal energy storage. These areas and the potential for energy delivery are presented in figure A.23 and in table A.15.

Figure A.23. Areas considered for expansion of geothermal energy solutions around Sligo town.

It is important to note that no site specific assessment of energy demand analysis of nearby or future users has been completed as part of this study. The assumptions on the deployment of shallow geothermal solutions in the areas highlighted are based on the following assumptions:

- Heat pump operating hours limited to 1800 hours per annum

- Heat pump COP/SPF 3 [1]
- Delivery temperature limited to 60ºC
- Cooling load Not considered

The options outlined in the scenarios in table 15 are based on heat only usage. The identification of cooling loads that may be present at for example the hospital or the University may act beneficially in the context of a shallow geothermal solution by either increasing capacity of reducing the amount of boreholes and drilled collector to meet energy demand.

No detailed assumptions were made for the deep geothermal scenarios. The deep closed loop options are provided on the basis of the outcomes of the design provided for a similar system for TUD in part B of this report. The open loop options remain highly speculative and subject to proving geothermal temperature gradient and the presence of sustainable flow rates in the Carboniferous limestone in Sligo town. There is a need for more deep geological information (e.g., deep exploratory holes and geophysical surveys) to allow the deep geothermal resource to be characterised.

Table A.15. Qualitative Assessment of Potential for additional Geothermal Energy Development in Sligo

Area	Space Available	Shallow GT Opportunity	Deep GT Opportunity	Potential Use
Sligo Racecourse	117,691	Up to 1200 No. closed loop array – c. 7 to 8 MW_{th}	Up to 30 deep closed loop heat exchangers to 2,000m – c. 3 MW_{th} Or Deep Open Loop system to c. 2,000m if suitable flow rates are achieved up to c. 5MW_{th}	Direct use heating and cooling in the nearby business and residences; Interseasonal storage & DHN connection
Cleveragh Business Park	25,565	Up to 210 No. closed loop array – c. 1 to 1.2MW_{th}	Limited space for deep geothermal delivery	Direct use heating and cooling in the nearby business and residences; Interseasonal storage & DHN connection
Lidl & Racecourse	50,357	Up to 400 No. closed loop array – c. 2 to 2.4MW_{th}	Up to 12 deep closed loop heat exchangers to 2,000m – c. 1.2 MW_{th}	Direct use heating and cooling in the nearby business and residences;

[1] COP assumed based on higher temperature application (COP/SPF may be higher following initial design screening)

			Or Deep Open Loop system to c. 2,000m if suitable flow rates are achieved up to c. 5MW$_{th}$	Interseasonal storage & DHN connection
Sligo University Hospital	122,827	Up to 250 No. closed loop array – c. 1.2 to 1.4MW$_{th}$ based on 25% available space identified in green areas only	Up to 8 deep closed loop heat exchangers to 2,000m – c. 1 MW$_{th}$ Or Deep Open Loop system to c. 2,000m if suitable flow rates are achieved up to c. 5MW$_{th}$	Delivery of simultaneous heating and cooling to the hospital facility; Interseasonal storage & DHN connection
Atlantic Technical University Sligo	270,064	Up to 600 No. closed loop array – c. to 3 to 4MW$_{th}$ based on 30% available space identified in green areas only	Up to 40 deep closed loop heat exchangers to 2,000m – c. 5 MW$_{th}$ Or Deep Open Loop system to c. 2,000m if suitable flow rates are achieved up to c. 5MW$_{th}$	Delivery of simultaneous heating and cooling to meet on site demand; Interseasonal storage & DHN connection

Whilst the potential for the integration of both the shallow and deep geothermal energy solutions for Sligo to any future planned development of a DHN in the town are not directly considered in the study, the design and feasibility acknowledges that the areas highlighted have the potential to integrate both low temperature shallow geothermal energy solutions and deeper closed loop energy storage facilities with any future DHN development.

13 SRSC GSHPP SYSTEM CONCLUSIONS

Based on the energy demand data provided for SRSC and the specifications of the proposed heat pump selected for the GSHP system, a thermo-hydraulic assessment has been used to propose the final design for the geothermal collector. The following conclusions can be drawn:

GSHP System Design:

- Based on the limited data available and existing equipment size, a 420 kW Heat pump would be able to deliver the majority of heat to the building, supplying a water temperature of 65°C.

- The design specification of the GSHP system proposed are based on the current building fabric without the implementation of any retrofit measures.

- The new HP will be integrated to existing secondary loop and infrastructure available at SRSC with only minimal upgrades on the secondary side required.

- If new wall mounted condensing boilers are installed to replace old boilers, space in existing plant room should be enough to accommodate new heat pump.

- Simultaneous Heating and Cooling will be relevant to the building (and beneficial to the ground loop) as well as providing improved long term energy efficiency, although a higher initial investment will be necessary.

Thermal model results:

- An energy demand profile comprising a base load heating demand of 506 MWh from a heat pump operating in heating only mode per annum was used. A monthly peak load demand expressed as the number of hours per month the system would operate at a load of greater than 420kW was input to the model.

- The monthly base load and peak demands were used to determine the geothermal collector length required to satisfy the demand and assess the effects on ground temperature to achieve sustainable operation over a period of 50 years.
- Based on the known ground conditions and thermal properties of both the overburden and the bedrock, the performance of the closed vertical collector comprising 48 No. 200m deep boreholes at a spacing of 10m, each installed with Double-U OD 40mm geothermal probes was modelled.
- The final borehole diameter for the geothermal boreholes is expected to be no less than 147mm if bedrock conditions permit it. The borehole annular space will be backfilled with GeothermX-GR thermally enhanced grout comprising a two component mix was confirmed as achieving a final thermal conductivity of 2 W/m/K.
- Collector operational temperatures based on the modelled demand in heating only mode are deemed sustainable over a period of 50 years of operation, with minimum ground temperatures not dropping below 4°C at year 50 during base load operation in the heating season.
- The collector model considers operation of the collector in dry conditions only with no additional heat exchange offered by active groundwater flow present across the vertical probe field. The resulting ground temperatures modelled are therefore conservative and improved temperatures may be achieved subject to confirmation of the presence of groundwater.

Hydraulic Model Results

The results of the assessment demonstrates that the collector layout and selection of the pipe diameters proposed in the design, satisfy the operational requirements for the heat pump as specified by the manufacturer. The following conclusions are drawn from the hydraulic modelling:

- The geothermal collector circulation pump specified for the system is adequate for achieving the nominal design flow rate stated by the HP manufacturer and results in efficient operation;
- A flow rate exceeding 70 m^3/hr at the heat pump is achieved with acceptable pumping efficiency and by regulating the pump speed in both circuits;
- **An acceptable pressure drop at the heat pumps is achieved with the 48 No. double-U probes connected to 50mm SDR 17 headers, with a total pressure drop in the final header of 0.38 bar at the nominal flow rate;**
- The Reynolds No. at furthest borehole elements in the final configuration has been checked and results in values exceeding 20,000, demonstrating that turbulent flow is achieved throughout the system;
- Balanced flow through each of the individual borehole loop circuits, as well as each of the heat pumps can be achieved through the use of balancing valves on each borehole circuit;

Any modification of the collector specifications referenced above will require a new hydraulic assessment to be performed and may change/invalidate the results provided.

Collector Final Design

The final collector design has been developed in line with current applicable best practice guidance and standards and on the basis of the results of the thermo-hydraulic modelling. A detailed design specification is presented in sections 7, 8 and 9 of the report and a detailed finish for the collector elements provided in appendix C. The following conclusion are drawn based on the proposed design:

- To satisfy the manufacturer maximum pressure drop specifications, the collector surface pipework will require connection of all 48 no. circuits in parallel. The proposed parallel arrangement facilitates the lowest possible pressure drop.
- The layout should include the implementation of grouped borehole surface pipework connections in shared trenches with the use of pre-insulated surface pipework so as to minimise any possible thermal short circuit of flow and return pipework.
- The use of pre-fabricated, water tight chamber with a diameter of no more than 1800mm is demonstrated as being the most effective way of achieving the layout but also facilitates the reduction of long term visual impact in the grassed areas around the SRSC car park. The proposed completion of the design outlined includes restoration of any of the grassed areas to the east of the site and all parking spaces. The chamber will be equipped with balancing valves on each borehole circuit and maximising redundancy in the event of long term servicing requirements and minimising any operational down time during system operation.
- A high level implementation timeline for the project to complete the geothermal collector as well as the retrofitting of the plant room elements would require works to be completed over a 8 to 12 month period (based on using 1 No. drilling rig to complete the collector elements and subject to verification of the site specific conditions), assuming works such as drilling, ground works for the installation of new pipework and completion of the plant room extension could be completed

simultaneously. The completion of the M&E elements of the plant room and connection to the existing pipework would require an additional estimated 3 months.

It is important to note that should an alternative layout would represent a variation and that such variation will require additional verification (thermal & hydraulic model) to demonstrate that such variations do not result in operational parameters not being within the HP manufacturer's specification.

14 SRSC RECOMMENDATIONS:

The final design and model of the shallow geothermal system solution selected for the SRSC including the completion of a closed loop geothermal array, suggest that subject to the design characteristics being met during the installation, the collector thermal performance throughout the operational life modelled is in line with current required standards. The section below outlines some recommendations for the installation phase of the project to ensure that the specification and performance can be verified.

The current design has been based on energy demand data derived from LPG consumption figures over 2020 and 2021. It is recommended that prior to the implementation of the next phase of the project, SRSC be retrofitted with a temporary, wireless and non-intrusive IoT monitoring system to gather independent data on building temperatures, moisture levels and derive a real time energy demand profile for at least one cooling and one heating season. This is proposed in the absence of detailed BSM data to illustrate this demand. The recommended IoT solution represents a non-intrusive, low cost solution to install sensors throughout the building and make building data available through an internet dashboard in minimal time. The data obtained from the independent system should be used to complete a final verification of the design and allow the cooling demand to be integrated to the design of the geothermal collector.

The potential for integration of a GSHP solution to the existing SRSC secondary, low temperature hot water system has been demonstrated as part of the study. The following recommendations are made on the basis of the assessment of the centre's energy demand, to facilitate the integration of the heat to the existing infrastructure and to bring the building's HVAC up to current energy, comfort, sustainability standards:

- The implementation of retrofit measures to improve the building fabric and reduce energy demand should be prioritised. This would have a beneficial effect on the proposed GSHP design by reducing the installed capacity requirement of the GSHP as well as a potential reduction in the geothermal collector array as the energy source. Subject to the level of the building fabric intervention, this could result in a decreased capital investment cost of the proposed GHSP solutions outlined in this feasibility.
- Both existing boilers are obsolete. Initially the old Rendamax boiler can be used as secondary backup to the system during the start-up and validation phase. However, the Rendamax boiler is also outdated and should be replaced with a high efficiency, condensing boiler of reduced size (only if LPG backup is acceptable). The old Buderus boiler should be decommissioned permanently.
- The replacement boilers should be wall mounted modular (e.g. 160 KW) condensing units of smaller size. These would facilitate increased operational efficiency and reduced operating costs to top up the energy delivered by the heat pump in parts of extreme peak requirement if this is needed;
- Allow a cooling (and dehumidification) for the building to be met using the new heat pump solution. This would be achieved by using both circuits of the heat pump;
- Expand the plant room to the rear in order to accommodate heat pump and cooling heat exchangers as well as a cooling manifold;
- Upgrade the pool AHU with cooling and dehumidification capacity;
- Bring cooling to the gym upstairs and old gym downstairs;
- Upgrade arena ventilation with modern AHU with heating and filtration;
- The electrical supply to the SRSC will need to be investigated to ensure that adequate supply is available for the operations of the new proposed heat pump. An early assessment

as part of the planning phase of the project should include this work and make provision for design and permitting of new or upgraded connection to be included if necessary.

The completion of the drilling operations for the closed loop array will require careful planning. In order to ensure continuity of the project and a reduction of risk with respect to the project timeline the following recommendations with respect to the drilling completion are made:

- For project expediency 2 number self-propelled drilling rigs are recommended. Suitable rigs should be available in Ireland, although a minimum of 8 weeks notice to commence drilling should be considered. It is also recommended that drilling take place at a time when the sports centre is less busy. The drilling, casing and grouting programme is anticipated to take up to 170 days, dependent upon the working hours permitted, inclement weather and the availability of borehole access points.
- Supply of suitable casing needs to be ordered 12 weeks in advance of operations commencing. Likewise for grouting materials.
- To minimise site storage and interruptions to sport centre operations, the drilling and completion of the collector should be implemented on a phased basis, where three different areas of the collector are completed. The boreholes, geothermal probes, testing and connection to the manifold chamber should completed separately. For example the boreholes in the southern section of the car park facing the road should be drilled and completed first. Once the drilling operations are completed in this area, the rigs could mode the eastern section of the collector whilst the surface connections and testing are completed in the first.
- All waste materials and drilling fluids should be collected every three days of operation. Suitable contractors should be identified at the planning phase of the project.
- A detailed work programme and schedule of works should be developed in conjunction with a specialist drilling contractor, ground works contractor to ensure the drilling and completion phase provides minimal disruption to the SRSC operations.

The installation of the geothermal collector and the completion of the surface pipework that will connect the geothermal borehole array to the heat pump is planned on the boundaries of the existing car park and to the E SE of the site. The following recommendations should be considered prior to the implementation of the next phase of the project with respect to the geothermal collector:

- A detailed assessment of existing services infrastructure in the SRSC car park and along the NE and NW boundaries of the energy centre should be undertaken. Drawings as well as the implementation of the GPR survey will required to carefully map the presence of water, electrical, gas, drainage and fibre services where the collector boreholes, the manifold chamber and surface pipework connections are currently designed. This should be implemented as part of the next phase of the project and a the positioning of the proposed borehole, surface pipework trenches and manifold chamber to reviewed based on the results of such survey;
- The positioning of the 48 No. closed loop heat exchanger has been completed on the basis of minimising the construction impact to the SRSC car park. However, the viability of implementing this should be reviewed subject to a more detailed site infrastructure assessment and where possible borehole repositioned.

15 REFERENCES

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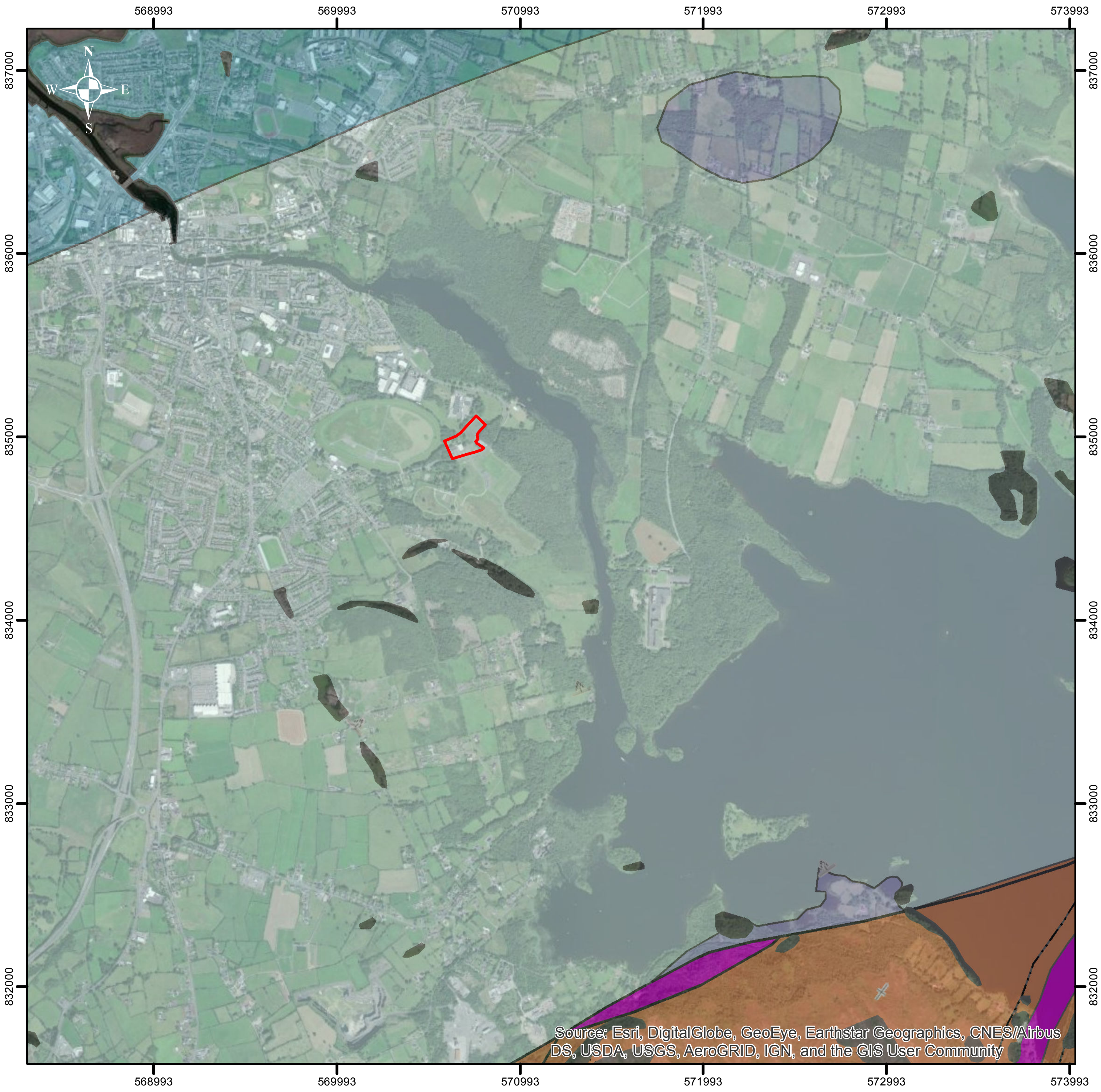
APPENDIX A

SRSC - FIGURES & DRAWINGS



Legend

- SRSC_General_Site_Location
- Dartry Limestone Formation
- Glencar Limestone Formation
- Serpentinite
- Mudbank limestone
- Slishwood Division, Pelitic & semi-pelitic paragneiss
- Area
- Fault
- Strike and dip of bedding, right way up
- Strike and dip of bedding, way up unknown
- Strike of vertical bedding/foliation

0 0.25 0.5 1 1.5 2 Kilometers

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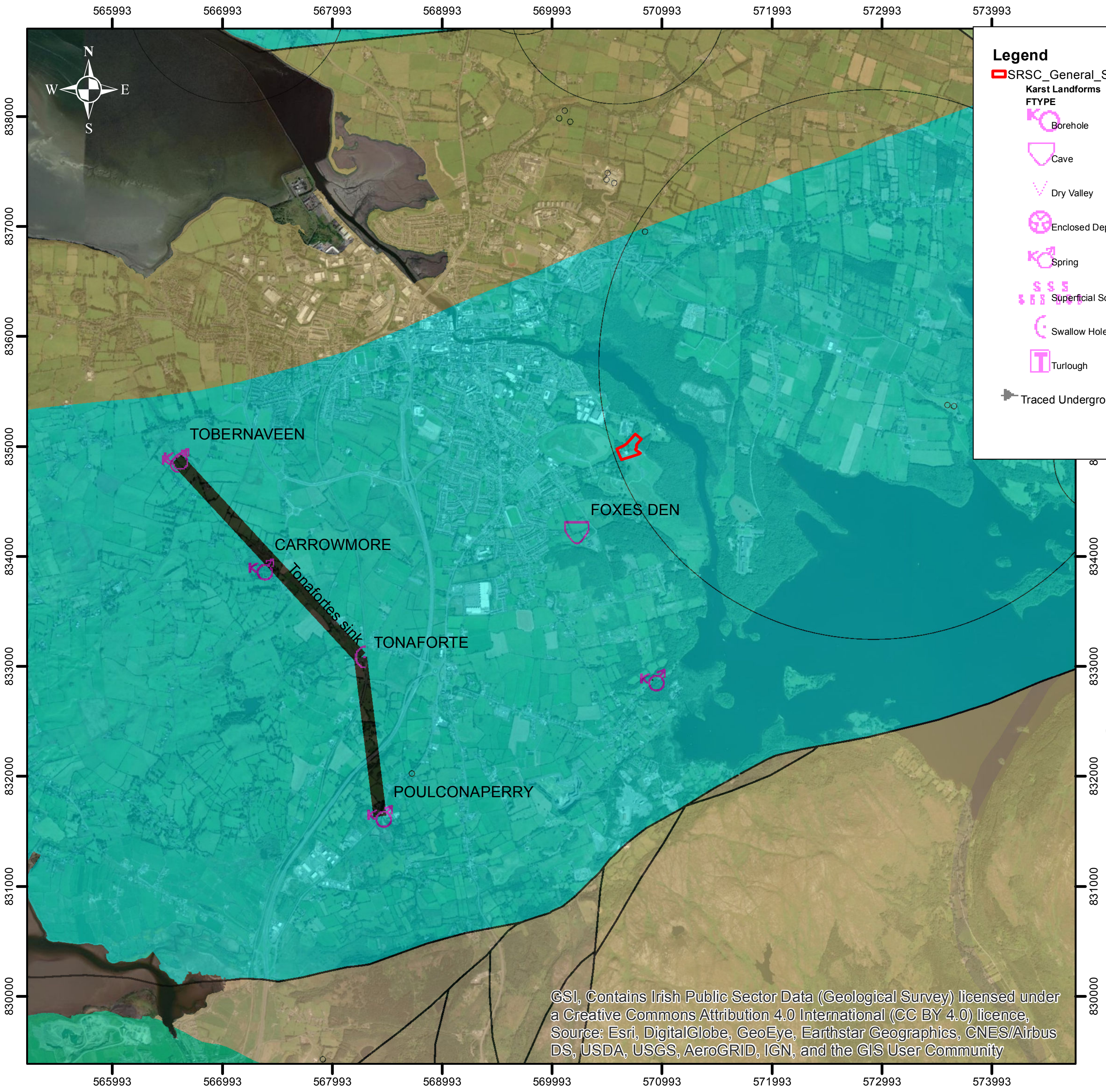
Scale: 1:30,000 @A4

Figure No. A.1 - Geological Setting SRSC

Coordinate System: ITM



Legend

SRSC_General_Site_Location

Karst Landforms

FTYPE

- Borehole
- Cave
- Dry Valley
- Enclosed Depression
- Spring
- Superficial Solution Features
- Swallow Hole
- Turlough

Traced Underground Connections

- Rkc - Regionally Important Aquifer - Karstified (conduit)
- Rkd - Regionally Important Aquifer - Karstified (diffuse)
- RK - Regionally Important Aquifer - Karstified
- Rf - Regionally Important Aquifer - Fissured bedrock
- Lm - Locally Important Aquifer - Bedrock which is Generally Moderately Productive
- Lk - Locally Important Aquifer - Karstified
- Ll - Locally Important Aquifer - Bedrock which is Moderately Productive only in Local Zones
- Pl - Poor Aquifer - Bedrock which is Generally Unproductive except for Local Zones
- Pu - Poor Aquifer - Bedrock which is Generally Unproductive
- Lake

Groundwater Wells and Springs

0 0.4 0.8 1.6 2.4 3.2 Kilometers

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Figure No. A.2 - Hydroeological Setting SRSC

Coordinate System: ITM

Legend

- SRSC GT BHLs 10m LAYOUT
- SRSC Central Manifold Chamber
- SRSC General Site Location

0 10 20 40 60 80 Meters

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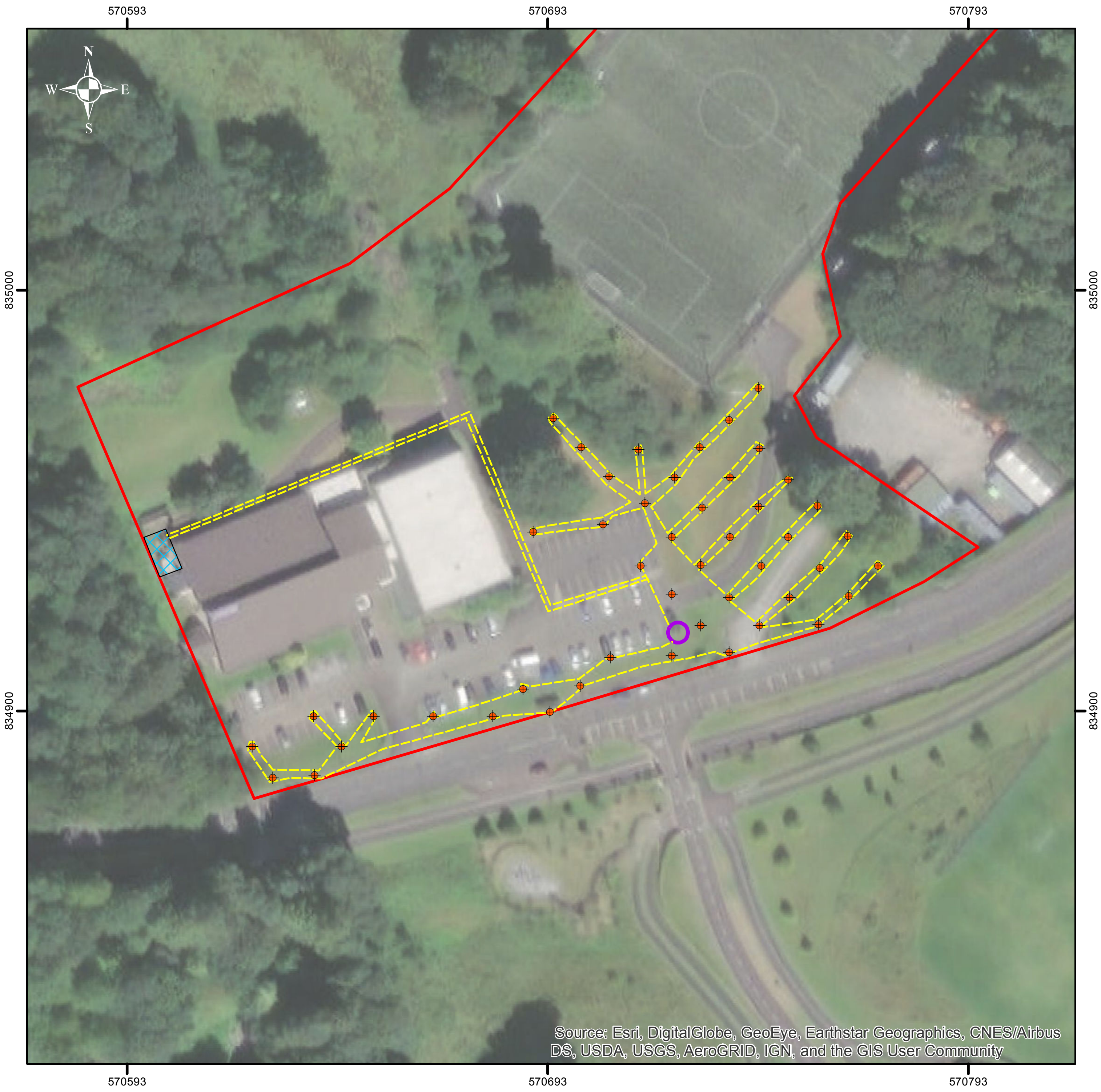
Figure No. A.18 - SRSC Geothermal Collector Layout

Coordinate System: ITM



Legend

- SRSC GT BHLs 10m LAYOUT
- SRSC_Surface Pipe Excavation Area
- Sligo_NewPlantRoom
- SRSC Central Manifold Chamber
- SRSC General Site Location

0 10 20 40 60 80 Meters

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Figure No. A.18.a - SRSC Geothermal Collector Layout

Coordinate System: ITM

Legend

GT_System

Shallow

Shallow and Deep

SRSC General Site Location

0 125 250 500 750 1,000 Meters

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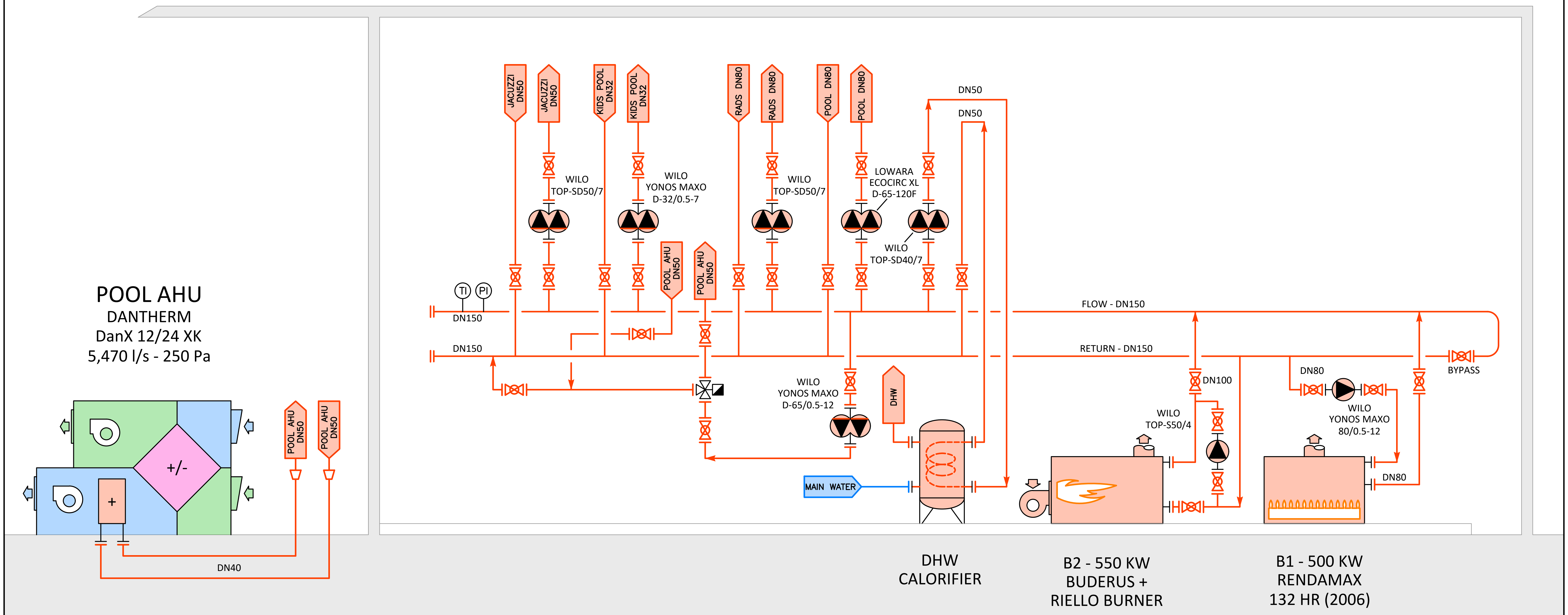
Figure No. A.23 - Sligo Additional GT Opportunities

Coordinate System: ITM



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REV.	DESCRIPTION OF CHANGES	DATE	DRAWN	CHECKED

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ISO 9001:2015 - ISO 14001:2015 - ISO 45001:2018

Job: GEOLOGICAL SURVEY IRELAND

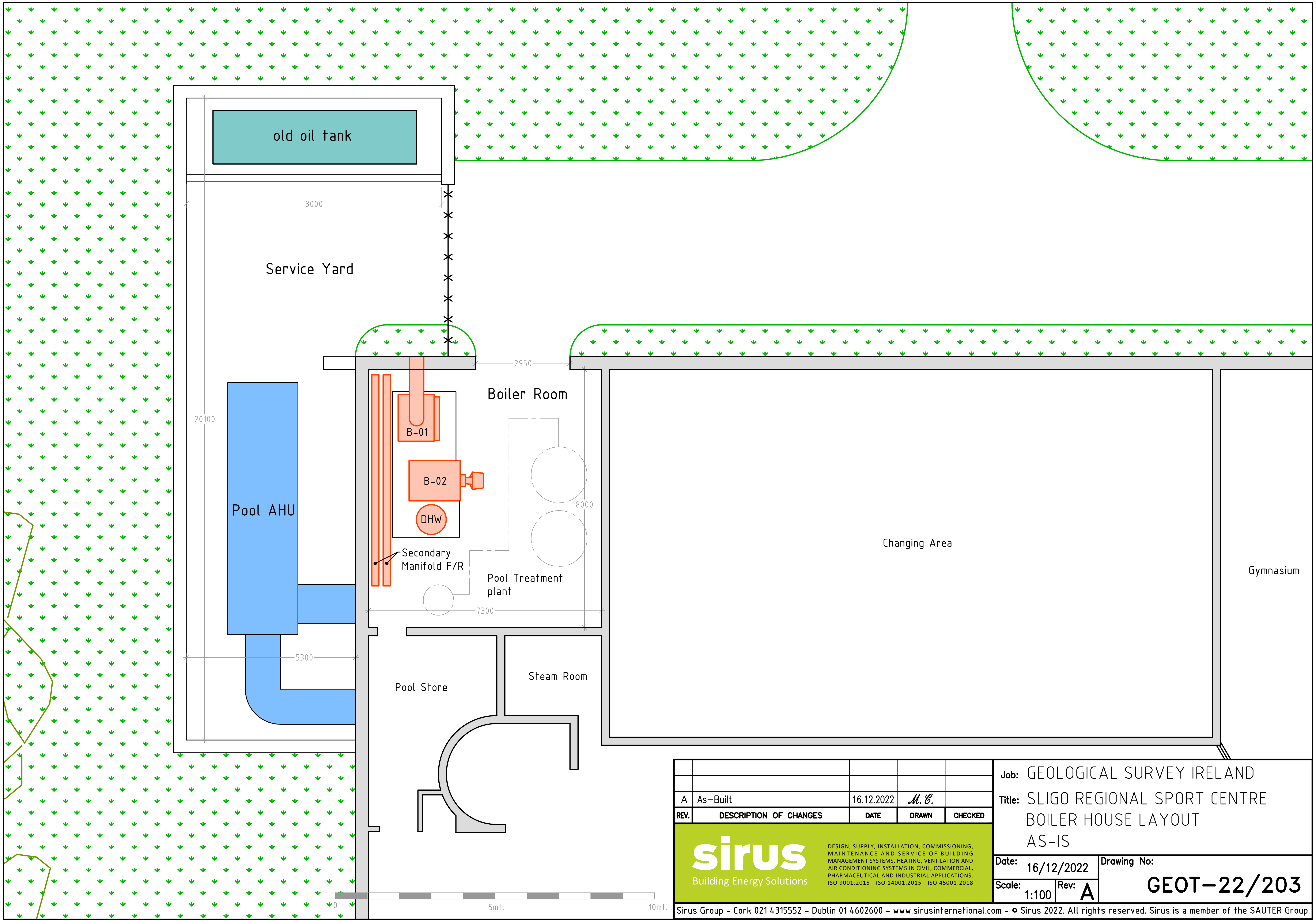
Title: SLIGO REGIONAL SPORT CENTRE
BOILER ROOM
PRINCIPLE SCHEMATIC – AS IS

Date: 08/11/2022

Drawing No: GEOT–22/900

Scale: ––

Rev: A



REV.	DESCRIPTION OF CHANGES	DATE	DRAWN	CHECKED
A	As–Built	16.12.2022	M.C.	

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Job: GEOLOGICAL SURVEY IRELAND

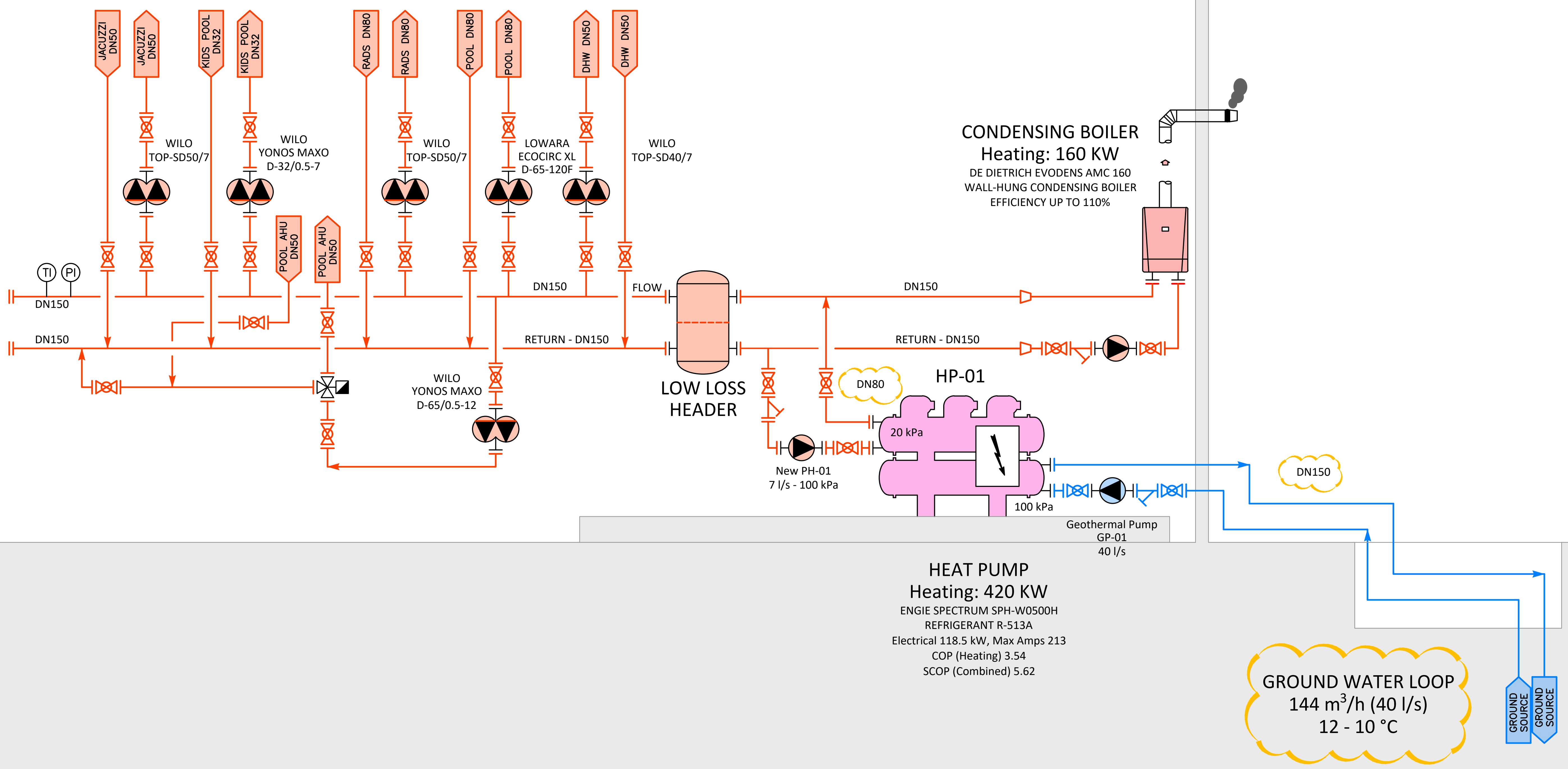
Title: SLIGO REGIONAL SPORT CENTRE
BOILER HOUSE LAYOUT
AS-IS

Date: 16/12/2022

Scale: 1:100

Rev: A

Drawing No: GEOT–22/203



REV.	DESCRIPTION OF CHANGES	DATE	DRAWN	CHECKED
B	INITIAL DESIGN FOR STUDY	12.12.2022	M.C.	
A	PRELIMINARY DESIGN	16.11.2022	M.C.	--

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Job: GEOLOGICAL SURVEY IRELAND

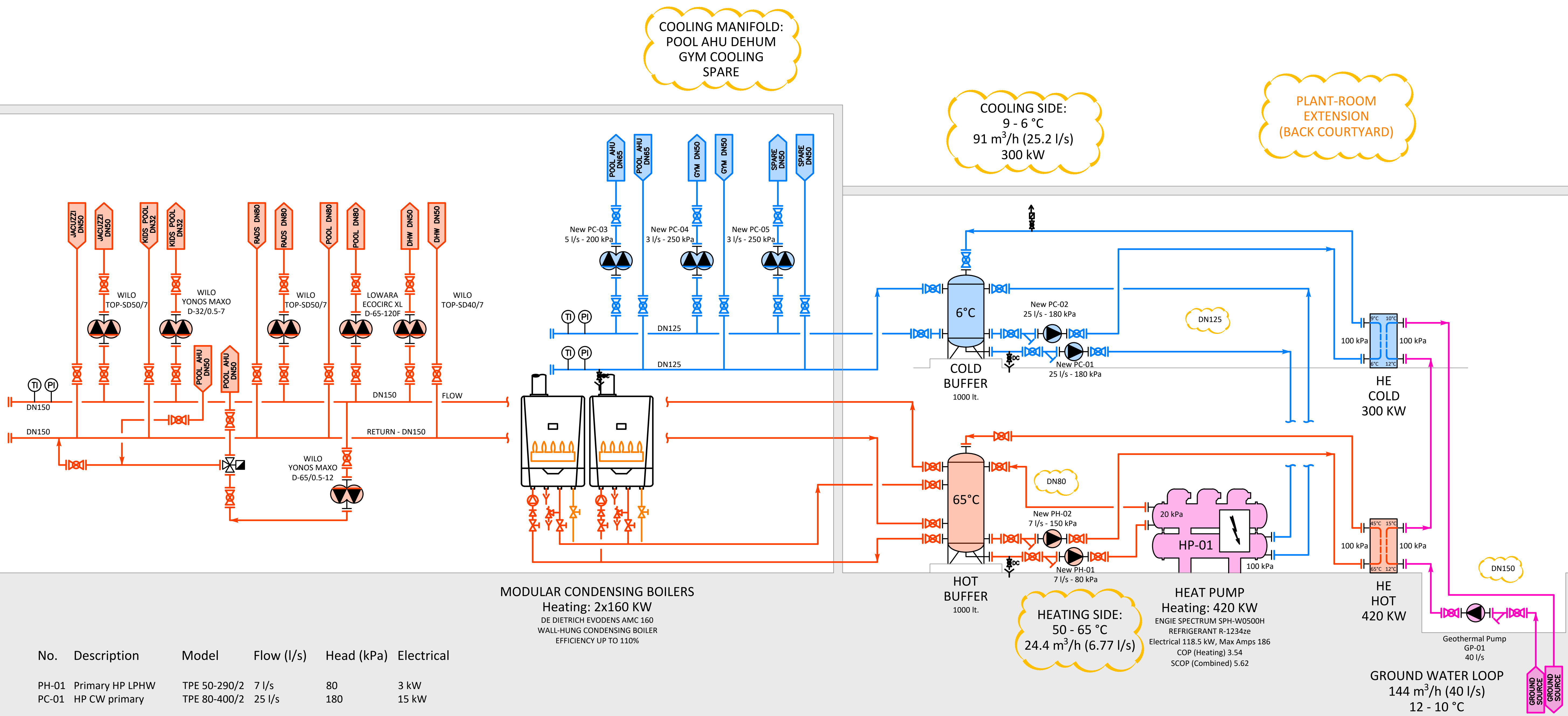
Title: SLIGO REGIONAL SPORT CENTRE
EAT PUMP OPTION 1 (HEAT ONLY)
PRELIMINARY DESIGN

Date: 12/12/2022

Scale: --

Rev: B

Drawing No: GEOT—22/902



No.	Description	Model	Flow (l/s)	Head (kPa)	Electrical
PH-01	Primary HP LPHW	TPE 50-290/2	7 l/s	80	3 kW
PC-01	HP CW primary	TPE 80-400/2	25 l/s	180	15 kW
PH-02	Hot Reject	TPE 50-290/2	7 l/s	150	3 kW
PC-02	Cold Reject	TPE 80-400/2	25 l/s	180	15 kW
PC-03	Secondary CW Pool	TPD 50-290/2	5 l/s	200	3 kW
PC-04	Secondary CW Gym	TPD 40-430/2	3 l/s	250	3 kW
PC-04	Secondary CW Spare	TPD 40-430/2	3 l/s	250	3 kW

REV.	DESCRIPTION OF CHANGES	DATE	DRAWN	CHECKED
B	INITIAL DESIGN FOR STUDY	12.12.2022	M.C.	
A	PRELIMINARY DESIGN	16.11.2022	M.C.	--

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ISO 9001:2015 - ISO 14001:2015 - ISO 45001:2018

Job: GEOLOGICAL SURVEY IRELAND

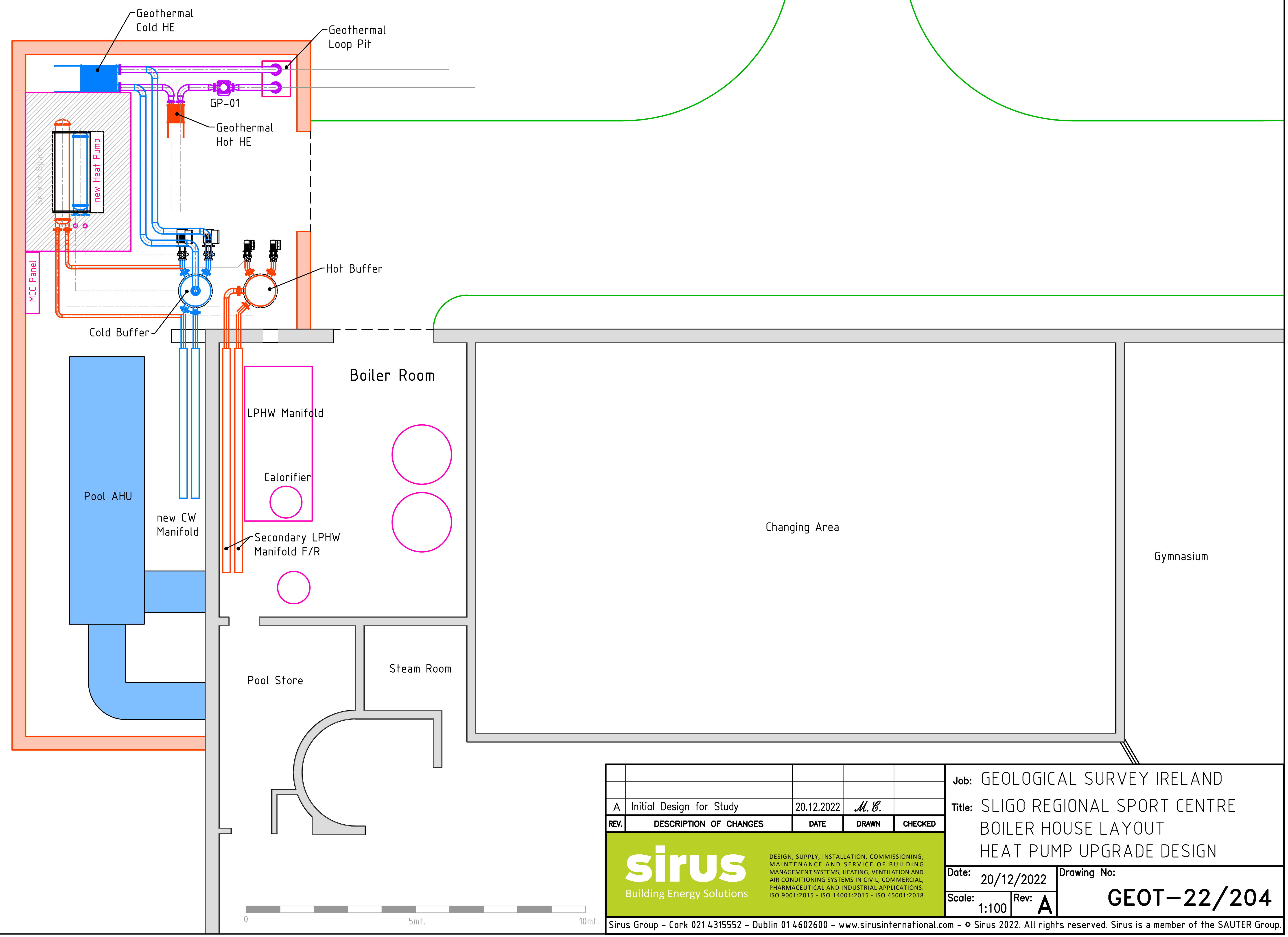
Title: SLIGO REGIONAL SPORT CENTRE
EAT PUMP OPTION 2 (HEAT+COOL)
INITIAL DESIGN

Date: 12/12/2022

Drawing No: GEOT-22/903

Scale: --

Rev: B



REV.	DESCRIPTION OF CHANGES	DATE	DRAWN	CHECKED
A	Initial Design for Study	20.12.2022	M. C.	

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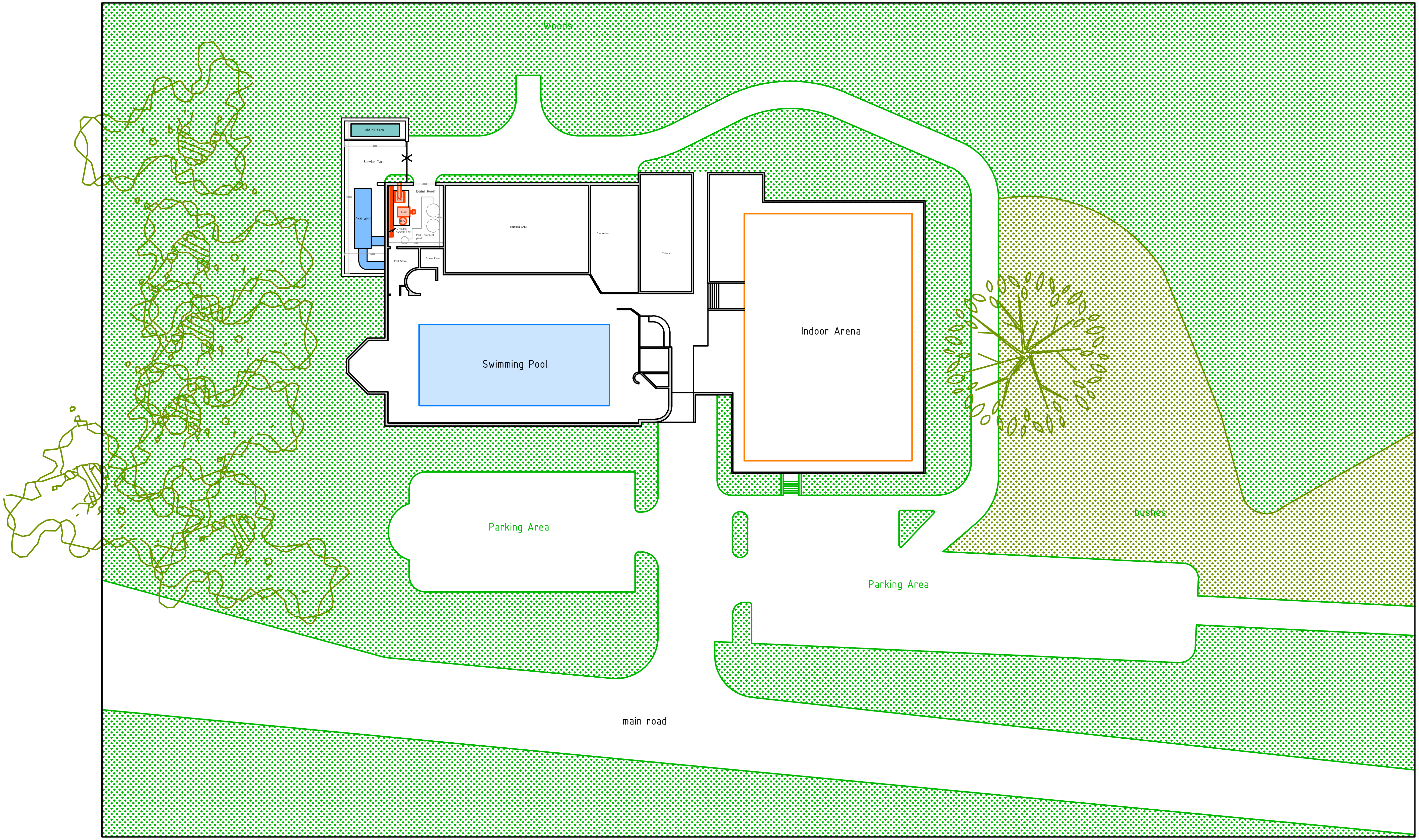
ISO 9001:2015 - ISO 14001:2015 - ISO 45001:2018

Job: GEOLOGICAL SURVEY IRELAND

Title: SLIGO REGIONAL SPORT CENTRE
BOILER HOUSE LAYOUT
HEAT PUMP UPGRADE DESIGN

Date: 20/12/2022
Drawing No: GEOT–22/204
Scale: 1:100
Rev: A



0 10mt. 20mt. 30mt. 40mt. 50mt.

REV.	DESCRIPTION OF CHANGES	DATE	DRAWN	CHECKED
A	Initial Design for Study	16.12.2022	M.C.	

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JOB : GEOLOGICAL SURVEY IRELAND

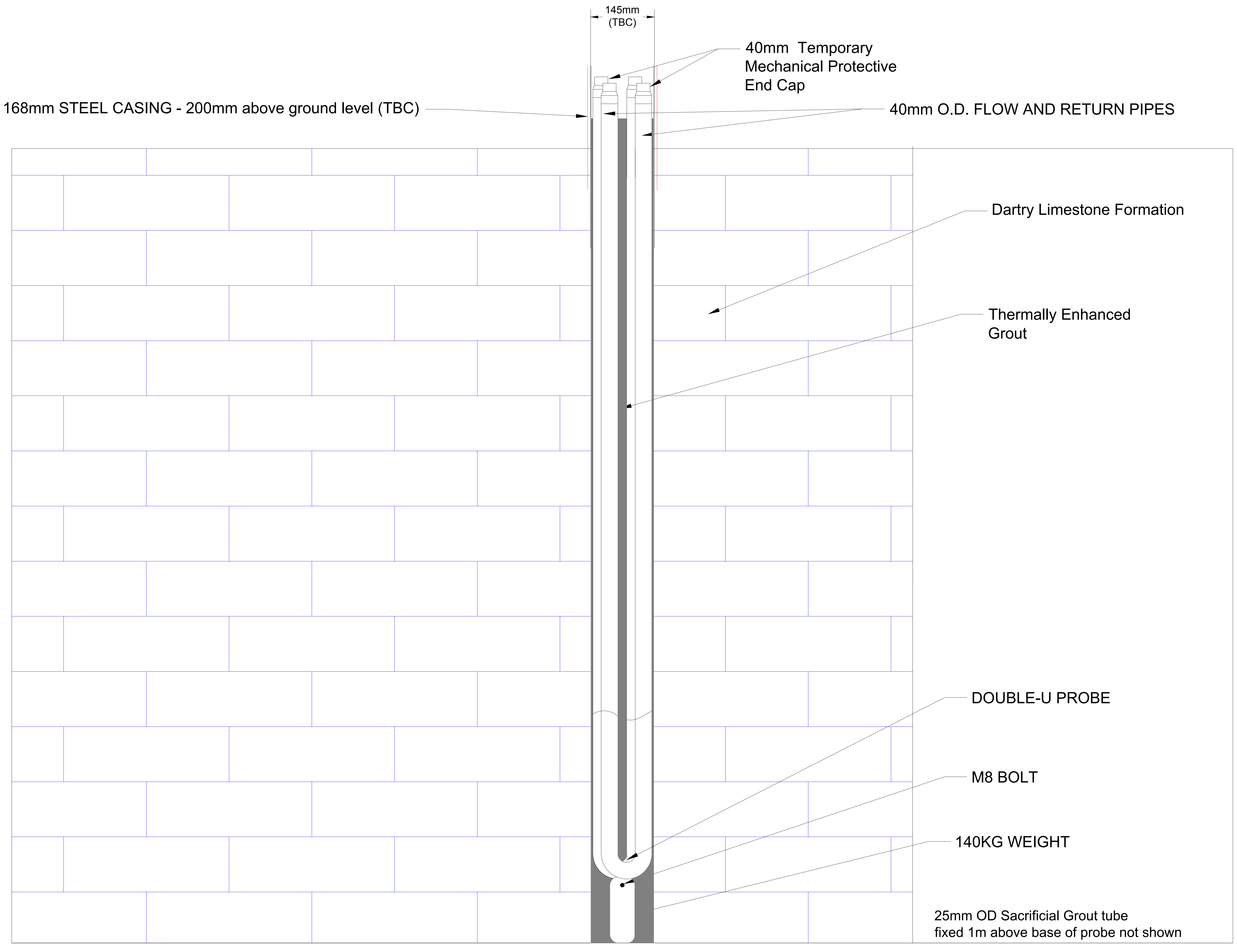
TITLE: SLIGO REGIONAL SPORT CENTRE
SITE LAYOUT
AS-IS

Date: 16/12/2022

Drawing No: GEOT-22/205

Scale: 1:500

Rev: A



Rev No.	Date	NOTES	Drw by	Chkd by
P01	07-12-21	DRAFT	RP	RP
P02	17-12-22	DRAFT - FOR INFORMATION	RP	RP

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DRAWING 0119 A

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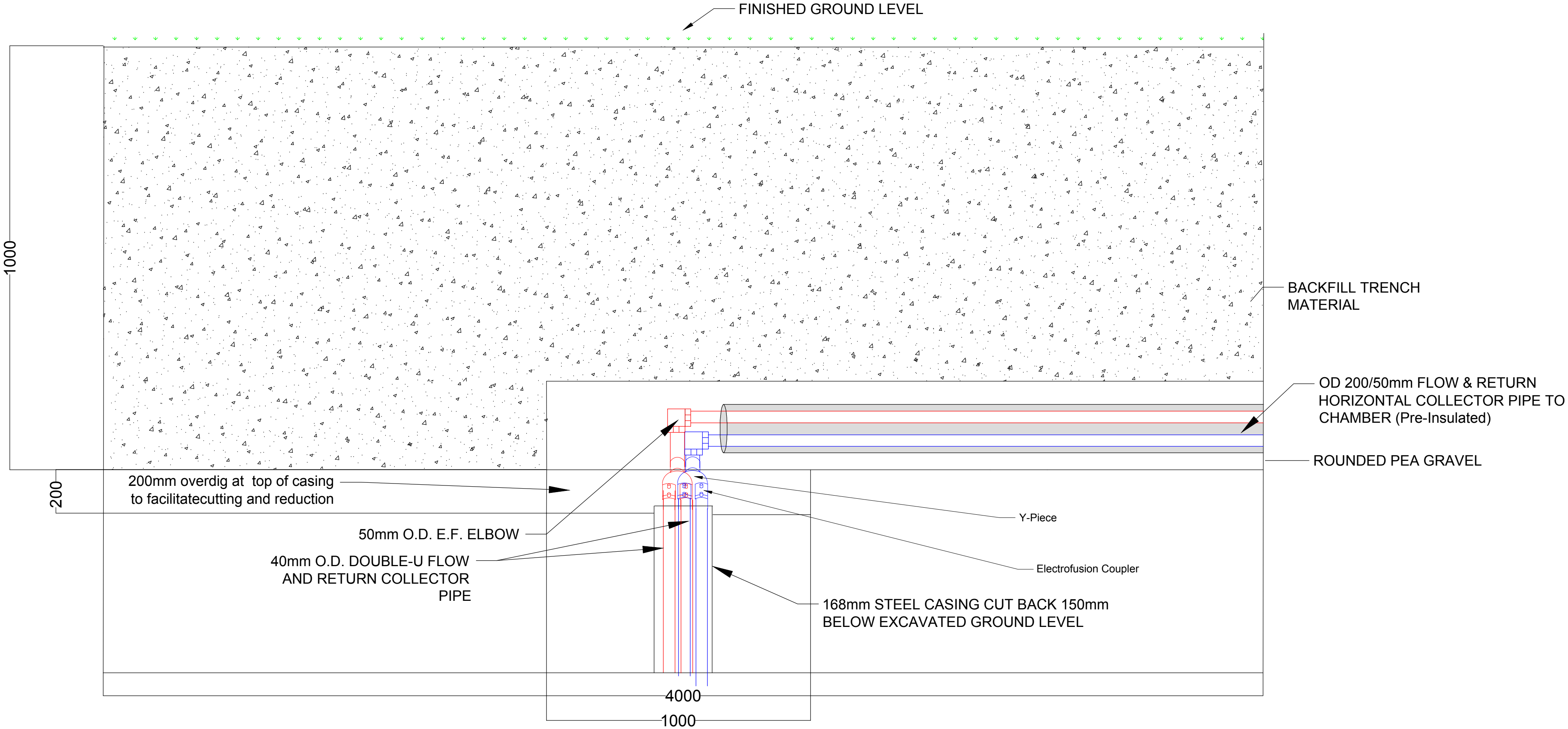

BOREHOLE CONNECTION TO MAIN FLOW & RETURN FINISHED DETAIL

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P01	07-02-22	DRAFT	SH	RP
P02	12-11-22	DRAFT - FOR INFORMATION ONLY	SH	RP

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Drawing 0119B

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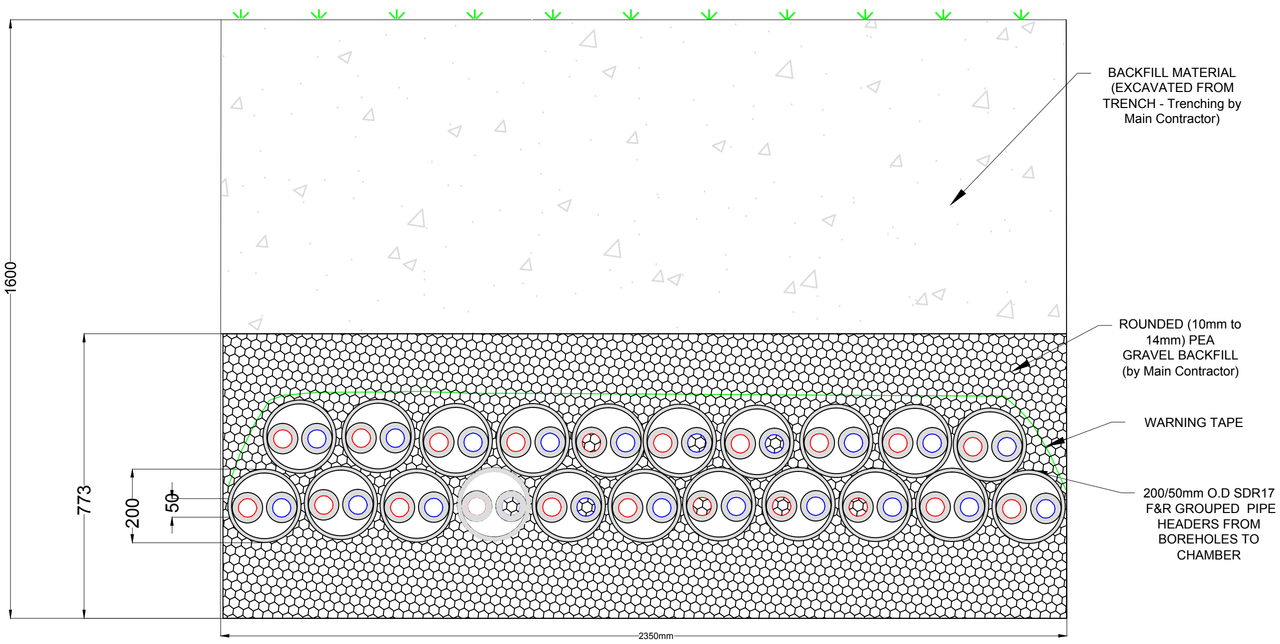

MAIN F&R PIPE FROM BOREHOLES TO MANIFOLD CHAMBER IN SHARED TRENCH

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Version: Rev A
Scale: 1:8 @ A4

Drawing 0119 C

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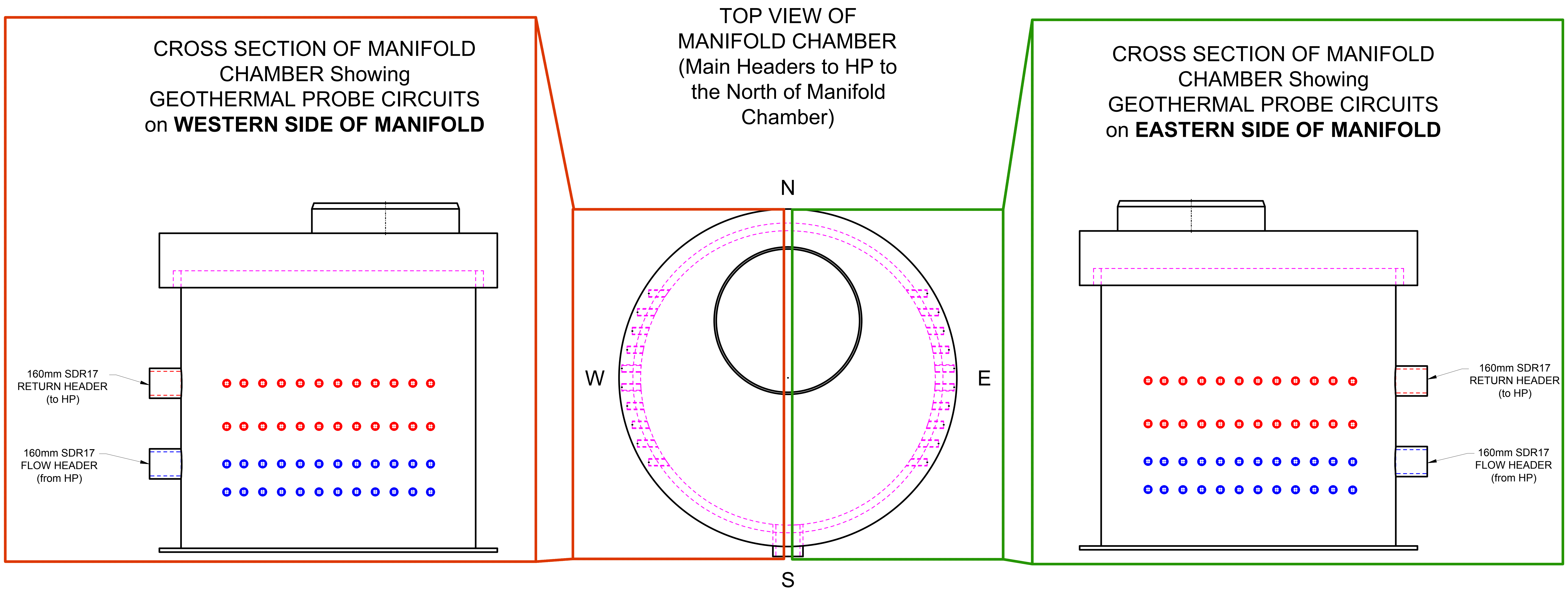

Rev No.	Date	NOTES	Drw by	Chkd by
P01	23/11/22	DRAFT - FOR INFORMATION ONLY	RP	RP

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Reference: GS0119 GSI SRSC
Date: 27/12/22
Version: Rev P01
Scale: 1:4 @ A2

Drawing 0119D

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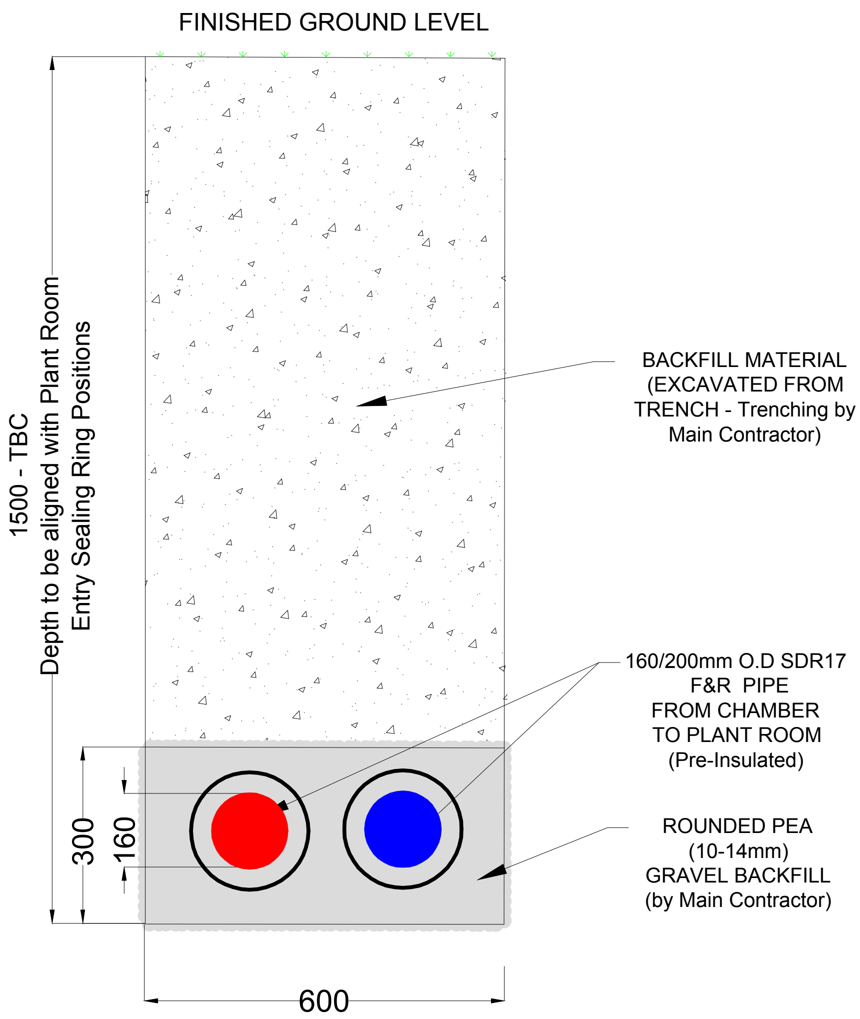

MAIN F&R PIPE FROM MANIFOLD CHAMBER TO PLANT ROOM

Rev No.	Date	NOTES	Drw by	Chkd by
P01	07-02-22	DRAFT	SH	RP
P0`2	12-11-22	DRAFT - FOR INFORMATION ONLY	SH	RP

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Reference: GS0119 GSI SRSC
Date: 12/11/2022
Version: Rev A
Scale: 1:8 @ A4

Drawing 0119E

FOR INFORMATION ONLY

APPENDIX B

SRSC - GEOTHERMAL COLLECTOR MODEL RESULTS

MEMORY NOTES FOR PROJECT
[]

QUICK FACTS

Cost	-	
Number of boreholes	48	
Borehole depth	200	m
Total borehole length	9.60E+03	m

D E S I G N   D A T A
=====================

GROUND

Ground thermal conductivity	2.75	W/(m·K)
Ground heat capacity	2.3	MJ/(m³·K)
Ground surface temperature	8	°C
Geothermal heat flux	0.06	W/m²

BOREHOLE

Configuration:	425 ("48 : 6 x 8 rectangle")	
Borehole depth	295	m
Borehole spacing	10	m
Borehole installation	Double-U	
Borehole diameter	152	mm
U-pipe diameter	40	mm
U-pipe thickness	3.6	mm
U-pipe thermal conductivity	0.42	W/(m·K)
U-pipe shank spacing	90	mm
Filling thermal conductivity	2	W/(m·K)
Contact resistance pipe/filling	0	(m·K)/W

THERMAL RESISTANCES

Borehole thermal resistances are calculated.
Number of multipoles 10
Internal heat transfer between upward and downward channel(s) is considered.

HEAT CARRIER FLUID

Thermal conductivity	0.48	W/(m·K)
Specific heat capacity	3795	J/(Kg·K)
Density	1052	Kg/m³
Viscosity	0.0052	Kg/(m·s)
Freezing point	-14	°C
Flow rate per borehole	0.73	l/s

BASE LOAD

Seasonal performance factor (DHW)	3
Seasonal performance factor (heating)	3.54
Seasonal performance factor (cooling)	3

Monthly energy values [MWh]

Month	Heat	Cool	Ground
JAN	71.5	0	51.3
FEB	23.82	0	17.09
MAR	23.82	0	17.09
APR	23.82	0	17.09
MAY	23.82	0	17.09
JUN	33.36	0	23.94
JUL	33.36	0	23.94
AUG	33.35	0	23.93
SEP	33.36	0	23.94
OCT	66.71	0	47.87
NOV	90.53	0	64.96
DEC	48.35	0	34.69
Total	505.8	0	362.9

PEAK LOAD

Monthly peak powers [kW]

Month	Peak heat	Duration [h	Peak cool	Duration [h]
JAN	0	0	0	0
FEB	0	0	0	0
MAR	0	0	0	0
APR	0	0	0	0
MAY	0	0	0	0
JUN	0	0	0	0
JUL	0	0	0	0
AUG	0	0	0	0
SEP	0	0	0	0
OCT	0	0	0	0
NOV	0	0	0	0
DEC	0	0	0	0

Number of simulation years	50
First month of operation	SEP

C A L C U L A T E D   V A L U E S
=================================

Total borehole length 1.42E+04 m

THERMAL RESISTANCES

Borehole therm. res. internal	0.2	(m·K)/W
Reynolds number	2863	
Thermal resistance fluid/pipe	0.01434	(m·K)/W
Thermal resistance pipe material	0.0752	(m·K)/W
Contact resistance pipe/filling	0	(m·K)/W
Borehole therm. res. fluid/ground	0.05314	(m·K)/W
Effective borehole thermal res.	0.07014	(m·K)/W

SPECIFIC HEAT EXTRACTION RATE [W/m]

Month	Base load	Peak heat	Peak cool
JAN	4.96	0	0
FEB	1.65	0	0
MAR	1.65	0	0
APR	1.65	0	0
MAY	1.65	0	0
JUN	2.32	0	0
JUL	2.32	0	0
AUG	2.32	0	0
SEP	2.32	0	0
OCT	4.63	0	0
NOV	6.28	0	0
DEC	3.36	0	0

BASE LOAD: MEAN FLUID TEMPERATURES (at end of month) [°C]

Year	1	2	5	10	50
JAN	11.22	9.58	8.65	7.62	4.37
FEB	11.22	10.43	9.53	8.51	5.27
MAR	11.22	10.44	9.54	8.53	5.3
APR	11.22	10.44	9.53	8.53	5.31
MAY	11.22	10.43	9.54	8.54	5.33
JUN	11.22	10.23	9.34	8.36	5.15
JUL	11.22	10.19	9.32	8.35	5.15
AUG	11.22	10.16	9.31	8.34	5.15
SEP	10.58	10.14	9.29	8.32	5.14
OCT	9.89	9.48	8.64	7.67	4.5
NOV	9.34	8.96	8.13	7.16	4
DEC	10.05	9.69	8.86	7.91	4.75

BASE LOAD: YEAR	50	
Minimum mean fluid temperature	4	°C at end of NOV
Maximum mean fluid temperature	5.33	°C at end of MAY

PEAK HEAT LOAD: MEAN FLUID TEMPERATURES (at end of month) [°C]

Year	1	2	5	10	50
JAN	11.22	9.58	8.65	7.62	4.37
FEB	11.22	10.43	9.53	8.51	5.27
MAR	11.22	10.44	9.54	8.53	5.3
APR	11.22	10.44	9.53	8.53	5.31
MAY	11.22	10.43	9.54	8.54	5.33
JUN	11.22	10.23	9.34	8.36	5.15
JUL	11.22	10.19	9.32	8.35	5.15
AUG	11.22	10.16	9.31	8.34	5.15
SEP	10.58	10.14	9.29	8.32	5.14
OCT	9.89	9.48	8.64	7.67	4.5
NOV	9.34	8.96	8.13	7.16	4
DEC	10.05	9.69	8.86	7.91	4.75

PEAK HEAT LOAD: YEAR	50	
Minimum mean fluid temperature	4	°C at end of NOV
Maximum mean fluid temperature	5.33	°C at end of MAY

PEAK COOL LOAD: MEAN FLUID TEMPERATURES (at end of month) [°C]

Year	1	2	5	10	50
JAN	11.22	9.58	8.65	7.62	4.37
FEB	11.22	10.43	9.53	8.51	5.27
MAR	11.22	10.44	9.54	8.53	5.3
APR	11.22	10.44	9.53	8.53	5.31
MAY	11.22	10.43	9.54	8.54	5.33
JUN	11.22	10.23	9.34	8.36	5.15
JUL	11.22	10.19	9.32	8.35	5.15
AUG	11.22	10.16	9.31	8.34	5.15
SEP	10.58	10.14	9.29	8.32	5.14
OCT	9.89	9.48	8.64	7.67	4.5
NOV	9.34	8.96	8.13	7.16	4
DEC	10.05	9.69	8.86	7.91	4.75

PEAK COOL LOAD: YEAR	50	
Minimum mean fluid temperature	4	°C at end of NOV
Maximum mean fluid temperature	5.33	°C at end of MAY

APPENDIX C

SRSC - HEAT PUMP SELECTION

Manufacturer name:	**ENGIE Refrigeration GmbH**
Model:	**Spectrum SPH-W0500-T1Q00-022H (R-513A)**
Refrigerant:	R-513A
ectrical connection (V/Hz):	400V/50Hz
Chiller selection software:	Selectum 2.88.124
Date report was created:	13.03.2023
Building project:	Sligo HP Schema
Offer no.:	22.01168_Rev.00
Originator:	FRL / 7
Database:	Local
Database status:	01.02.2023
CPR-Engine:	2810

Certified in accordance with the AHRI Water-Cooled Water-Chilling and Heat Pump Water-Heating Packages Certification Program, which is based on AHRI Standard 550/590 (I-P) and AHRI Standard 551/591 (SI). Heat Pump Water-Heating unit operating in heating is only certified at full-load standard rating conditions. Certified units may be found in the AHRI Directory at www.ahridirectory.org.

SPECTRUM SPH-W0500

Specified parameters

Required refrigerating capacity	420,0 kW
Supply voltage	400V/50Hz

Chilled medium - Water

Chilled medium inlet temperature	10,00 °C
Chilled medium outlet temperature	5,00 °C
Volume flow	72,0 m³/h | 20,00 L/s
Fouling factor	0,000018 m²K/W | 0,0180 m²K/kW

Cooling medium - Water

Cooling medium inlet temperature	50,00 °C
Cooling medium outlet temperature	65,00 °C
Volume flow	24,5 m³/h | 6,819 L/s
Fouling factor	0,000044 m²K/W | 0,0440 m²K/kW

device data (8000)

Dimensions and weights

Length	3253 mm
Width	1390 mm
Height	1878 mm
Transport weight	1700 kg
Dead weight	1615 kg
Full weight	1800 kg

Other data

Refrigerant charge R-513A	85 kg
Chilled medium content evaporator	80 kg
Cooling medium content condenser	60 kg
Sound pressure level at 1m	76 dB(A)
Sound power level	94 dB(A)
Compressor	TTH375 HHS (400)
Evaporator	VRMH 41.94.200.2 (34) (5002)
Evaporator connection	DN 100 PN 16
Condenser	CRMH 27.82.275.2 (47) (8002)
Condenser piping connection	DN 100 PN 16
Maximum electrical installed load	131,0 kW
Maximum operating current	211 A

Variable volume rate control

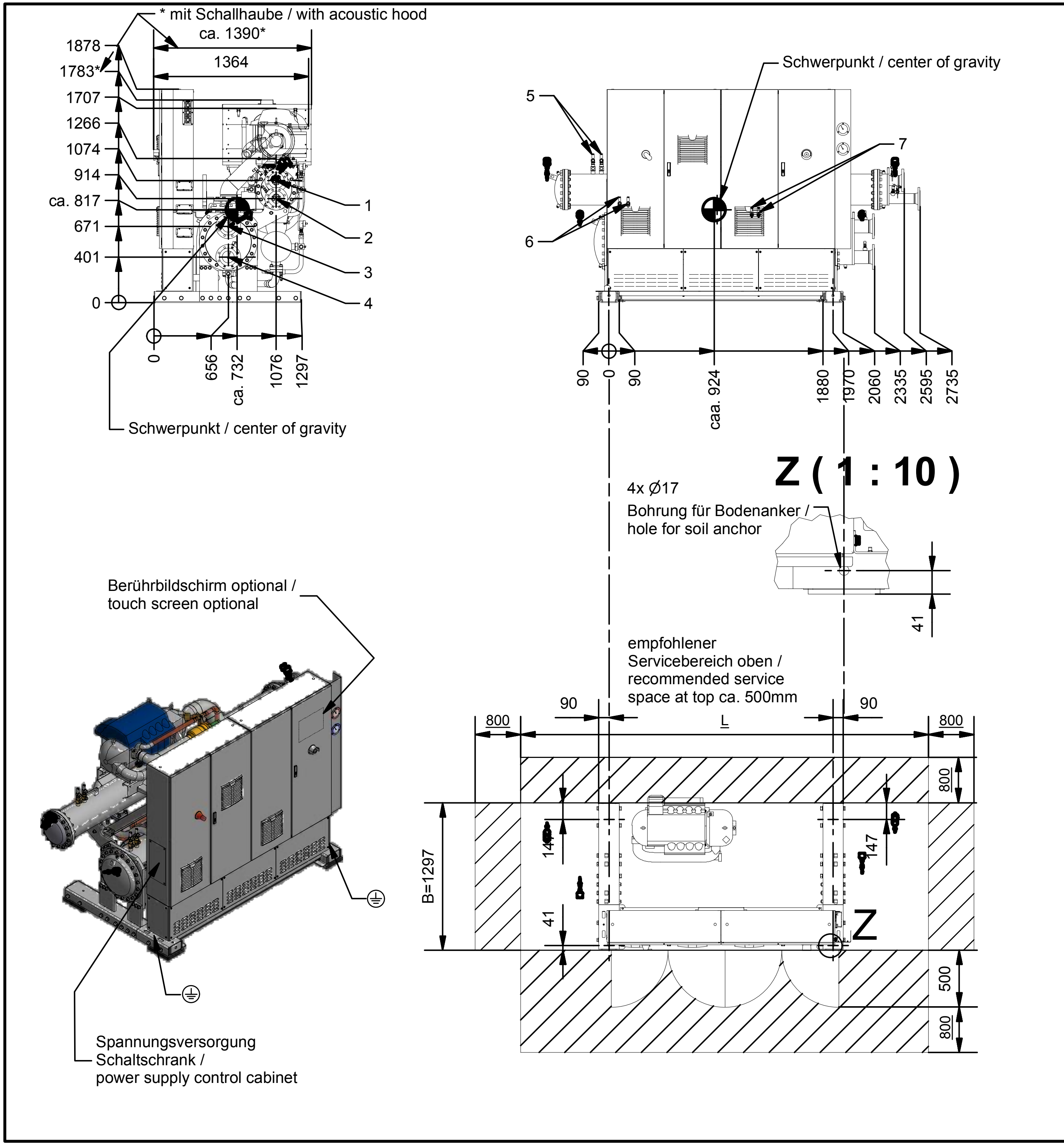
Minimum flow rate evaporator	18,4 m³/h
Maximum flow rate evaporator	88,2 m³/h
Minimum flow rate condenser	14,3 m³/h
Maximum flow rate condenser	68,5 m³/h

Design point

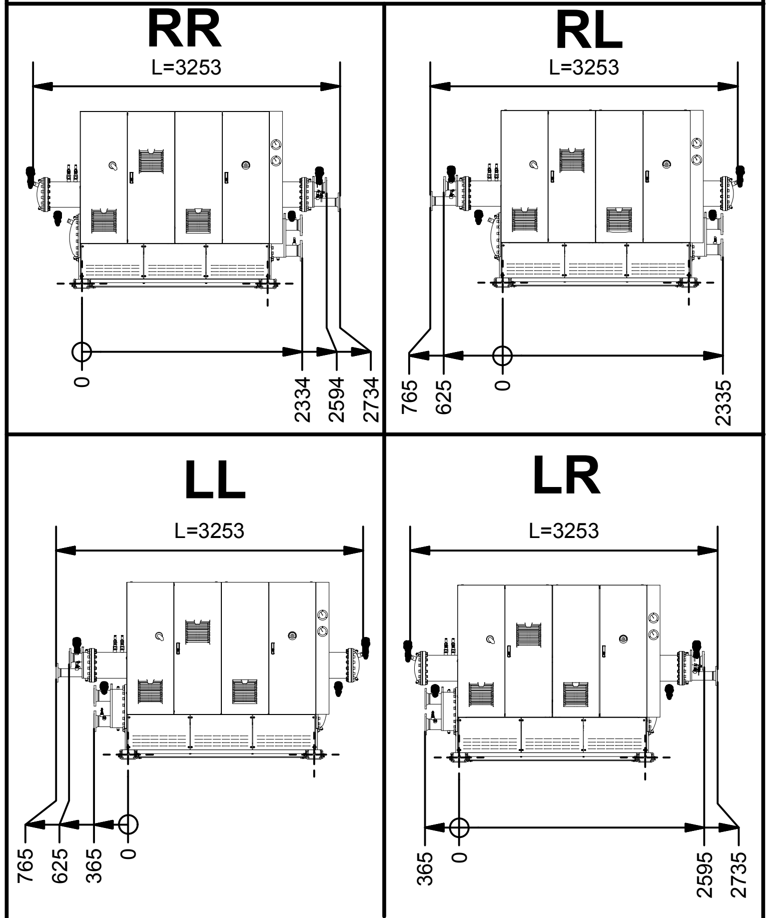
		100%
Compressor		
Number of compressors		1
Requested heating capacity	**kW**	**420**
Cooling capacity	kW	301
Current consumption	A	189
Electrical power consumption	kW	120,1
Pressure ratio		5,59
COP (heating capacity)		**3,51**
COP acc. to EN14511		3,47
SCOP (W10/W55) acc. to EN14825		**4,95**
Maximum heating capacity	kW	476
Evaporator		
Evaporation temperature	°C	4,42
Chilled medium inlet temperature	**°C**	**10,00**
Chilled medium outlet temperature	**°C**	**5,00**
Volume flow	m³/h	51,6
Flow rate	m/s	1,40
Reynolds number		16738
Pressure drop total	bar	0,37
Number of passes		2
Prandtl number		10
Condenser		
Condensation temperature	°C	65,30
Cooling medium inlet temperature	**°C**	**50,00**
Cooling medium outlet temperature	**°C**	**65,00**
Volume flow	m³/h	24,5
Flow rate	m/s	0,86
Reynolds number		27594
Pressure drop total	bar	0,16
Number of passes		2
Prandtl number		3

Simultanuous Heating and Cooling (SHC)

		100%	83%
Compressor			
Number of compressors		1	1
Requested heating capacity	kW	420	371
Cooling capacity	kW	301	250
Current consumption	A	189	191
Electrical power consumption	kW	120,1	121,5
Pressure ratio		5,59	5,57
COP (heating capacity)		3,51	3,05
COP acc. to EN14511		3,47	3,02
SCOP		6,00	5,11
Maximum heating capacity	kW	476	
Evaporator			
Evaporation temperature	°C	4,42	4,49
Chilled medium inlet temperature	°C	10,00	9,15
Chilled medium outlet temperature	°C	5,00	5,00
Volume flow	m^3/h	51,6	
Flow rate	m/s	1,40	
Reynolds number		16738	
Pressure drop total	bar	0,37	
Number of passes		2	
Prandtl number		10	
Condenser			
Condensation temperature	°C	65,30	65,30
Cooling medium inlet temperature	°C	50,00	51,53
Cooling medium outlet temperature	°C	65,00	65,00
Volume flow	m^3/h	24,5	
Flow rate	m/s	0,86	
Reynolds number		27594	
Pressure drop total	bar	0,16	
Number of passes		2	
Prandtl number		3	



Anschlussvarianten / connection variants



1	Wärmeträgeraustritt	heat medium outlet	DIN EN 1092-1 11 B1 DN80 - PN16
2	Wärmeträgereintritt	heat medium inlet	DIN EN 1092-1 11 B1 DN80 - PN16
3	Kälteträgeraustritt	chilled medium outlet	DIN EN 1092-1 11 B1 DN100 - PN16
4	Kälteträgereintritt	chilled medium inlet	DIN EN 1092-1 11 B1 DN100 - PN16
5	Optionales Sicherheitsventil Verflüssiger	optional safety valve condenser	G 1/2" ISO 228
6	Optionales Sicherheitsventil Verdampfer	optional safety valve evaporator	G 1/2" ISO 228
7	Optionales Sicherheitsventil Economiser	optional safety valve economizer	G 1/2" ISO 228

Achtung / attention:
Toleranz Außenabmessungen: ± 30mm / tolerance of outside dimensions: ±30mm
Technische Änderungen vorbehalten / subject to technical modifications

Gewicht / weight

Typ / type	Transportgewicht / transport weight [kg]	Betriebsgewicht /operation weight [kg]
SPH-W0500-T1Q00-022H	1700	1800

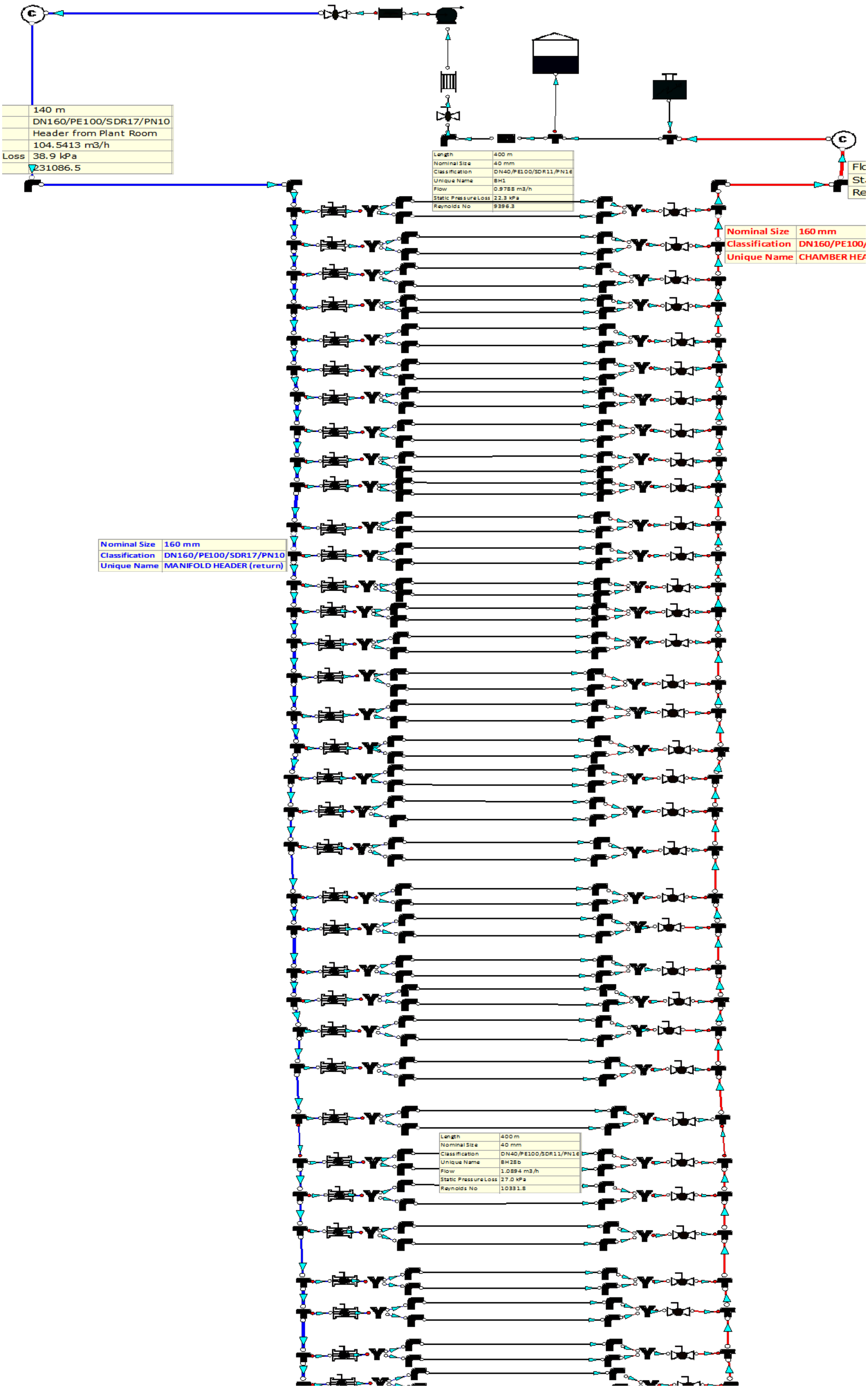
ENGIE Refrigeration GmbH
Josephine-Hirner-Straße 1 & 3 D-88131 Lindau

Benennung / Designation:	Zeichnungsnummer / Drawing Number:	Rev. / Rev.:
Spectrum SPH_W0500-T1Q00-022H	HA2084M	A

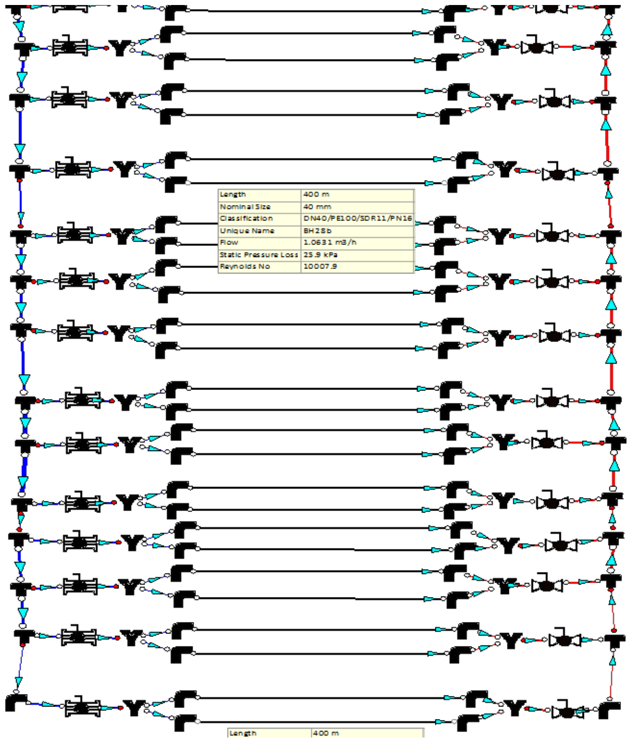
Datum / Date	Bearb. / Editor	Datum / Date	Prüfer / Approved
18.01.2023	N.Dudic	18.01.2023	R.Giesa

APPENDIX D

SRSC - HYDRAULIC MODEL RESULTS



140 m
DN160/PE100/SDR17/PN10
Header from Plant Room
104.5413 m3/h
Loss 38.9 kPa
231086.5
Length 400 m
Nominal Size 40 mm
Classification DN40/PE100/SDR11/PN16
Unique Name BH1
Flow 0.9788 m3/h
Static Pressure Loss 22.3 kPa
Reynolds No 9396.3
Nominal Size 160 mm
Classification DN160/PE100/
Unique Name CHAMBER HEA
Nominal Size 160 mm
Classification DN160/PE100/SDR17/PN10
Unique Name MANIFOLD HEADER (return)
Length 400 m
Nominal Size 40 mm
Classification DN40/PE100/SDR11/PN16
Unique Name BH28b
Flow 1.0894 m3/h
Static Pressure Loss 27.0 kPa
Reynolds No 10331.8


Length
400 m
Nominal Size
40 mm
Classification
DN40/PE100/SDR11/PN16
Unique Name
BH28b
Flow
1.0631 m3/h
Static Pressure Loss
25.9 kPa
Reynolds No
10007.9
Length
400 m

PE Pipe or Tube

Unique Name	Status	Length (*)	Inside Diameter (*)	Design Velocity (*)	Design Pressure Gradient (*)	Heat Loss Model	Heat Transfer Coeff (U Value)	Average Soil Temperature (*)	Out Stagnation Pressure (bar a)	In Velocity (m/s)	In Stagnation Pressure (bar a)	Element Type	User Number	Economic Velocity (m/s)	Pressure Gradient (Pa/m)	Friction Loss (kPa)	Flow (m3/h)
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.08	161.2	PE Pipe or Tube	-1781	1.52	0.7	0	4.2888
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.15	161.2	PE Pipe or Tube	-1780	1.56	2.3	0	8.5678
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.04	161.2	PE Pipe or Tube	-1779	1.46	0.2	0	2.1058
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.04	161.6	PE Pipe or Tube	-1778	1.46	0.2	0	2.1058
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.15	161.6	PE Pipe or Tube	-1777	1.56	2.3	0	8.5682
	On	10	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.78	161.6	PE Pipe or Tube	-1776	1.62	41.3	0.4	43.5224
	On	10	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.78	161.2	PE Pipe or Tube	-1775	1.62	41.4	0.4	43.5178
	On	10	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.39	161.2	PE Pipe or Tube	-1774	1.6	11.7	0.1	21.6971
	On	10	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.39	161.6	PE Pipe or Tube	-1773	1.61	11.7	0.1	21.6984
	On	0.1	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.48	161.2	PE Pipe or Tube	-1771	1.47	82.1	0	2.2278
	On	0.1	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.46	161.2	PE Pipe or Tube	-1770	1.46	76.7	0	2.1454
GT20-RH	On	22.5	43.9	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.41	161.6	PE Pipe or Tube	-1769	1.47	55	1.2	2.2279
GT19-RH	On	40	43.9	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.39	161.6	PE Pipe or Tube	-1768	1.47	51.4	2.1	2.1455
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.38	161.3	PE Pipe or Tube	-1767	1.41	70.5	0	1.1139
BH20b	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.38	161.5	PE Pipe or Tube	-1766	1.41	70.5	28.2	1.1139
BH20a	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.38	161.5	PE Pipe or Tube	-1765	1.41	70.5	28.2	1.1139
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.36	161.3	PE Pipe or Tube	-1764	1.41	65.9	0	1.0727
BH19b	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.36	161.5	PE Pipe or Tube	-1763	1.41	65.9	26.4	1.0727
	On	0.3	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.46	161.6	PE Pipe or Tube	-1762	1.47	76.7	0	2.1455
	On	0.3	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.48	161.6	PE Pipe or Tube	-1761	1.47	82	0	2.2279
BH19a	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.36	161.5	PE Pipe or Tube	-1760	1.41	65.9	26.4	1.0727
	On	0.3	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.48	161.6	PE Pipe or Tube	-1759	1.47	82.6	0	2.2366
BH21a	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.38	161.5	PE Pipe or Tube	-1758	1.41	71	28.4	1.1183
BH21b	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.38	161.5	PE Pipe or Tube	-1757	1.41	71	28.4	1.1183
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.38	161.3	PE Pipe or Tube	-1756	1.41	71	0	1.1183
GT21-RH	On	21	43.9	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.41	161.6	PE Pipe or Tube	-1755	1.47	55.4	1.2	2.2366
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.31	161.6	PE Pipe or Tube	-1754	1.6	7.8	0	17.325
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.31	161.2	PE Pipe or Tube	-1753	1.6	7.8	0	17.324
	On	0.1	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.48	161.2	PE Pipe or Tube	-1752	1.47	82.7	0	2.2366
GT5-RH	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.38	161.5	PE Pipe or Tube	-1751	1.41	71	0	1.1183
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.38	161.5	PE Pipe or Tube	-1750	1.41	71	0	1.1183
GT21-RH	On	21	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.48	161.3	PE Pipe or Tube	-1749	1.47	82.7	1.7	2.2366
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.38	161.3	PE Pipe or Tube	-1748	1.41	71	0	1.1183
GT5-RH	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.38	161.5	PE Pipe or Tube	-1747	1.41	70.5	0	1.1139
GT20-RH	On	22.5	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.48	161.3	PE Pipe or Tube	-1746	1.47	82.1	1.8	2.2278
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.38	161.5	PE Pipe or Tube	-1745	1.41	70.5	0	1.1139
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.38	161.3	PE Pipe or Tube	-1744	1.41	70.5	0	1.1139
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.35	161.2	PE Pipe or Tube	-1743	1.6	9.7	0	19.5518
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.35	161.6	PE Pipe or Tube	-1742	1.6	9.7	0	19.5529
GT3-RH	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.36	161.5	PE Pipe or Tube	-1741	1.41	65.9	0	1.0727
GT19-RH	On	40	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.46	161.3	PE Pipe or Tube	-1740	1.46	76.7	3.1	2.1454
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.36	161.5	PE Pipe or Tube	-1739	1.41	65.9	0	1.0727
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.36	161.3	PE Pipe or Tube	-1738	1.41	65.9	0	1.0727
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.3	PE Pipe or Tube	-1737	1.41	67	0	1.0826
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.37	161.5	PE Pipe or Tube	-1736	1.41	67	0	1.0826
GT16-RH	On	35	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.47	161.3	PE Pipe or Tube	-1735	1.47	78	2.7	2.1652
GT2-RH	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.37	161.5	PE Pipe or Tube	-1734	1.41	67	0	1.0826
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.3	PE Pipe or Tube	-1733	1.41	68.2	0	1.0934
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.37	161.5	PE Pipe or Tube	-1732	1.41	68.2	0	1.0934
GT4-RH	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.37	161.5	PE Pipe or Tube	-1731	1.41	68.2	0	1.0934
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.3	PE Pipe or Tube	-1730	1.41	67.2	0	1.0839
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.37	161.5	PE Pipe or Tube	-1729	1.41	67.2	0	1.0839
GT6-RH	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.37	161.5	PE Pipe or Tube	-1728	1.41	67.2	0	1.0839
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.36	161.3	PE Pipe or Tube	-1727	1.41	64.3	0	1.0573
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.36	161.5	PE Pipe or Tube	-1726	1.41	64.3	0	1.0573
GT19-RH	On	46	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.46	161.3	PE Pipe or Tube	-1725	1.46	74.9	3.4	2.1146
GT3-RH	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.36	161.5	PE Pipe or Tube	-1724	1.41	64.3	0	1.0573

	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.12	161.6	PE Pipe or Tube	-1723	1.54	1.4	0	6.4534
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.12	161.2	PE Pipe or Tube	-1722	1.54	1.4	0	6.4533
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.37	161.5	PE Pipe or Tube	-1721	1.41	67	0	1.0823
GT20-RH	On	34	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.47	161.4	PE Pipe or Tube	-1720	1.47	78	2.7	2.1645
GT5-RH	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.37	161.5	PE Pipe or Tube	-1719	1.41	67	0	1.0823
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.3	PE Pipe or Tube	-1718	1.41	68.1	0	1.0915
GT21-RH	On	32	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.47	161.3	PE Pipe or Tube	-1717	1.47	79.2	2.5	2.183
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.37	161.5	PE Pipe or Tube	-1716	1.41	68.1	0	1.0915
GT5-RH	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.37	161.5	PE Pipe or Tube	-1715	1.41	68.1	0	1.0915
	On	0.1	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.47	161.2	PE Pipe or Tube	-1714	1.47	79.2	0	2.183
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.08	161.6	PE Pipe or Tube	-1712	1.52	0.7	0	4.2889
GT21-RH	On	32	43.9	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.4	161.6	PE Pipe or Tube	-1711	1.47	53.1	1.7	2.183
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.3	PE Pipe or Tube	-1710	1.41	68.1	0	1.0915
BH27b	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.5	PE Pipe or Tube	-1709	1.41	68.1	27.2	1.0915
BH27a	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.5	PE Pipe or Tube	-1708	1.41	68.1	27.2	1.0915
	On	0.3	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.47	161.6	PE Pipe or Tube	-1707	1.47	79.2	0	2.183
BH25a	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.36	161.5	PE Pipe or Tube	-1705	1.41	64.3	25.7	1.0573
	On	0.3	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.47	161.6	PE Pipe or Tube	-1704	1.47	78	0	2.1646
	On	0.3	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.47	161.6	PE Pipe or Tube	-1702	1.47	75	0	2.1678
BH24b	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.5	PE Pipe or Tube	-1701	1.41	67.2	26.9	1.0839
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.3	PE Pipe or Tube	-1700	1.41	67.2	0	1.0839
GT18-RH	On	40	43.9	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.4	161.6	PE Pipe or Tube	-1699	1.47	52.4	2.1	2.1678
	On	0.1	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.47	161.2	PE Pipe or Tube	-1698	1.47	78.2	0	2.1678
	On	0.3	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.46	161.6	PE Pipe or Tube	-1697	1.46	74.8	0	2.1146
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.19	161.6	PE Pipe or Tube	-1696	1.57	3.3	0	10.736
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.19	161.2	PE Pipe or Tube	-1695	1.57	3.3	0	10.7356
BH25b	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.36	161.5	PE Pipe or Tube	-1694	1.41	64.3	25.7	1.0573
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.36	161.3	PE Pipe or Tube	-1693	1.41	64.3	0	1.0573
BH26a	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.5	PE Pipe or Tube	-1692	1.41	67	26.8	1.0823
BH26b	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.5	PE Pipe or Tube	-1691	1.41	67	26.8	1.0823
GT19-RH	On	46	43.9	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.39	161.6	PE Pipe or Tube	-1690	1.46	50.1	2.3	2.1146
GT20-RH	On	34	43.9	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.4	161.6	PE Pipe or Tube	-1689	1.47	52.3	1.8	2.1646
	On	0.1	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.46	161.2	PE Pipe or Tube	-1688	1.46	74.9	0	2.1146
	On	0.1	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.47	161.2	PE Pipe or Tube	-1687	1.47	78	0	2.1646
BH22a	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.5	PE Pipe or Tube	-1686	1.41	67	26.8	1.0826
	On	0.3	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.47	161.6	PE Pipe or Tube	-1685	1.47	79.4	0	2.1868
MANIFOLD HEADER (return)	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.23	161.6	PE Pipe or Tube	-1684	1.58	4.6	0	12.9229
	On	0.3	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.47	161.6	PE Pipe or Tube	-1683	1.47	78	0	2.1652
BH22b	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.5	PE Pipe or Tube	-1682	1.41	67	26.8	1.0826
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.23	161.2	PE Pipe or Tube	-1681	1.58	4.7	0	12.9223
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.3	PE Pipe or Tube	-1680	1.41	67	0	1.0826
BH23a	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.5	PE Pipe or Tube	-1679	1.41	68.2	27.3	1.0934
BH23b	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.5	PE Pipe or Tube	-1678	1.41	68.2	27.3	1.0934
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.3	PE Pipe or Tube	-1677	1.41	68.2	0	1.0934
BH24a	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.5	PE Pipe or Tube	-1676	1.41	67.2	26.9	1.0839
GT16-RH	On	35	43.9	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.4	161.6	PE Pipe or Tube	-1675	1.47	52.3	1.8	2.1652
GT17-RH	On	31	43.9	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.4	161.6	PE Pipe or Tube	-1674	1.47	53.2	1.6	2.1868
	On	0.1	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.47	161.2	PE Pipe or Tube	-1673	1.47	78	0	2.1652
	On	0.1	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.47	161.2	PE Pipe or Tube	-1672	1.47	79.4	0	2.1868
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.27	161.6	PE Pipe or Tube	-1671	1.59	6.1	0	15.0882
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.27	161.2	PE Pipe or Tube	-1670	1.59	6.1	0	15.0875
	On	31	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.47	161.3	PE Pipe or Tube	-1669	1.47	79.4	2.5	2.1868
	On	40	42	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.43	161.3	PE Pipe or Tube	-1668	1.47	64.9	2.6	2.1678
	On	10	42	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.4	0.22	161.3	PE Pipe or Tube	-1667	1.41	19.1	0.2	1.0823
	On	10	42	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.4	0.22	161.3	PE Pipe or Tube	-1666	1.41	19.1	0.2	1.0823
	On	0.3	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.46	161.6	PE Pipe or Tube	-1665	1.46	74.3	0	2.1058
BH28a	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.36	161.5	PE Pipe or Tube	-1664	1.41	63.9	25.6	1.0529
BH28b	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.36	161.5	PE Pipe or Tube	-1663	1.41	63.9	25.6	1.0529
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.36	161.3	PE Pipe or Tube	-1662	1.41	63.9	0	1.0529
GT21-RH	On	47.5	43.9	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.39	161.6	PE Pipe or Tube	-1661	1.46	49.8	2.4	2.1058
	On	0.1	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.46	161.2	PE Pipe or Tube	-1660	1.46	74.3	0	2.1058
GT5-RH	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.36	161.5	PE Pipe or Tube	-1659	1.41	63.9	0	1.0529

	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.36	161.5	PE Pipe or Tube	-1658	1.41	63.9	0	1.0529
GT21-RH	On	47.5	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.46	161.3	PE Pipe or Tube	-1657	1.46	74.3	3.5	2.1058
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.36	161.3	PE Pipe or Tube	-1656	1.41	63.9	0	1.0529
	On	0.1	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.49	161.2	PE Pipe or Tube	-1653	1.47	82.6	0	2.2383
	On	0.1	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.47	161.2	PE Pipe or Tube	-1652	1.47	77	0	2.1522
GT20-RH	On	22.5	43.9	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.41	161.6	PE Pipe or Tube	-1651	1.47	55.3	1.2	2.2383
GT19-RH	On	40	43.9	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.39	161.6	PE Pipe or Tube	-1650	1.47	51.6	2.1	2.1522
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.38	161.3	PE Pipe or Tube	-1649	1.41	70.9	0	1.1192
BH20b	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.38	161.5	PE Pipe or Tube	-1648	1.41	70.9	28.4	1.1191
BH20a	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.38	161.5	PE Pipe or Tube	-1647	1.41	70.9	28.4	1.1191
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.36	161.3	PE Pipe or Tube	-1646	1.41	66.2	0	1.0761
BH19b	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.36	161.5	PE Pipe or Tube	-1645	1.41	66.2	26.5	1.0761
	On	0.3	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.47	161.6	PE Pipe or Tube	-1644	1.47	77	0	2.1522
	On	0.3	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.49	161.6	PE Pipe or Tube	-1643	1.47	82.6	0	2.2383
BH19a	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.36	161.5	PE Pipe or Tube	-1642	1.41	66.2	26.5	1.0761
	On	0.3	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.49	161.6	PE Pipe or Tube	-1641	1.47	83.3	0	2.2491
BH21a	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.38	161.5	PE Pipe or Tube	-1640	1.41	71.5	28.6	1.1245
BH21b	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.38	161.5	PE Pipe or Tube	-1639	1.41	71.5	28.6	1.1245
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.38	161.3	PE Pipe or Tube	-1638	1.41	71.5	0	1.1246
GT21-RH	On	21	43.9	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.41	161.6	PE Pipe or Tube	-1637	1.47	55.8	1.2	2.2491
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.7	161.6	PE Pipe or Tube	-1636	1.62	34	0	39.1316
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.7	161.2	PE Pipe or Tube	-1635	1.62	34.1	0	39.1277
	On	0.1	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.49	161.2	PE Pipe or Tube	-1634	1.47	83.3	0	2.2491
GT5-RH	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.38	161.5	PE Pipe or Tube	-1633	1.41	71.5	0	1.1245
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.38	161.5	PE Pipe or Tube	-1632	1.41	71.5	0	1.1245
GT21-RH	On	21	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.49	161.3	PE Pipe or Tube	-1631	1.47	83.3	1.7	2.2491
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.38	161.3	PE Pipe or Tube	-1630	1.41	71.5	0	1.1246
GT5-RH	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.38	161.5	PE Pipe or Tube	-1629	1.41	70.9	0	1.1191
GT20-RH	On	22.5	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.49	161.3	PE Pipe or Tube	-1628	1.47	82.6	1.9	2.2383
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.38	161.5	PE Pipe or Tube	-1627	1.41	70.9	0	1.1191
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.38	161.3	PE Pipe or Tube	-1626	1.41	70.9	0	1.1192
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.74	161.2	PE Pipe or Tube	-1625	1.62	37.7	0	41.3659
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.74	161.6	PE Pipe or Tube	-1624	1.62	37.6	0	41.37
GT3-RH	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.36	161.5	PE Pipe or Tube	-1623	1.41	66.2	0	1.0761
GT19-RH	On	40	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.47	161.3	PE Pipe or Tube	-1622	1.47	77	3.1	2.1522
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.36	161.5	PE Pipe or Tube	-1621	1.41	66.2	0	1.0761
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.36	161.3	PE Pipe or Tube	-1620	1.41	66.2	0	1.0761
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.3	PE Pipe or Tube	-1619	1.41	67.6	0	1.0891
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.37	161.5	PE Pipe or Tube	-1618	1.41	67.6	0	1.0891
GT16-RH	On	35	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.47	161.3	PE Pipe or Tube	-1617	1.47	78.7	2.8	2.1782
GT2-RH	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.37	161.5	PE Pipe or Tube	-1616	1.41	67.6	0	1.0891
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.3	PE Pipe or Tube	-1615	1.41	68.8	0	1.0994
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.37	161.5	PE Pipe or Tube	-1614	1.41	68.8	0	1.0994
GT4-RH	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.37	161.5	PE Pipe or Tube	-1613	1.41	68.8	0	1.0994
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.3	PE Pipe or Tube	-1612	1.41	67.6	0	1.0886
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.37	161.5	PE Pipe or Tube	-1611	1.41	67.6	0	1.0885
GT6-RH	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.37	161.5	PE Pipe or Tube	-1610	1.41	67.6	0	1.0885
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.36	161.3	PE Pipe or Tube	-1609	1.41	64.9	0	1.0636
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.36	161.5	PE Pipe or Tube	-1608	1.41	64.9	0	1.0636
GT19-RH	On	46	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.46	161.3	PE Pipe or Tube	-1607	1.46	75.5	3.5	2.1272
GT3-RH	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.36	161.5	PE Pipe or Tube	-1606	1.41	64.9	0	1.0636
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.5	161.6	PE Pipe or Tube	-1605	1.61	18.8	0	28.2004
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.5	161.2	PE Pipe or Tube	-1604	1.61	18.8	0	28.1982
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.37	161.5	PE Pipe or Tube	-1603	1.41	67.7	0	1.0892
GT20-RH	On	34	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.47	161.4	PE Pipe or Tube	-1602	1.47	78.8	2.7	2.1785
GT5-RH	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.37	161.5	PE Pipe or Tube	-1601	1.41	67.7	0	1.0892
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.3	PE Pipe or Tube	-1600	1.41	68.7	0	1.0985
GT21-RH	On	32	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.48	161.3	PE Pipe or Tube	-1599	1.47	80	2.6	2.1969
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.37	161.5	PE Pipe or Tube	-1598	1.41	68.7	0	1.0984
GT5-RH	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.37	161.5	PE Pipe or Tube	-1597	1.41	68.7	0	1.0984
	On	0.1	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.48	161.2	PE Pipe or Tube	-1596	1.47	80	0	2.1969
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.46	161.2	PE Pipe or Tube	-1595	1.61	16.3	0	26.0199

	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.46	161.6	PE Pipe or Tube	-1594	1.61	16.2	0	26.0217
GT21-RH	On	32	43.9	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.4	161.6	PE Pipe or Tube	-1593	1.47	53.6	1.7	2.1969
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.3	PE Pipe or Tube	-1592	1.41	68.7	0	1.0985
BH27b	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.5	PE Pipe or Tube	-1591	1.41	68.7	27.5	1.0984
BH27a	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.5	PE Pipe or Tube	-1590	1.41	68.7	27.5	1.0984
	On	0.3	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.48	161.6	PE Pipe or Tube	-1589	1.47	79.9	0	2.1969
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.54	161.2	PE Pipe or Tube	-1588	1.62	21.5	0	30.3252
BH25a	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.36	161.5	PE Pipe or Tube	-1587	1.41	64.9	26	1.0636
	On	0.3	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.47	161.6	PE Pipe or Tube	-1586	1.47	78.7	0	2.1785
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.54	161.6	PE Pipe or Tube	-1585	1.62	21.4	0	30.3277
	On	0.3	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.47	161.6	PE Pipe or Tube	-1584	1.47	75.5	0	2.1771
BH24b	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.5	PE Pipe or Tube	-1583	1.41	67.6	27	1.0885
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.3	PE Pipe or Tube	-1582	1.41	67.6	0	1.0886
GT18-RH	On	40	43.9	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.4	161.6	PE Pipe or Tube	-1581	1.47	52.7	2.1	2.1771
	On	0.1	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.47	161.2	PE Pipe or Tube	-1580	1.47	78.7	0	2.1771
	On	0.3	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.46	161.6	PE Pipe or Tube	-1579	1.46	75.5	0	2.1272
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.58	161.6	PE Pipe or Tube	-1578	1.62	24.3	0	32.505
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.58	161.2	PE Pipe or Tube	-1577	1.62	24.3	0	32.5022
BH25b	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.36	161.5	PE Pipe or Tube	-1576	1.41	64.9	26	1.0636
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.36	161.3	PE Pipe or Tube	-1575	1.41	64.9	0	1.0636
BH26a	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.5	PE Pipe or Tube	-1574	1.41	67.7	27.1	1.0892
BH26b	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.5	PE Pipe or Tube	-1573	1.41	67.7	27.1	1.0892
GT19-RH	On	46	43.9	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.39	161.6	PE Pipe or Tube	-1572	1.46	50.6	2.3	2.1272
GT20-RH	On	34	43.9	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.4	161.6	PE Pipe or Tube	-1571	1.47	52.8	1.8	2.1785
	On	0.1	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.46	161.2	PE Pipe or Tube	-1570	1.46	75.5	0	2.1272
	On	0.1	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.47	161.2	PE Pipe or Tube	-1569	1.47	78.8	0	2.1785
BH22a	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.5	PE Pipe or Tube	-1568	1.41	67.6	27	1.0891
	On	0.3	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.48	161.6	PE Pipe or Tube	-1567	1.47	80	0	2.1987
MANIFOLD HEADER (return)	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.62	161.6	PE Pipe or Tube	-1566	1.62	27.3	0	34.7039
	On	0.3	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.47	161.6	PE Pipe or Tube	-1565	1.47	78.7	0	2.1782
BH22b	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.5	PE Pipe or Tube	-1564	1.41	67.6	27	1.0891
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.62	161.2	PE Pipe or Tube	-1563	1.62	27.4	0	34.7008
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.3	PE Pipe or Tube	-1562	1.41	67.6	0	1.0891
BH23a	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.5	PE Pipe or Tube	-1561	1.41	68.8	27.5	1.0994
BH23b	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.5	PE Pipe or Tube	-1560	1.41	68.8	27.5	1.0994
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.3	PE Pipe or Tube	-1559	1.41	68.8	0	1.0994
BH24a	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.5	PE Pipe or Tube	-1558	1.41	67.6	27	1.0885
GT16-RH	On	35	43.9	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.4	161.6	PE Pipe or Tube	-1557	1.47	52.7	1.8	2.1782
GT17-RH	On	31	43.9	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.4	161.6	PE Pipe or Tube	-1556	1.47	53.6	1.7	2.1987
	On	0.1	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.47	161.2	PE Pipe or Tube	-1555	1.47	78.7	0	2.1782
	On	0.1	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.48	161.2	PE Pipe or Tube	-1554	1.47	80.1	0	2.1987
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.66	161.6	PE Pipe or Tube	-1553	1.62	30.5	0	36.8823
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.66	161.2	PE Pipe or Tube	-1552	1.62	30.6	0	36.8789
	On	31	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.48	161.3	PE Pipe or Tube	-1551	1.47	80.1	2.5	2.1987
	On	40	42	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.44	161.3	PE Pipe or Tube	-1550	1.47	65.3	2.6	2.1771
	On	10	42	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.4	0.22	161.3	PE Pipe or Tube	-1549	1.41	19.3	0.2	1.0893
	On	10	42	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.4	0.22	161.3	PE Pipe or Tube	-1548	1.41	19.3	0.2	1.0893
	On	0.3	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.46	161.6	PE Pipe or Tube	-1547	1.46	75.4	0	2.1263
BH28a	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.36	161.5	PE Pipe or Tube	-1546	1.41	64.9	25.9	1.0631
BH28b	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.36	161.5	PE Pipe or Tube	-1545	1.41	64.9	25.9	1.0631
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.36	161.3	PE Pipe or Tube	-1544	1.41	64.9	0	1.0631
GT21-RH	On	47.5	43.9	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.39	161.6	PE Pipe or Tube	-1543	1.46	50.6	2.4	2.1263
	On	0.1	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.46	161.2	PE Pipe or Tube	-1542	1.46	75.5	0	2.1262
GT5-RH	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.36	161.5	PE Pipe or Tube	-1541	1.41	64.9	0	1.0631
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.36	161.5	PE Pipe or Tube	-1540	1.41	64.9	0	1.0631
GT21-RH	On	47.5	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.46	161.3	PE Pipe or Tube	-1539	1.46	75.5	3.6	2.1262
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.36	161.3	PE Pipe or Tube	-1538	1.41	64.9	0	1.0631
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.43	161.6	PE Pipe or Tube	-1537	1.61	13.9	0	23.8248
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.43	161.2	PE Pipe or Tube	-1536	1.61	13.9	0	23.8232
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.82	161.2	PE Pipe or Tube	-1037	1.62	45.3	0	45.6962
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.82	161.6	PE Pipe or Tube	-1036	1.62	45.1	0	45.7014
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.3	PE Pipe or Tube	-1035	1.41	67.6	0	1.0894

GT21-RH	On	47.5	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.47	161.3	PE Pipe or Tube	-1034	1.47	78.7	3.7	2.1788
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.37	161.5	PE Pipe or Tube	-1033	1.41	67.6	0	1.0894
GT5-RH	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.37	161.5	PE Pipe or Tube	-1032	1.41	67.6	0	1.0894
	On	0.1	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.47	161.2	PE Pipe or Tube	-1031	1.47	78.7	0	2.1788
GT21-RH	On	47.5	43.9	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.4	161.6	PE Pipe or Tube	-1028	1.47	52.7	2.5	2.1788
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.3	PE Pipe or Tube	-1027	1.41	67.6	0	1.0894
BH28b	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.5	PE Pipe or Tube	-1026	1.41	67.6	27	1.0894
BH28a	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.5	PE Pipe or Tube	-1025	1.41	67.6	27	1.0894
	On	0.3	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.47	161.6	PE Pipe or Tube	-1024	1.47	78.7	0	2.1788
Header to Plant Room	On	0.5	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.1	1.87	161.1	PE Pipe or Tube	-1022	1.62	208.3	0.1	104.5222
	On	10	42	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.4	0.22	161.3	PE Pipe or Tube	-1021	1.41	20.2	0.2	1.1193
	On	10	42	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.4	0.22	161.3	PE Pipe or Tube	-1020	1.41	20.2	0.2	1.1193
	On	40	42	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.45	161.3	PE Pipe or Tube	-1018	1.47	68	2.7	2.2293
	On	31	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.49	161.3	PE Pipe or Tube	-1017	1.47	83.1	2.6	2.2468
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	1.06	161.2	PE Pipe or Tube	-1015	1.63	72.4	0	59.0718
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	1.06	161.6	PE Pipe or Tube	-1014	1.63	72.2	0	59.0799
	On	0.1	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.49	161.2	PE Pipe or Tube	-1013	1.47	83.1	0	2.2468
	On	0.1	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.48	161.2	PE Pipe or Tube	-1012	1.47	81.3	0	2.2202
GT17-RH	On	31	43.9	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.41	161.6	PE Pipe or Tube	-1011	1.47	55.6	1.7	2.2468
GT16-RH	On	35	43.9	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.41	161.6	PE Pipe or Tube	-1010	1.47	54.5	1.9	2.2202
BH24a	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.38	161.5	PE Pipe or Tube	-1009	1.41	70.3	28.1	1.1146
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.38	161.3	PE Pipe or Tube	-1008	1.41	71.3	0	1.1234
BH23b	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.38	161.5	PE Pipe or Tube	-1007	1.41	71.3	28.5	1.1234
BH23a	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.38	161.5	PE Pipe or Tube	-1006	1.41	71.3	28.5	1.1234
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.38	161.3	PE Pipe or Tube	-1005	1.41	69.8	0	1.1101
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	1.02	161.2	PE Pipe or Tube	-1004	1.62	67.5	0	56.852
BH22b	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.38	161.5	PE Pipe or Tube	-1003	1.41	69.8	27.9	1.1101
	On	0.3	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.48	161.6	PE Pipe or Tube	-1002	1.47	81.3	0	2.2202
MANIFOLD HEADER (return)	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	1.02	161.6	PE Pipe or Tube	-1001	1.63	67.3	0	56.8594
	On	0.3	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.49	161.6	PE Pipe or Tube	-1000	1.47	83	0	2.2468
BH22a	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.38	161.5	PE Pipe or Tube	-999	1.41	69.8	27.9	1.1101
	On	0.1	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.49	161.2	PE Pipe or Tube	-998	1.47	82.6	0	2.2386
	On	0.1	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.47	161.2	PE Pipe or Tube	-997	1.47	78.9	0	2.182
GT20-RH	On	34	43.9	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.41	161.6	PE Pipe or Tube	-996	1.47	55.3	1.9	2.2386
GT19-RH	On	46	43.9	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.4	161.6	PE Pipe or Tube	-995	1.47	52.8	2.4	2.182
BH26b	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.38	161.5	PE Pipe or Tube	-994	1.41	70.9	28.4	1.1193
BH26a	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.38	161.5	PE Pipe or Tube	-993	1.41	70.9	28.4	1.1193
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.3	PE Pipe or Tube	-992	1.41	67.7	0	1.091
BH25b	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.5	PE Pipe or Tube	-991	1.41	67.7	27.1	1.091
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.98	161.2	PE Pipe or Tube	-990	1.62	62.7	0	54.6056
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.98	161.6	PE Pipe or Tube	-989	1.63	62.5	0	54.6125
	On	0.3	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.47	161.6	PE Pipe or Tube	-988	1.47	78.8	0	2.182
	On	0.1	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.48	161.2	PE Pipe or Tube	-987	1.47	81.9	0	2.2293
GT18-RH	On	40	43.9	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.41	161.6	PE Pipe or Tube	-986	1.47	54.9	2.2	2.2293
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.38	161.3	PE Pipe or Tube	-985	1.41	70.3	0	1.1147
BH24b	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.38	161.5	PE Pipe or Tube	-984	1.41	70.3	28.1	1.1146
	On	0.3	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.48	161.6	PE Pipe or Tube	-983	1.47	78.5	0	2.2293
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.94	161.6	PE Pipe or Tube	-982	1.63	57.9	0	52.383
	On	0.3	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.49	161.6	PE Pipe or Tube	-981	1.47	82.5	0	2.2386
BH25a	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.5	PE Pipe or Tube	-980	1.41	67.7	27.1	1.091
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.94	161.2	PE Pipe or Tube	-979	1.62	58.1	0	52.3766
	On	0.3	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.49	161.6	PE Pipe or Tube	-978	1.47	84	0	2.2606
BH27a	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.38	161.5	PE Pipe or Tube	-977	1.41	72.1	28.8	1.1303
BH27b	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.38	161.5	PE Pipe or Tube	-976	1.41	72.1	28.8	1.1303
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.38	161.3	PE Pipe or Tube	-975	1.41	72.1	0	1.1303
GT21-RH	On	32	43.9	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.41	161.6	PE Pipe or Tube	-974	1.47	56.3	1.8	2.2606
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.86	161.6	PE Pipe or Tube	-973	1.63	49.2	0	47.9622
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.86	161.2	PE Pipe or Tube	-972	1.62	49.4	0	47.9566
	On	0.1	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.49	161.2	PE Pipe or Tube	-971	1.47	84	0	2.2606
GT5-RH	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.38	161.5	PE Pipe or Tube	-970	1.41	72.1	0	1.1303
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.38	161.5	PE Pipe or Tube	-969	1.41	72.1	0	1.1303
GT21-RH	On	32	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.49	161.3	PE Pipe or Tube	-968	1.47	84	2.7	2.2606

	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.38	161.3	PE Pipe or Tube	-967	1.41	72.1	0	1.1303
GT5-RH	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.38	161.5	PE Pipe or Tube	-966	1.41	70.9	0	1.1193
GT20-RH	On	34	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.49	161.4	PE Pipe or Tube	-965	1.47	82.6	2.8	2.2386
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.38	161.5	PE Pipe or Tube	-964	1.41	70.9	0	1.1193
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.9	161.2	PE Pipe or Tube	-963	1.62	53.7	0	50.195
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.9	161.6	PE Pipe or Tube	-962	1.63	53.5	0	50.2009
GT3-RH	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.37	161.5	PE Pipe or Tube	-961	1.41	67.7	0	1.091
GT19-RH	On	46	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.47	161.3	PE Pipe or Tube	-960	1.47	78.9	3.6	2.182
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.37	161.5	PE Pipe or Tube	-959	1.41	67.7	0	1.091
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.3	PE Pipe or Tube	-958	1.41	67.7	0	1.091
GT6-RH	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.38	161.5	PE Pipe or Tube	-957	1.41	70.3	0	1.1146
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.38	161.5	PE Pipe or Tube	-956	1.41	70.3	0	1.1146
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.38	161.3	PE Pipe or Tube	-955	1.41	70.3	0	1.1147
GT4-RH	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.38	161.5	PE Pipe or Tube	-954	1.41	71.3	0	1.1234
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.38	161.5	PE Pipe or Tube	-953	1.41	71.3	0	1.1234
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.38	161.3	PE Pipe or Tube	-952	1.41	71.3	0	1.1234
GT2-RH	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.38	161.5	PE Pipe or Tube	-951	1.41	69.8	0	1.1101
GT16-RH	On	35	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.48	161.3	PE Pipe or Tube	-950	1.47	81.3	2.8	2.2202
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.38	161.5	PE Pipe or Tube	-949	1.41	69.8	0	1.1101
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.38	161.3	PE Pipe or Tube	-948	1.41	69.8	0	1.1101
	On	1	26	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	167.8	74.82	189.1	PE Pipe or Tube	-740	1.61	2132427.5	2132.4	143
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.33	161.3	PE Pipe or Tube	-738	1.4	55.8	0	0.9788
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.33	161.5	PE Pipe or Tube	-737	1.4	55.8	0	0.9788
	On	29	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.42	161.3	PE Pipe or Tube	-736	1.46	64.9	1.9	1.9577
GT2-RH	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.33	161.5	PE Pipe or Tube	-735	1.4	55.8	0	0.9788
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.34	161.3	PE Pipe or Tube	-734	1.41	59	0	1.0097
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.34	161.6	PE Pipe or Tube	-733	1.41	59	0	1.0097
	On	21	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.44	161.3	PE Pipe or Tube	-732	1.46	68.6	1.4	2.0193
GT4-RH	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.34	161.6	PE Pipe or Tube	-731	1.41	59	0	1.0097
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.36	161.3	PE Pipe or Tube	-730	1.41	64.5	0	1.0623
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.36	161.6	PE Pipe or Tube	-729	1.41	64.5	0	1.0623
	On	0.1	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.46	161.3	PE Pipe or Tube	-728	1.47	75	0	2.1246
GT6-RH	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.36	161.6	PE Pipe or Tube	-727	1.41	64.5	0	1.0623
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.36	161.3	PE Pipe or Tube	-726	1.41	65.8	0	1.0741
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.36	161.6	PE Pipe or Tube	-725	1.41	65.8	0	1.0741
BH4_H	On	5	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.47	161.3	PE Pipe or Tube	-724	1.47	76.5	0.4	2.1482
GT3-RH	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.36	161.6	PE Pipe or Tube	-723	1.41	65.8	0	1.0741
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.3	PE Pipe or Tube	-722	1.41	66.9	0	1.0846
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.37	161.6	PE Pipe or Tube	-721	1.41	66.9	0	1.0846
GT5-RH	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.37	161.6	PE Pipe or Tube	-720	1.41	66.9	0	1.0846
	On	5	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.47	161.3	PE Pipe or Tube	-719	1.47	77.9	0.4	2.1692
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.36	161.3	PE Pipe or Tube	-718	1.41	65.9	0	1.075
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.36	161.6	PE Pipe or Tube	-717	1.41	65.9	0	1.075
	On	12	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.47	161.3	PE Pipe or Tube	-716	1.47	76.7	0.9	2.1499
GT2-RH	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.36	161.6	PE Pipe or Tube	-715	1.41	65.9	0	1.075
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.36	161.6	PE Pipe or Tube	-714	1.41	64.6	0	1.0628
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.36	161.3	PE Pipe or Tube	-713	1.41	64.6	0	1.0628
GT7-RH	On	20	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.46	161.3	PE Pipe or Tube	-712	1.47	75.1	1.5	2.1256
GT4-RH	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.36	161.6	PE Pipe or Tube	-711	1.41	64.6	0	1.0628
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.36	161.3	PE Pipe or Tube	-710	1.41	63.3	0	1.051
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.36	161.5	PE Pipe or Tube	-709	1.41	63.3	0	1.0509
GT8-RH	On	28	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.46	161.3	PE Pipe or Tube	-708	1.46	73.7	2.1	2.1019
GT6-RH	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.36	161.5	PE Pipe or Tube	-707	1.41	63.3	0	1.0509
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.36	161.3	PE Pipe or Tube	-706	1.41	63.4	0	1.0514
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.36	161.5	PE Pipe or Tube	-705	1.41	63.4	0	1.0514
GT9-RH	On	31	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.46	161.3	PE Pipe or Tube	-704	1.46	73.7	2.3	2.1029
GT3-RH	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.36	161.5	PE Pipe or Tube	-703	1.41	63.4	0	1.0514
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.3	PE Pipe or Tube	-702	1.41	66.3	0	1.0792
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.37	161.6	PE Pipe or Tube	-701	1.41	66.3	0	1.0792
GT10-RH	On	23	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.47	161.3	PE Pipe or Tube	-700	1.47	77.2	1.8	2.1585
GT5-RH	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.37	161.6	PE Pipe or Tube	-699	1.41	66.3	0	1.0792
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.3	PE Pipe or Tube	-698	1.41	67.1	0	1.0864

	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.37	161.6	PE Pipe or Tube	-697	1.41	67.1	0	1.0864
GT11-RH	On	23	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.47	161.3	PE Pipe or Tube	-696	1.47	78.2	1.8	2.1728
GT2-RH	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.37	161.6	PE Pipe or Tube	-695	1.41	67.1	0	1.0864
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.39	161.3	PE Pipe or Tube	-694	1.42	73.5	0	1.1437
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.39	161.6	PE Pipe or Tube	-693	1.42	73.5	0	1.1437
GT12-RH	On	5	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.5	161.3	PE Pipe or Tube	-692	1.47	85.7	0.4	2.2874
GT4-RH	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.39	161.6	PE Pipe or Tube	-691	1.42	73.5	0	1.1437
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.38	161.3	PE Pipe or Tube	-690	1.41	70.1	0	1.113
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.38	161.6	PE Pipe or Tube	-689	1.41	70.1	0	1.1129
GT13-RH	On	18	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.48	161.3	PE Pipe or Tube	-688	1.47	81.6	1.5	2.2259
GT6-RH	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.38	161.6	PE Pipe or Tube	-687	1.41	70.1	0	1.1129
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.38	161.3	PE Pipe or Tube	-686	1.41	69.7	0	1.1098
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.38	161.6	PE Pipe or Tube	-685	1.41	69.7	0	1.1097
GT3-RH	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.38	161.6	PE Pipe or Tube	-684	1.41	69.7	0	1.1097
GT14-RH	On	23	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.48	161.3	PE Pipe or Tube	-683	1.47	81.2	1.9	2.2195
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.3	PE Pipe or Tube	-682	1.41	68	0	1.0941
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.37	161.5	PE Pipe or Tube	-681	1.41	68	0	1.0941
GT15-RH	On	30	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.47	161.3	PE Pipe or Tube	-680	1.47	79.2	2.4	2.1882
GT5-RH	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.37	161.5	PE Pipe or Tube	-679	1.41	68	0	1.0941
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.3	PE Pipe or Tube	-678	1.41	66.4	0	1.0791
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.37	161.5	PE Pipe or Tube	-677	1.41	66.4	0	1.0791
GT16-RH	On	38	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.47	161.3	PE Pipe or Tube	-676	1.47	77.3	2.9	2.1582
GT2-RH	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.37	161.5	PE Pipe or Tube	-675	1.41	66.4	0	1.0791
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.3	PE Pipe or Tube	-674	1.41	68.8	0	1.1014
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.37	161.5	PE Pipe or Tube	-673	1.41	68.8	0	1.1014
GT17-RH	On	31	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.48	161.3	PE Pipe or Tube	-672	1.47	80.1	2.5	2.2028
GT4-RH	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.37	161.5	PE Pipe or Tube	-671	1.41	68.8	0	1.1014
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.3	PE Pipe or Tube	-670	1.41	69.2	0	1.1045
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.37	161.5	PE Pipe or Tube	-669	1.41	69.2	0	1.1045
GT18-RH	On	31.5	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.48	161.3	PE Pipe or Tube	-668	1.47	80.6	2.5	2.2091
GT6-RH	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.37	161.5	PE Pipe or Tube	-667	1.41	69.2	0	1.1045
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.3	PE Pipe or Tube	-666	1.41	67.3	0	1.0873
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.37	161.5	PE Pipe or Tube	-665	1.41	67.3	0	1.0872
GT19-RH	On	40	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.47	161.3	PE Pipe or Tube	-664	1.47	78.3	3.1	2.1745
GT3-RH	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.37	161.5	PE Pipe or Tube	-663	1.41	67.3	0	1.0872
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	1.14	161.6	PE Pipe or Tube	-662	1.63	82.7	0	63.6413
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	1.14	161.2	PE Pipe or Tube	-661	1.63	83.1	0	63.6322
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.39	161.3	PE Pipe or Tube	-660	1.41	72.8	0	1.1364
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.39	161.6	PE Pipe or Tube	-659	1.41	72.8	0	1.1364
GT20-RH	On	22.5	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.49	161.3	PE Pipe or Tube	-658	1.47	84.8	1.9	2.2728
GT5-RH	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.39	161.6	PE Pipe or Tube	-657	1.41	72.8	0	1.1364
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.39	161.3	PE Pipe or Tube	-656	1.42	73.6	0	1.1442
GT21-RH	On	21	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.5	161.3	PE Pipe or Tube	-655	1.47	85.8	1.8	2.2883
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.39	161.6	PE Pipe or Tube	-653	1.42	73.6	0	1.1441
GT5-RH	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.39	161.6	PE Pipe or Tube	-652	1.42	73.6	0	1.1441
	On	0.1	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.5	161.2	PE Pipe or Tube	-648	1.47	85.8	0	2.2883
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	1.1	161.2	PE Pipe or Tube	-647	1.63	77.7	0	61.3599
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	1.1	161.6	PE Pipe or Tube	-645	1.63	77.4	0	61.3683
GT21-RH	On	21	43.9	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.42	161.6	PE Pipe or Tube	-642	1.47	57.5	1.2	2.2883
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.39	161.3	PE Pipe or Tube	-640	1.42	73.6	0	1.1442
BH21b	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.39	161.6	PE Pipe or Tube	-639	1.42	73.6	29.5	1.1441
BH21a	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.39	161.6	PE Pipe or Tube	-637	1.42	73.6	29.5	1.1441
	On	0.3	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.5	161.6	PE Pipe or Tube	-635	1.47	85.8	0	2.2883
	On	0.1	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.44	161.3	PE Pipe or Tube	-630	1.46	68.6	0	2.0193
	On	0.1	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.42	161.3	PE Pipe or Tube	-627	1.46	64.9	0	1.9577
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	1.33	161.3	PE Pipe or Tube	-621	1.62	111.3	0	74.5634
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	1.29	161.3	PE Pipe or Tube	-618	1.63	105.3	0	72.3756
	On	0.1	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.47	161.2	PE Pipe or Tube	-615	1.47	79.2	0	2.1882
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	1.18	161.2	PE Pipe or Tube	-611	1.63	88.4	0	65.8065
BH19a	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.5	PE Pipe or Tube	-605	1.41	67.3	26.9	1.0872
	On	0.1	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	1.87	161.3	PE Pipe or Tube	-602	1.62	208.3	0	104.5213
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	1.87	161.3	PE Pipe or Tube	-600	1.62	208.3	0	104.5213

	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	1.76	161.3	PE Pipe or Tube	-593	1.62	186.2	0	98.421
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	1.68	161.3	PE Pipe or Tube	-592	1.62	171.3	0	94.1044
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	1.57	161.3	PE Pipe or Tube	-587	1.62	150.4	0	87.7281
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	1.49	161.3	PE Pipe or Tube	-586	1.62	137.1	0	83.4676
	On	0.2	130	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	1.61	161.3	PE Pipe or Tube	-581	1.62	173.3	0	76.7826
Header to Plant Room	On	140	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.1	1.87	161.3	PE Pipe or Tube	-576	1.62	208.3	29.2	104.5213
	On	0.3	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.49	161.6	PE Pipe or Tube	-573	1.47	84.7	0	2.2728
	On	0.1	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	1.87	161.6	PE Pipe or Tube	-570	1.62	207.4	0	104.543
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	1.18	161.6	PE Pipe or Tube	-569	1.63	88	0	65.8161
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	1.29	161.6	PE Pipe or Tube	-565	1.63	104.9	0	72.3869
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	1.37	161.6	PE Pipe or Tube	-562	1.63	117	0	76.795
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	1.49	161.6	PE Pipe or Tube	-559	1.63	136.5	0	83.4818
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	1.57	161.6	PE Pipe or Tube	-556	1.63	149.7	0	87.7435
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	1.68	161.6	PE Pipe or Tube	-549	1.63	170.6	0	94.1217
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	1.8	161.6	PE Pipe or Tube	-548	1.63	193	0	100.5643
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	1.76	161.6	PE Pipe or Tube	-545	1.63	185.4	0	98.4394
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	1.87	161.6	PE Pipe or Tube	-541	1.62	207.4	0	104.5429
Header from Plant Room	On	140	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	1.87	162	PE Pipe or Tube	-536	1.62	207.4	29	104.5413
	On	0.3	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.48	161.6	PE Pipe or Tube	-535	1.47	77.2	0	2.2091
BH18b	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.5	PE Pipe or Tube	-532	1.41	69.2	27.7	1.1045
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.3	PE Pipe or Tube	-531	1.41	69.2	0	1.1045
GT18-RH	On	31.5	43.9	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.41	161.6	PE Pipe or Tube	-530	1.47	54	1.7	2.2091
	On	0.1	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.48	161.2	PE Pipe or Tube	-529	1.47	80.6	0	2.2091
	On	0.3	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.47	161.6	PE Pipe or Tube	-524	1.47	78.3	0	2.1745
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	1.22	161.6	PE Pipe or Tube	-521	1.63	93.5	0	68.0254
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	1.22	161.2	PE Pipe or Tube	-520	1.63	93.9	0	68.0153
BH19b	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.5	PE Pipe or Tube	-516	1.41	67.3	26.9	1.0872
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.3	PE Pipe or Tube	-514	1.41	67.3	0	1.0873
BH20a	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.39	161.6	PE Pipe or Tube	-513	1.41	72.8	29.1	1.1364
BH20b	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.39	161.6	PE Pipe or Tube	-510	1.41	72.8	29.1	1.1364
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.39	161.3	PE Pipe or Tube	-509	1.41	72.8	0	1.1364
GT19-RH	On	40	43.9	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.4	161.6	PE Pipe or Tube	-507	1.47	52.5	2.1	2.1745
GT20-RH	On	22.5	43.9	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.42	161.6	PE Pipe or Tube	-505	1.47	56.8	1.3	2.2728
	On	0.1	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.47	161.2	PE Pipe or Tube	-503	1.47	78.3	0	2.1745
	On	0.1	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.49	161.2	PE Pipe or Tube	-501	1.47	84.8	0	2.2728
BH16a	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.5	PE Pipe or Tube	-497	1.41	66.4	26.5	1.0791
	On	0.3	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.48	161.6	PE Pipe or Tube	-491	1.47	80.1	0	2.2028
MANIFOLD HEADER (return)	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	1.25	161.6	PE Pipe or Tube	-490	1.63	99.2	0	70.2284
	On	0.3	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.47	161.6	PE Pipe or Tube	-487	1.47	77.2	0	2.1582
BH16b	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.5	PE Pipe or Tube	-484	1.41	66.4	26.5	1.0791
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	1.25	161.3	PE Pipe or Tube	-483	1.63	99.6	0	70.2179
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.3	PE Pipe or Tube	-482	1.41	66.4	0	1.0791
BH17a	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.5	PE Pipe or Tube	-481	1.41	68.8	27.5	1.1014
BH17b	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.5	PE Pipe or Tube	-478	1.41	68.8	27.5	1.1014
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.3	PE Pipe or Tube	-476	1.41	68.8	0	1.1014
BH18a	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.5	PE Pipe or Tube	-475	1.41	69.2	27.7	1.1045
GT16-RH	On	38	43.9	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.4	161.6	PE Pipe or Tube	-473	1.47	51.8	2	2.1582
GT17-RH	On	31	43.9	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.4	161.6	PE Pipe or Tube	-471	1.47	53.7	1.7	2.2028
	On	0.1	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.47	161.2	PE Pipe or Tube	-469	1.47	77.3	0	2.1582
	On	0.1	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.48	161.2	PE Pipe or Tube	-467	1.47	80.1	0	2.2028
	On	0.3	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.48	161.6	PE Pipe or Tube	-465	1.47	78.2	0	2.2259
BH13b	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.38	161.6	PE Pipe or Tube	-462	1.41	70.1	28	1.1129
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.38	161.3	PE Pipe or Tube	-461	1.41	70.1	0	1.113
GT13-RH	On	18	43.9	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.41	161.6	PE Pipe or Tube	-460	1.47	54.7	1	2.2259
	On	0.1	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.48	161.3	PE Pipe or Tube	-459	1.47	81.6	0	2.2259
	On	0.3	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.47	161.6	PE Pipe or Tube	-458	1.47	79.1	0	2.1882
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	1.33	161.6	PE Pipe or Tube	-457	1.63	110.8	0	74.5752
	On	0.3	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.48	161.6	PE Pipe or Tube	-454	1.47	81.2	0	2.2195
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	1.41	161.6	PE Pipe or Tube	-451	1.63	123.3	0	79.0212
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	1.41	161.3	PE Pipe or Tube	-450	1.62	123.8	0	79.0082
BH14a	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.38	161.6	PE Pipe or Tube	-449	1.41	69.7	27.9	1.1097
BH14b	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.38	161.6	PE Pipe or Tube	-446	1.41	69.7	27.9	1.1097

	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.38	161.3	PE Pipe or Tube	-444	1.41	69.7	0	1.1098
BH15a	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.5	PE Pipe or Tube	-443	1.41	68	27.2	1.0941
BH15b	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.5	PE Pipe or Tube	-440	1.41	68	27.2	1.0941
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.3	PE Pipe or Tube	-439	1.41	68	0	1.0941
GT14-RH	On	23	43.9	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.41	161.6	PE Pipe or Tube	-437	1.47	54.4	1.3	2.2195
GT15-RH	On	30	43.9	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.4	161.6	PE Pipe or Tube	-435	1.47	53	1.6	2.1882
	On	0.1	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.2	0.48	161.2	PE Pipe or Tube	-433	1.47	81.2	0	2.2195
BH11a	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.6	PE Pipe or Tube	-427	1.41	67.1	26.9	1.0864
	On	0.3	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.5	161.6	PE Pipe or Tube	-421	1.47	85.6	0	2.2874
MANIFOLD HEADER (return)	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	1.45	161.6	PE Pipe or Tube	-420	1.63	130	0	81.3087
	On	0.3	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.47	161.6	PE Pipe or Tube	-417	1.47	78.1	0	2.1728
BH11b	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.6	PE Pipe or Tube	-414	1.41	67.1	26.9	1.0864
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	1.45	161.3	PE Pipe or Tube	-413	1.62	130.6	0	81.2954
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.3	PE Pipe or Tube	-412	1.41	67.1	0	1.0864
BH12a	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.39	161.6	PE Pipe or Tube	-411	1.42	73.5	29.4	1.1437
BH12b	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.39	161.6	PE Pipe or Tube	-408	1.42	73.5	29.4	1.1437
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.39	161.3	PE Pipe or Tube	-406	1.42	73.5	0	1.1437
BH13a	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.38	161.6	PE Pipe or Tube	-405	1.41	70.1	28	1.1129
GT11-RH	On	23	43.9	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.4	161.6	PE Pipe or Tube	-403	1.47	52.4	1.2	2.1728
GT12-RH	On	5	43.9	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.42	161.6	PE Pipe or Tube	-401	1.47	57.4	0.3	2.2874
	On	0.1	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.47	161.3	PE Pipe or Tube	-399	1.47	78.2	0	2.1728
	On	0.1	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.5	161.3	PE Pipe or Tube	-397	1.47	85.7	0	2.2874
	On	0.3	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.46	161.6	PE Pipe or Tube	-395	1.46	70.7	0	2.1019
BH8b	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.36	161.5	PE Pipe or Tube	-392	1.41	63.3	25.3	1.0509
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.36	161.3	PE Pipe or Tube	-391	1.41	63.3	0	1.051
GT8-RH	On	28	43.9	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.39	161.6	PE Pipe or Tube	-390	1.46	49.4	1.4	2.1019
	On	0.1	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.46	161.3	PE Pipe or Tube	-389	1.46	73.7	0	2.1019
	On	0.3	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.47	161.6	PE Pipe or Tube	-388	1.47	77.2	0	2.1585
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	1.53	161.6	PE Pipe or Tube	-387	1.63	143.2	0	85.6404
	On	0.3	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.46	161.6	PE Pipe or Tube	-384	1.46	73.7	0	2.1029
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	1.61	161.6	PE Pipe or Tube	-381	1.63	156.5	0	89.8457
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	1.6	161.3	PE Pipe or Tube	-380	1.62	157.1	0	89.8297
BH9a	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.36	161.5	PE Pipe or Tube	-379	1.41	63.4	25.3	1.0514
BH9b	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.36	161.5	PE Pipe or Tube	-376	1.41	63.4	25.3	1.0514
MANIFOLD HEADER (flow)	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	1.53	161.3	PE Pipe or Tube	-375	1.62	143.7	0	85.6258
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.36	161.3	PE Pipe or Tube	-374	1.41	63.4	0	1.0514
BH10a	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.6	PE Pipe or Tube	-373	1.41	66.3	26.5	1.0792
BH10b	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.6	PE Pipe or Tube	-370	1.41	66.3	26.5	1.0792
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.3	PE Pipe or Tube	-369	1.41	66.3	0	1.0792
GT9-RH	On	31	43.9	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.39	161.6	PE Pipe or Tube	-367	1.46	49.4	1.5	2.1029
GT10-RH	On	23	43.9	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.4	161.6	PE Pipe or Tube	-365	1.47	51.7	1.2	2.1585
	On	0.1	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.46	161.3	PE Pipe or Tube	-363	1.46	73.7	0	2.1029
	On	0.1	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.47	161.3	PE Pipe or Tube	-361	1.47	77.2	0	2.1585
BH6a	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.36	161.6	PE Pipe or Tube	-287	1.41	65.9	26.3	1.075
	On	0.3	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.46	161.6	PE Pipe or Tube	-281	1.47	75.1	0	2.1256
MANIFOLD HEADER (return)	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	1.64	161.6	PE Pipe or Tube	-280	1.63	163.4	0	91.9715
	On	0.3	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.47	161.6	PE Pipe or Tube	-277	1.47	76.6	0	2.1499
BH6b	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.36	161.6	PE Pipe or Tube	-274	1.41	65.9	26.3	1.075
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	1.64	161.3	PE Pipe or Tube	-273	1.62	164.1	0	91.955
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.36	161.3	PE Pipe or Tube	-272	1.41	65.9	0	1.075
BH7a	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.36	161.6	PE Pipe or Tube	-271	1.41	64.6	25.8	1.0628
BH7b	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.36	161.6	PE Pipe or Tube	-268	1.41	64.6	25.8	1.0628
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.36	161.3	PE Pipe or Tube	-266	1.41	64.6	0	1.0628
BH8a	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.36	161.5	PE Pipe or Tube	-265	1.41	63.3	25.3	1.0509
GT2-RH	On	12	43.9	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.39	161.6	PE Pipe or Tube	-263	1.47	51.4	0.6	2.1499
GT7-RH	On	20	43.9	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.39	161.6	PE Pipe or Tube	-261	1.47	50.3	1	2.1256
	On	0.1	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.47	161.3	PE Pipe or Tube	-259	1.47	76.7	0	2.1499
	On	0.1	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.46	161.3	PE Pipe or Tube	-257	1.47	75.1	0	2.1256
	On	0.1	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.47	161.3	PE Pipe or Tube	-220	1.47	77.9	0	2.1692
	On	0.1	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.47	161.3	PE Pipe or Tube	-218	1.47	76.5	0	2.1482
GT5-RH	On	5	43.9	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.4	161.6	PE Pipe or Tube	-216	1.47	52.2	0.3	2.1692
BH4_H	On	5	43.9	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.39	161.6	PE Pipe or Tube	-214	1.47	51.3	0.3	2.1482

	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.3	PE Pipe or Tube	-212	1.41	66.9	0	1.0846
BH5b	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.6	PE Pipe or Tube	-211	1.41	66.9	26.8	1.0846
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	1.72	161.3	PE Pipe or Tube	-209	1.62	178.7	0	96.2733
BH5a	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.37	161.6	PE Pipe or Tube	-208	1.41	66.9	26.8	1.0846
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.36	161.3	PE Pipe or Tube	-207	1.41	65.8	0	1.0741
BH4b	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.36	161.6	PE Pipe or Tube	-205	1.41	65.8	26.3	1.0741
BH4a	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.36	161.6	PE Pipe or Tube	-202	1.41	65.8	26.3	1.0741
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	1.8	161.3	PE Pipe or Tube	-201	1.62	193.8	0	100.5452
	On	0.3	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.47	161.6	PE Pipe or Tube	-197	1.47	76.5	0	2.1482
MANIFOLD HEADER (return)	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	1.72	161.6	PE Pipe or Tube	-196	1.63	178	0	96.291
	On	0.3	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.47	161.6	PE Pipe or Tube	-193	1.47	77.9	0	2.1692
	On	0.1	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.46	161.3	PE Pipe or Tube	-76	1.47	75	0	2.1246
GT6-RH	On	13	43.9	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.39	161.6	PE Pipe or Tube	-71	1.47	50.3	0.7	2.1246
GT4-RH	On	21	43.9	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.37	161.6	PE Pipe or Tube	-69	1.46	46	1	2.0193
GT2-RH	On	29	43.9	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.5	0.36	161.6	PE Pipe or Tube	-67	1.46	43.5	1.3	1.9577
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.36	161.3	PE Pipe or Tube	-63	1.41	64.5	0	1.0623
BH3b	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.36	161.6	PE Pipe or Tube	-62	1.41	64.5	25.8	1.0623
BH3a	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.36	161.6	PE Pipe or Tube	-59	1.41	64.5	25.8	1.0623
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.34	161.3	PE Pipe or Tube	-58	1.41	59	0	1.0097
BH2b	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.34	161.6	PE Pipe or Tube	-56	1.41	59	23.6	1.0097
CHAMBER HEADER (flow)	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	1.83	161.3	PE Pipe or Tube	-54	1.62	201.1	0	102.5643
BH2a	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.34	161.6	PE Pipe or Tube	-53	1.41	59	23.6	1.0097
	On	0.1	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.33	161.3	PE Pipe or Tube	-52	1.4	55.8	0	0.9788
BH1	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.33	161.5	PE Pipe or Tube	-50	1.4	55.8	22.3	0.9788
BH1	On	400	32.3	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.3	0.33	161.5	PE Pipe or Tube	-47	1.4	55.8	22.3	0.9788
	On	0.3	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.42	161.6	PE Pipe or Tube	-21	1.46	64.9	0	1.9577
	On	0.2	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	1.83	161.6	PE Pipe or Tube	-20	1.62	200.2	0	102.5838
	On	0.3	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.44	161.6	PE Pipe or Tube	-17	1.46	68.5	0	2.0193
	On	0.3	40.4	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	161.6	0.46	161.6	PE Pipe or Tube	-13	1.47	72	0	2.1246
	On	5.75	140.7	1.15	360	Ignore Heat Loss/Gain	Calculate U Value	15	162	1.87	162	PE Pipe or Tube	-2	1.62	207.4	1.2	104.5413

Connector

Unique Name	Status	Elevation (*)	User Number	Stagnation Pressure (bar a)	Temperature (C)
Primary (Brine Circulator)	On	0	4	162	14.4
Primary (Brine Circulator)	On	0	48	161.1	13.1

T Junction

Unique Name	Status	Elevation (*)	Branch Loss (kPa)	Temperature (C)	Channel Stagnation Pressure (bar a)	Straight Loss (kPa)	Straight K (based on channel flow)	Straight Flow (m3/h)	User Number	Branch K (based on channel flow)	Branch Flow (m3/h)	Friction Loss (kPa)	Channel Flow (m3/h)	Element Type
	On	1	1.6	14.3	161.6	0	0.0002	98.4394	14	0.973	2.1246	0	100.564	T Junction
	On	1	1.6	14.3	161.6	0	0.0001	100.5643	18	0.9703	2.0193	0	102.5836	T Junction
	On	1	1.7	14.3	161.6	0	0.0001	102.5838	22	0.9688	1.9577	0	104.5414	T Junction
	On	1	-1.7	13.1	161.3	-0.6	-0.3451	102.5646	55	-0.95	1.9573	0	104.5219	T Junction
	On	1	-1.6	13.1	161.3	-0.6	-0.3434	100.5456	59	-0.95	2.019	0	102.5645	T Junction
	On	1	1.5	14.3	161.6	0	0.0002	94.1217	170	0.9763	2.1692	0	96.2909	T Junction
	On	1	1.5	14.3	161.6	0	0.0002	96.291	174	0.9745	2.1482	0	98.4393	T Junction
	On	1	-1.5	13.1	161.3	-0.6	-0.3397	96.2737	183	-0.95	2.1478	0	98.4215	T Junction
	On	1	-1.4	13.1	161.3	-0.5	-0.3385	94.1047	187	-0.95	2.1688	0	96.2736	T Junction
	On	1	1.3	14.3	161.6	0	0.0002	89.8457	240	0.9778	2.1256	0	91.9713	T Junction
	On	1	1.4	14.3	161.6	0	0.0002	91.9715	244	0.9771	2.1499	0	94.1214	T Junction
	On	1	-1.4	13.1	161.3	-0.5	-0.3379	91.9554	249	-0.95	2.1495	0	94.1049	T Junction
	On	1	-1.3	13.1	161.3	-0.5	-0.3375	89.83	253	-0.95	2.1253	0	91.9553	T Junction
	On	1	1.2	14.2	161.6	0	0.0002	83.4818	340	0.9842	2.1585	0	85.6402	T Junction
	On	1	1.2	14.2	161.6	0	0.0002	85.6404	344	0.9803	2.1029	0	87.7432	T Junction
	On	1	-1.2	13.1	161.3	-0.4	-0.336	85.6261	353	-0.95	2.1025	0	87.7286	T Junction
	On	1	-1.1	13.1	161.3	-0.4	-0.3339	83.4679	357	-0.95	2.1581	0	85.626	T Junction
	On	1	1.1	14.2	161.6	0	0.0003	79.0212	376	0.9956	2.2874	0	81.3086	T Junction

	On	1	1.1	14.2	161.6	0	0.0003	81.3087	380	0.9872	2.1728	0	83.4815	T Junction
	On	1	-1.1	13.1	161.3	-0.4	-0.3325	81.2957	385	-0.95	2.1724	0	83.4681	T Junction
	On	1	-1	13.1	161.3	-0.4	-0.3291	79.0086	389	-0.95	2.287	0	81.2956	T Junction
	On	1	0.9	14.1	161.6	0	0.0003	72.3869	408	1.0011	2.1882	0	74.5751	T Junction
	On	1	0.9	14.1	161.6	0	0.0003	74.5752	412	0.9991	2.2195	0	76.7947	T Junction
	On	1	-1.2	13.1	161.3	-0.5	-0.2759	74.5637	421	-0.95	2.2191	0	76.7828	T Junction
	On	1	0.8	14.1	161.6	0	0.0004	68.0254	444	1.0114	2.2028	0	70.2283	T Junction
	On	1	0.8	14.1	161.6	0	0.0003	70.2284	448	1.0034	2.1582	0	72.3866	T Junction
	On	1	-0.8	13.1	161.3	-0.3	-0.3263	70.2182	453	-0.95	2.1579	0	72.3761	T Junction
	On	1	-0.8	13.1	161.3	-0.3	-0.3238	68.0156	457	-0.95	2.2025	0	70.2181	T Junction
	On	1	0.7	14	161.6	0	0.0004	63.6413	480	1.0209	2.1745	0	65.8158	T Junction
	On	1	-0.7	13.1	161.2	-0.2	-0.3212	63.6325	489	-0.95	2.1742	0	65.8067	T Junction
	On	1	-0.6	13.1	161.2	-0.2	-0.317	61.3601	493	-0.95	2.2725	0	63.6326	T Junction
	On	1	1.3	14.2	161.6	0	0.0002	87.7435	518	0.9786	2.1019	0	89.8454	T Junction
	On	1	1	14.2	161.6	0	0.0003	76.795	522	0.9958	2.2259	0	79.0209	T Junction
	On	1	0.8	14.1	161.6	0	0.0004	65.8161	527	1.0176	2.2091	0	68.0252	T Junction
	On	1	0.7	14	161.6	0	0.0005	61.3683	529	1.0379	2.2728	0	63.6411	T Junction
	On	1	-0.7	13.1	161.2	-0.3	-0.3221	65.8068	530	-0.95	2.2088	0	68.0155	T Junction
	On	1	-1	13.1	161.3	-0.2	-0.3215	76.7829	535	-0.95	2.2255	0	79.0085	T Junction
	On	1	-1.2	13.1	161.3	-0.5	-0.337	87.7284	540	-0.95	2.1015	0	89.83	T Junction
	On	1	-1.5	13.1	161.3	-0.6	-0.3409	98.4213	544	-0.95	2.1242	0	100.5455	T Junction
	On	1	-0.8	13.1	161.3	-0.3	-0.3271	72.3759	558	-0.95	2.1879	0	74.5638	T Junction
	On	1	-0.6	13.1	161.2	-0.2	-0.3147	59.0721	581	-0.95	2.288	0	61.3601	T Junction
	On	1	0.6	14	161.6	0	0.0005	59.0799	586	1.049	2.2883	0	61.3682	T Junction
Primary (Brine Circulator)	On	0	670.9	12.5	161.1	3.6	0.5473	104.5119	633	101	143.1916	0	247.7036	T Junction
	On	1	0.6	14	161.6	0	0.0006	54.6125	826	1.066	2.2468	0	56.8593	T Junction
	On	1	0.6	14	161.6	0	0.0005	56.8594	829	1.0511	2.2202	0	59.0796	T Junction
	On	1	-0.5	13.1	161.2	-0.2	-0.3142	56.8522	832	-0.95	2.2199	0	59.0722	T Junction
	On	1	-0.5	13.1	161.2	-0.2	-0.3113	54.6058	835	-0.95	2.2465	0	56.8524	T Junction
	On	1	0.5	13.9	161.6	0	0.0007	50.2009	847	1.0838	2.182	0	52.3829	T Junction
	On	1	-0.4	13.2	161.2	-0.1	-0.3082	50.1953	850	-0.95	2.1817	0	52.377	T Junction
	On	1	-0.4	13.2	161.2	-0.1	-0.3041	47.9569	853	-0.95	2.2383	0	50.1952	T Junction
	On	1	0.5	14	161.6	0	0.0006	52.383	858	1.0767	2.2293	0	54.6123	T Junction
	On	1	0.4	13.9	161.6	0	0.0008	47.9622	859	1.1108	2.2386	0	50.2008	T Junction
	On	1	-0.5	13.2	161.2	-0.2	-0.3094	52.3769	860	-0.95	2.229	0	54.6059	T Junction
	On	1	-0.4	13.2	161.2	-0.1	-0.3006	45.6965	867	-0.95	2.2603	0	47.9568	T Junction
	On	1	0.4	13.9	161.6	0	0.0008	45.7014	870	1.1363	2.2606	0	47.962	T Junction
	On	0	164.1	12.4	161.1	0.9	0.1337	104.5113	883	24.7	143.1907	0	247.702	T Junction
	On	1	0.3	13.2	161.2	0.2	0.5917	2.1786	892	1.0185	43.518	0	45.6966	T Junction
	On	1	0.4	13.9	161.6	0.1	0.2461	2.1788	895	1.1441	43.5224	0	45.7011	T Junction
	On	1	0	13.8	161.6	0	0.0037	0	1329	1.748	43.5222	0	43.5222	T Junction
	On	1	0	13.2	161.2	0	-0.2262	0	1332	-0.0361	43.5181	0	43.5181	T Junction
	On	1	-0.3	13.2	161.2	-0.1	-0.2915	39.1279	1335	-0.95	2.2381	0	41.366	T Junction
	On	1	0.3	13.8	161.6	0	0.0011	39.1316	1340	1.2169	2.2383	0	41.3699	T Junction
	On	1	-0.2	13.2	161.2	-0.1	-0.2875	36.8791	1347	-0.95	2.2489	0	39.128	T Junction
	On	1	0.3	13.8	161.6	0	0.0013	36.8823	1350	1.2615	2.2491	0	39.1314	T Junction
	On	1	0.3	13.7	161.6	0	0.0015	32.505	1360	1.348	2.1987	0	34.7038	T Junction
	On	1	0.3	13.8	161.6	0	0.0013	34.7039	1363	1.2837	2.1782	0	36.8822	T Junction
	On	1	-0.2	13.2	161.2	-0.1	-0.2856	34.701	1366	-0.9423	2.178	0	36.879	T Junction
	On	1	-0.1	13.2	161.2	-0.1	-0.2808	32.5024	1369	-0.7181	2.1986	0	34.701	T Junction
	On	1	0.2	13.7	161.6	0	0.0019	28.2004	1381	1.4616	2.1272	0	30.3276	T Junction
	On	1	-0.1	13.1	161.2	0	-0.2739	28.1983	1384	-0.4479	2.127	0	30.3254	T Junction
	On	1	0	13.1	161.2	0	-0.2677	26.02	1387	-0.2409	2.1783	0	28.1984	T Junction
	On	1	0.2	13.7	161.6	0	0.0017	30.3277	1392	1.4068	2.1771	0	32.5048	T Junction
	On	1	0.2	13.6	161.6	0	0.0023	26.0217	1393	1.5965	2.1785	0	28.2002	T Junction
	On	1	-0.1	13.1	161.2	-0.1	-0.277	30.3254	1394	-0.5631	2.1769	0	32.5023	T Junction
	On	1	0	13.2	161.2	0	-0.2623	23.8233	1401	-0.0855	2.1968	0	26.0201	T Junction
	On	1	0.2	13.6	161.6	0	0.0027	23.8248	1404	1.749	2.1969	0	26.0217	T Junction
	On	1	0.1	13.2	161.2	0.1	0.5862	2.1261	1421	0.8999	21.6972	0	23.8233	T Junction
	On	1	0.1	13.6	161.6	0	0.2044	2.1263	1424	1.0977	21.6984	0	23.8247	T Junction
	On	1	0	13.6	161.6	0	0.0037	0	1429	1.748	21.6983	0	21.6983	T Junction
	On	1	0	13.2	161.2	0	-0.2262	0	1432	-0.0361	21.6972	0	21.6972	T Junction

On	1	0	13.2	161.2	0	-0.2522	17.3241	1435	0.2612	2.2277	0	19.5518	T Junction
On	1	0.2	13.6	161.6	0	0.0049	17.325	1440	2.5501	2.2279	0	19.5528	T Junction
On	1	0	13.2	161.2	0	-0.2554	15.0876	1447	0.3489	2.2365	0	17.3241	T Junction
On	1	0.1	13.5	161.6	0	0.0063	15.0882	1450	3.0701	2.2366	0	17.3248	T Junction
On	1	0.1	13.5	161.6	0	0.0109	10.736	1460	3.25	2.1868	0	12.9229	T Junction
On	1	0.1	13.5	161.6	0	0.0078	12.9229	1463	3.25	2.1652	0	15.0882	T Junction
On	1	0	13.2	161.2	0	-0.2643	12.9224	1466	0.4056	2.1651	0	15.0876	T Junction
On	1	0	13.2	161.2	0	-0.2967	10.7357	1469	0.4695	2.1868	0	12.9224	T Junction
On	1	0	13.4	161.6	0	0.0231	0	1481	3.25	8.5681	0	8.5681	T Junction
On	1	0	13.2	161.2	0	-0.5617	0	1484	0.5446	8.5679	0	8.5679	T Junction
On	1	0	13.2	161.2	0	0.5627	2.1645	1487	-0.7081	4.2888	0	6.4533	T Junction
On	1	0	13.4	161.6	0	0.1139	2.1678	1492	0.9822	8.5682	0	10.736	T Junction
On	1	0	13.4	161.6	0	0.0428	4.2889	1493	3.25	2.1646	0	6.4534	T Junction
On	1	0	13.1	161.2	0	0.5758	2.1678	1494	0.3563	8.5679	0.1	10.7356	T Junction
On	1	0	13.2	161.2	0	-1.5	0	1501	0.5733	4.2888	0	4.2888	T Junction
On	1	0	13.3	161.6	0	-0.0087	2.183	1504	0.8755	2.1058	0	4.2888	T Junction

Bend

Unique Name	Status	Elevation (*)	User Number	Flow (m3/h)	Friction Loss (kPa)	Element Type	In Stagnation Pressure (bar a)	Out Stagnation Pressure (bar a)
	On	1	15	1.0623	0	Bend	161.6	161.6
	On	1	17	1.0623	0	Bend	161.6	161.6
	On	1	19	1.0097	0	Bend	161.6	161.6
	On	1	21	1.0097	0	Bend	161.6	161.6
	On	1	23	0.9788	0	Bend	161.5	161.5
	On	1	25	0.9788	0	Bend	161.5	161.5
	On	1	52	0.9788	0	Bend	161.3	161.3
	On	1	54	0.9788	0	Bend	161.3	161.3
	On	1	56	1.0097	0	Bend	161.3	161.3
	On	1	58	1.0097	0	Bend	161.3	161.3
	On	1	60	1.0623	0	Bend	161.3	161.3
	On	1	62	1.0623	0	Bend	161.3	161.3
Primary (Brine Circulator)	On	0	96	104.5117	0.3	Bend	161	161
	On	1	171	1.0846	0	Bend	161.6	161.6
	On	1	173	1.0846	0	Bend	161.6	161.6
	On	1	175	1.0741	0	Bend	161.6	161.6
	On	1	177	1.0741	0	Bend	161.6	161.6
	On	1	180	1.0741	0	Bend	161.3	161.3
	On	1	182	1.0741	0	Bend	161.3	161.3
	On	1	184	1.0846	0	Bend	161.3	161.3
	On	1	186	1.0846	0	Bend	161.3	161.3
	On	1	231	1.075	0	Bend	161.6	161.6
	On	1	235	1.075	0	Bend	161.3	161.3
	On	1	239	1.0509	0	Bend	161.5	161.5
	On	1	241	1.0628	0	Bend	161.6	161.6
	On	1	243	1.0628	0	Bend	161.6	161.6
	On	1	245	1.075	0	Bend	161.6	161.6
	On	1	248	1.075	0	Bend	161.3	161.3
	On	1	250	1.0628	0	Bend	161.3	161.3
	On	1	252	1.0628	0	Bend	161.3	161.3
	On	1	254	1.051	0	Bend	161.3	161.3
	On	1	333	1.0509	0	Bend	161.5	161.5
	On	1	337	1.051	0	Bend	161.3	161.3
	On	1	341	1.0792	0	Bend	161.6	161.6
	On	1	343	1.0792	0	Bend	161.6	161.6
	On	1	345	1.0514	0	Bend	161.5	161.5
	On	1	347	1.0514	0	Bend	161.5	161.5
	On	1	350	1.0514	0	Bend	161.3	161.3
	On	1	352	1.0514	0	Bend	161.3	161.3
	On	1	354	1.0792	0	Bend	161.3	161.3

On	1	356	1.0792	0	Bend	161.3	161.3
On	1	367	1.0864	0	Bend	161.6	161.6
On	1	371	1.0864	0	Bend	161.3	161.3
On	1	375	1.1129	0	Bend	161.6	161.6
On	1	377	1.1437	0	Bend	161.6	161.6
On	1	379	1.1437	0	Bend	161.6	161.6
On	1	381	1.0864	0	Bend	161.6	161.6
On	1	384	1.0864	0	Bend	161.3	161.3
On	1	386	1.1437	0	Bend	161.3	161.3
On	1	388	1.1437	0	Bend	161.3	161.3
On	1	390	1.113	0	Bend	161.3	161.3
On	1	401	1.1129	0	Bend	161.6	161.6
On	1	405	1.113	0	Bend	161.3	161.3
On	1	409	1.0941	0	Bend	161.5	161.5
On	1	411	1.0941	0	Bend	161.5	161.5
On	1	413	1.1097	0	Bend	161.6	161.6
On	1	415	1.1097	0	Bend	161.6	161.6
On	1	418	1.1098	0	Bend	161.3	161.3
On	1	420	1.1098	0	Bend	161.3	161.3
On	1	422	1.0941	0	Bend	161.3	161.3
On	1	424	1.0941	0	Bend	161.3	161.3
On	1	435	1.0791	0	Bend	161.5	161.5
On	1	439	1.0791	0	Bend	161.3	161.3
On	1	443	1.1045	0	Bend	161.5	161.5
On	1	445	1.1014	0	Bend	161.5	161.5
On	1	447	1.1014	0	Bend	161.5	161.5
On	1	449	1.0791	0	Bend	161.5	161.5
On	1	452	1.0791	0	Bend	161.3	161.3
On	1	454	1.1014	0	Bend	161.3	161.3
On	1	456	1.1014	0	Bend	161.3	161.3
On	1	458	1.1045	0	Bend	161.3	161.3
On	1	469	1.1045	0	Bend	161.5	161.5
On	1	473	1.1045	0	Bend	161.3	161.3
On	1	477	1.1364	0	Bend	161.6	161.6
On	1	479	1.1364	0	Bend	161.6	161.6
On	1	481	1.0872	0	Bend	161.5	161.5
On	1	488	1.0873	0	Bend	161.3	161.3
On	1	490	1.1364	0	Bend	161.3	161.3
On	1	492	1.1364	0	Bend	161.3	161.3
On	1	502	104.543	0.5	Bend	161.6	161.6
On	1	507	104.5429	0.5	Bend	161.6	161.6
On	1	548	104.5213	0.5	Bend	161.3	161.3
On	1	549	104.5213	0.3	Bend	161.3	161.3
On	1	553	1.0872	0	Bend	161.5	161.5
On	1	555	1.0873	0	Bend	161.3	161.3
On	1	575	1.1441	0	Bend	161.6	161.6
On	1	577	1.1441	0	Bend	161.6	161.6
On	1	578	1.1442	0	Bend	161.3	161.3
On	1	580	1.1442	0	Bend	161.3	161.3
On	1	823	1.1101	0	Bend	161.5	161.5
On	1	824	1.1101	0	Bend	161.3	161.3
On	1	825	1.1146	0	Bend	161.5	161.5
On	1	827	1.1234	0	Bend	161.5	161.5
On	1	828	1.1234	0	Bend	161.5	161.5
On	1	830	1.1101	0	Bend	161.5	161.5
On	1	831	1.1101	0	Bend	161.3	161.3
On	1	833	1.1234	0	Bend	161.3	161.3
On	1	834	1.1234	0	Bend	161.3	161.3
On	1	836	1.1147	0	Bend	161.3	161.3
On	1	841	1.1146	0	Bend	161.5	161.5
On	1	842	1.1147	0	Bend	161.3	161.3
On	1	845	1.1193	0	Bend	161.5	161.5

On	1	846	1.1193	0	Bend	161.5	161.5
On	1	848	1.091	0	Bend	161.5	161.5
On	1	849	1.091	0	Bend	161.3	161.3
On	1	851	1.1193	0	Bend	161.3	161.3
On	1	852	1.1193	0	Bend	161.3	161.3
On	1	861	1.091	0	Bend	161.5	161.5
On	1	862	1.091	0	Bend	161.3	161.3
On	1	863	1.1303	0	Bend	161.5	161.5
On	1	864	1.1303	0	Bend	161.5	161.5
On	1	865	1.1303	0	Bend	161.3	161.3
On	1	866	1.1303	0	Bend	161.3	161.3
On	1	888	1.0894	0	Bend	161.5	161.5
On	1	889	1.0894	0	Bend	161.5	161.5
On	1	890	1.0894	0	Bend	161.3	161.3
On	1	891	1.0894	0	Bend	161.3	161.3
On	1	1327	1.1191	0	Bend	161.5	161.5
On	1	1328	1.1191	0	Bend	161.5	161.5
On	1	1330	1.0761	0	Bend	161.5	161.5
On	1	1331	1.0761	0	Bend	161.3	161.3
On	1	1333	1.1192	0	Bend	161.3	161.3
On	1	1334	1.1192	0	Bend	161.3	161.3
On	1	1341	1.0761	0	Bend	161.5	161.5
On	1	1342	1.0761	0	Bend	161.3	161.3
On	1	1343	1.1245	0	Bend	161.5	161.5
On	1	1344	1.1245	0	Bend	161.5	161.5
On	1	1345	1.1246	0	Bend	161.3	161.3
On	1	1346	1.1246	0	Bend	161.3	161.3
On	1	1357	1.0891	0	Bend	161.5	161.5
On	1	1358	1.0891	0	Bend	161.3	161.3
On	1	1359	1.0885	0	Bend	161.5	161.5
On	1	1361	1.0994	0	Bend	161.5	161.5
On	1	1362	1.0994	0	Bend	161.5	161.5
On	1	1364	1.0891	0	Bend	161.5	161.5
On	1	1365	1.0891	0	Bend	161.3	161.3
On	1	1367	1.0994	0	Bend	161.3	161.3
On	1	1368	1.0994	0	Bend	161.3	161.3
On	1	1370	1.0886	0	Bend	161.3	161.3
On	1	1375	1.0885	0	Bend	161.5	161.5
On	1	1376	1.0886	0	Bend	161.3	161.3
On	1	1379	1.0892	0	Bend	161.5	161.5
On	1	1380	1.0892	0	Bend	161.5	161.5
On	1	1382	1.0636	0	Bend	161.5	161.5
On	1	1383	1.0636	0	Bend	161.3	161.3
On	1	1385	1.0893	0	Bend	161.3	161.3
On	1	1386	1.0893	0	Bend	161.3	161.3
On	1	1395	1.0636	0	Bend	161.5	161.5
On	1	1396	1.0636	0	Bend	161.3	161.3
On	1	1397	1.0984	0	Bend	161.5	161.5
On	1	1398	1.0984	0	Bend	161.5	161.5
On	1	1399	1.0985	0	Bend	161.3	161.3
On	1	1400	1.0985	0	Bend	161.3	161.3
On	1	1417	1.0631	0	Bend	161.5	161.5
On	1	1418	1.0631	0	Bend	161.5	161.5
On	1	1419	1.0631	0	Bend	161.3	161.3
On	1	1420	1.0631	0	Bend	161.3	161.3
On	1	1427	1.1139	0	Bend	161.5	161.5
On	1	1428	1.1139	0	Bend	161.5	161.5
On	1	1430	1.0727	0	Bend	161.5	161.5
On	1	1431	1.0727	0	Bend	161.3	161.3
On	1	1433	1.1139	0	Bend	161.3	161.3
On	1	1434	1.1139	0	Bend	161.3	161.3
On	1	1441	1.0727	0	Bend	161.5	161.5

	On	1	1442	1.0727	0	Bend	161.3	161.3
	On	1	1443	1.1183	0	Bend	161.5	161.5
	On	1	1444	1.1183	0	Bend	161.5	161.5
	On	1	1445	1.1183	0	Bend	161.3	161.3
	On	1	1446	1.1183	0	Bend	161.3	161.3
	On	1	1457	1.0826	0	Bend	161.5	161.5
	On	1	1458	1.0826	0	Bend	161.3	161.3
	On	1	1459	1.0839	0	Bend	161.5	161.5
	On	1	1461	1.0934	0	Bend	161.5	161.5
	On	1	1462	1.0934	0	Bend	161.5	161.5
	On	1	1464	1.0826	0	Bend	161.5	161.5
	On	1	1465	1.0826	0	Bend	161.3	161.3
	On	1	1467	1.0934	0	Bend	161.3	161.3
	On	1	1468	1.0934	0	Bend	161.3	161.3
	On	1	1470	1.0839	0	Bend	161.3	161.3
	On	1	1475	1.0839	0	Bend	161.5	161.5
	On	1	1476	1.0839	0	Bend	161.3	161.3
	On	1	1479	1.0823	0	Bend	161.5	161.5
	On	1	1480	1.0823	0	Bend	161.5	161.5
	On	1	1482	1.0573	0	Bend	161.5	161.5
	On	1	1483	1.0573	0	Bend	161.3	161.3
	On	1	1485	1.0823	0	Bend	161.3	161.3
	On	1	1486	1.0823	0	Bend	161.3	161.3
	On	1	1495	1.0573	0	Bend	161.5	161.5
	On	1	1496	1.0573	0	Bend	161.3	161.3
	On	1	1497	1.0915	0	Bend	161.5	161.5
	On	1	1498	1.0915	0	Bend	161.5	161.5
	On	1	1499	1.0915	0	Bend	161.3	161.3
	On	1	1500	1.0915	0	Bend	161.3	161.3
	On	1	1517	1.0529	0	Bend	161.5	161.5
	On	1	1518	1.0529	0	Bend	161.5	161.5
	On	1	1519	1.0529	0	Bend	161.3	161.3
	On	1	1520	1.0529	0	Bend	161.3	161.3
	On	1	1521	2.1058	0	Bend	161.2	161.2
	On	1	1524	2.1058	0	Bend	161.6	161.6

Ball Valve

Unique Name	Status	Elevation (*)	User Number	Flow (m3/h)	Friction Loss (kPa)	Element Type	In Stagnation Pressure (bar a)	Out Stagnation Pressure (bar a)
	On	1	68	1.9577	0	Ball Valve	161.6	161.6
	On	1	70	2.0193	0	Ball Valve	161.6	161.6
	On	1	72	2.1246	0	Ball Valve	161.6	161.6
	On	1	189	2.1482	0	Ball Valve	161.6	161.6
	On	1	191	2.1692	0	Ball Valve	161.6	161.6
	On	1	256	2.1499	0	Ball Valve	161.6	161.6
	On	1	258	2.1256	0	Ball Valve	161.6	161.6
	On	1	338	2.1019	0	Ball Valve	161.6	161.6
	On	1	359	2.1029	0	Ball Valve	161.6	161.6
	On	1	361	2.1585	0	Ball Valve	161.6	161.6
	On	1	392	2.1728	0	Ball Valve	161.6	161.6
	On	1	394	2.2874	0	Ball Valve	161.6	161.6
	On	1	406	2.2259	0	Ball Valve	161.6	161.6
	On	1	427	2.2195	0	Ball Valve	161.6	161.6
	On	1	429	2.1882	0	Ball Valve	161.6	161.6
	On	1	460	2.1582	0	Ball Valve	161.6	161.6
	On	1	462	2.2028	0	Ball Valve	161.6	161.6
	On	1	474	2.2091	0	Ball Valve	161.6	161.6
	On	1	495	2.1745	0	Ball Valve	161.6	161.6
	On	1	497	2.2728	0	Ball Valve	161.6	161.6
	On	1	583	2.2883	0	Ball Valve	161.6	161.6

	On	1	837	2.2202	0	Ball Valve	161.6	161.6
	On	1	838	2.2468	0	Ball Valve	161.6	161.6
	On	1	843	2.2293	0	Ball Valve	161.6	161.6
	On	1	854	2.182	0	Ball Valve	161.6	161.6
	On	1	855	2.2386	0	Ball Valve	161.6	161.6
	On	1	868	2.2606	0	Ball Valve	161.6	161.6
	On	1	893	2.1788	0	Ball Valve	161.6	161.6
	On	1	1336	2.1522	0	Ball Valve	161.6	161.6
	On	1	1337	2.2383	0	Ball Valve	161.6	161.6
	On	1	1348	2.2491	0	Ball Valve	161.6	161.6
	On	1	1371	2.1782	0	Ball Valve	161.6	161.6
	On	1	1372	2.1987	0	Ball Valve	161.6	161.6
	On	1	1377	2.1771	0	Ball Valve	161.6	161.6
	On	1	1388	2.1272	0	Ball Valve	161.6	161.6
	On	1	1389	2.1785	0	Ball Valve	161.6	161.6
	On	1	1402	2.1969	0	Ball Valve	161.6	161.6
	On	1	1422	2.1263	0	Ball Valve	161.6	161.6
	On	1	1436	2.1455	0	Ball Valve	161.6	161.6
	On	1	1437	2.2279	0	Ball Valve	161.6	161.6
	On	1	1448	2.2366	0	Ball Valve	161.6	161.6
	On	1	1471	2.1652	0	Ball Valve	161.6	161.6
	On	1	1472	2.1868	0	Ball Valve	161.6	161.6
	On	1	1477	2.1678	0	Ball Valve	161.6	161.6
	On	1	1488	2.1146	0	Ball Valve	161.6	161.6
	On	1	1489	2.1646	0	Ball Valve	161.6	161.6
	On	1	1502	2.183	0	Ball Valve	161.6	161.6
	On	1	1522	2.1058	0	Ball Valve	161.6	161.6

Straight Globe Valve

Unique Name	Status	Elevation (*)	User Number	Flow (m3/h)	Friction Loss (kPa)	Element Type	In Stagnation Pressure (bar a)	Out Stagnation Pressure (bar a)
	On	1	75	1.9577	0.2	Straight Globe Valve	161.3	161.3
	On	1	77	2.0193	0.2	Straight Globe Valve	161.3	161.3
	On	1	78	2.1246	0.3	Straight Globe Valve	161.3	161.3
	On	1	193	2.1482	0.3	Straight Globe Valve	161.3	161.3
	On	1	195	2.1692	0.3	Straight Globe Valve	161.3	161.3
	On	1	260	2.1499	0.3	Straight Globe Valve	161.3	161.3
	On	1	262	2.1256	0.3	Straight Globe Valve	161.3	161.3
	On	1	339	2.1019	0.3	Straight Globe Valve	161.3	161.3
	On	1	363	2.1029	0.3	Straight Globe Valve	161.3	161.3
	On	1	365	2.1585	0.3	Straight Globe Valve	161.3	161.3
	On	1	396	2.1728	0.3	Straight Globe Valve	161.3	161.3
	On	1	398	2.2874	0.3	Straight Globe Valve	161.3	161.3
	On	1	407	2.2259	0.3	Straight Globe Valve	161.3	161.3
	On	1	431	2.2195	0.3	Straight Globe Valve	161.3	161.2
	On	1	433	2.1882	0.3	Straight Globe Valve	161.3	161.2
	On	1	464	2.1582	0.3	Straight Globe Valve	161.2	161.2
	On	1	466	2.2028	0.3	Straight Globe Valve	161.2	161.2
	On	1	475	2.2091	0.3	Straight Globe Valve	161.2	161.2
	On	1	499	2.1745	0.3	Straight Globe Valve	161.2	161.2
	On	1	501	2.2728	0.3	Straight Globe Valve	161.2	161.2
	On	1	585	2.2883	0.3	Straight Globe Valve	161.2	161.2
	On	1	839	2.2202	0.3	Straight Globe Valve	161.2	161.2
	On	1	840	2.2468	0.3	Straight Globe Valve	161.2	161.2
	On	1	844	2.2293	0.3	Straight Globe Valve	161.2	161.2
	On	1	856	2.182	0.3	Straight Globe Valve	161.2	161.2
	On	1	857	2.2386	0.3	Straight Globe Valve	161.2	161.2
	On	1	869	2.2606	0.3	Straight Globe Valve	161.2	161.2
	On	1	894	2.1788	0.3	Straight Globe Valve	161.2	161.2
	On	1	1338	2.1522	0.3	Straight Globe Valve	161.2	161.2

	On	1	1339	2.2383	0.3	Straight Globe Valve	161.2	161.2
	On	1	1349	2.2491	0.3	Straight Globe Valve	161.2	161.2
	On	1	1373	2.1782	0.3	Straight Globe Valve	161.2	161.2
	On	1	1374	2.1987	0.3	Straight Globe Valve	161.2	161.2
	On	1	1378	2.1771	0.2	Straight Globe Valve	161.2	161.2
	On	1	1390	2.1272	0.3	Straight Globe Valve	161.2	161.2
	On	1	1391	2.1785	0.3	Straight Globe Valve	161.2	161.2
	On	1	1403	2.1969	0.3	Straight Globe Valve	161.2	161.2
	On	1	1423	2.1262	0.3	Straight Globe Valve	161.2	161.2
	On	1	1438	2.1454	0.3	Straight Globe Valve	161.2	161.2
	On	1	1439	2.2278	0.3	Straight Globe Valve	161.2	161.2
	On	1	1449	2.2366	0.3	Straight Globe Valve	161.2	161.2
	On	1	1473	2.1652	0.3	Straight Globe Valve	161.2	161.2
	On	1	1474	2.1868	0.3	Straight Globe Valve	161.2	161.2
	On	1	1478	2.1678	0.2	Straight Globe Valve	161.2	161.2
	On	1	1490	2.1146	0.3	Straight Globe Valve	161.2	161.2
	On	1	1491	2.1646	0.3	Straight Globe Valve	161.2	161.2
	On	1	1503	2.183	0.3	Straight Globe Valve	161.2	161.2
	On	1	1523	2.1058	0.3	Straight Globe Valve	161.2	161.2

Plate Heat Exchanger

Unique Name	Status	Elevation (*)	Pressure Loss Model	User Number	Flow (m3/h)	Friction Loss (kPa)	Element Type	In Stagnation Pressure (bar a)	Out Stagnation Pressure (bar a)
Heat Exchanger	On	0	Fixed Value	134	104.5117	100	Plate Heat Exchanger	161	160

Known Flow Boundary

Unique Name	Status	Elevation (*)	Temperature (*)	Flow Direction	Flow (*)	Fluid	User Number	Element Type	Flow (m3/h)	Solids Delivered (kg/s)	Stagnation Pressure (bar a)	Density (kg/m3)	Viscosity (kgf s/m2)
	On	0	12	Into Network	143	water	572	Known Flow Boundary	143	0	189.1	1008.22	0

Y Junction

Unique Name	Status	Elevation (*)	Branch Loss (kPa)	Temperature (C)	Channel Stagnation Pressure (bar a)	Straight Loss (kPa)	Straight K (based on channel flow)	Straight Flow (m3/h)	User Number	Branch K (based on channel flow)	Branch Flow (m3/h)	Friction Loss (kPa)	Channel Flow (m3/h)	Element Type
	On	1	0	14	161.6	0	0	0	589	0	2.2883	0	2.2883	Y Junction
	On	1	0	14	161.3	0	0	0	591	0	2.2883	0	2.2883	Y Junction
	On	1	0	14	161.6	0	0	0	592	0	2.2728	0	2.2728	Y Junction
	On	1	0	14	161.3	0	0	0	593	0	2.2728	0	2.2728	Y Junction
	On	1	0	14	161.5	0	0	0	594	0	2.1745	0	2.1745	Y Junction
	On	1	0	14	161.3	0	0	0	595	0	2.1745	0	2.1745	Y Junction
	On	1	0	14	161.5	0	0	0	596	0	2.2091	0	2.2091	Y Junction
	On	1	0	14	161.3	0	0	0	597	0	2.2091	0	2.2091	Y Junction
	On	1	0	14.1	161.5	0	0	0	598	0	2.2028	0	2.2028	Y Junction
	On	1	0	14.1	161.3	0	0	0	599	0	2.2028	0	2.2028	Y Junction
	On	1	0	14.1	161.5	0	0	0	600	0	2.1582	0	2.1582	Y Junction
	On	1	0	14.1	161.3	0	0	0	601	0	2.1582	0	2.1582	Y Junction
	On	1	0	14.1	161.5	0	0	0	602	0	2.1882	0	2.1882	Y Junction
	On	1	0	14.1	161.3	0	0	0	603	0	2.1883	0	2.1883	Y Junction
	On	1	0	14.1	161.3	0	0	0	604	0	2.2195	0	2.2195	Y Junction
	On	1	0	14.1	161.6	0	0	0	605	0	2.2195	0	2.2195	Y Junction
	On	1	0	14.1	161.6	0	0	0	606	0	2.2259	0	2.2259	Y Junction
	On	1	0	14.1	161.3	0	0	0	607	0	2.2259	0	2.2259	Y Junction
	On	1	0	14.1	161.6	0	0	0	608	0	2.2874	0	2.2874	Y Junction
	On	1	0	14.1	161.3	0	0	0	609	0	2.2874	0	2.2874	Y Junction
	On	1	0	14.2	161.6	0	0	0	610	0	2.1727	0	2.1727	Y Junction
	On	1	0	14.2	161.3	0	0	0	611	0	2.1728	0	2.1728	Y Junction
	On	1	0	14.2	161.6	0	0	0	612	0	2.1585	0	2.1585	Y Junction
	On	1	0	14.2	161.3	0	0	0	613	0	2.1585	0	2.1585	Y Junction

On	1	0	14.2	161.5	0	0	0	614	0	2.1029	0	2.1029	Y Junction
On	1	0	14.2	161.3	0	0	0	615	0	2.1029	0	2.1029	Y Junction
On	1	0	14.2	161.5	0	0	0	616	0	2.1019	0	2.1019	Y Junction
On	1	0	14.2	161.3	0	0	0	617	0	2.1019	0	2.1019	Y Junction
On	1	0	14.2	161.6	0	0	0	618	0	2.1256	0	2.1256	Y Junction
On	1	0	14.2	161.3	0	0	0	619	0	2.1256	0	2.1256	Y Junction
On	1	0	14.2	161.6	0	0	0	620	0	2.1499	0	2.1499	Y Junction
On	1	0	14.2	161.3	0	0	0	621	0	2.1499	0	2.1499	Y Junction
On	1	0	14.3	161.3	0	0	0	622	0	2.1693	0	2.1693	Y Junction
On	1	0	14.3	161.6	0	0	0	623	0	2.1692	0	2.1692	Y Junction
On	1	0	14.3	161.6	0	0	0	624	0	2.1482	0	2.1482	Y Junction
On	1	0	14.3	161.3	0	0	0	625	0	2.1482	0	2.1482	Y Junction
On	1	0	14.3	161.6	0	0	0	626	0	2.1245	0	2.1245	Y Junction
On	1	0	14.3	161.3	0	0	0	627	0	2.1246	0	2.1246	Y Junction
On	1	0	14.3	161.6	0	0	0	628	0	2.0193	0	2.0193	Y Junction
On	1	0	14.3	161.3	0	0	0	629	0	2.0193	0	2.0193	Y Junction
On	1	0	14.3	161.5	0	0	0	630	0	1.9577	0	1.9577	Y Junction
On	1	0	14.3	161.3	0	0	0	631	0	1.9577	0	1.9577	Y Junction
On	1	0	13.9	161.5	0	0	0	871	0	2.2606	0	2.2606	Y Junction
On	1	0	13.9	161.3	0	0	0	872	0	2.2606	0	2.2606	Y Junction
On	1	0	13.9	161.5	0	0	0	873	0	2.2386	0	2.2386	Y Junction
On	0	0	13.9	161.4	0	0	0	874	0	2.2386	0	2.2386	Y Junction
On	1	0	13.9	161.5	0	0	0	875	0	2.182	0	2.182	Y Junction
On	1	0	13.9	161.3	0	0	0	876	0	2.182	0	2.182	Y Junction
On	1	0	13.9	161.5	0	0	0	877	0	2.2293	0	2.2293	Y Junction
On	1	0	13.9	161.3	0	0	0	878	0	2.2293	0	2.2293	Y Junction
On	1	0	13.9	161.5	0	0	0	879	0	2.2468	0	2.2468	Y Junction
On	1	0	13.9	161.3	0	0	0	880	0	2.2468	0	2.2468	Y Junction
On	1	0	13.9	161.5	0	0	0	881	0	2.2202	0	2.2202	Y Junction
On	1	0	13.9	161.3	0	0	0	882	0	2.2202	0	2.2202	Y Junction
On	1	0	13.8	161.5	0	0	0	896	0	2.1788	0	2.1788	Y Junction
On	1	0	13.8	161.3	0	0	0	897	0	2.1788	0	2.1788	Y Junction
On	1	0	13.7	161.5	0	0	0	1351	0	2.2491	0	2.2491	Y Junction
On	1	0	13.7	161.3	0	0	0	1352	0	2.2491	0	2.2491	Y Junction
On	1	0	13.8	161.5	0	0	0	1353	0	2.2383	0	2.2383	Y Junction
On	1	0	13.8	161.3	0	0	0	1354	0	2.2383	0	2.2383	Y Junction
On	1	0	13.8	161.5	0	0	0	1355	0	2.1522	0	2.1522	Y Junction
On	1	0	13.8	161.3	0	0	0	1356	0	2.1522	0	2.1522	Y Junction
On	1	0	13.6	161.5	0	0	0	1405	0	2.1969	0	2.1969	Y Junction
On	1	0	13.6	161.3	0	0	0	1406	0	2.1969	0	2.1969	Y Junction
On	1	0	13.6	161.5	0	0	0	1407	0	2.1785	0	2.1785	Y Junction
On	0	0	13.6	161.4	0	0	0	1408	0	2.1785	0	2.1785	Y Junction
On	1	0	13.6	161.5	0	0	0	1409	0	2.1272	0	2.1272	Y Junction
On	1	0	13.6	161.3	0	0	0	1410	0	2.1272	0	2.1272	Y Junction
On	1	0	13.7	161.5	0	0	0	1411	0	2.1771	0	2.1771	Y Junction
On	1	0	13.7	161.3	0	0	0	1412	0	2.1771	0	2.1771	Y Junction
On	1	0	13.7	161.5	0	0	0	1413	0	2.1987	0	2.1987	Y Junction
On	1	0	13.7	161.3	0	0	0	1414	0	2.1988	0	2.1988	Y Junction
On	1	0	13.7	161.5	0	0	0	1415	0	2.1782	0	2.1782	Y Junction
On	1	0	13.7	161.3	0	0	0	1416	0	2.1782	0	2.1782	Y Junction
On	1	0	13.6	161.5	0	0	0	1425	0	2.1262	0	2.1262	Y Junction
On	1	0	13.6	161.3	0	0	0	1426	0	2.1263	0	2.1263	Y Junction
On	1	0	13.5	161.5	0	0	0	1451	0	2.2366	0	2.2366	Y Junction
On	1	0	13.5	161.3	0	0	0	1452	0	2.2366	0	2.2366	Y Junction
On	1	0	13.5	161.5	0	0	0	1453	0	2.2278	0	2.2278	Y Junction
On	1	0	13.5	161.3	0	0	0	1454	0	2.2279	0	2.2279	Y Junction
On	1	0	13.5	161.5	0	0	0	1455	0	2.1454	0	2.1454	Y Junction
On	1	0	13.5	161.3	0	0	0	1456	0	2.1455	0	2.1455	Y Junction
On	1	0	13.3	161.5	0	0	0	1505	0	2.183	0	2.183	Y Junction
On	1	0	13.3	161.3	0	0	0	1506	0	2.183	0	2.183	Y Junction
On	1	0	13.3	161.5	0	0	0	1507	0	2.1646	0	2.1646	Y Junction
On	0	0	13.3	161.4	0	0	0	1508	0	2.1646	0	2.1646	Y Junction

	On	1	0	13.3	161.5	0	0	0	1509	0	2.1146	0	2.1146	Y Junction
	On	1	0	13.3	161.3	0	0	0	1510	0	2.1147	0	2.1147	Y Junction
	On	1	0	13.4	161.5	0	0	0	1511	0	2.1678	0	2.1678	Y Junction
	On	1	0	13.4	161.3	0	0	0	1512	0	2.1678	0	2.1678	Y Junction
	On	1	0	13.4	161.5	0	0	0	1513	0	2.1868	0	2.1868	Y Junction
	On	1	0	13.4	161.3	0	0	0	1514	0	2.1868	0	2.1868	Y Junction
	On	1	0	13.4	161.5	0	0	0	1515	0	2.1652	0	2.1652	Y Junction
	On	1	0	13.4	161.3	0	0	0	1516	0	2.1652	0	2.1652	Y Junction
	On	1	0	13.3	161.5	0	0	0	1525	0	2.1058	0	2.1058	Y Junction
	On	1	0	13.3	161.3	0	0	0	1526	0	2.1058	0	2.1058	Y Junction

Accumulator

Unique Name	Status	Elevation to Vessel Base (*)	Temperature (*)	Surface Pressure (*)	Liquid Level above Base (*)	Fluid	User Number	Element Type	Net Flow (m3/h)	Solids Delivered (kg/s)	Density (kg/m3)	Viscosity (kgf s/m2)
Primary Side Expansion Vessel	On	0	12	3	1	Glycol 30%	639	Accumulator	144.241	0	999.55	0

Butterfly Valve

Unique Name	Status	Elevation (*)	User Number	Flow (m3/h)	Friction Loss (kPa)	Element Type	In Stagnation Pressure (bar a)	Out Stagnation Pressure (bar a)
	On	0	899	104.5413	0.8	Butterfly Valve	162	162
	On	0	901	104.5117	0.2	Butterfly Valve	161	161

Tilting Disk Check Valve

Unique Name	Status	Elevation (*)	User Number	Flow (m3/h)	Friction Loss (kPa)	Element Type	In Stagnation Pressure (bar a)	Out Stagnation Pressure (bar a)
	On	0	905	104.5412	0.7	Tilting Disk Check Valve	162	162

Inline Filter

Unique Name	Status	Elevation (*)	Filter Name	User Number	Flow (m3/h)	Friction Loss (kPa)	Element Type	In Stagnation Pressure (bar a)	Out Stagnation Pressure (bar a)
Strainer Valve	On	0	Round Wire Screen	906	104.5113	7.1	Inline Filter	161.1	161

Centrifugal Pump

Unique Name	Status	Elevation (*)	User Number	Duty Flow (m3/h)	Duty Pressure Rise (kPa)	Duty NPSH Available (m Fluid)	Duty Efficiency (%)	Duty Power (Watt)	Duty NPSH Required (m Fluid)	Element Type	In Stagnation Pressure (bar a)	Out Stagnation Pressure (bar a)
Primary Side Pump	On	0	910	104.5507	203.6	1620.6	66.78	8855.2	1.9	Centrifugal Pump	160	162