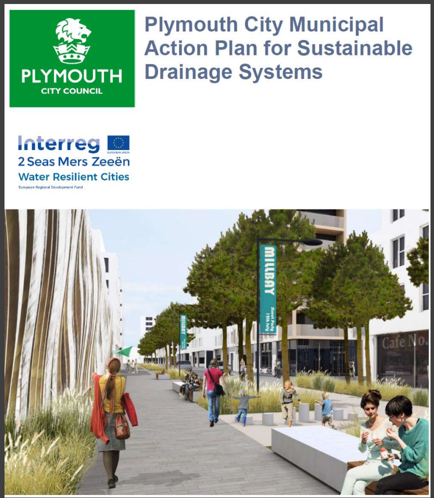
Installing Sustainable Drainage and Heat Networks in the Urban Environment

John Green MEng PhD CEng MIET

Plymouth City Council

12th February 2020

Water Resilient Cities

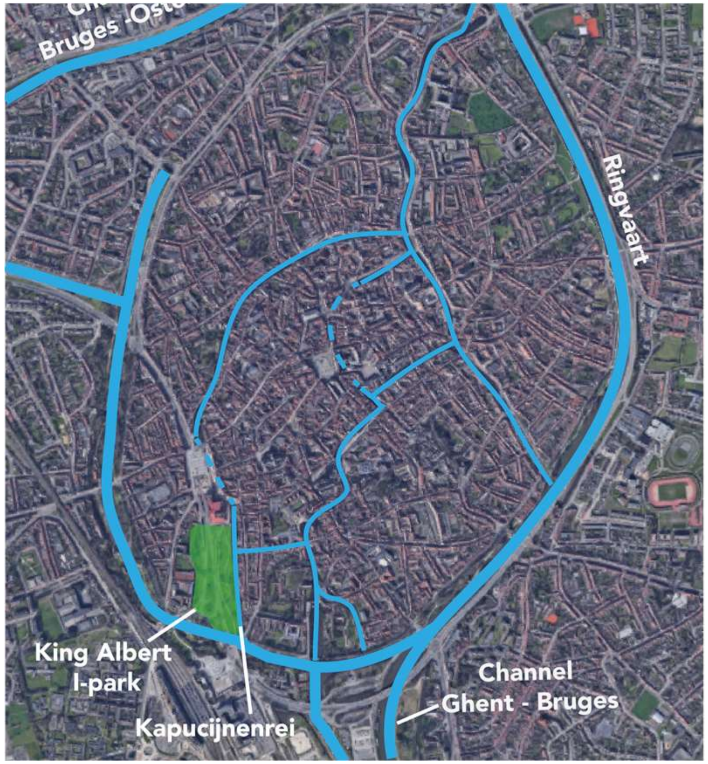


Municipal Action Plan for SuDS

Guide to retrofitting sustainable drainage systems into urban areas

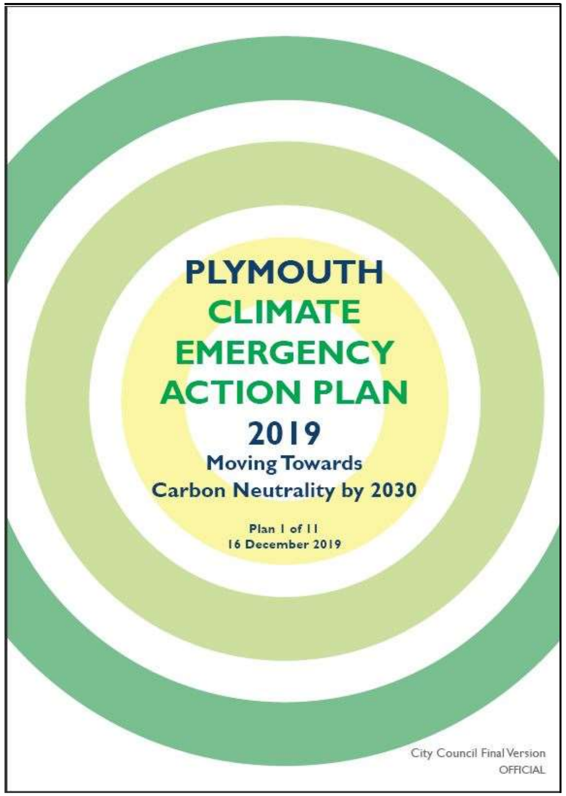
waterresilientcities.eu

Interreg
2 Seas Mers Zeeën
Water Resilient Cities
European Regional Development Fund



Sustainable Drainage Systems

Action to tackle climate change



Pledge to make Plymouth carbon neutral by 2030

Climate Emergency Action Plan

Plymouth City Council's Corporate Carbon Reduction Plan

14:10 **Plymouth's Local Flood Risk Management Strategy**
Andy Cottam, Plymouth City Council
Anthony Raine, South West Water
John Yianni, Pell Frischmann

14:30 **The challenges of delivering public realm improvements**
Richard Bara, Plymouth City Council

14:45 **Delivery of in ground infrastructure, including sustainable drainage, into Millbay Boulevard**
Chris Yalden & Annabel Harris, AWP

15:00 **Ground source district heating systems and wells in Millbay Boulevard and the Civic Square**
Jon Selman, Plymouth City Council

15:15 **Site visit practicalities**

15:20 **Site visit to the Millbay Boulevard development, via the wells in the Civic Square**

16:00 **Close**

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Plymouth Local Flood Risk Management Strategy (LFRMS)

LFRMS Part 1
Non-Technical


Document Title: Local Flood Risk Management Strategy

Local Flood Risk Management Strategy Part 1

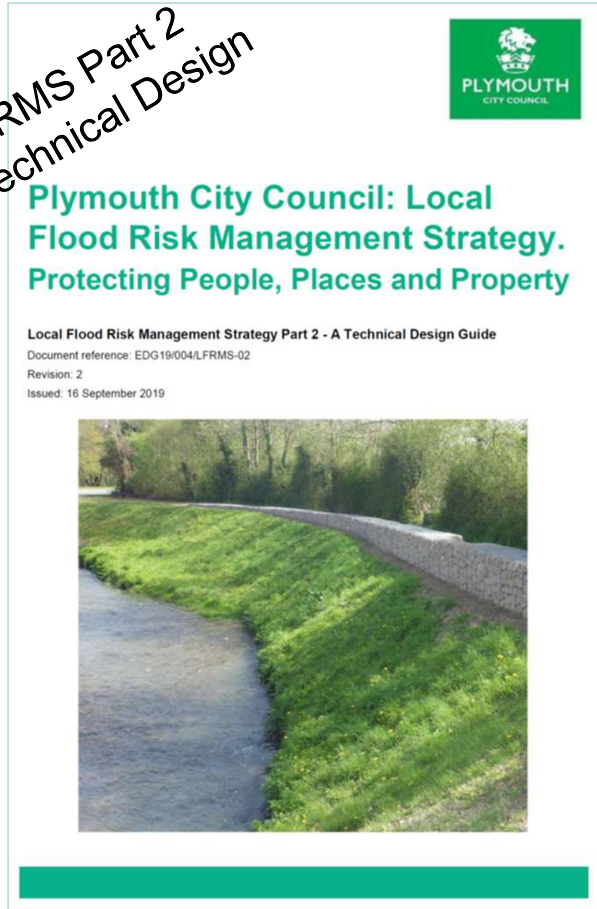
Non-Technical Strategic Summary

Doc ref: EDG19/004/FRMS-01
Issued: 4 September 2019

- 1 -

Non-Technical Summary

LFRMS Part 2
Technical Design


Plymouth City Council: Local Flood Risk Management Strategy.
Protecting People, Places and Property

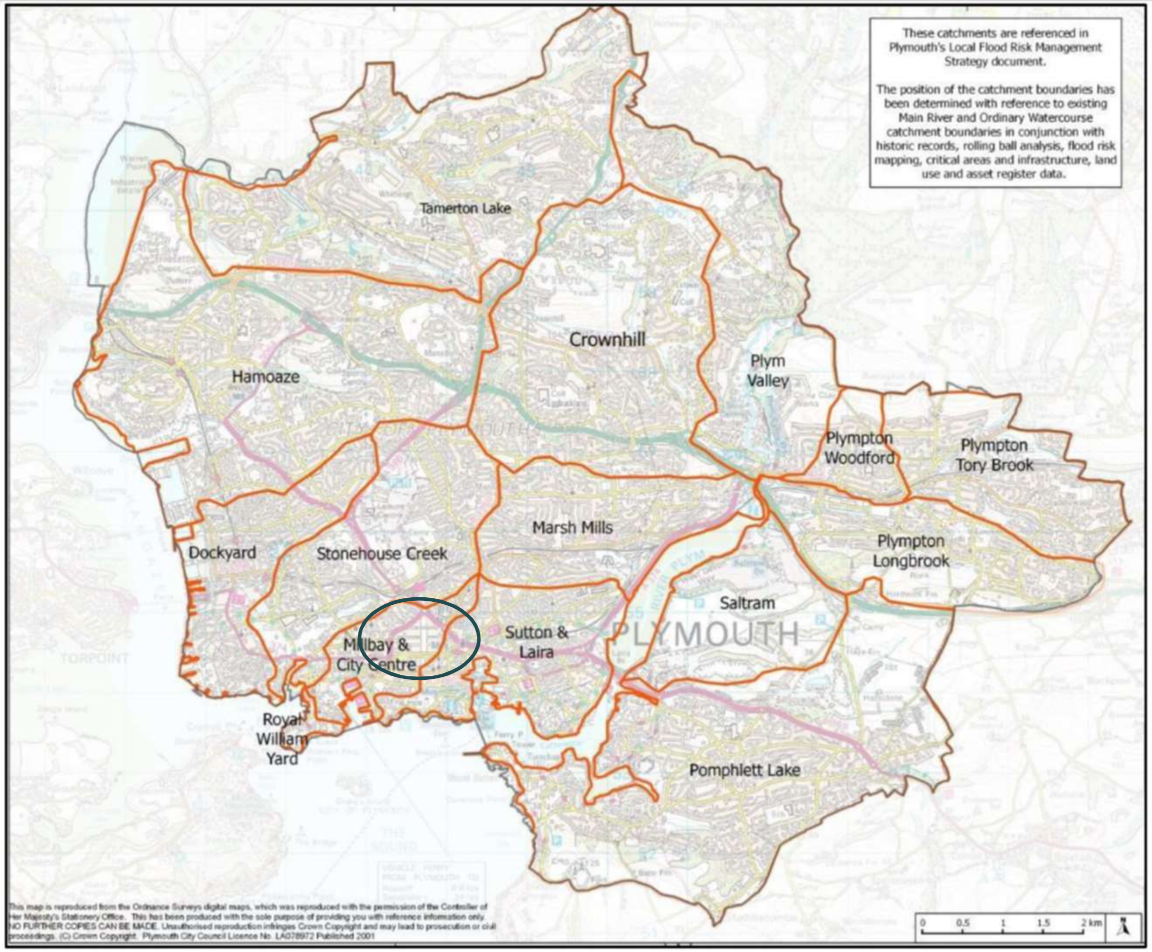
Local Flood Risk Management Strategy Part 2 - A Technical Design Guide

Document reference: EDG19/004/LFRMS-02

Revision: 2

Issued: 16 September 2019

Plymouth City Centre



LFRMS Outline

Plymouth divided into 16 hydrological catchments

Each catchment has Objectives and Strategy to address specific issues and flood risks in each catchment

The City Centre covers two catchments:
- Millbay & City Centre
- Sutton & Laira

Millbay & City Centre drains to the west
Sutton & Laira drains to the east

LFRMS Catchment Summaries

Millbay and City catchment

Millbay is a tidal inlet much of which has been reclaimed and now comprises the eastern end of Union Street and the Octagon area. It is very low-lying and sewers can become tide-locked preventing surface water from draining away during high tides.

There are areas of tidal flood risk in the immediate vicinity of the docks, the extent of which and the depth to which they flood will increase over time with sea level rise. The Plymouth Coastal Modelling Study indicates that any wave overtopping is likely to drain back to the sea without penetrating inland. Future sea level rise presents a risk of overtopping of sea defences leading to flooding in Bath Street, Martin Street, and Union Street/Octagon. This risk of tidal flooding has been mitigated with defences comprised of raised ground levels in connection with new developments in Millbay.

Sewerage capacity has been improved with improvement works on Millbay tanks, which increases the capacity to store surface water which cannot be discharged to the sea. Improved surface water sewer infrastructure is planned to improve the capacity of the sewers and to separate surface water from foul and combined sewers.

LFRMS Strategies

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Millbay and City	
Key Issues	Surface water flood risk around Union St and the Octagon, very low ground levels ~ 2m AOD. Some tidal flood risk around Millbay development areas. Possibilities to raise ground levels. Future tidal flood risk is an issue. Reduced capacity within surface water and combined sewerage systems.
Objectives	Reduce extent and frequency of surface water flooding. Increase sewerage capacity. Development opportunities for using storage and SuDS. Identify key developments to address flood risk holistically
Strategy	**Improve capacity within combined sewerage and highway drainage systems. Manage interactions between sewerage and surface water systems and tidal influences. Minimise risk from future predicted tidal flooding.**
Delivery	Western Approach and King Street IUDM Strategic Surface Water Drainage Corridors designated for City Centre. Regulation of surface water drainage for future developments through planning consultation with LLFA. Teats Hill slipway refurbishment

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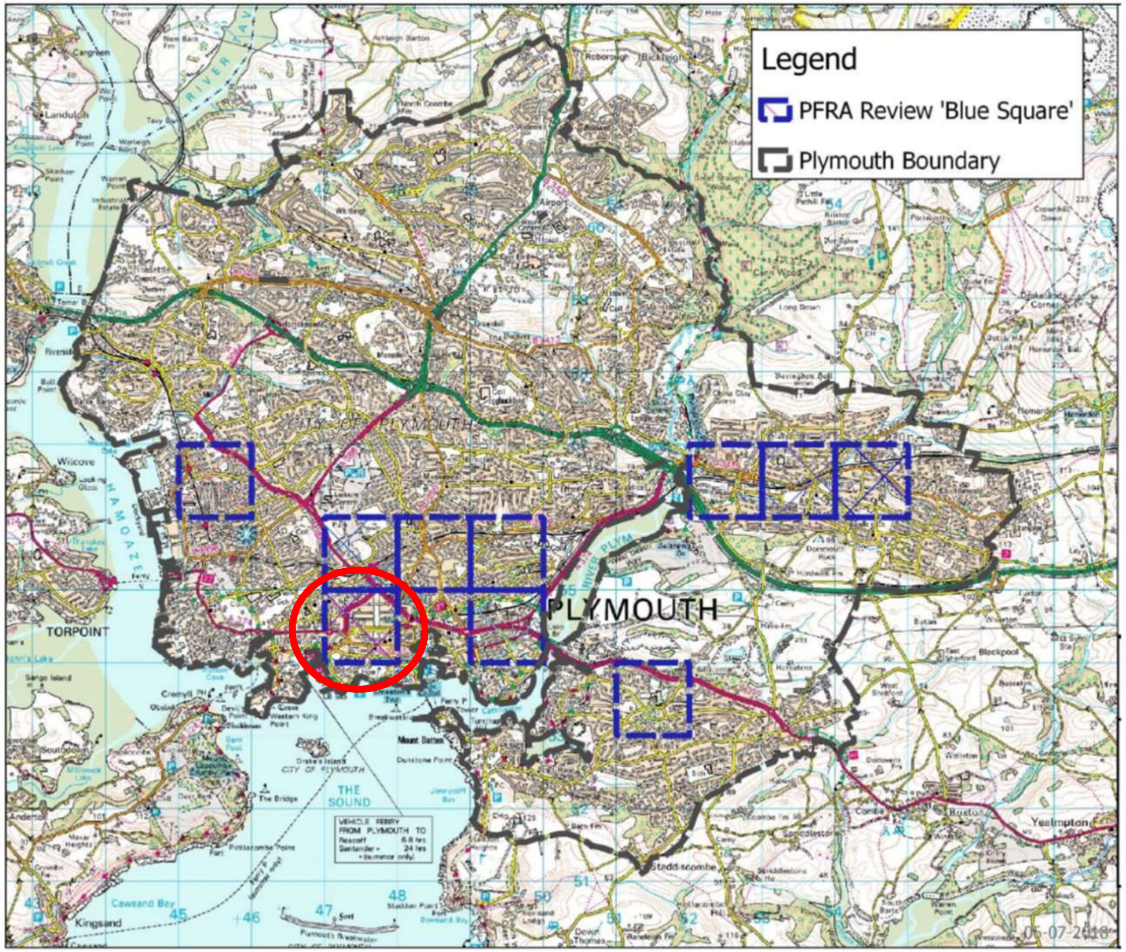
Preliminary Flood Risk Assessment (PFRA) Review

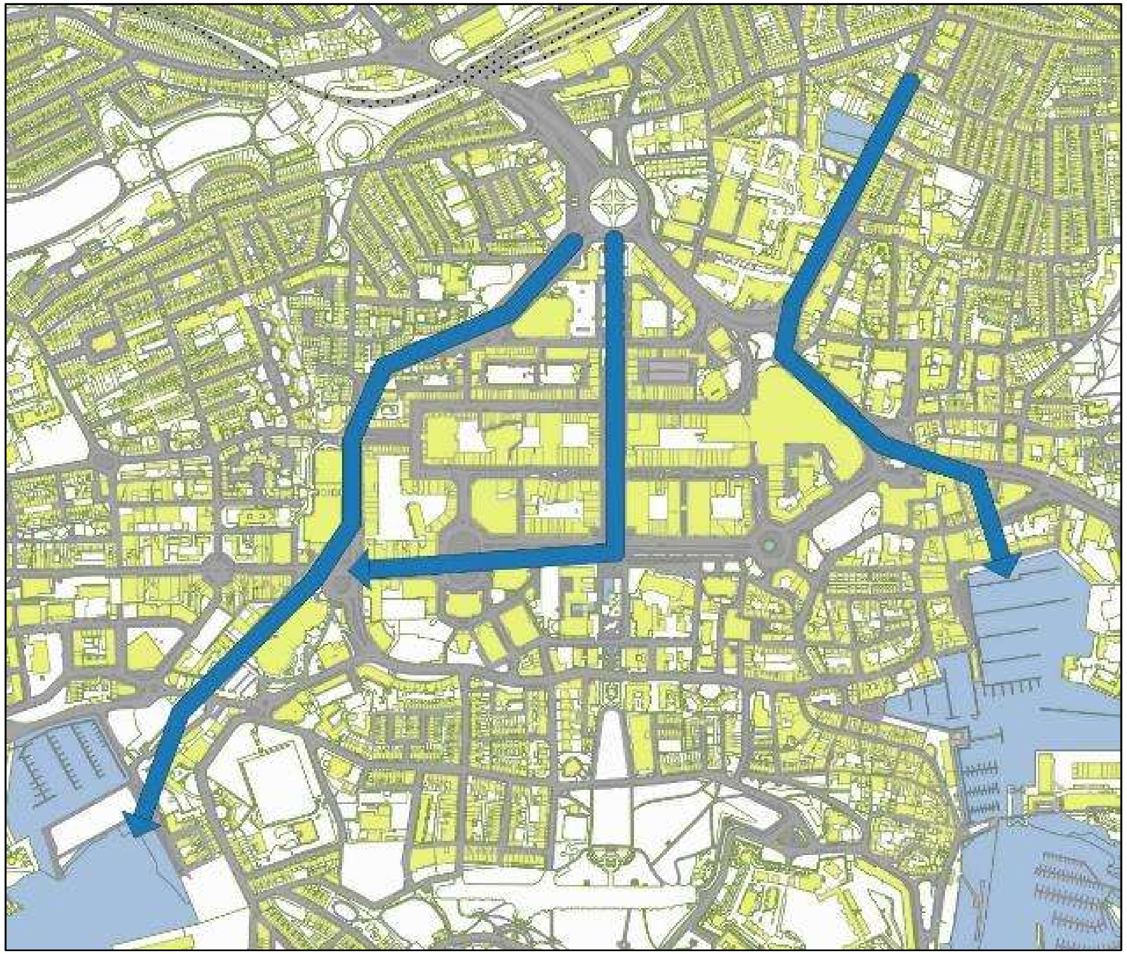


The PFRA Review identified areas at increased risk of flooding to properties and or local infrastructure.

These are within ‘Blue Squares’.

The city centre is located within a Blue Square, reflecting the increased risk of surface water flooding.

Strategic Surface Water Drainage Corridors



The Strategic Surface Water Drainage Corridors identify a surface water flow route through the city.

These will be implemented through raising awareness of drainage issues and the management of future development to facilitate improvements for the wider area

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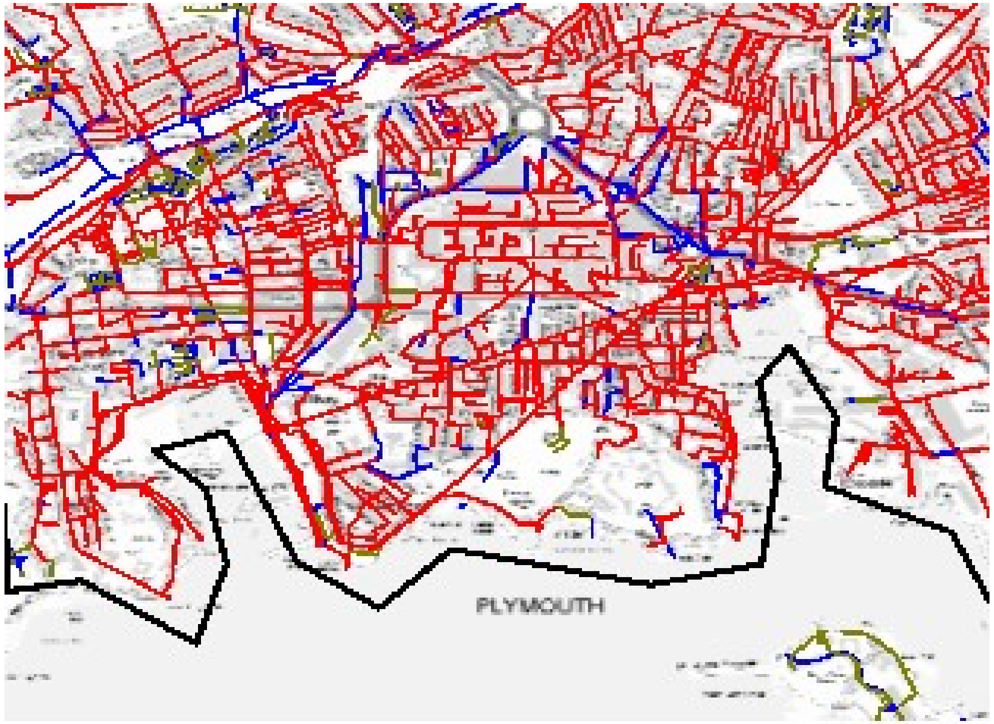
Surface Water Separation



A key strategy identified in the FRMS to reduce the risk of flooding is **surface water separation.**

The city centre drainage is dominated by combined sewers that carry surface water and foul water in the same pipe, which has a limited capacity.

By removing the surface water from these combined sewers, the capacity of the sewer is increased.

Surface water is then discharged to the sea, and foul water is treated accordingly

Surface water separation increases the capacity of the combined sewers reducing the risk of flooding due to surcharging during heavy rainfall.

Flood Risk Management in Plymouth

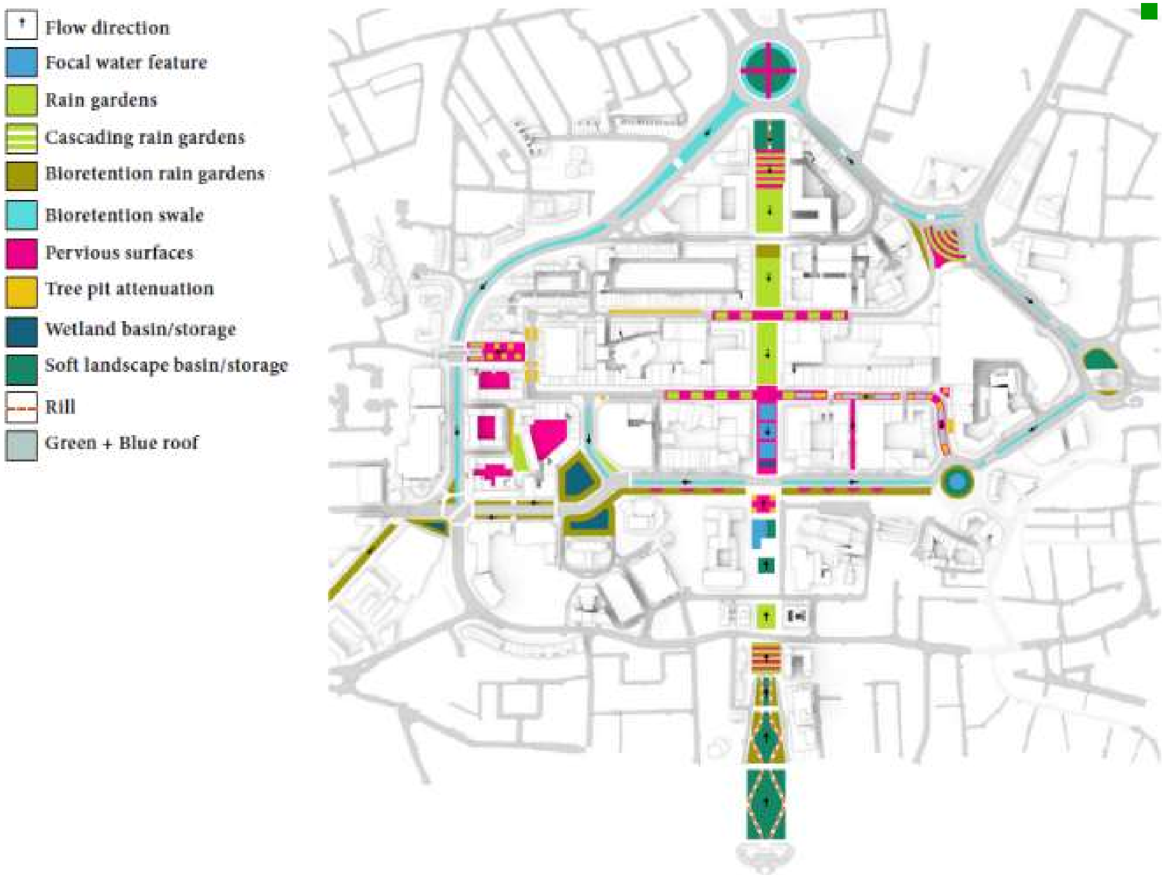
Co-ordinated Working

Flood risk management in Plymouth is managed by three Risk Management Authorities:

- LLFA (PCC)
- Environment Agency
- South West Water

The three organisations now work together to reduce and management flood risk from all sources, including drainage.

City Centre Strategic Drainage Corridors



- Better Places Programme

Area and Options: Western Approach

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Proposal:

- Complete Surface Water Separation in the City Centre
- Rehabilitation of existing surface water sewers at Millbay
- New surface water pumping station at Millbay
- New surface water drainage network throughout City Centre
  - Including retrofitted SuDS and attenuation
  - Integration with Plymouth Better Places and Water Resilient Cities Interreg projects
- Reduce risk of flooding to 52 properties

Area and Options: Western Approach

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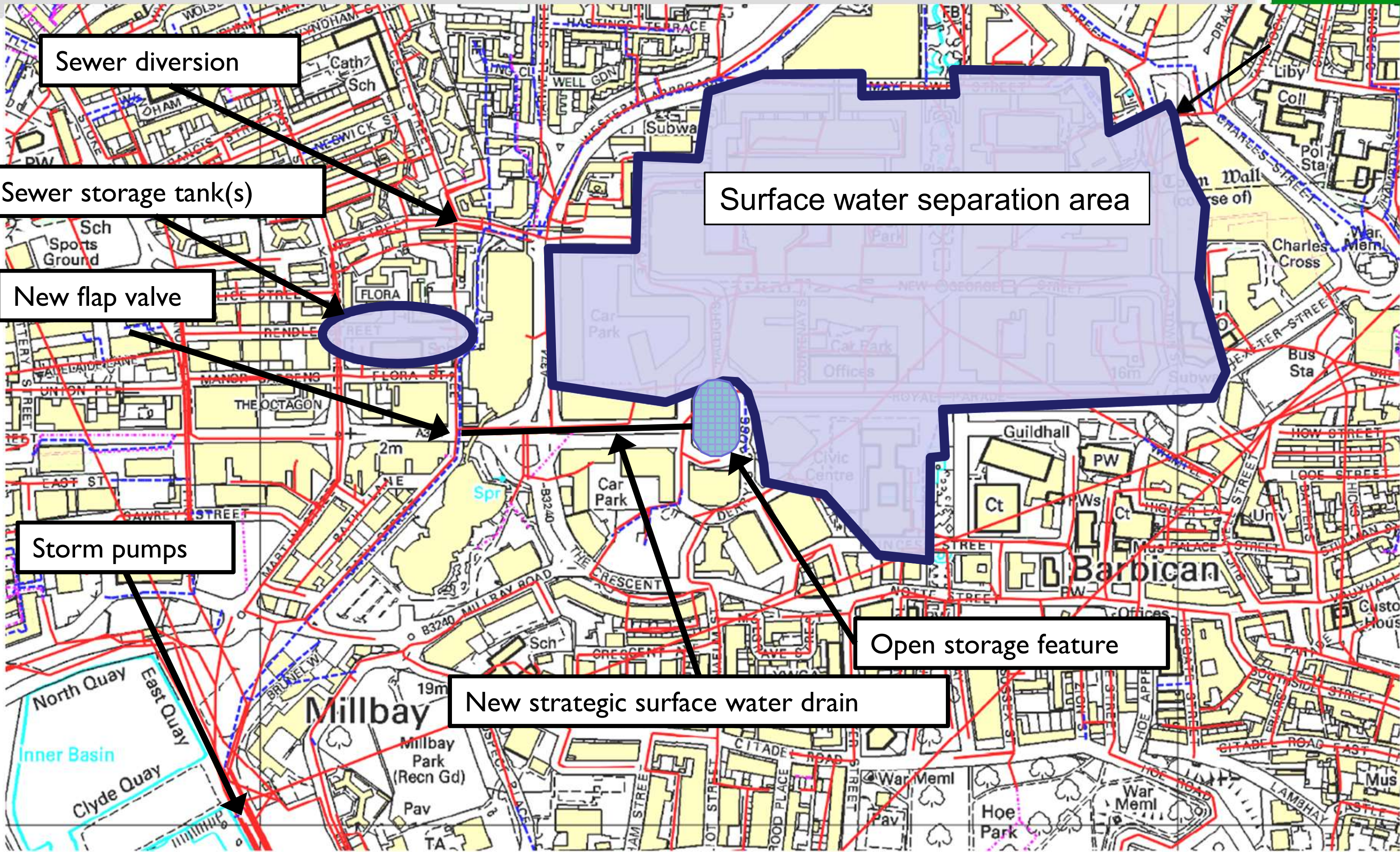

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South West Water Partnership

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South West Water

Pell Frischmann

Benefits to Collaboration

- Cost effectiveness
- Support OFWAT's efficiency challenge
- Access to grant funding
- Development of one integrated Model
- Reduction of Urban Flood Risk
- Knowledge sharing
- Reduction in Combined Sewer Overflow spills and improved water quality

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Plymouth Bathing Waters – Background (Central catchment)

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- Early 1990s all discharges were crude into various outfalls in Plymouth Sound – ebb tide release.
- 1995-2000 scheme introduced tunnel system, collection the crude outfalls to new STW at Central
- 2000-2005 included construction of 8,000m^3 additional storm storage at Central STW and some CSOs had screening (Stonehouse)
- 2015-2020 NEP scheme to address CSOs across catchment. Subject to challenge using hydrodynamic modelling which resulted in Stormwater UV at Central STW CSO and 'enhanced' performance at fewer high-priority CSOs.
- Justification for stormwater UV required Defra approval and was contingent on a longer term strategy to reduce Central STW CSO spills towards 3 per BS. Agreed to target this over 3 AMPs. Notional storage 60,000m^3 required.
- 2020-2025 includes Ph1 of the long term strategy to provide equivalent benefit that 20,000m^3 would provide.

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Tunnel System Location

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Tunnel System Schematic

South West Water

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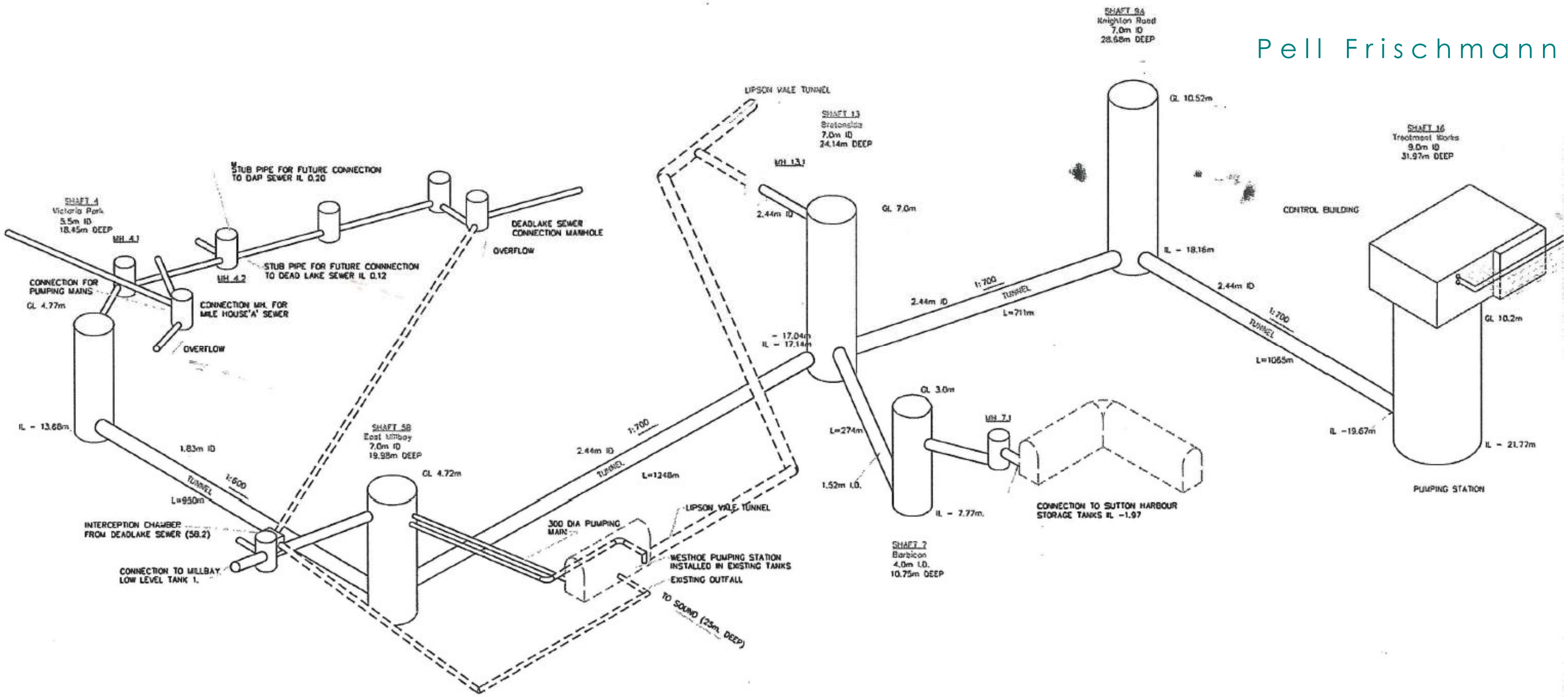

Western Approach Model Output

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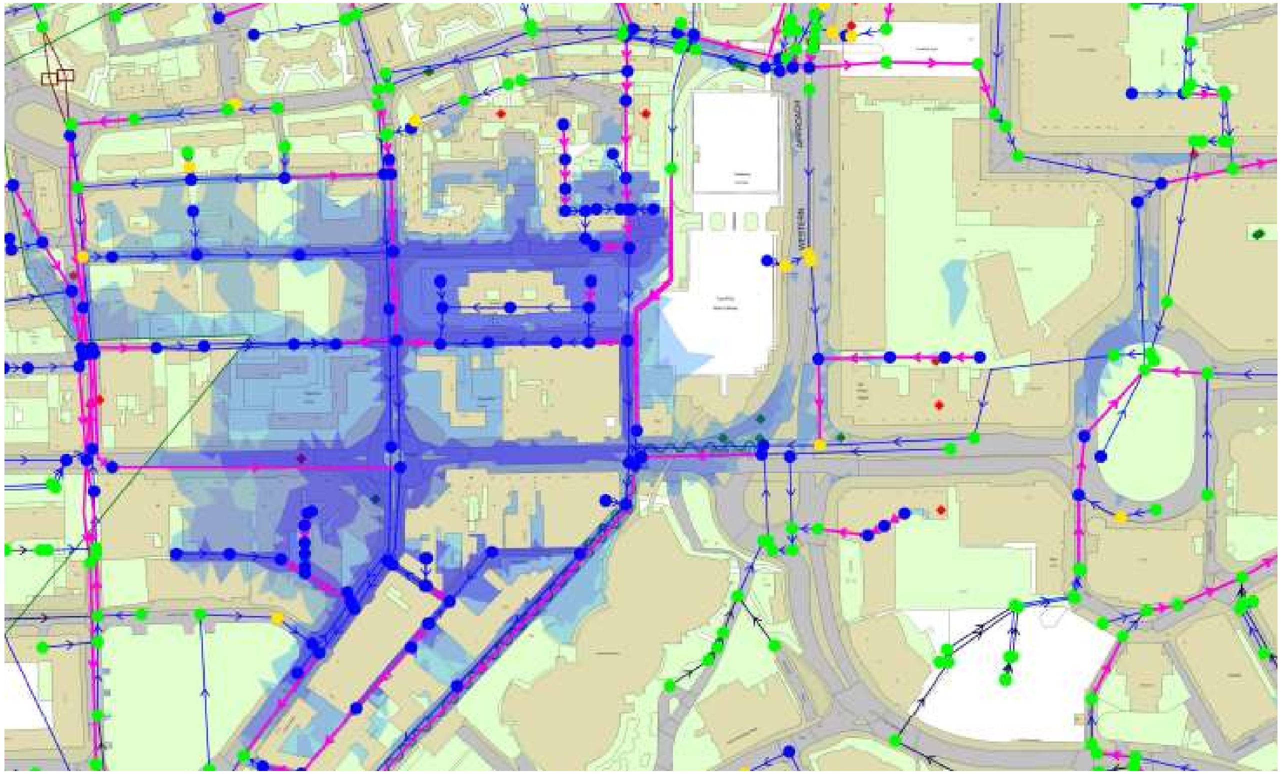

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Pell Frischmann Partnership

Plymouth City Council

- South West Water Framework Consultant since Privatisation
- Created IUDM from Bathing Water Model
- Coordinated and chaired stack holder meetings
- Produced Municipal Action Plan
- Concept Surface water separation design in Plymstock
- Detailed surface water separation in Plympton
- Concept SUDs design.

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Sustainable Urban Drainage

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The Four Pilars od SUDs

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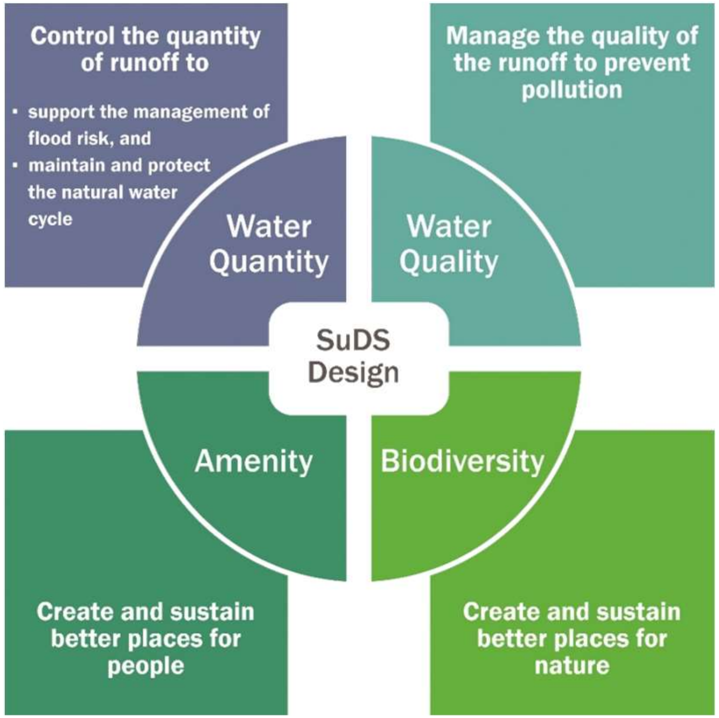

Sustainable Urban Drainage

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SUDs Hierarchy

Most Sustainable ↕ Least Sustainable	SuDS Technique	Flood reduction	Pollution reduction	Landscape & wildlife benefit
Most Sustainable	**Living roofs**	✓	✓	✓
	Basins and Ponds - Constructed Wetlands - Balancing Ponds - Detention basins - Retention Ponds	✓	✓	✓
	Filter Strips and Swales	✓	✓	✓
	Infiltration devices - soakaways - infiltration trenches and basins	✓	✓	✓
	Permeable surfaces and filter drains - gravelled areas - solid paving blocks - porous paviors	✓	✓	✗
Least Sustainable	**Tanked systems** - over-sized pipes/tanks - storm cells	✓	✗	✗

South West Water

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Challenges of Delivering Public Realm Improvements

Richard Bara Urban Designer, City of Plymouth Strategic Planning & Infrastructure

Challenges of Delivering Public Realm Improvements

New Public Realm schemes generally delivers on a myriad of benefits:

1. Urban Green Infrastructure – Trees and Plants,
2. Better Water Management – Use of Sustainable Urban Drainage Systems (SuDs),
3. Provides routes for walking & cycling,
4. Space for people to meet and talk,
5. Space for recreation,
6. Space for markets and events,
7. Provides space for our essential infrastructure – power sewers and communications,
8. Space for new infrastructure like here in Plymouth with our new District Heating Network, and 5G,
9. Future infrastructure?
10. As well as providing beautiful spaces for people access and to enjoy.

Challenges of Delivering Public Realm Improvements

Challenges:

1. Limitations with existing underground infrastructure,
2. Limitations with the existing underlying ground conditions,
3. Finance and its timing,
4. Future proofing for the next generation.

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City of Plymouth UK

Public Realm Examples

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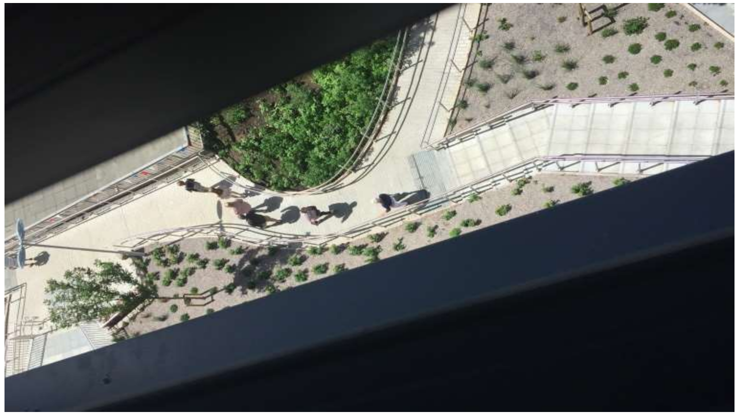

Market Way

Civic Square

Old Town Street – New George Street East

Millbay Boulevard

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Delivery of in ground infrastructure, including sustainable drainage, into Millbay Boulevard

Chris Yalden and Annabel Harris

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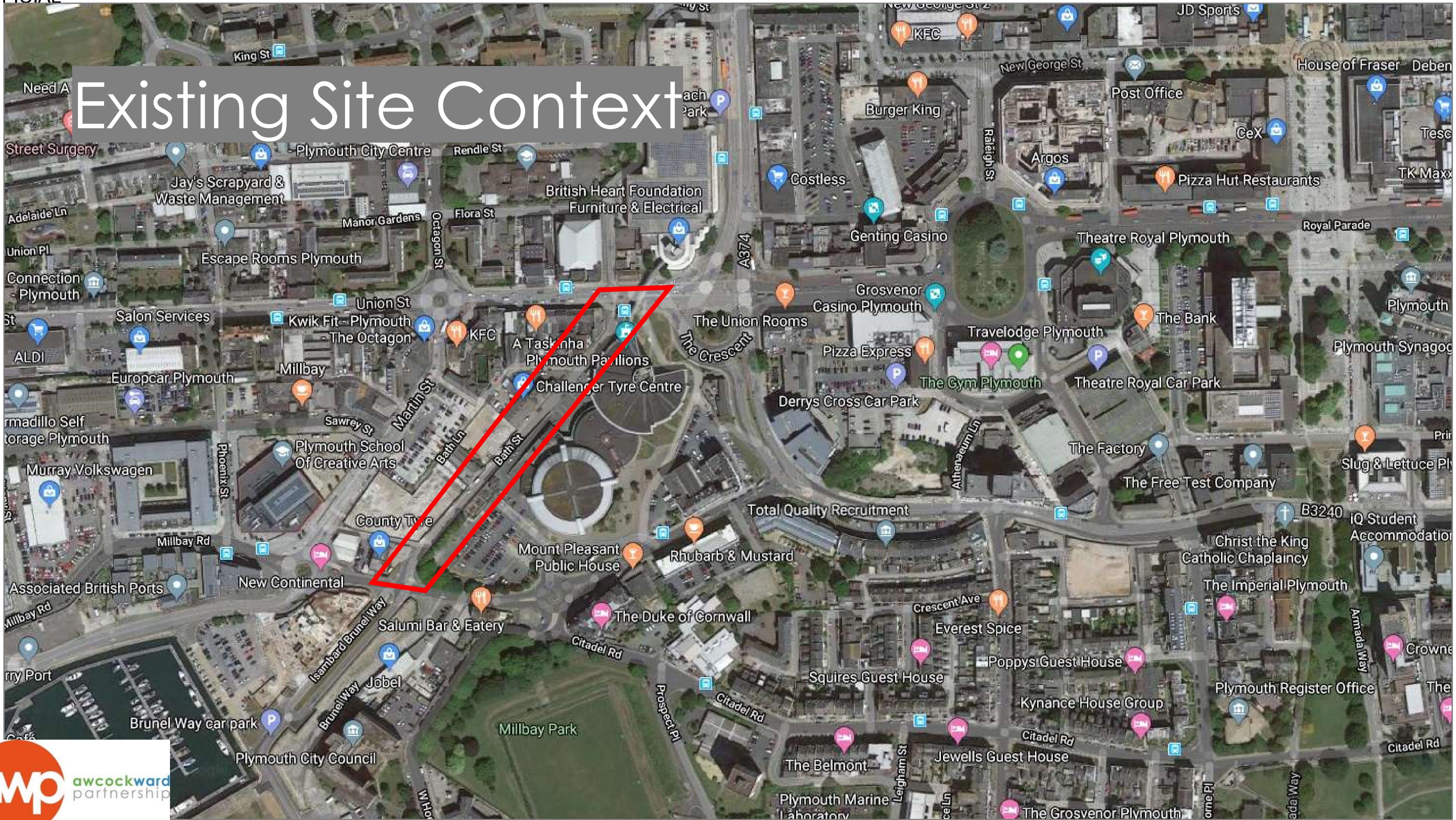

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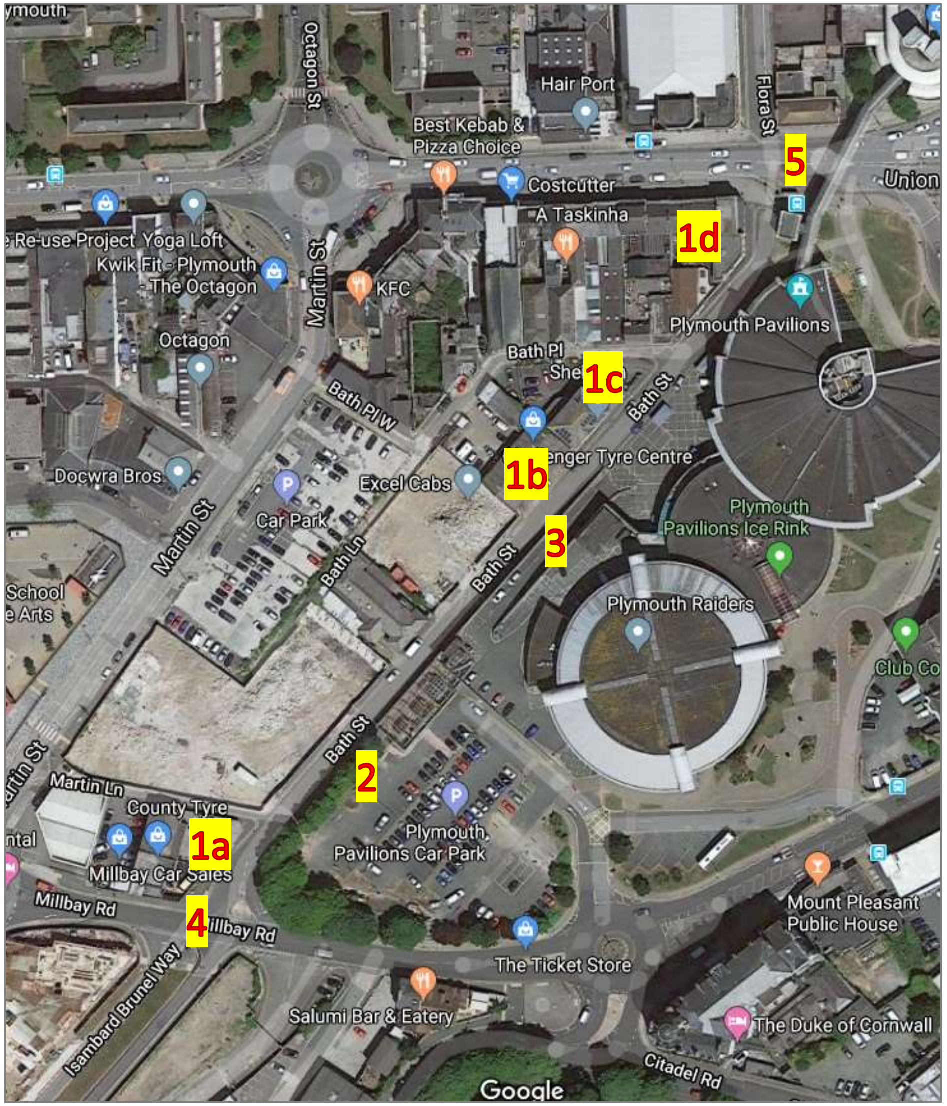
Existing Site Constraints

1. Adjacent businesses

   a) County Tyres
   b) Challenger Tyres
   c) Shekinah Mission,
   d) Jesters Nightclub

2. Proposed Hotel Development
3. Pavilions Ramp Demolition and Proposed Wall
4. Millbay Road
5. Union Street



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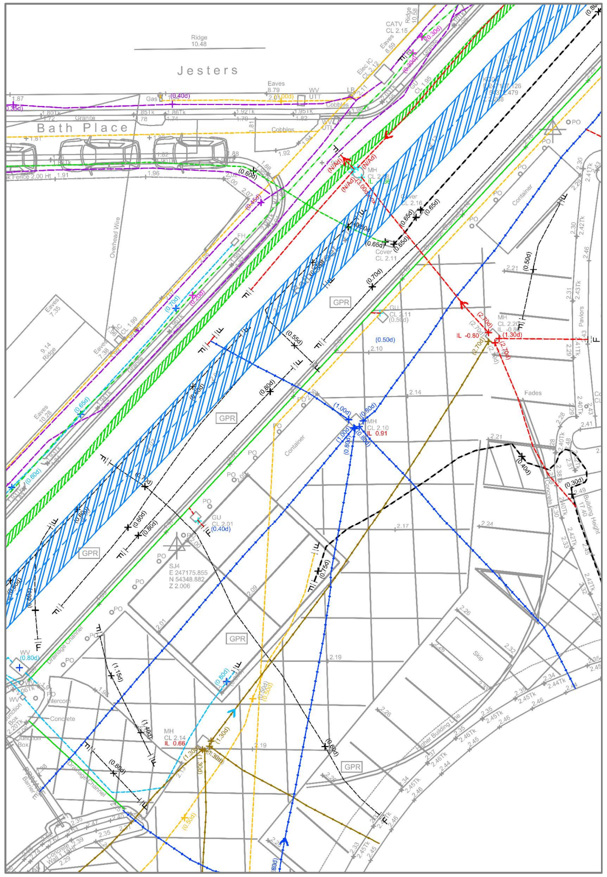
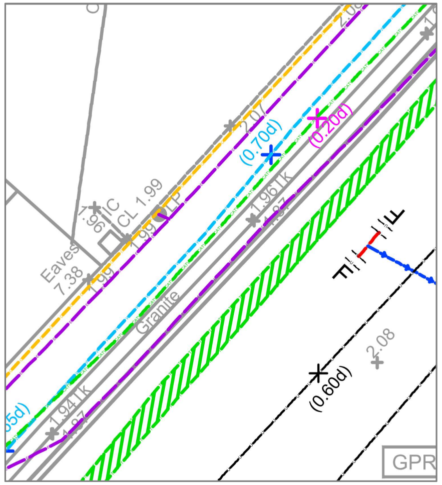
Existing Site Constraints

1. Utilities
   a) Gas
   b) Electric
   c) Water
   d) Virgin Media
   e) Vodafone

2. Drainage
   a) Highway System
   b) Foul Sewer
   c) Surface Water Sewer





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New Infrastructure

1. Sustainable Urban Drainage Systems
2. Ground Source Heating System
3. EV Charging Points
4. Water bottle filling station
5. Events electrical supply
6. 5G Duct Provision
7. CCTV

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Proposed Infrastructure Solution

Drainage

1. Rain Gardens
2. Attenuation Tanks
3. Tree Pits

Ground Source District Heating

1. 2 x 300mm Spine Pipes
2. 125mm Distribution Network
3. 2 x Borehole Wells
4. Ducting (LV and Telecoms Connections)

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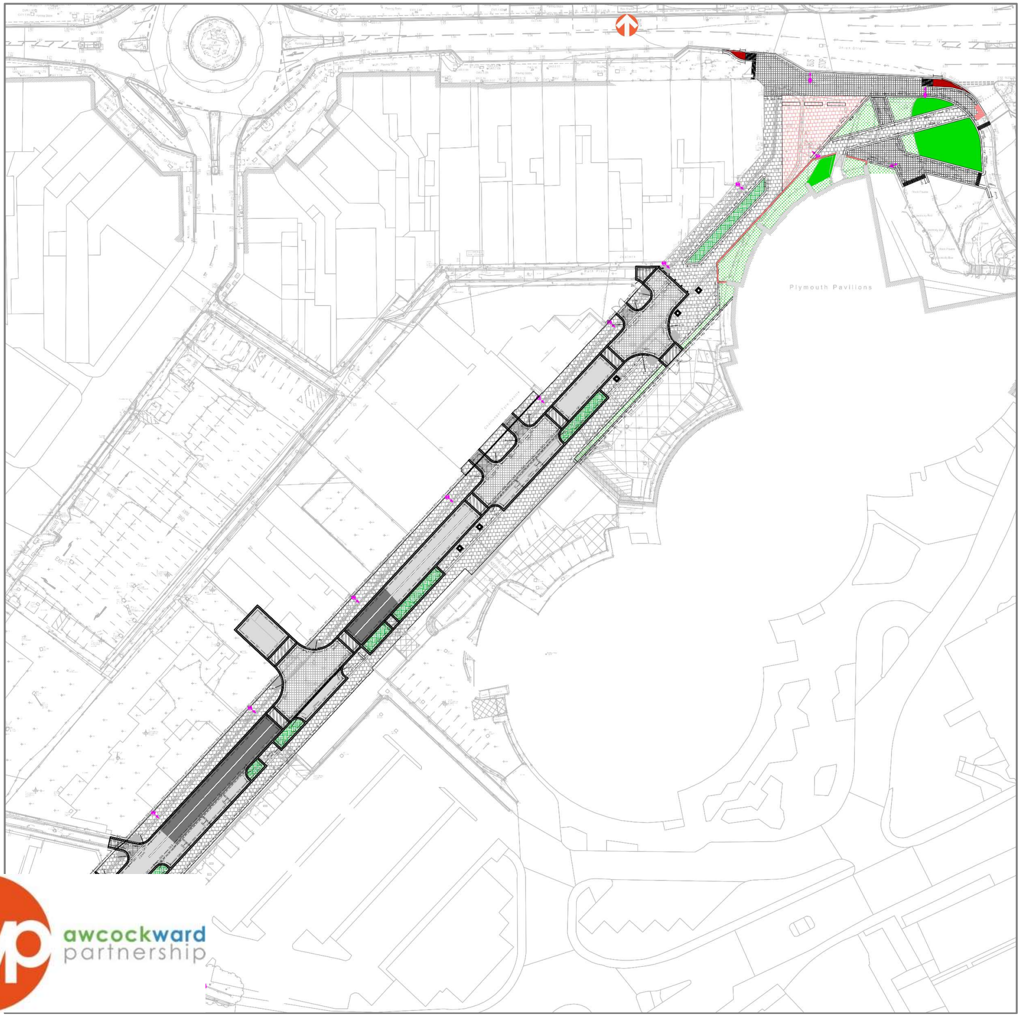
Overview of Proposed Scheme



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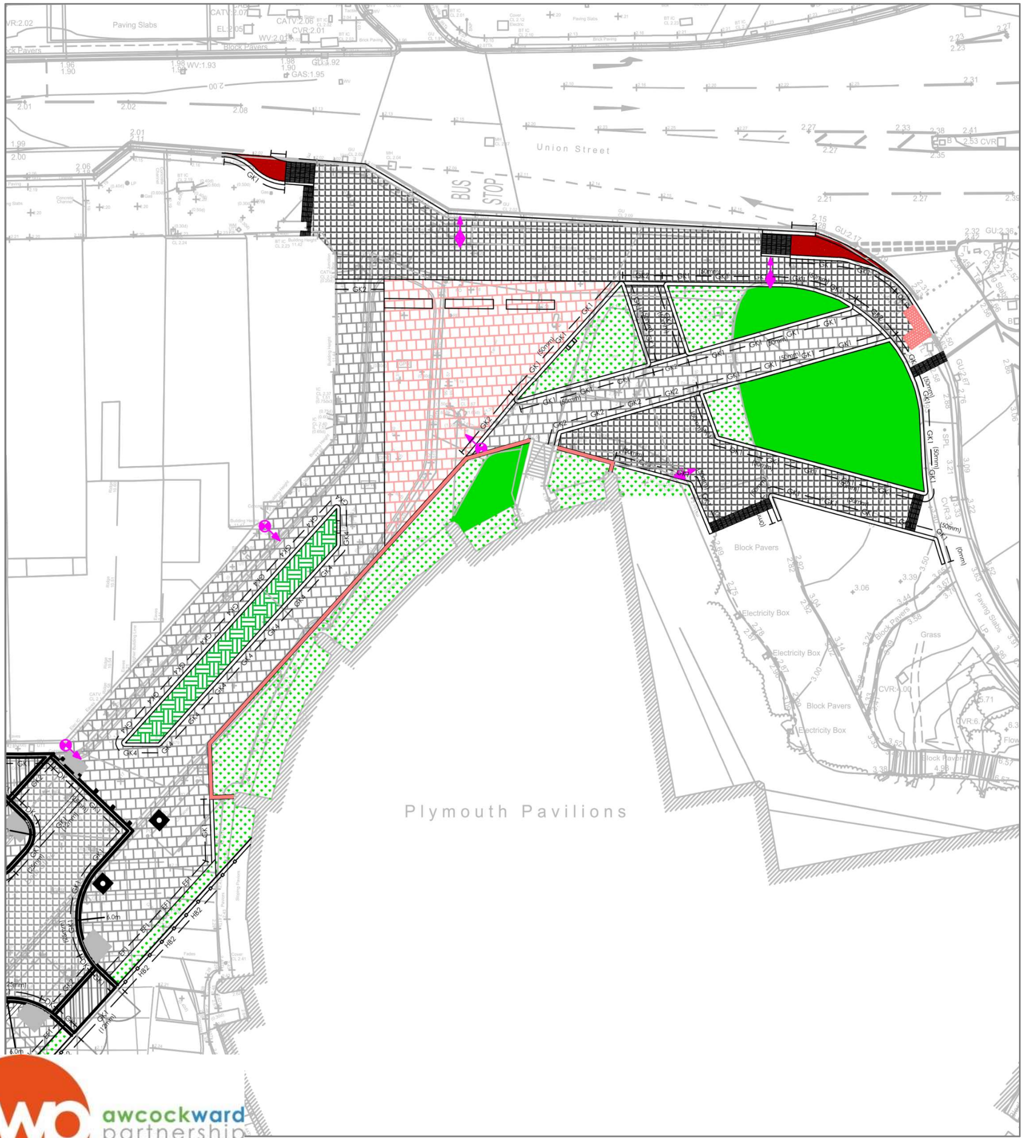

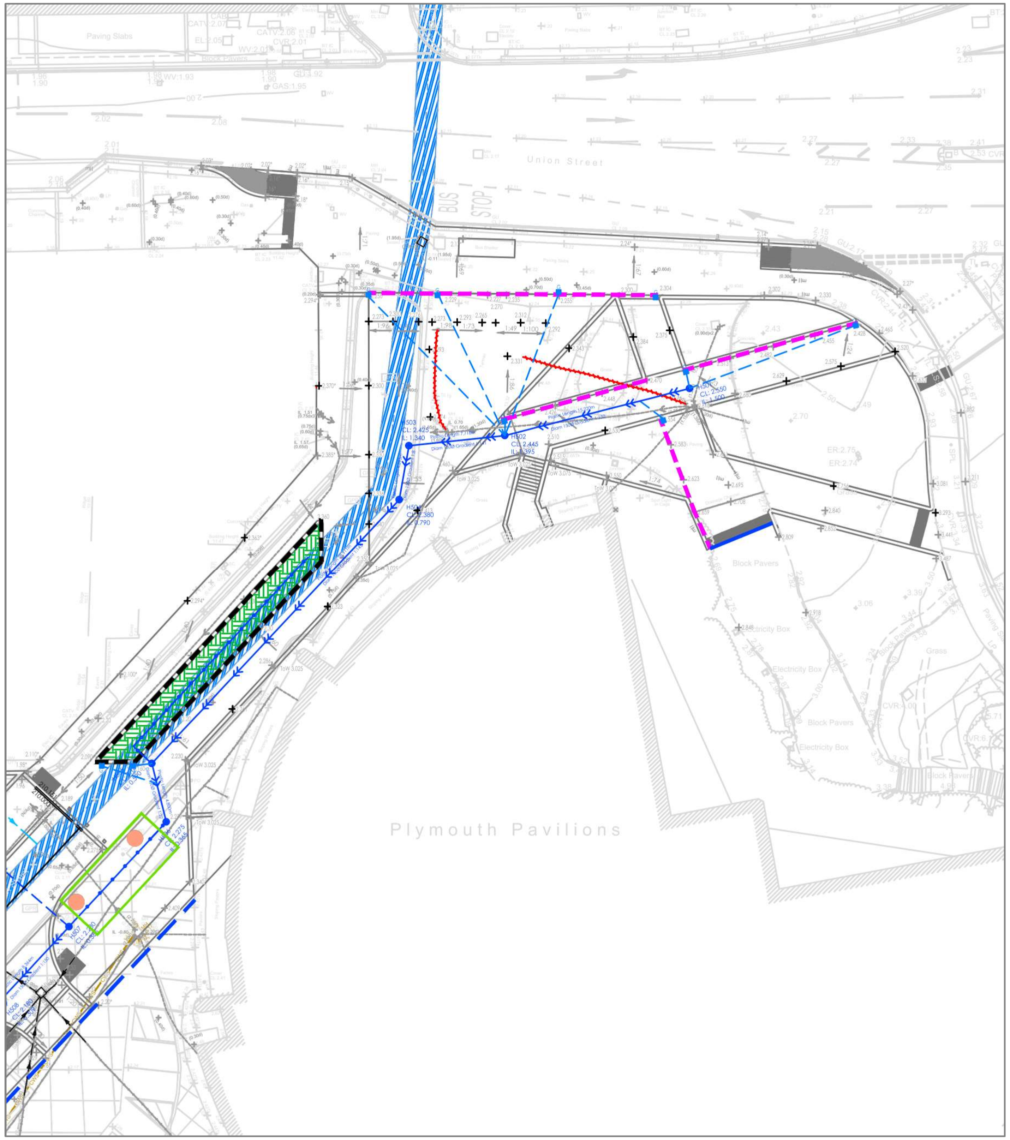

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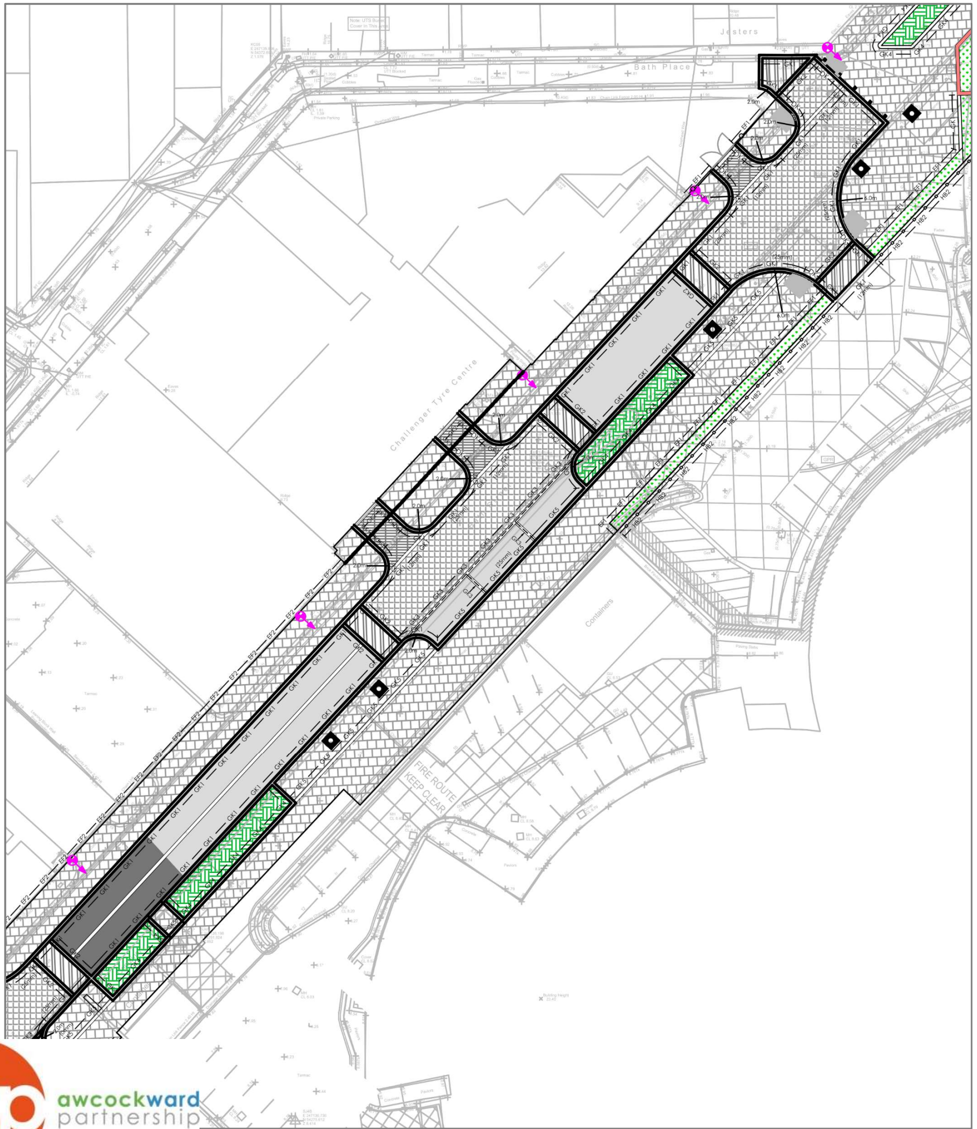

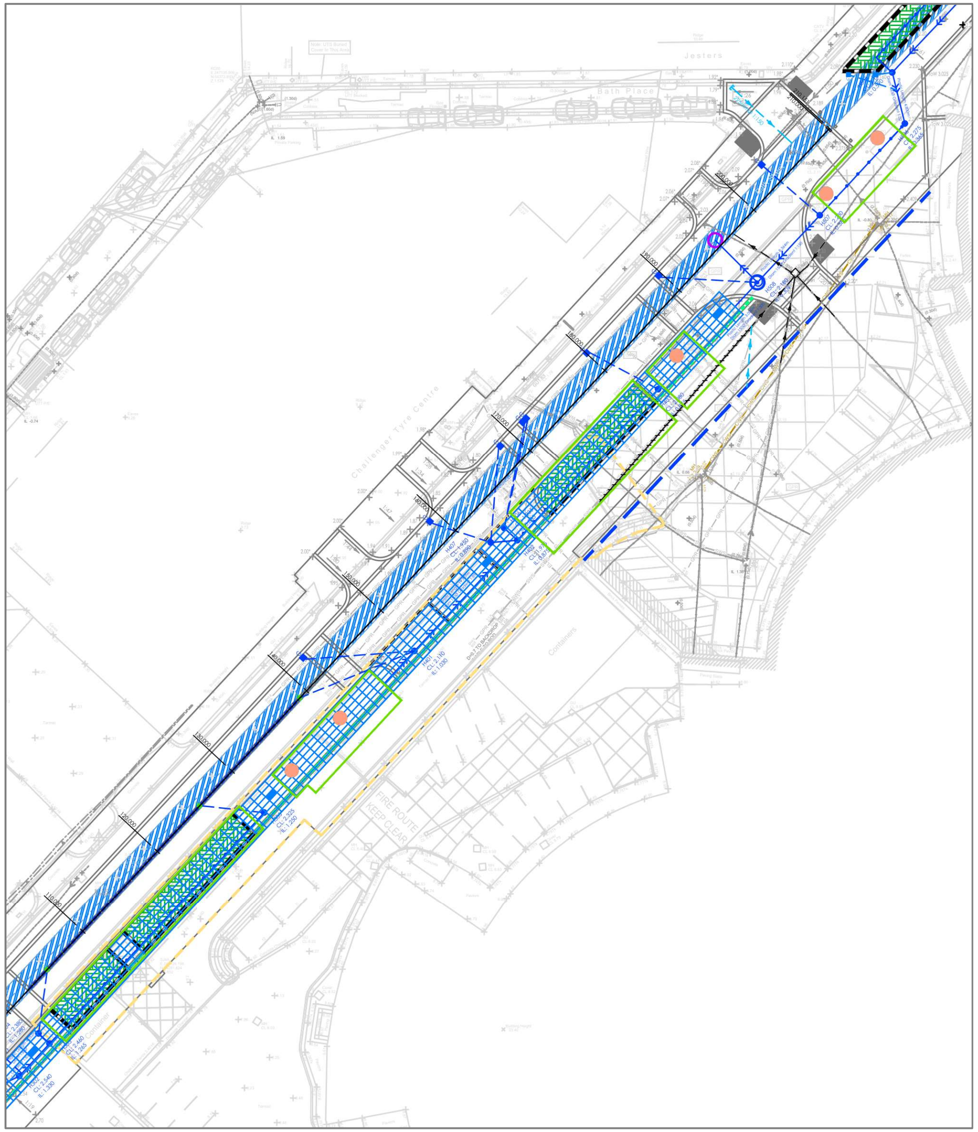

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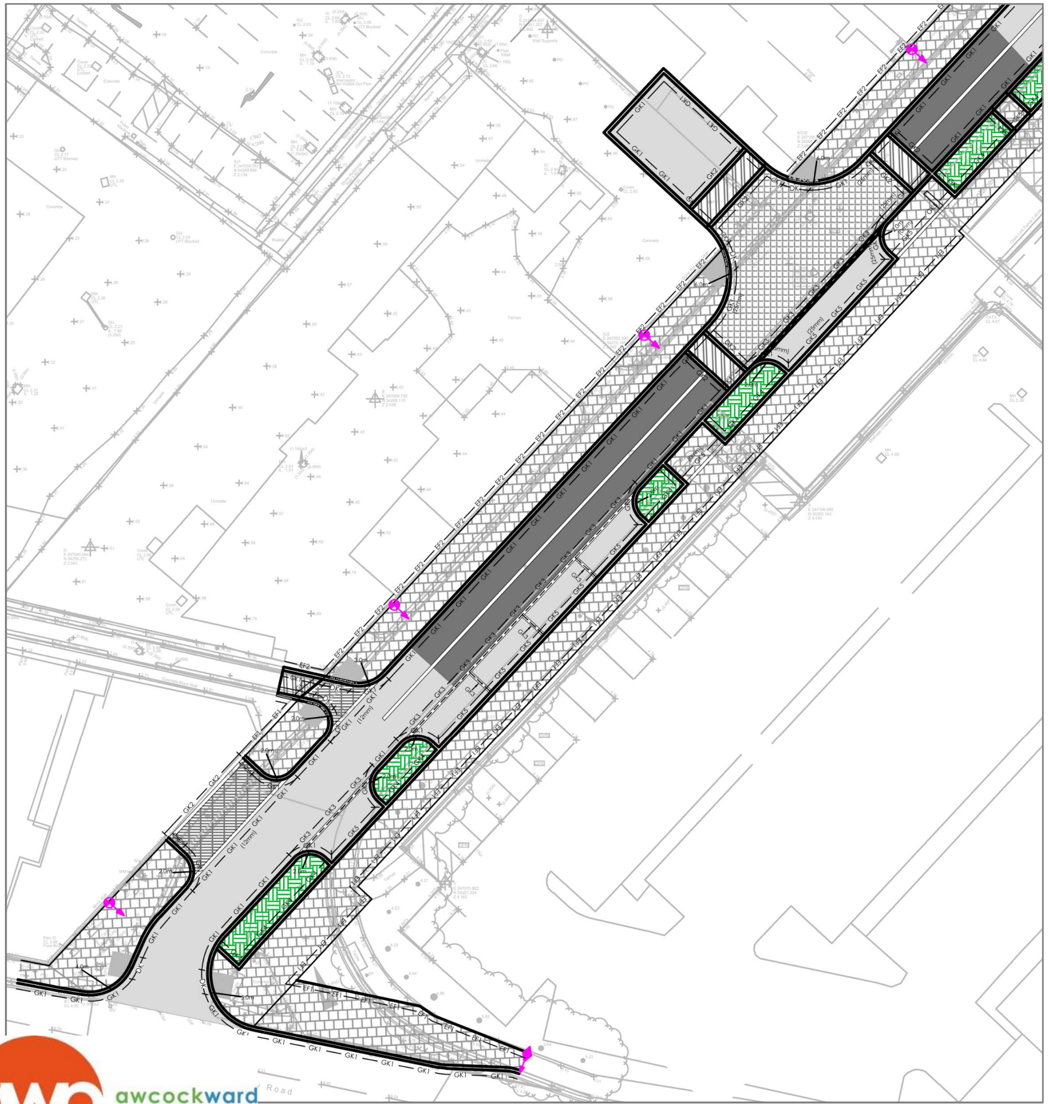

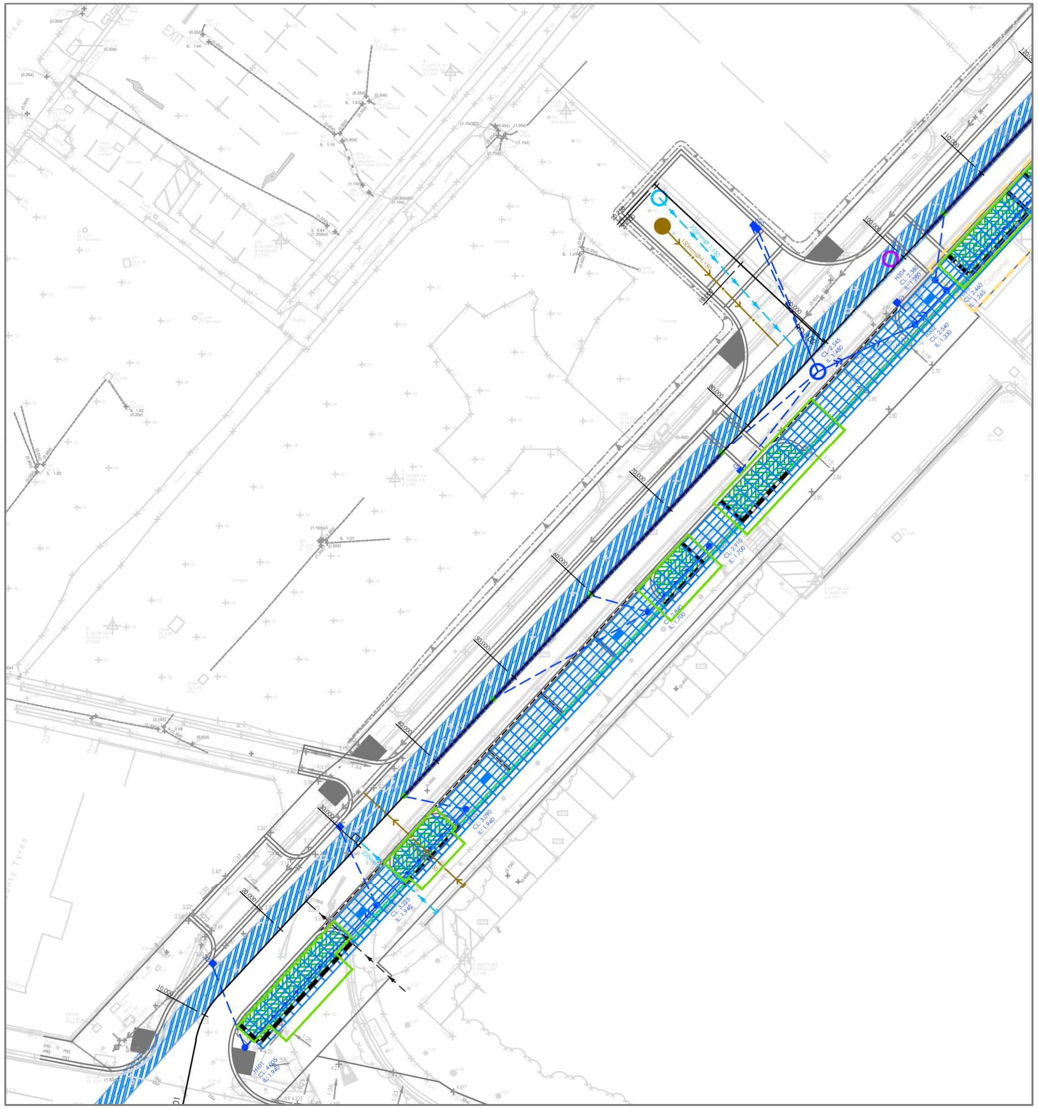

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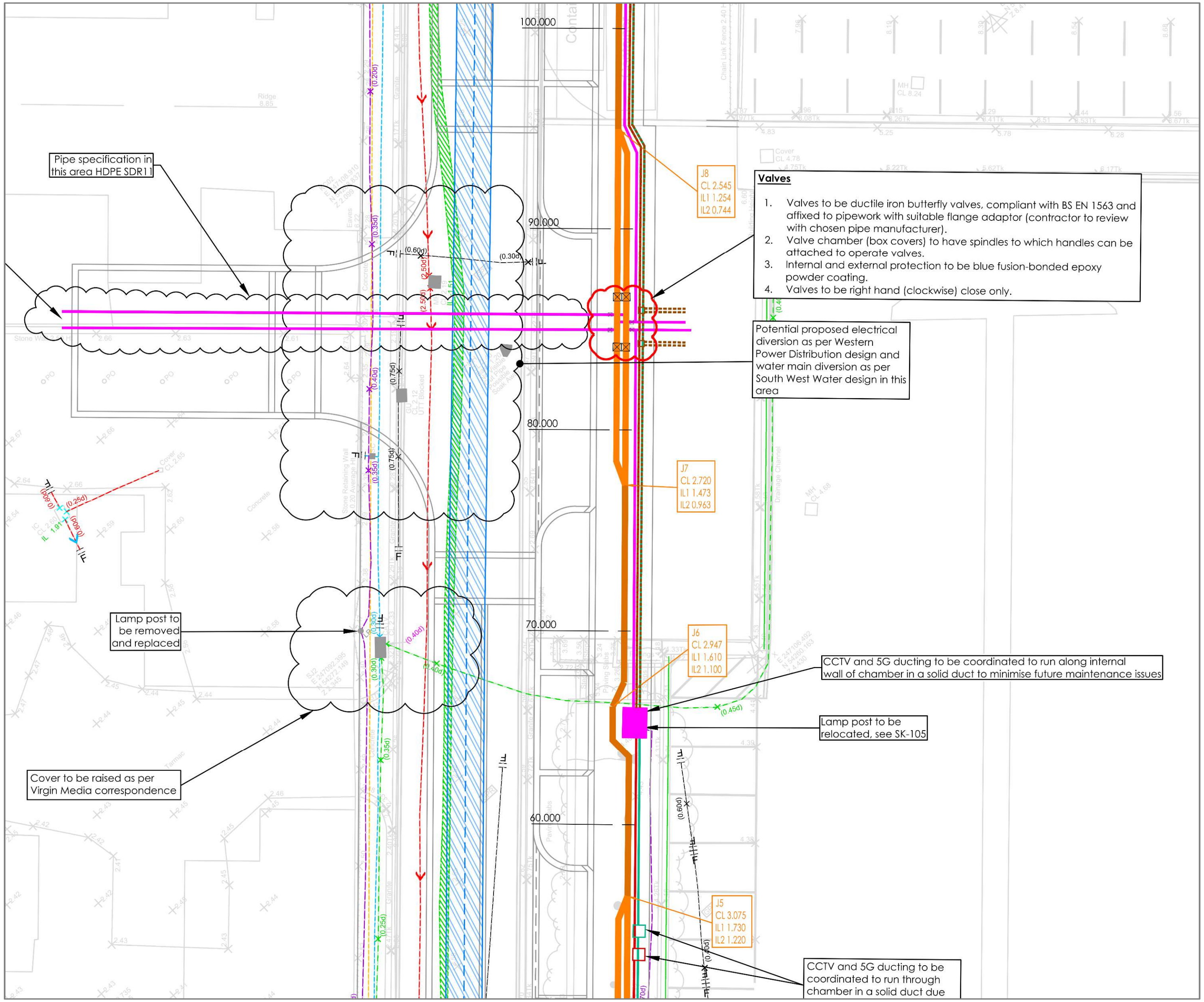

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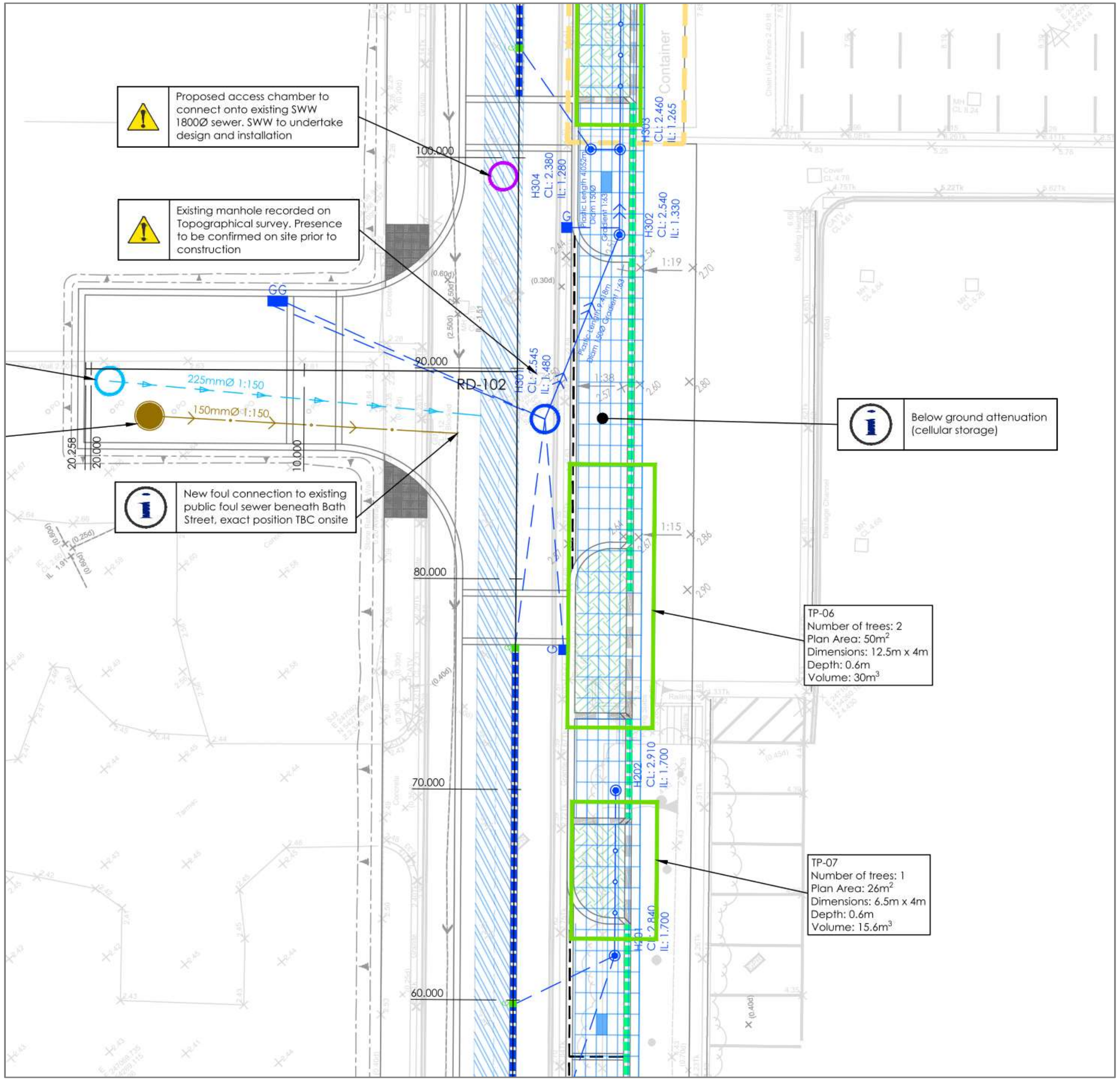

Proposed access chamber to connect onto existing SWW 1800Ø sewer. SWW to undertake design and installation
Existing manhole recorded on Topographical survey. Presence to be confirmed on site prior to construction
New foul connection to existing public foul sewer beneath Bath Street, exact position TBC onsite
Below ground attenuation (cellular storage)
TP-06
Number of trees: 2
Plan Area: 50m2
Dimensions: 12.5m x 4m
Depth: 0.6m
Volume: 30m3
TP-07
Number of trees: 1
Plan Area: 26m2
Dimensions: 6.5m x 4m
Depth: 0.6m
Volume: 15.6m3
225mmØ 1:150
150mmØ 1:150
RD-102
H304 CL: 2.380 IL: 1.280
H303 CL: 2.460 IL: 1.265
H302 CL: 2.540 IL: 1.330
H301 CL: 2.545 IL: 1.480
H202 CL: 2.910 IL: 1.700
H201 CL: 2.840 IL: 1.700
100.000
90.000
80.000
70.000
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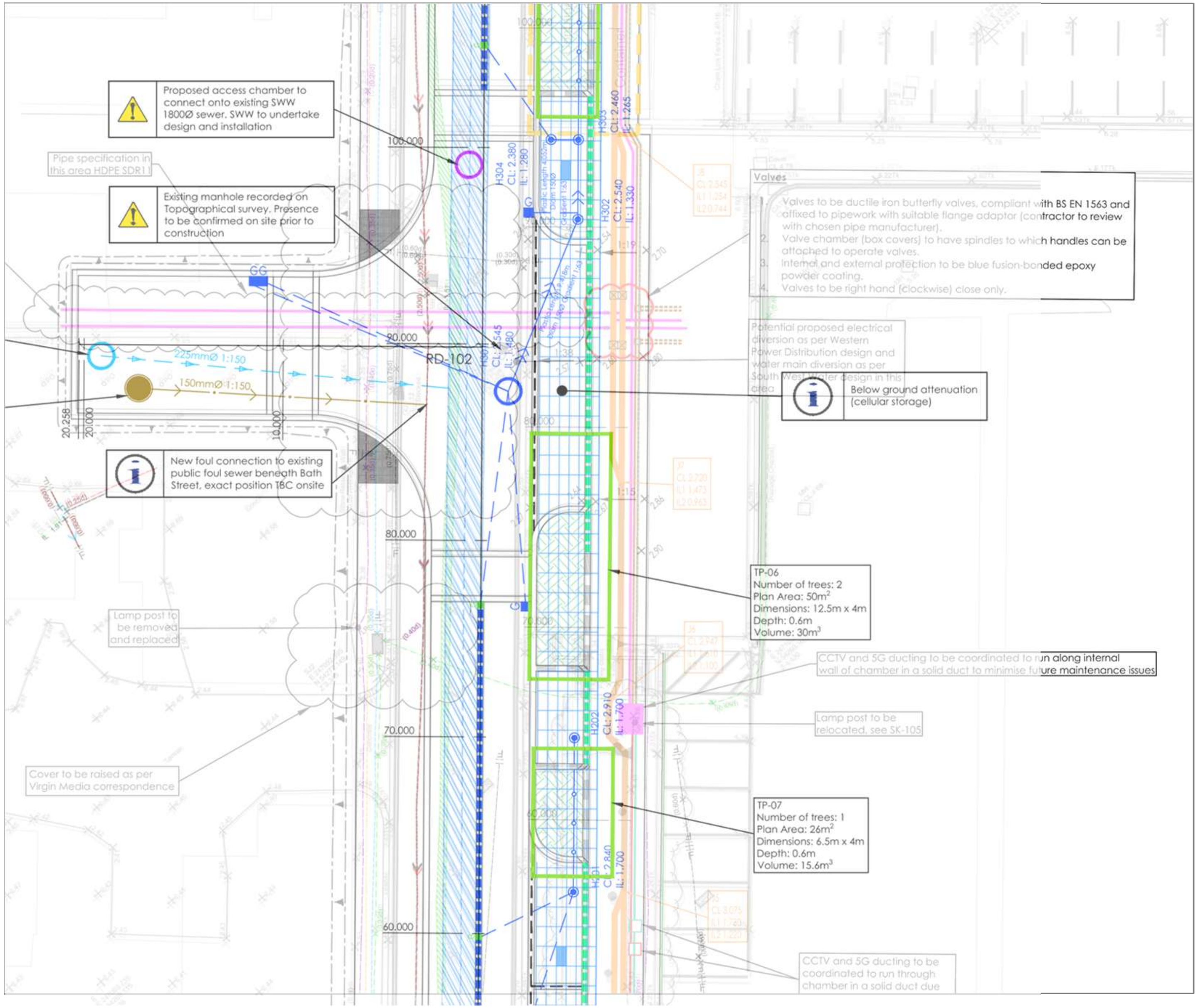
20.258
20.000
10.000
Container


Proposed access chamber to connect onto existing SWW 1800Ø sewer. SWW to undertake design and installation
Pipe specification in this area HDPE SDR11
Existing manhole recorded on Topographical survey. Presence to be confirmed on site prior to construction
225mmØ 1:150
150mmØ 1:150
RD-102
New foul connection to existing public foul sewer beneath Bath Street, exact position TBC onsite
Lamp post to be removed and replaced
Cover to be raised as per Virgin Media correspondence
Valves
1. Valves to be ductile iron butterfly valves, compliant with BS EN 1563 and affixed to pipework with suitable flange adaptor (contractor to review with chosen pipe manufacturer).
2. Valve chamber (box covers) to have spindles to which handles can be attached to operate valves.
3. Internal and external protection to be blue fusion-bonded epoxy powder coating.
4. Valves to be right hand (clockwise) close only.
Potential proposed electrical diversion as per Western Power Distribution design and water main diversion as per South West Water design in this area
Below ground attenuation (cellular storage)
TP-06
Number of trees: 2
Plan Area: 50m²
Dimensions: 12.5m x 4m
Depth: 0.6m
Volume: 30m³
CCTV and 5G ducting to be coordinated to run along internal wall of chamber in a solid duct to minimise future maintenance issues
Lamp post to be relocated, see SK-105
TP-07
Number of trees: 1
Plan Area: 26m²
Dimensions: 6.5m x 4m
Depth: 0.6m
Volume: 15.6m³
CCTV and 5G ducting to be coordinated to run through chamber in a solid duct due
H304 CL: 2.380 IL: 1.280
H303 CL: 2.460 IL: 1.265
H302 CL: 2.540 IL: 1.330
H202 CL: 2.910 IL: 1.700
H201 CL: 2.840 IL: 1.700
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70.000
60.000

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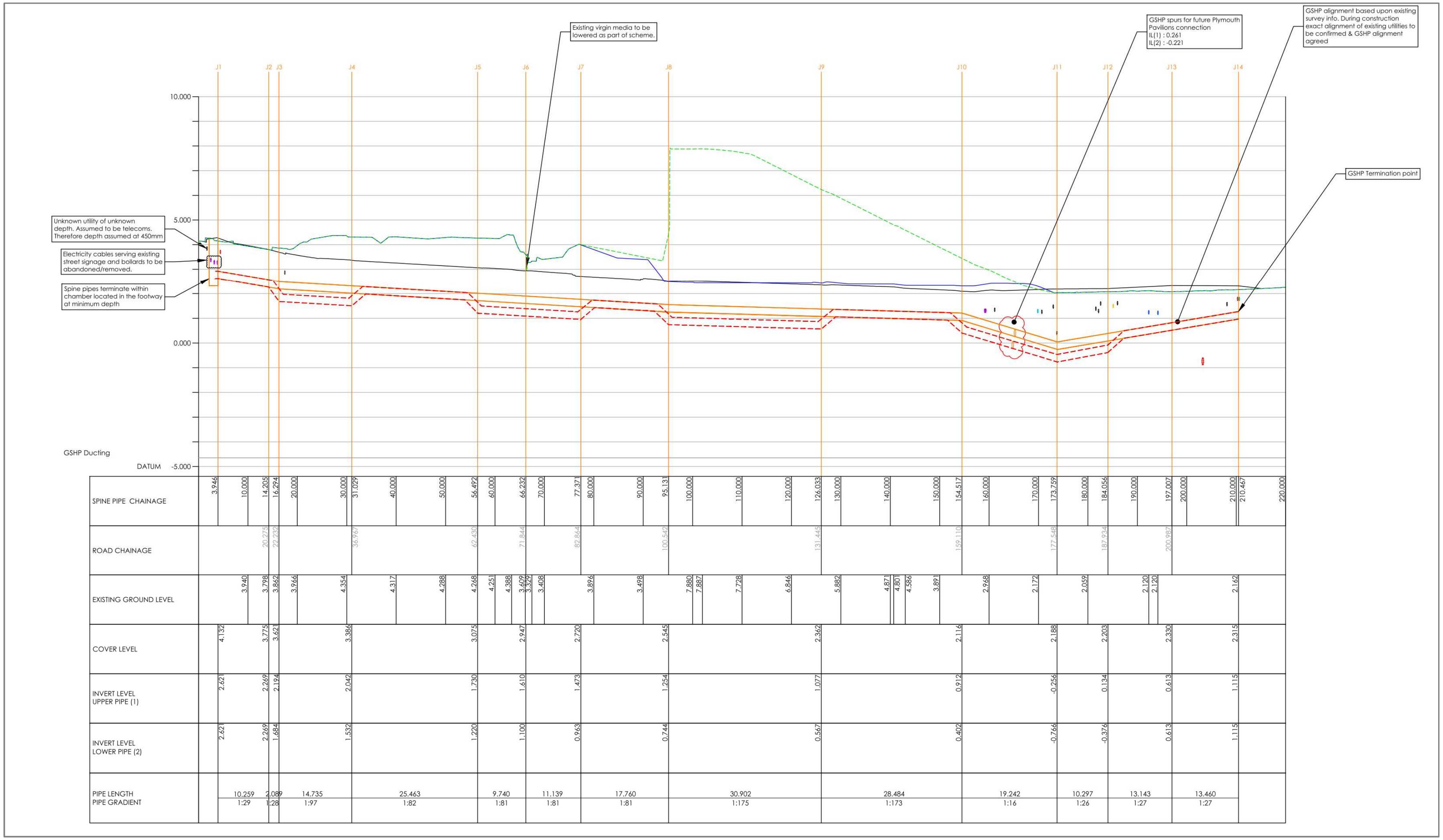

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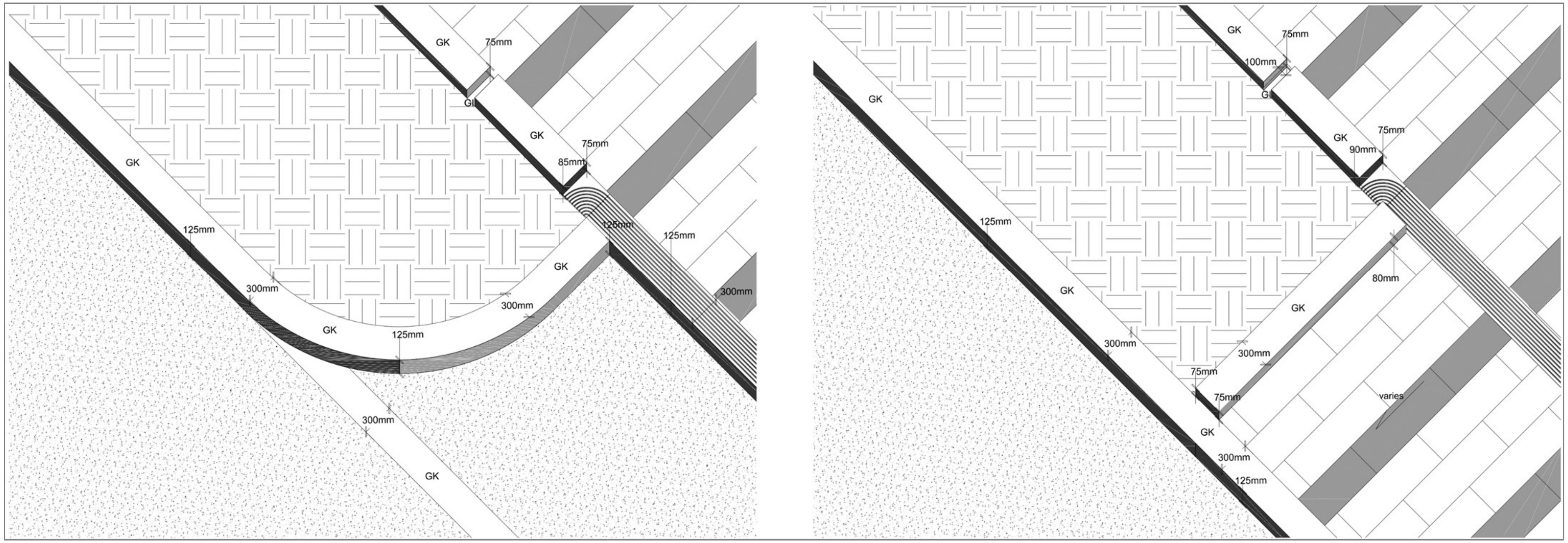
Technical Details

- Getting Water into the System



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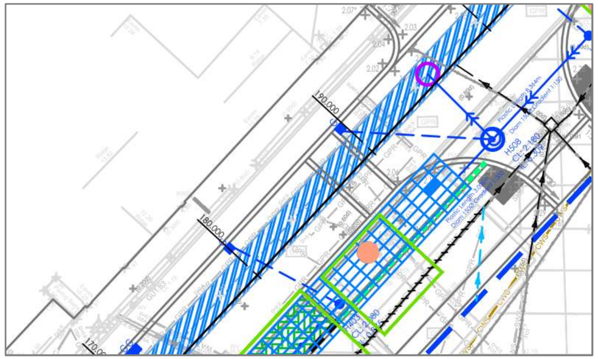
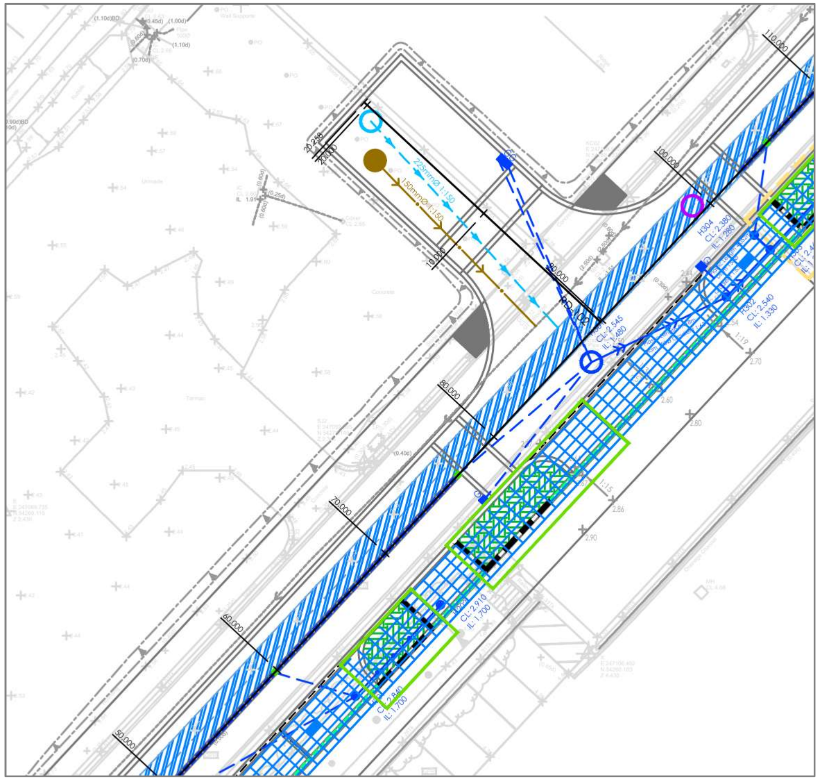
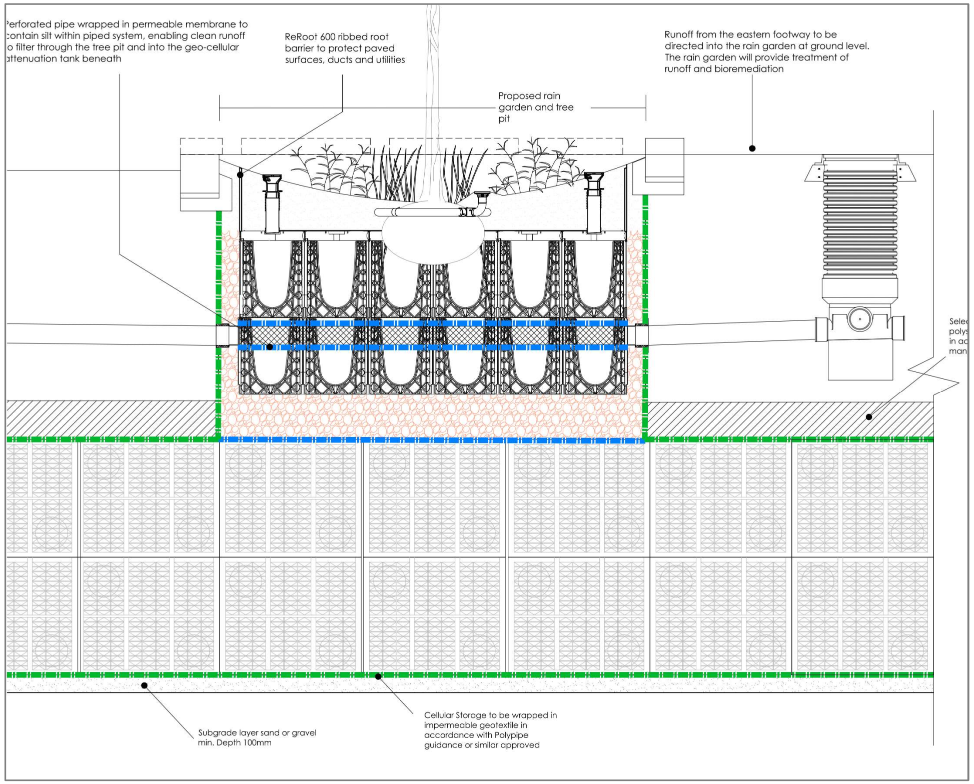
Technical Details

- Getting Water into the System







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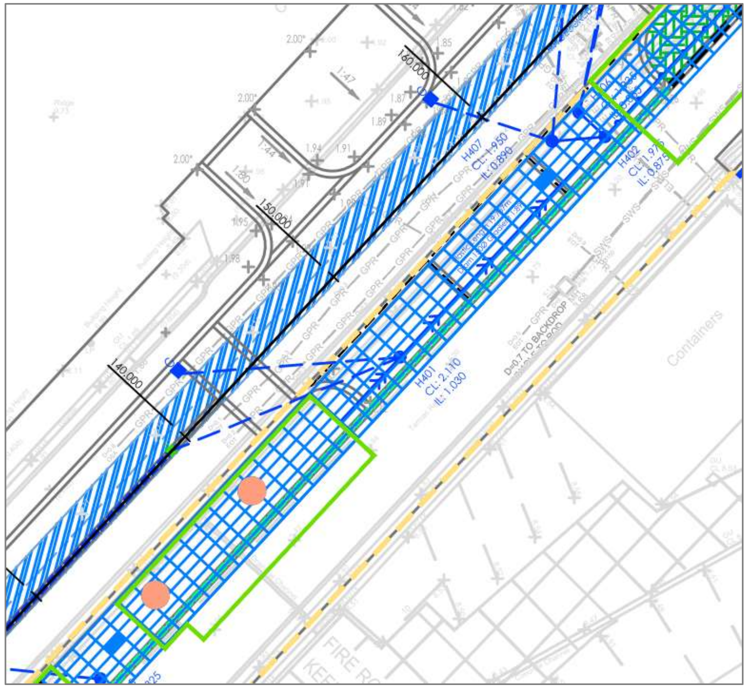
Technical Details

- Maintenance Aspects

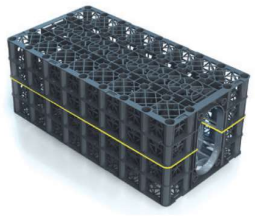


2A

Polystorm Access

Polystorm Access provides a 1m x 0.5m vertical shaft within a Polystorm geocellular structure to enable surface access for remote camera inspection and maintenance activities such as flushing and rodding.

2B



Polystorm Inspect

Product code: PSM4

Polystorm Inspect provides a tunnel along the length of a fully installed Polystorm system to enable horizontal access for inspection and maintenance. It can also be used in conjunction with Polystorm Access.

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Site Progress

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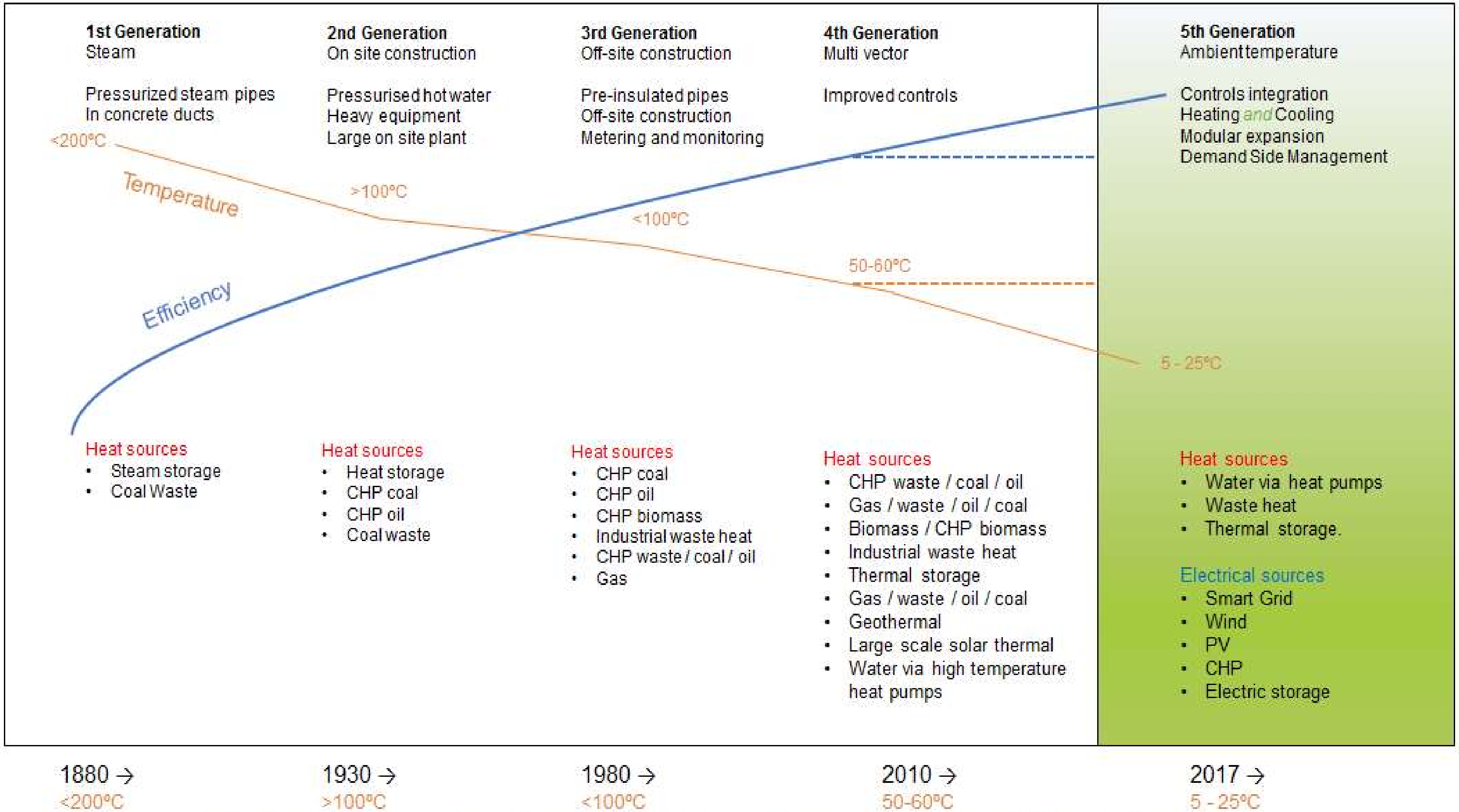
Plymouth Heat Network

- Heat and transport next big challenges in decarbonisation, following electricity.
- Generating heat represents the biggest energy use in the UK so, to meet our targets, we will have to decarbonise nearly all heat generation in buildings.
- Currently 70% buildings (80% homes) heated by gas.
- Heat networks have a role to play, combined with heat pumps (electrification of heat), as well as heat pumps for individual buildings.

Heat Networks transition



Heat network trends to lower distribution temperatures and higher efficiency

Interreg North-West Europe HeatNet NWE

European Regional Development Fund

EUROPEAN UNION

5th generation benefits

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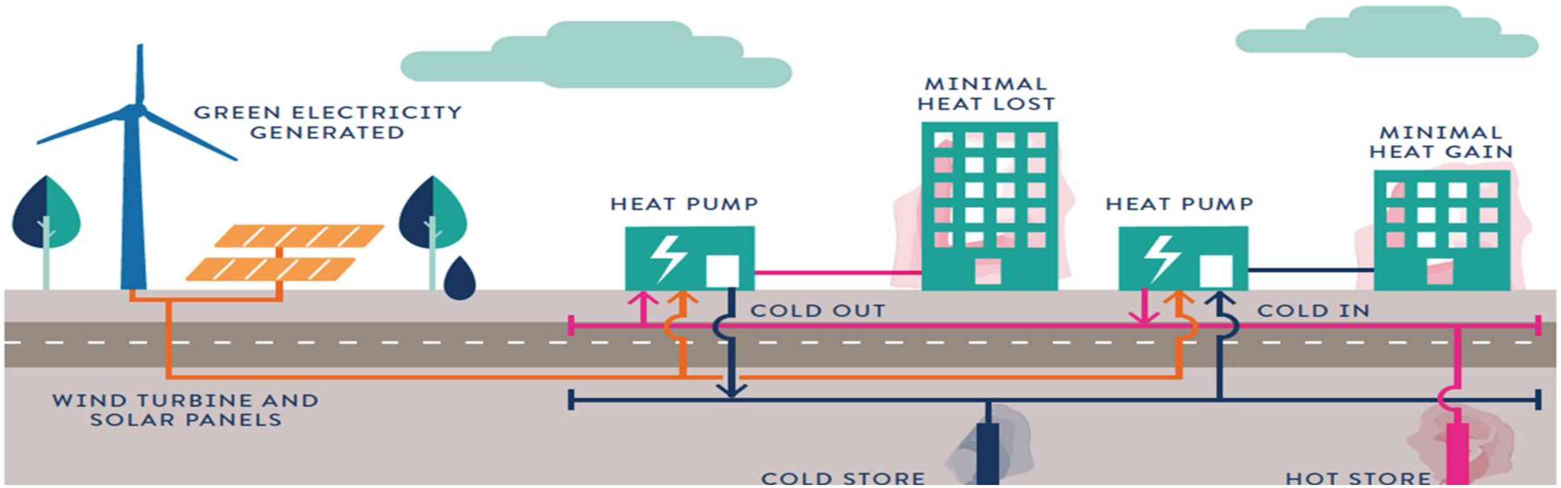
- Resilient to climate change- cooling and heating
- Rejected energy recovered and shared, reducing primary energy
- Helps buildings achieve future compliance
- No flues or emissions- air quality benefits
- Flexible- plug and play (decentralised)
- Allows greater use of renewable energy and waste heat sources
- Opportunity to offer ‘grid services’ to electricity network



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District Energy Opportunity Areas

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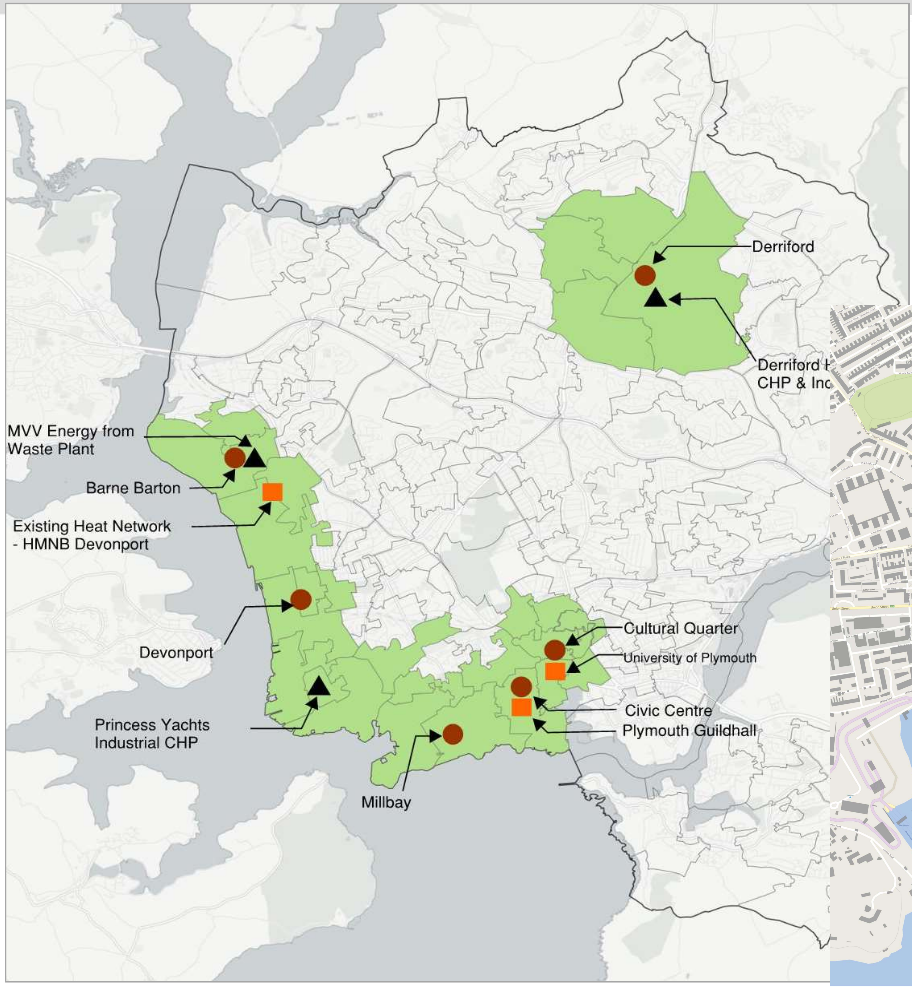

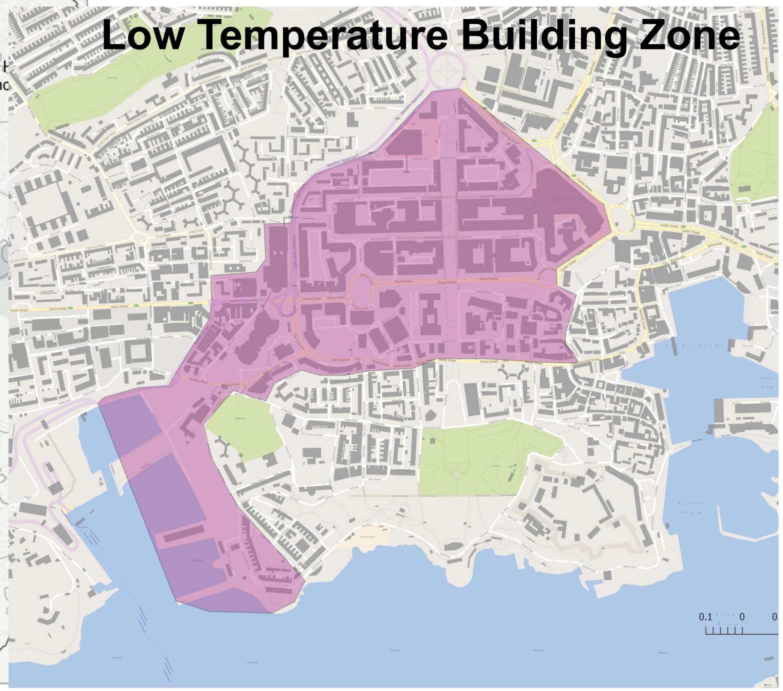

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Ground Source

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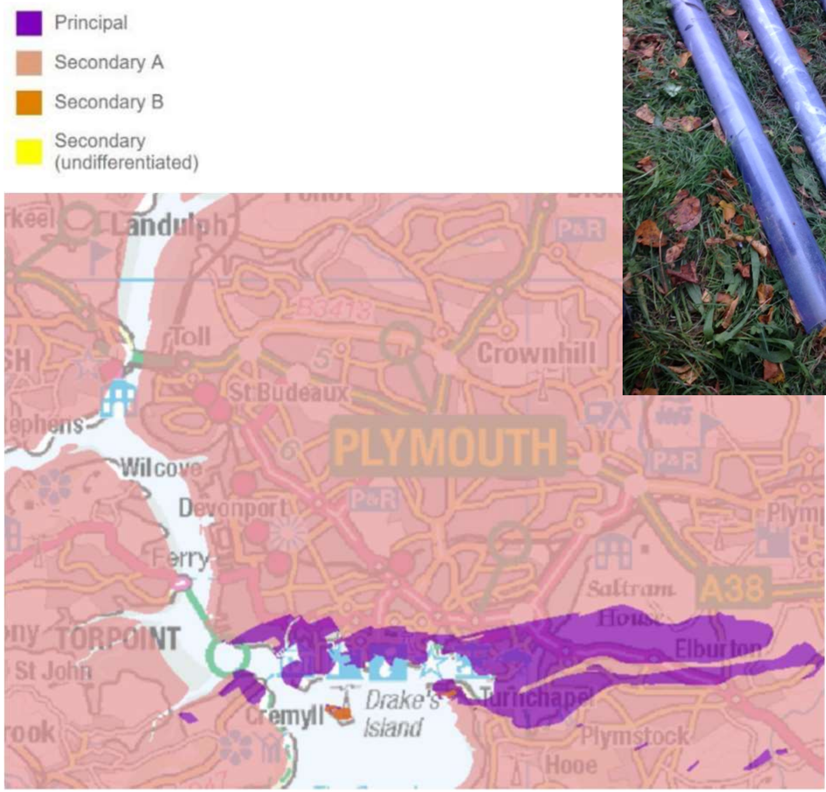
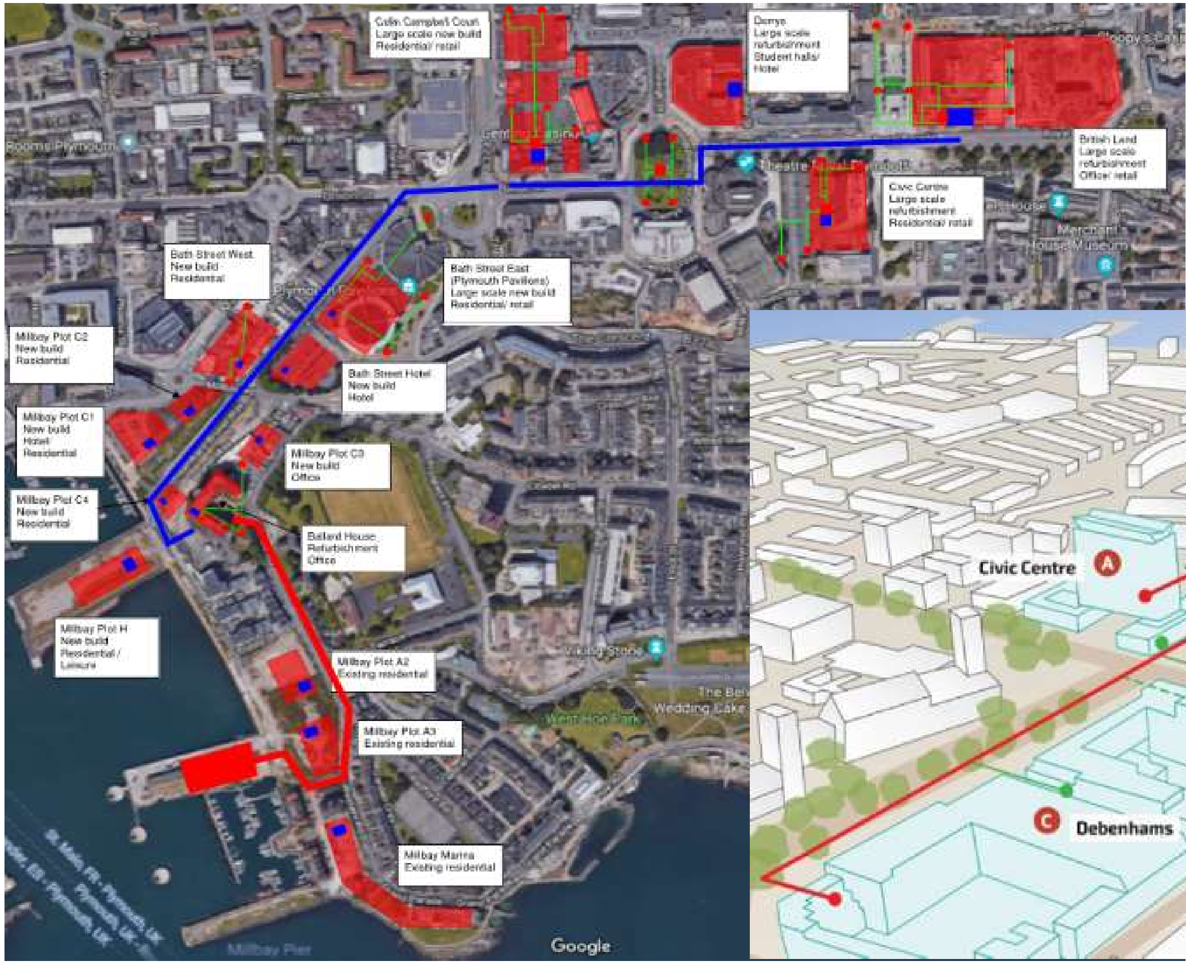
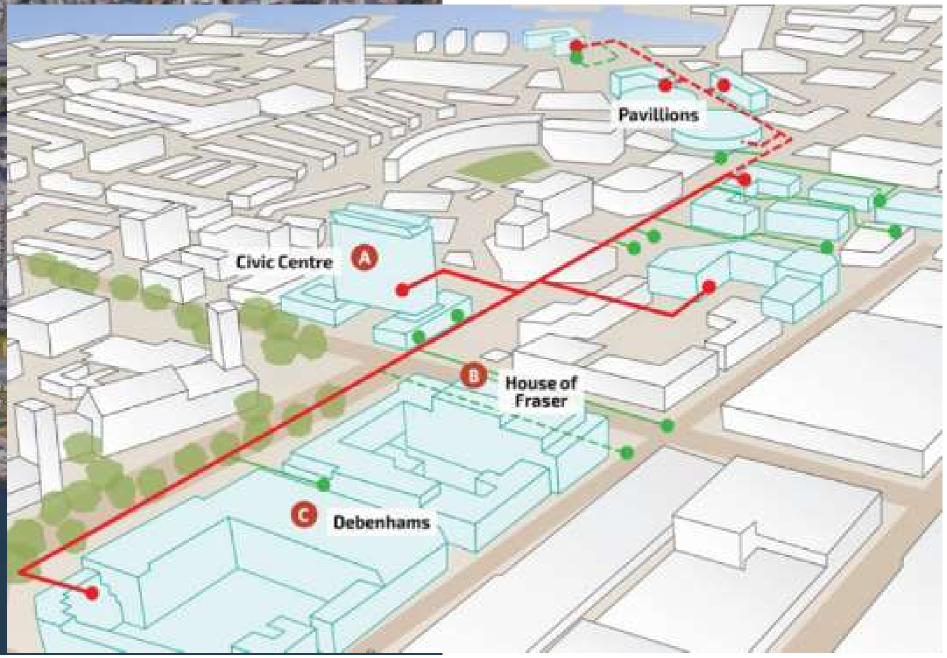
Aquifer Bedrock



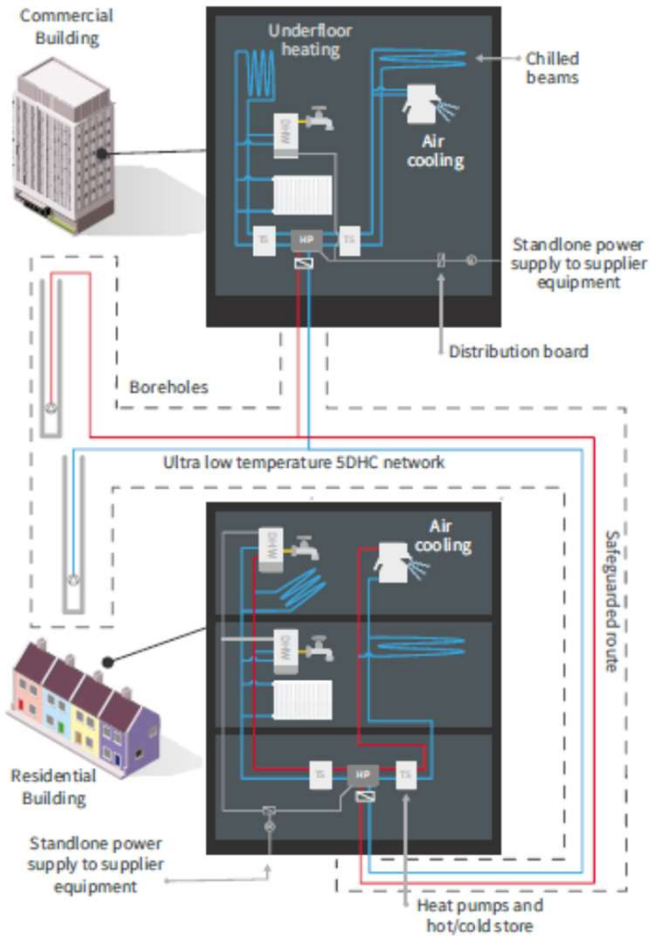
City Centre scheme





City Centre scheme

- EU HeatNet Interreg project is funding new wells and enabling infrastructure.
- Using a combination of ground source heat pumps (utilising principal aquifer in underlying limestone), and in future Marine heat pumps.
- Potential links to electricity network/ flexibility markets through use of heat pumps and storage.



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Enabling works

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Civic Centre wells

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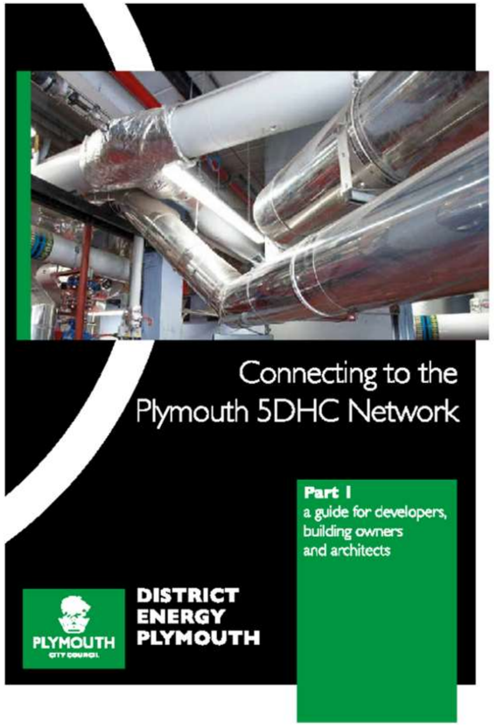
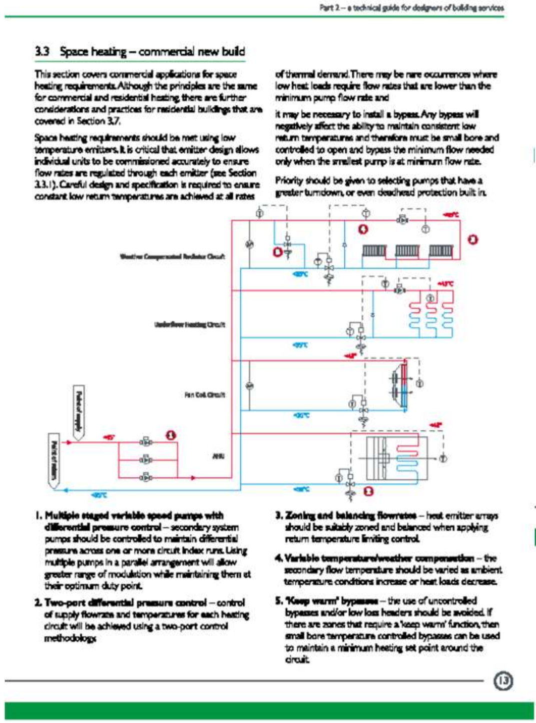
Connections packs




Part 2 – a technical guide for designers of building services

3.3 Space heating – commercial new build

This section covers commercial applications for space heating requirements. Although the principles are the same for commercial and residential heating, there are further considerations and practices for residential buildings that are covered in Section 3.7.

Space heating requirements should be met using low temperature emitters. It is critical that emitter design allows individual units to be commissioned accurately to ensure flow rates are regulated through each emitter (see Section 3.3.1). Careful design and specification is required to ensure constant low return temperatures are achieved at all rates of thermal demand. There may be rare occurrences where low heat loads require flow rates that are lower than the minimum pump flow rate and

it may be necessary to install a bypass. Any bypass will negatively affect the ability to maintain consistent low return temperatures and therefore must be small bore and controlled to open and bypass the minimum flow needed only when the smallest pump is at minimum flow rate.

Priority should be given to selecting pumps that have a greater turndown, or even deadhead protection built in.

Underfloor Heating Circuit
Fan Coil Circuit
AHU

1. **Multiple staged variable speed pumps with differential pressure control** – secondary system pumps should be controlled to maintain differential pressure across one or more circuit index runs. Using multiple pumps in a parallel arrangement will allow greater range of modulation while maintaining them at their optimum duty point.
2. **Two-port differential pressure control** – control of supply flowrate and temperatures for each heating circuit will be achieved using a two-port control methodology.
3. **Zoning and balancing flowrates** – heat emitter arrays should be suitably zoned and balanced when applying return temperature limiting control.
4. **Variable temperature/weather compensation** – the secondary flow temperature should be varied as ambient temperature conditions increase or heat loads decrease.
5. **'Keep warm' bypasses** – the use of uncontrolled bypasses and/or low loss headers should be avoided. If there are zones that require a 'keep warm' function, then small bore temperature controlled bypasses can be used to maintain a minimum heating set point around the circuit.

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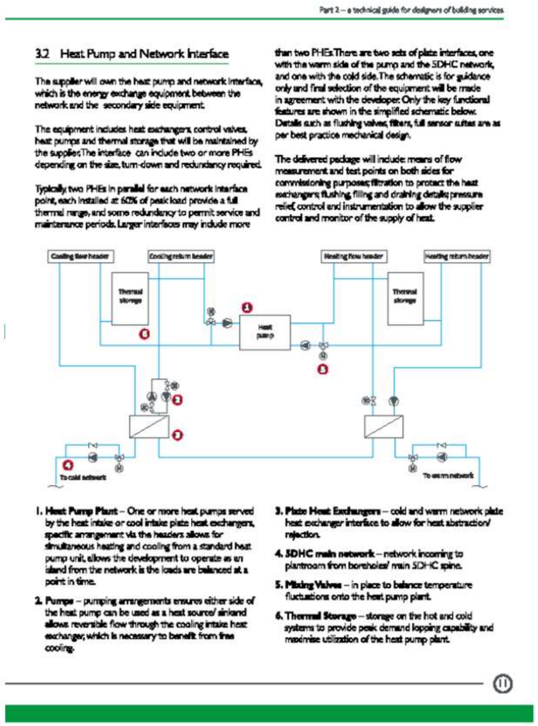
Part 2 – a technical guide for designers of building services

3.2 Heat Pump and Network Interface

The supplier will own the heat pump and network interface, which is the energy exchange equipment between the network and the secondary side equipment.

The equipment includes heat exchangers, control valves, heat pumps and thermal storage that will be maintained by the supplier. The interface can include two or more PHEs depending on the size, turn-down and redundancy required.

Typically, two PHEs in parallel for each network interface point, each installed at 60% of peak load provide a full thermal range, and some redundancy to permit service and maintenance periods. Larger interfaces may include more than two PHEs. There are two sets of plate interfaces, one with the warm side of the pump and the 5DHC network, and one with the cold side. The schematic is for guidance only and final selection of the equipment will be made in agreement with the developer. Only the key functional features are shown in the simplified schematic below. Details such as flushing valves, filters, full sensor suites are as per best practice mechanical design.

The delivered package will include: means of flow measurement and test points on both sides for commissioning purposes; filtration to protect the heat exchangers; flushing, filling and draining details; pressure relief, control and instrumentation to allow the supplier control and monitor of the supply of heat.

Cooling flow header
Cooling return header
Heating flow header
Heating return header
Thermal storage
Thermal storage
To cold network
To warm network

1. **Heat Pump Plant** – One or more heat pumps served by the heat intake or cool intake plate heat exchangers, specific arrangement via the headers allows for simultaneous heating and cooling from a standard heat pump unit, allows the development to operate as an island from the network is the loads are balanced at a point in time.
2. **Pumps** – pumping arrangements ensures either side of the heat pump can be used as a heat source/ sinkand allows reversible flow through the cooling intake heat exchanger, which is necessary to benefit from free cooling.
3. **Plate Heat Exchangers** – cold and warm network plate heat exchanger interface to allow for heat abstraction/ rejection.
4. **5DHC main network** – network incoming to plantroom from boreholes/ main 5DHC spine.
5. **Mixing Valves** – in place to balance temperature fluctuations onto the heat pump plant.
6. **Thermal Storage** – storage on the hot and cold systems to provide peak demand lopping capability and maximise utilization of the heat pump plant.

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Thank you!

Site visit to Millbay Boulevard

- Groups of 20
- 6 group leaders in hi-viz jackets
- Departing from the entrance
- We are not coming back here
- Please take your belongings

- Annabel Harris, AWP
- Headley Martin, South West Highways
- John Yianni, Pell Frischmann
- Jon Selman, Plymouth City Council
- Mick O'Connor, South West Highways
- Richard Bara, Plymouth City Council