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BUILT ENVIROMENT SERVICES (M5X01836)

DESIGN CRITERIA – WATER SUPPLY AND WASTE DRAINAGE

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Question 1

1.0 Introduction

As a result of climate change and rising populations in urban areas, at times of heavy rainfall, large volumes of surface water are entering the sewers. This is causing severe flooding and the risk of raw sewage being released into our rivers and fields. This has the potential for devastating effects on public health. The London 'Super Sewer' is currently under construction to eradicate London's sewage problems.

1.1 Sir Joseph Bazalgette

Joseph Bazalgette was a 19th century civil engineer that specialised in drainage and reclamation. In 1856 he was made chief of London's Metropolitan Board of Works. "The board's purpose was to provide infrastructure to cope with London's rapid population and economic growth. During the mid-19th century the transmission of Cholera was industrious. *From 1853 - 1854 more than 10,000 Londoners were killed by the disease.*" (BBC, 2015)

It was thought that the cholera epidemic was caused by foul air from the 'Great Stink of London' of 1858 and the toxic human and industrial waste exposed around the city. The many deaths and unliveable conditions within London gave good reason for environmental legislation and new infrastructure.

Bazalgette's solution was to flow foul water from old sewers and underground rivers to new, low-level sewers, built behind embankments on the riverfront. From there waste would be taken to new treatment works. By 1866 most of London was connected to a sewer network thanks to Bazalgette.

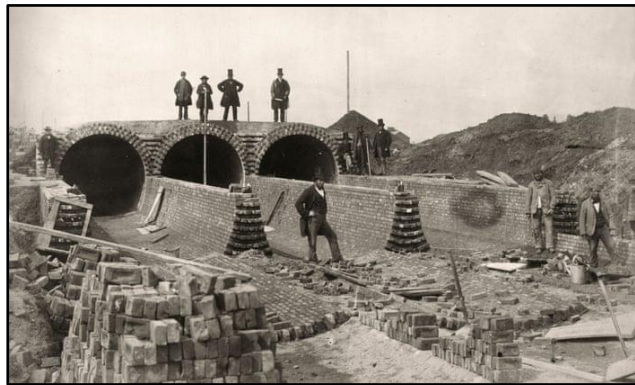


Figure A.1 Joseph Bazalgette (standing top right) oversees the construction of London's sewers in the 1850s. Photograph: (Herschan, 1850s)

"During 8 years of construction 100 miles long of main sewer were constructed with another 450 miles of sewer feeding them. It is estimated that the main sewer system took 318 million bricks and 670,000m³ of concrete to construct. The project cost £3m (around £342m today)" (ICE, 2017)

1.1.1 Modern Day Relevance

From these events we can directly link them to modern day construction, it proves just how important it is to minimize air pollution and water contamination. All construction sites generate high levels of CO₂ and dust (typically from concrete, cement, wood, stone, silica) from activities such as demolition and burning. Surface water run-off carries pollutants from our sites, such as diesel and oil, toxic chemicals, and building materials by-products like cement. If these substances get into our waterways, they can poison water, contaminate farmland and in turn harm animal life. It also shows how important it is to provide sanitary facilities for workers on site.

In addition, the sewer was constructed over 150 years ago with a further increase in population foreseen. It is highly important we construct for the future and sustainably in this way this.



“Joseph Bazalgette created a sewer system which he originally sized for London's needs of the time. He then doubled it to anticipate the future beyond. These are the qualities that I admire.”
(Foster, 2003)

1.2 Current System Problems

Currently millions of tonnes of raw sewage overflows into the Thames river every year due to the sewer reaching its maximum capacity. The population of London is currently 9 million which is predicted to reach 13 million in the next 30 years. The population of London when the first sewer was constructed was just 4 million. Dozens of new apartment blocks and workplaces are being constructed every year and each must join up to the existing Victorian sewer network.

An increase in rainfall as a result of climate change puts extra strain on sewers across the UK. From 2000-2018 the UK's eight warmest and 4 out of its 5 wettest years had occurred. Higher temperatures increase evaporation and consequently rainfall. The below graph shows London's annual average temperature increase (RED) compared to the five year average (BLUE).

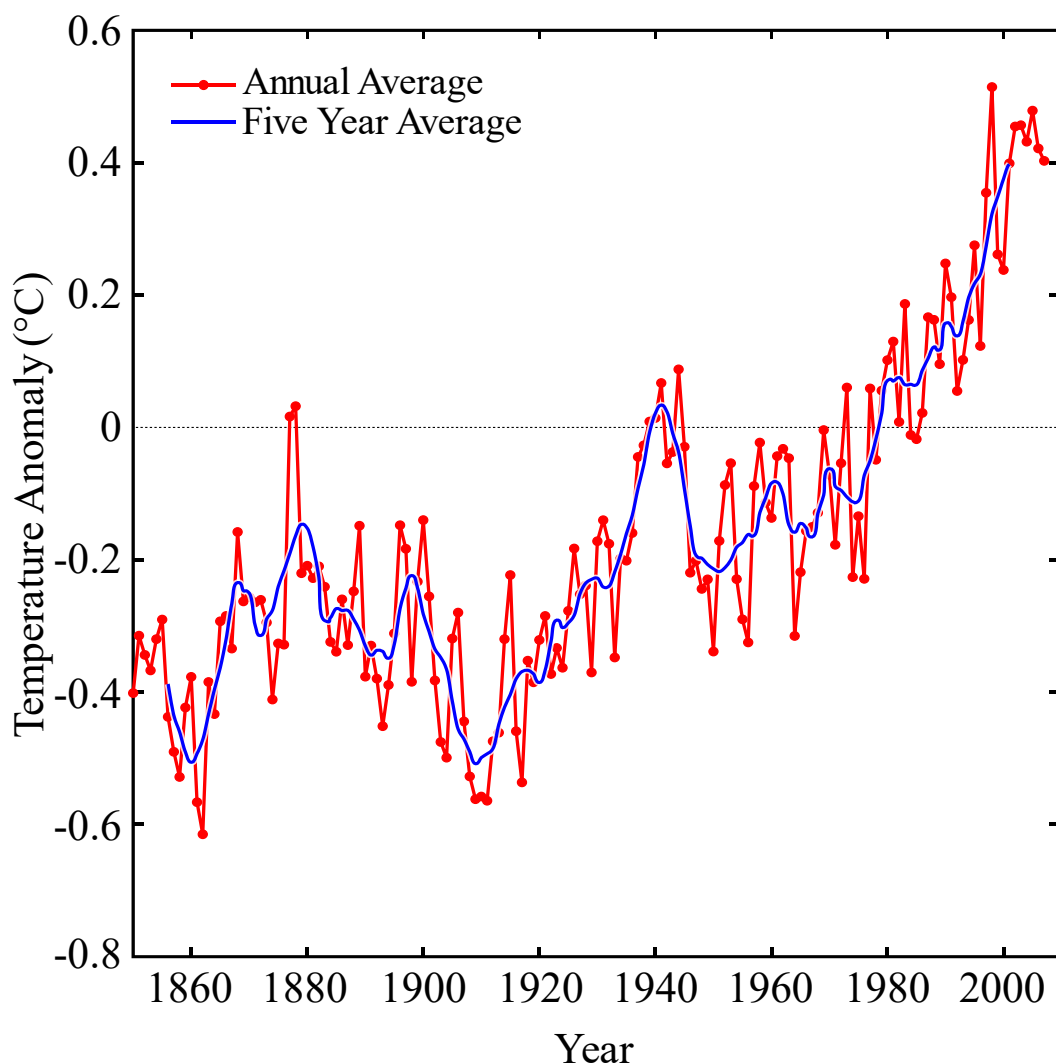


Figure A.2: The graph was completed by the Climatic Research Unit of the University of East Anglia and the Hadley Centre of the UK Meteorological Office. (Brohan, 2006)



1.3 London Tideway Super Sewer Project

The 'London Tideway Super Sewer' project is a £5bn answer to London's sewage and rain water issues. It is to stretch 25km under the Thames to intercept, store and convey raw sewage and rain water to Beckton Treatment Works in East London. The clean water is then released back into the River Thames. Planning decisions were made in 2014 and the construction stage is expected to be complete in 2023. Tideway is the organisation delivering the London Tideway Super Sewer. Once constructed, the main tunnel will have an internal diameter of 7.2m and will run from -30m at Acton in the west of London, under central London down to -60m at Abbey Mills in the east of the city using gravity to transfer waste.

London Tideway Super Sewer Project Timeline

- **2014;** Financing and planning decisions were made, and tenders were received from main contractors,
- **2015;** Main financing body and contractor awarded,
- **2016;** Preliminary construction works begins,
- **2018;** Tunnelling Begins,
- **2019:** Linking to main sewer begins,
- **2021;** Tunnelling ends,
- **2022;** Commissioning Stage,
- **2023;** Works Completed.

1.3.1 Combined Sewer Overflows (CSO)

"Combined Sewer Overflows (CSO) is when mixed sewage and stormwater are bypassed from a combined sewer system control section into a river, stream, lake, or ocean through a designed diversion outfall, but without treatment." (What is CSO?, 2016)

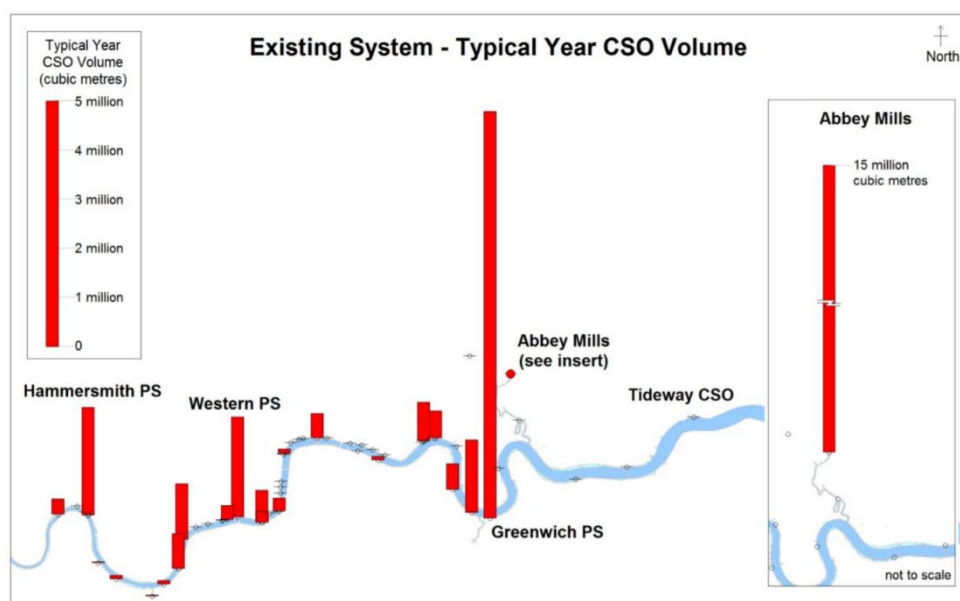


Figure A.3 (Tideway, 2016)



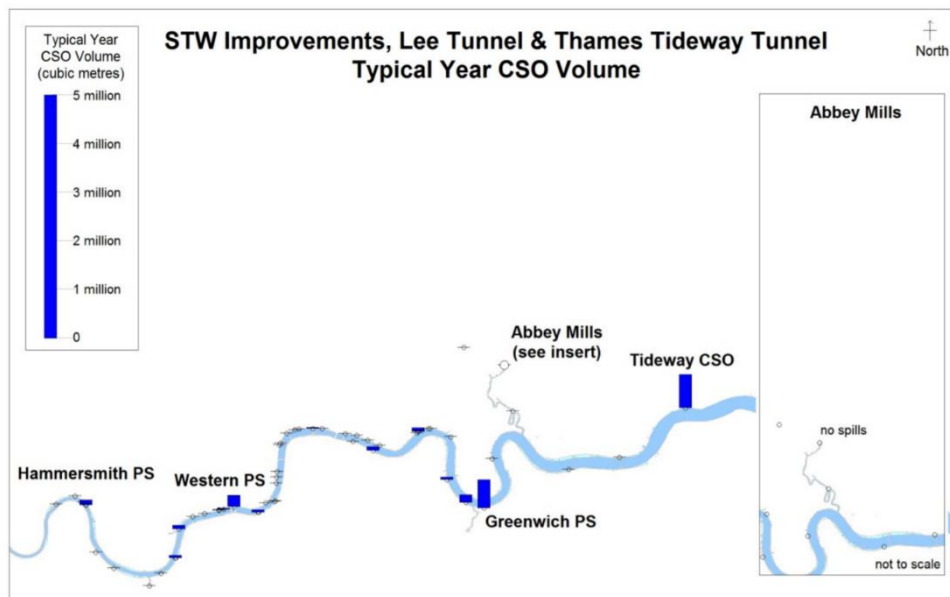


Figure A.4 (Tideway, 2016)

Figure A.3 shows the typical CSO spill volume into the Thames River annually whilst the Joseph Bazalgette Victorian sewer is operational and **figure A.4** shows the projected annual CSO spill once the Thames Tideway Sewer has been completed. The expectable change in spill from now to when the sewer is operational in 2023 is profound. Where Abbey Mills was spilling over 15m cubic metres into the Thames it is set to have ZERO spills from 2023 onwards.

1.3.2 Other advantages

There are many reasons to support the project, for instance;

- The purpose of the project is to conform to new EU environmental standards. The city stands to be fined hundreds of millions of pounds a year by the EU if it continues to allow the Thames to be polluted.
- The sewer gradually declines towards Abbey Mills in the east of the city using gravity to transfer waste which means it is sustainable in that there are means no pumps needed to transfer waste.
- Marine life in the river will recover with the help of marine experts as a result of the project.
- The project employs over 4,000 workers currently and directly gives concrete and plant providers vital business.
- A rejuvenated river economy and completely new areas of public space will be the outcome from a healthy river.

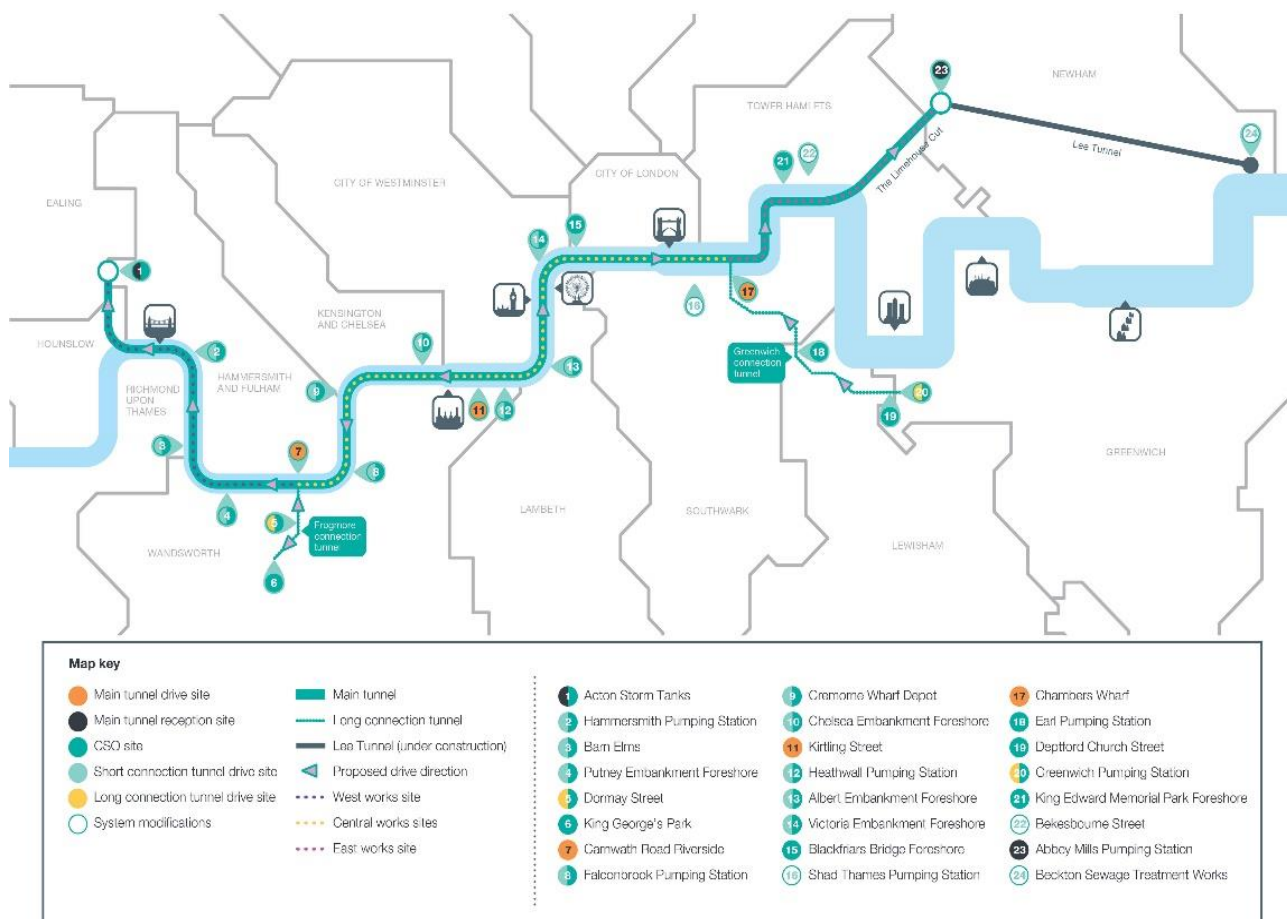


Figure A.5: The above map shows the route in which the main and connection tunnels will take, 90% of the main tunnel runs underneath the river Thames. Credit: **Tideway, 2016.**

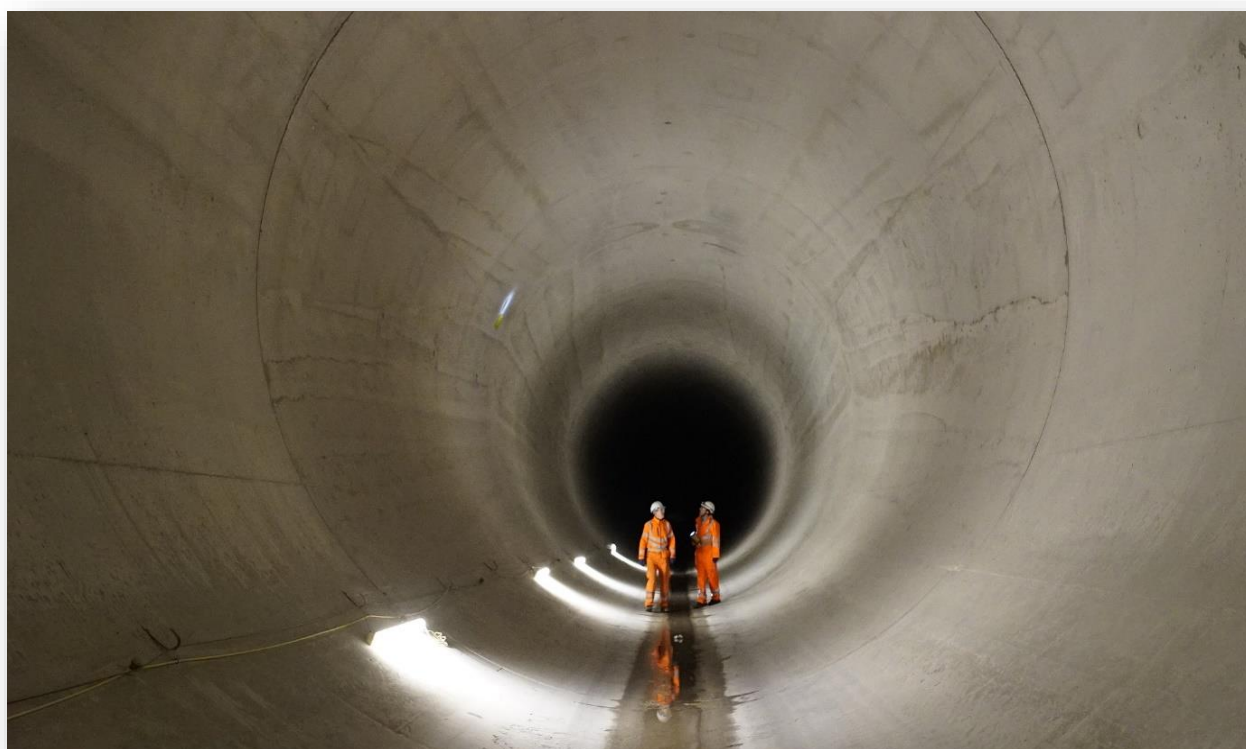


Figure A.6: A view from within a completed section of the main sewer. (London Super Sewer, 2018)



1.4 Project Considerations

Having 44 different construction sites open at one time in central London can cause serious logistical, environmental, noise and vibration issues, as well as all the problems that come with working in proximity of pedestrians. In addition, London has been inhabited for 1000s of years and there is not knowing what could be below the surface.

1.4.1 Noise & Vibration

As a result of piling work and bore hole drilling done by Thames Tideway Tunnel, neighbouring buildings can experience severe noise and vibration as a result. These can cause structural harm to neighbouring buildings and the contractor can be prosecuted for any damage as a result. Responding to a report of excessive noise a **Thames Tideway Tunnel spokesman** said: *“There are strict guidelines which limit noise levels and working hours and we aim to do everything we can beyond these to reduce any disruption. We provide regular information to residents and we are available to talk to anyone with any concerns.”*

In addition to this, noise monitoring and a noise and vibration management plan should be implemented to control these variables. The plans are available online and one for the Albert Embankment can be found on **Appendix A.1. Part N5 Page 31** shows Tideway’s noise and vibration investigation. The site is to connect the existing local combined sewer overflows underneath Vauxhall Bridge to the main tunnel.

1.4.2 Environmental Impact

Environmental impact must be assessed during planning. The project plan of the Albert Embankment development on **Appendix A.1 Part N5 Pages 23-29** gives reference to;

- Limiting the impacts from construction,
- Water quality, water resources and flood risk,
- Water quality and resources,
- Flood risk,
- Air quality, emissions, dust and odour,
- Biodiversity and geological conservation,
- Landscape and visual effects,
- Land use and open space.

1.4.3 Logistics

Like the Leadenhall building project, there is small work space within central London. Therefore, logistically getting plant, concrete and other materials to site can cause further congestion. This can be a nuisance and can be punishable by fines. Therefore, other modes of transport must be utilised to relieve the streets. *“We’ve tried to utilise the river as much as possible, to alleviate the traffic on the roads in the current planning route,” says Tideway spokesman Cantwell. “We use barges and boats to transport 90 percent of our material to and from the site, which is something that has never been done before.”*

Tideway also produce ‘Transport Assessments’ for each of their 44 sites across London. They are available to the public, the assessment for the Albert Embankment Foreshore site can be found on **Appendix A.2**. It includes information on transportation methods, peak traffic levels, street widths and proposed transport routes.



Design access statements have also been made available to the public which outline site boundaries, pedestrian routes, traffic and cycle diversions. They also provide designs of the finished product and information about their purpose (**see appendix A.3**)

1.4.4 Below Ground Conditions

Since the project covers such a large area of London with 44 sites operational at its peak there is a big possibility that utility wires/pipes, WW2 bombs and other archaeology will be below ground. All of which can result in long setbacks, redesigning and in-turn added costs for the client. See **appendix A.1 N5 Pages 33-35** for tideway's assessment of archaeology and listed buildings.

1.5 Attitudes

Public perception of large-scale projects highly important. Listening to the community can help improve the projects buildability and can help correct any overlooked construction aspects.

1.5.1 For

The gauge of the huge sewer is necessary, said **Thames Water engineer Phil Stride**; *"It ranks with the building of the underground, Crossrail and the Channel tunnel itself. But it will solve the problem of pollution in the Thames for 100 years. Now, 39m tonnes of sewage goes into the Thames every year; this tunnel will collect 96% of it."*

1.5.2 Against

"There is considerable debate about the overall scale of the project and the value for money of some of the 16 overflows. An alternative approach would be to deal with excess water at or near source, prior to it entering drainage or sewer networks." Instead we must *'see stormwater as an opportunity to enhance the public realm rather than as a threat, we must use stormwater close to its source in buildings, and we must implement green roofs for slowing down runoff and improving water quality.'* (**Richard Ashley (Professor of urban water and researcher at the Department of Civil and Structural Engineering, 2015)**)

Chartered Institution of Water and Environment Management (CIWEM) also supported this method saying, *"This house considers that the Thames Tunnel would be worse value than controlling rainwater near source."*

1.6 Legislation and Governing Bodies

- These discharges, of combined raw sewage and rainwater, need to be reduced to comply with the EU's Waste Water Treatment Directive (UWWTD) and to improve the ecology of the river.
- The Environment Agency and other government bodies put pressure on construction companies to reduce pollution and to conform to environmental regulations. Penalties can include unlimited fines and even imprisonment.



Question 2

2.0 Introduction

There are variety of ways in which houses are supplied water in the UK, each way can depend on the properties age, property type, location and water supplier. The Water Supply (Water Quality) Regulations 2018 (**Appendix B.1**) and Approved document G 2015 (**Appendix B.2**) set out the installation requirements and information for anyone installing, modifying or maintaining domestic plumbing systems. The Water Regulations Advisory Scheme (WRAS) Guidance Note 09-02-05 must also be strictly adhered to.

2.1 UK Housing Stock

According to the 'Welsh Housing Conditions Survey 2017-18 Report' published by the Welsh Government, Wales is said to have the oldest housing stock of all four UK nations. Over a quarter of all dwellings (26 per cent) are built prior to 1919. The full report can be found on **appendix B.3**.

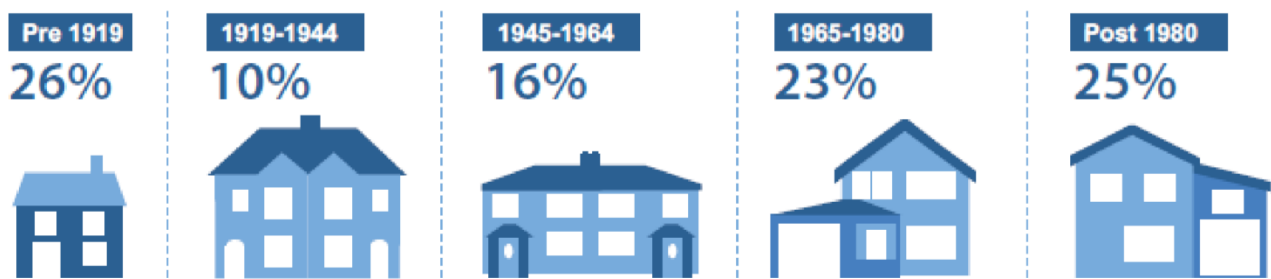


Figure B.1: Shows Wales' ageing housing stock. **Source:** Government, (2017-2018)

2.2 Cold Water Supplies

The 2 main types of cold-water supplies in the UK are direct and indirect. Although for mid/high rise buildings, boosted supplies are essential to pass water through break tanks to keep water pressurized (**See appendix B.4**).

2.2.1 Direct System

The mains water comes in through a rising main and directly feeds all the cold taps and a water heater, this means that all the taps and other water feeds are at mains water pressure. For efficiency, a high-pressure water supply is essential, particularly at periods of high demand. Pipework in this system is minimal and the storage cistern supplying hot water are only 115 litres in capacity. The diagram for this system can be found on **appendix B.5**.

2.2.2 Indirect System

The indirect system sends fresh water into the property through to the stopcock valve. Once the water has reached here, you can get drinking water from the kitchen sink, but the rest of the



water is moved to a storage cistern which supplies the water for the rest of the property. The cold-water storage cistern has a minimum capacity of 230 litres, which is commonly located in the roof space. The diagram for this system can be found on **appendix B.6**.

To check what system is in the home, isolate the water supply at your stop cock. When you have isolated the supply turn your bath and wash basin, cold water taps on. If after 10 seconds cold water continues to run then you have an indirect system, if the water has stopped you have a direct system.

2.2.3 Advantages & Disadvantages

Figure B.2: Direct Cold-Water System

Advantages	Disadvantages
Cheaper to install (Less pipework is needed, and less time needed to install).	More pressure on fittings can result in more noise and wear.
Less risk of contamination.	During peak usage period, pressure within the system can be reduced.
More efficient due to less pipework and more pressure.	In an event of an emergency, there is little water available due to the smaller cistern.
Drinking water available at every draw-off point and maintenance valves can be fitted to isolate each section of pipework.	
Can be situated within airing cupboard due to a smaller cistern.	

Figure B.3: Indirect Cold-Water System

Advantages	Disadvantages
This system has less pressure, meaning less noise and wear on fittings.	Less efficient as water must travel further through pipework.
The water authorities prefer this system as it imposes less demand on the main at peak times.	The system requires more pipework than a direct system and is therefore more expensive to install.
It provides an adequate emergency storage in an event of a shortage.	Doesn't supply drinking water to all taps in the house.
Less maintenance in pipes and fittings.	More structural support needed in the property for large heavy cistern.

2.3 Hot Water Supplies

Currently there are two main conducts of supplying hot water systems in the UK; directly and indirectly. Older domestic properties may have cylindrical systems that can be vented or unvented. Instantaneous systems are widely used and form combination and condensing boilers. These boilers are fed directly from the mains.

2.3.1 Direct System

The water is heated directly from the heat source either by an immersion heater or by the boiler. The diagram for this system can be found on **appendix B.7**.



2.3.2 Indirect System

The central heating and the hot water are separate. The water is heated via a coil from a boiler. The diagram for this system can be found on **appendix B.8**.

2.4 Instantaneous Combination & Condensing Boilers

Combination (non-condensing) and condensing boilers act as water heaters and a central heating boiler in a **single compact** unit. This is an instantaneous system which involves using to heat the water to a useable temperature without the need to store the water. Water supply is from the mains and therefore a direct system. The system is sealed and has an expansion vessel and is pre-plumbed and wired for easy installation. Both boilers are powered by fossil fuels that therefore produce tons of CO₂.

The difference between combination and condensing is that condensing is more efficient. They are more efficient because firstly, they discharge gasses at 50-100 degrees and not 120-200. Secondly, liquid from the condensation is drained away and the heat in this waste flue is used to pre-heat the cold water going into the boiler, this is known as the secondary heating effect. Combination boilers are now compulsory in domestic properties and require a SEDBUK (Season Efficiency of Boilers in the UK) minimum efficiency rating of 86%. The diagram for the condensing boiler system can be found on **appendix B.9**.

British Standard 6798 regulates: Specification for selection, installation, inspection, commissioning, servicing and maintenance of gas-fired boilers.

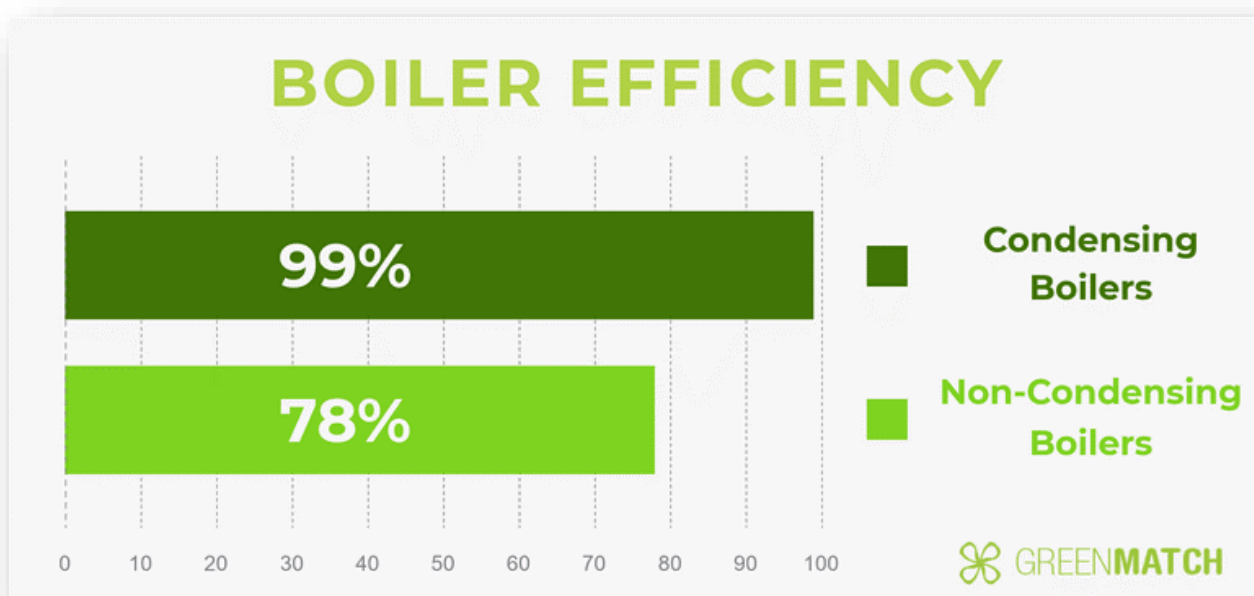


Figure B.4: The condensing boiler is far more efficient than the most efficient non-condensing boiler (**GreenMatch, 2018**) Therefore condensing boilers produce far less CO₂ than a combination boiler, resulting in fuel savings.



2.4.1 Advantages & Disadvantages

Figure B.5: Condensing Hot Water System	
Advantages	Disadvantages
Saves costs by not keeping water stored at a required temperature. The boilers also only heat water that is needed.	The more complex system can be more expensive to maintain and repair.
These systems save installation time and floor space as there is no need to install cistern in the roof space and associated pipework.	Very high installation and unit cost.
Condensing boilers significantly reduce carbon emissions.	
Cost efficient in the long-run.	
Exhaust gas is recycled through the condensing heat exchange.	

2.5 Frequency

It can be assumed that the most common type of cold-water system in Wales is the indirect system because this system it is most commonly found in older housing, where in Wales 75% of houses are built before 1980 (**See Figure B.1**). Whereas the direct system is the most popular in modern houses which make up the other 25%.

In hot water systems, approximately 14 million households are fitted with a combination or condensing gas boiler making them the most common hot water system. These systems are 'direct' supply. I can assume that most households will be fitted with pre-2005 combination boilers. Over the next few years that majority will change when condensing boilers will replace combi's when older buildings undergo retro-fit and when more new-build housing estates are constructed.



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Appendices

A.1 – Tideway Albert Embankment Site Planning Statement (January 2013)

URL: <https://www.tideway.london/media/1847/701-planning-statement-appendix-n-planning-assessment-albert-embankment-foreshore.pdf> planning statement

Part N5 Pages 23-29 gives reference to environmental impact;

- Limiting the impacts from construction,
- Water quality, water resources and flood risk,
- Water quality and resources,
- Flood risk,
- Air quality, emissions, dust and odour,
- Biodiversity and geological conservation,
- Landscape and visual effects,
- Land use and open space.

Appendix A.1. Part N5 Page 31 shows Tideway's noise and vibration investigation.

Appendix A.1 N5 Pages 33-35 shows Tideway's assessment of archaeology and listed buildings.

A.2 – Tideway Albert Embankment Site Transport Statement (January 2013)

URL: <https://www.tideway.london/media/1727/71013-transport-assessment-albert-embankment-foreshore.pdf>

A.3 - Tideway Albert Embankment Site Design and Access Statement (January 2013)

URL: <https://www.tideway.london/media/1782/704-design-and-access-statement-albert-embankment-foreshore.pdf>

B.1 - The Water Supply (Water Quality) Regulations 2018

<http://www.legislation.gov.uk/wsi/2018/647/made>

B.2 – Approved Document G (2015)

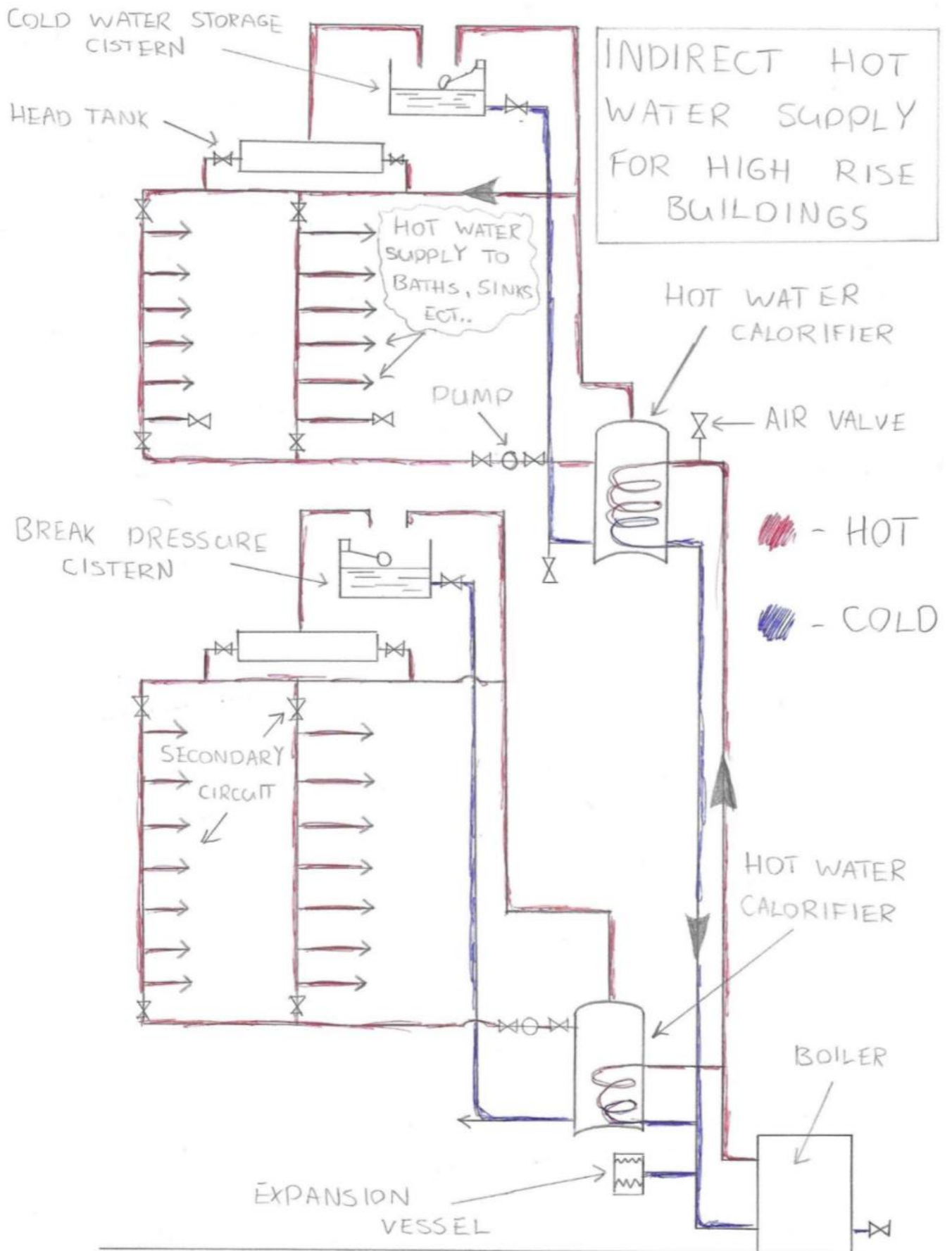
URL: https://www.designingbuildings.co.uk/wiki/Approved_Document_G

B.3 – Welsh Housing Conditions Survey 2017-18 Report

URL: <https://gov.wales/docs/statistics/2018/181206-welsh-housing-conditions-survey-headline-report-2017-18-en.pdf>

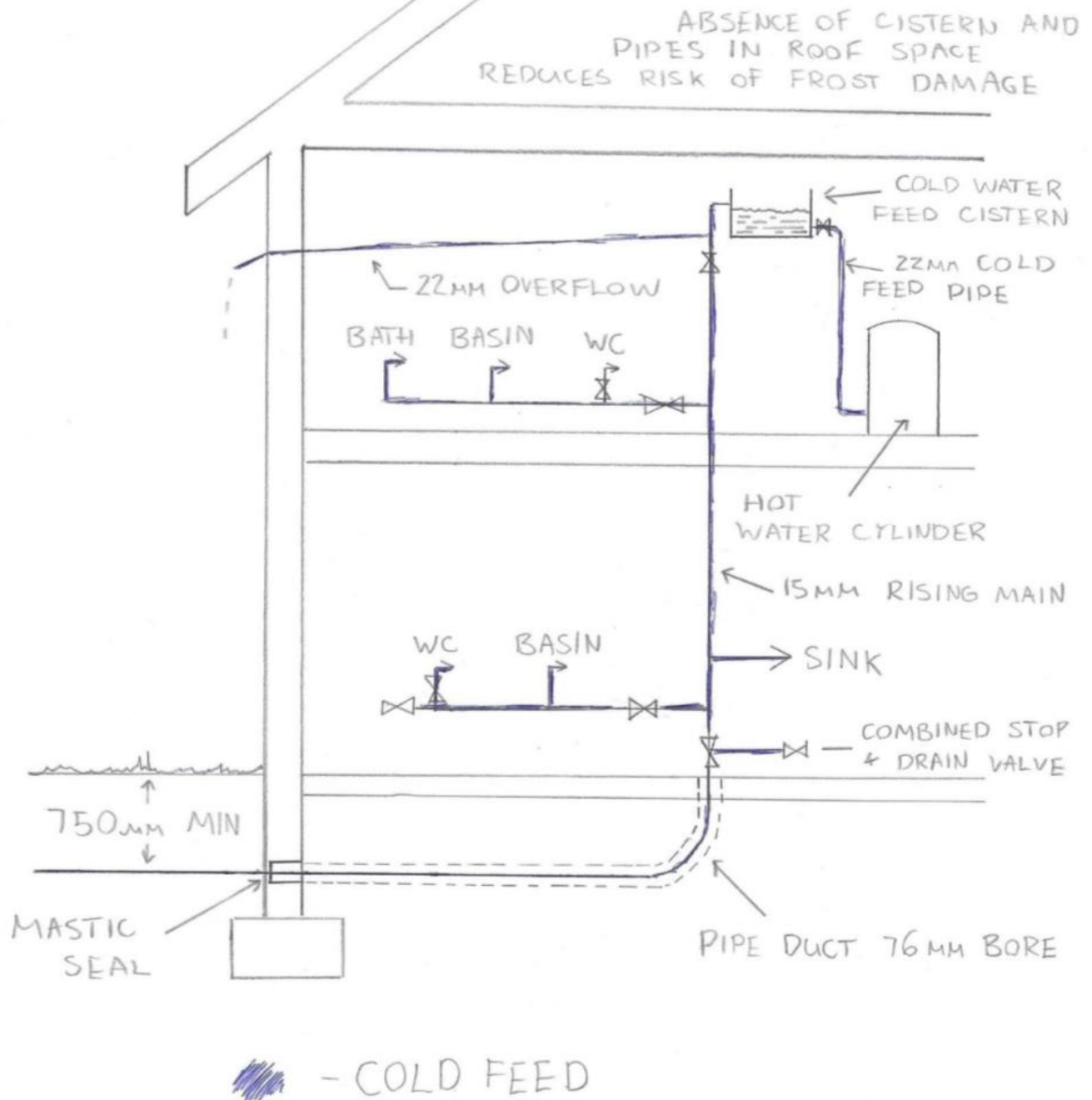


B.4 - Sealed Indirect Hot Water System for a High-Rise Building Diagram



B.5 - Direct Cold-Water System Diagram

DIRECT COLD WATER SUPPLY

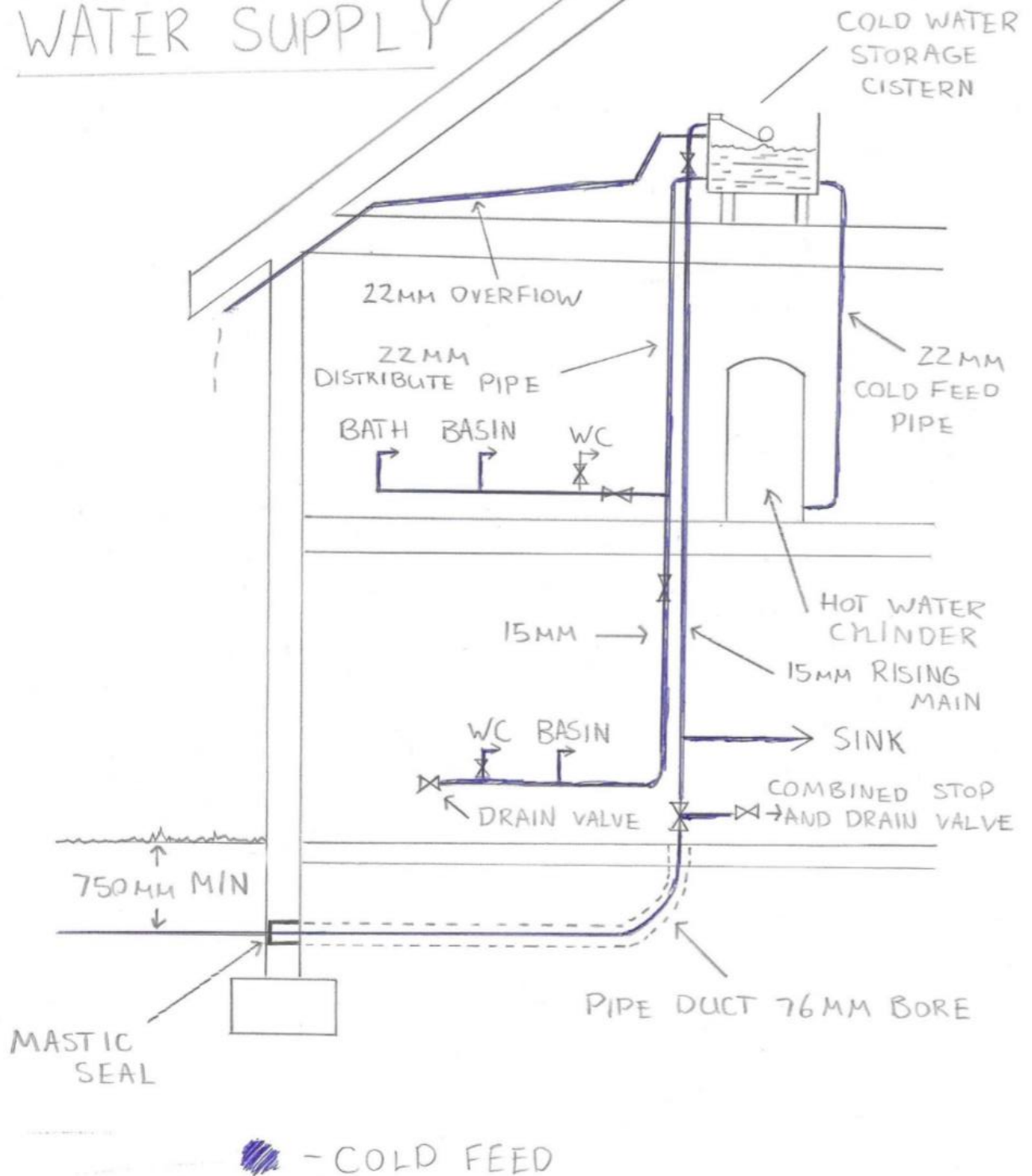


REF: THE WATER SUPPLY REGULATIONS (1999)



B.6 - Indirect Cold-Water System Diagram

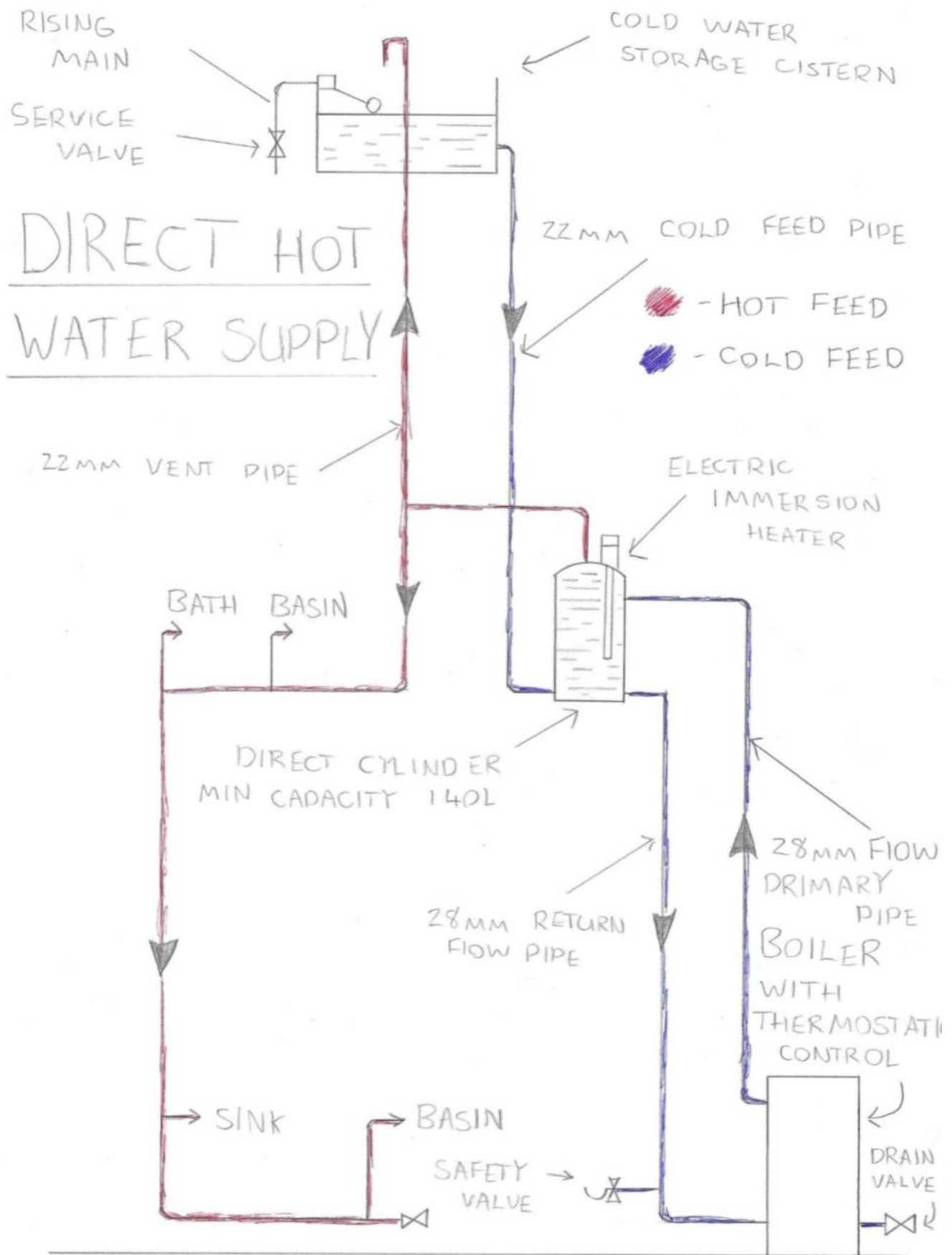
INDIRECT COLD WATER SUPPLY



REF: THE WATER SUPPLY REGULATIONS (1999)



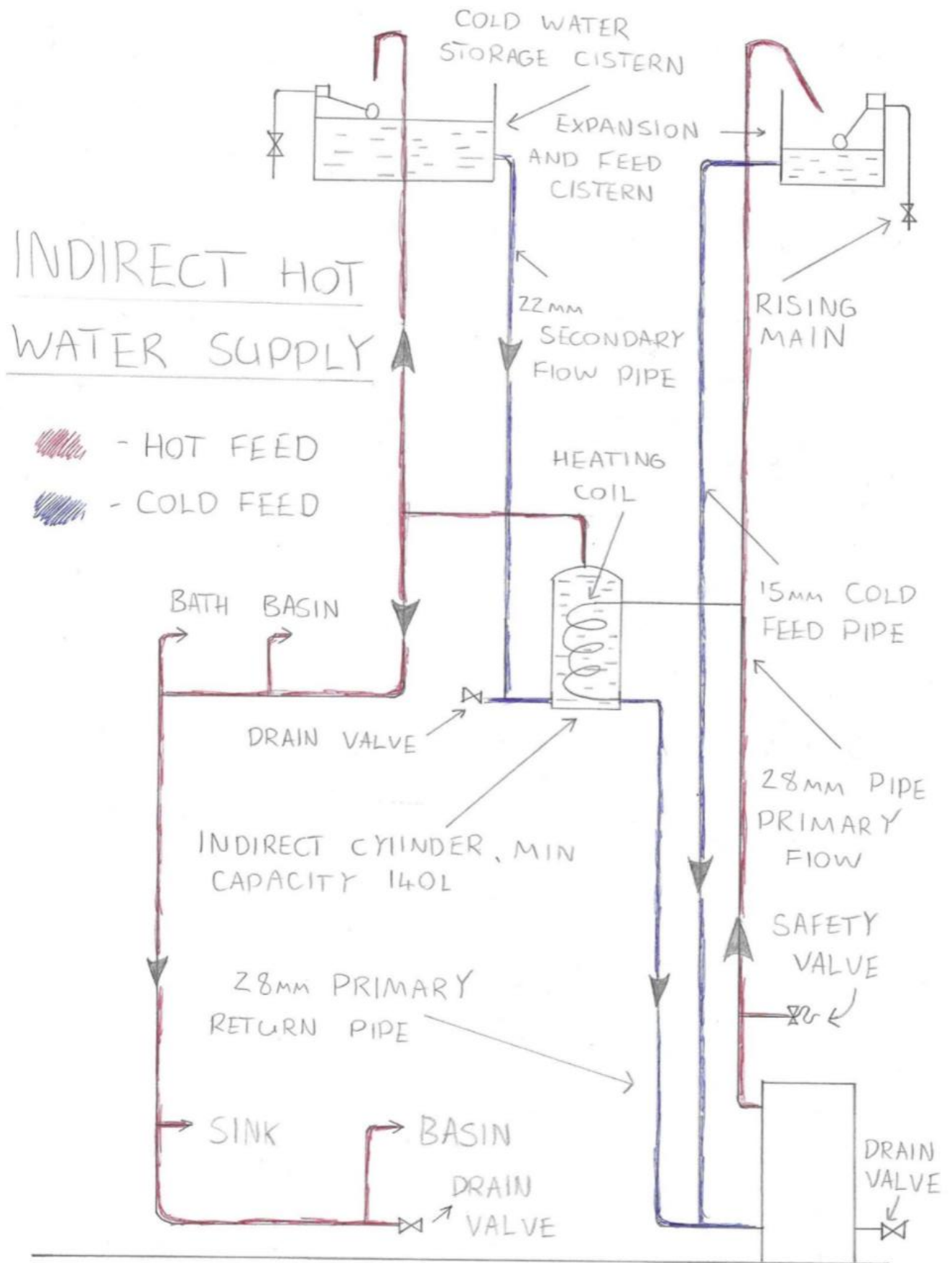
B.7 - Direct Hot Water System Diagram



REF: THE WATER SUPPLY REGULATIONS (1999)



B.8 - Indirect Hot Water System Diagram



REF: THE WATER SUPPLY REGULATIONS (1999)



B.9 - Condensing Boiler Diagram

REF: BUILDING REGULATIONS. DOMESTIC BUILDING SERVICES COMPLIANCE GUIDE.

COMBINATION BOILER

