Cardiff Council

Atlantic Wharf

Atlantic Wharf Drainage Strategy Report

CAH-ARP-AX-XX-RP-C-XX-0410

P02 | 24 August 2021

This report takes into account the particular instructions and requirements of our client.

It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

Job number 281124

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1 Introduction

The Atlantic Wharf development is proposed to redevelop part of Cardiff Bay over a period of seven years. The development area incorporates the area of the Red Dragon Centre and associated car parks, County Hall and associated car parks.

The red line boundary for the masterplan is shown in Figure 1 below.

Figure 1 – Extent of Atlantic Wharf masterplan area

The proposed development shown in Figure 1 will include the new Cardiff Arena as well as residential, hotel, commercial and office buildings and a new multistorey car park. There will also be additional areas of water bodies which will be created as part of the scheme, fed from Bute East Dock.

This Drainage Strategy will consider the surface water and foul drainage across the area shown above, considering the appropriate standards and legislation. The area of the Arena and the attached hotel will be considered within a separate drainage strategy provided as part of a detailed planning application and is therefore not considered in further detail.

2 Legislative Background

2.1 Surface Water Drainage

The Flood and Water Management Act 2010 was enacted by UK government in 2010, and reformed the way that flooding, including from surface water, was considered. Part of this Act was known as Schedule 3, which dealt with the approval and adoption of surface water drainage features. This part of the act was to make approval of Sustainable Drainage (SuDS) features mandatory, along with their adoption if they served more than one property, in order to allow for more widespread adoption of SuDS.

On 7th January 2019, the Sustainable Drainage (Approval and Adoption) (Wales) 2018 legislation came into force, which enacted Schedule 3. In practice, any development which is larger than 100m^2 and impacts on surface water drainage requires approval from a SuDS Approval Body (SAB). If a SuDS feature serves more than one property, adoption of this feature is mandatory by the SAB.

As the Atlantic Wharf Masterplan area is approximately 15ha it will require SAB approval from Cardiff Council. Adoption may also be required for much of the surface water drainage system due to the development of parcels by different developers.

In order to gain SAB approval, the proposals must be designed in accordance with the Welsh Government Statutory Standards for Sustainable Drainage Systems 2018. This document provides guidance on the design, construction, operation and maintenance of drainage systems, along with requirements which must be met for discharge and water quality.

3 Site Description

3.1 Existing Surface Water Drainage

3.1.1 Existing Drainage

The area is currently served by a series of surface water drainage systems, with highways drainage and surface water sewers within the site, shown in Appendix B.

DCWW records show a 1125mm diameter concrete surface water sewer which runs down Schooner Way before crossing under the Red Dragon Centre at 1350mm dia. Verbal communications with DCWW have suggested that this has been diverted as part of the construction of the Red Dragon Centre, however there are no records of the route of this diversion. A survey of this sewer has been requested to confirm the location and depth of the diverted sewer.

An existing 450mm-600mm diameter surface water sewer is shown on DCWW records to run down Hemingway Road before connecting to the 1350mm surface water sewer. A survey of existing utilities in this area did not identify the depth of this sewer.

The existing sewers run along the adopted highways of Schooner Way, Hemingway Road and Lloyd George Avenue, therefore easement agreements may not be present. Should the extent of adopted highways change, easement agreements may be required to ensure that DCWW will maintain rights of access to their assets.

Through discussions with Cardiff Council, it is believed that all the existing buildings within the extent of the Atlantic Wharf masterplan outfall to the existing DCWW sewers which run through the area.

3.1.2 Dock Feeder

Record drawings indicate the Dock Feeder Culvert flows north to south through the proposed site. A further culvert runs from Bute East Dock in the east and joins the Dock Feeder Culvert in the south-east corner of the site. Plans received from Associated British Ports (ABP) have shown an indicative route, which is shown in Appendix A.

Information from ABP suggests that the Dock Feeder Culvert that runs through the car parks of County Hall and Red Dragon Centre is a reinforced concrete box culvert 2.25m width by 1.8m height. The outfall from the Bute East Dock is noted on the ABP plan as a 2.4m diameter corrugated steel pipe. Both these culverts join in the south-east, the downstream culvert crossing the A4232 road is shown by ABP as being 3.01m in diameter.

3.1.3 Bute East Dock

Bute East Dock is at the eastern boundary of the masterplan. This is owned by ABP and forms part of the system of surface water management which maintains the docks system across Cardiff with water. The dock is fed from the north by a tilting weir which is part of the dock feeder network. The outfall is to the south of the dock to a 2.4m diameter corrugated steel culvert, it runs beneath the Water Quarter residential plot, Hemingway Road and the car park west of Future Inn before connecting into a large, open stilling basin structure which includes a weir that controls the level of Bute East Dock. ABP indicate that the weir is at a level of 7.92mAOD.

3.1.4 Surface Water Pumping Station

The surface water sewer which runs under the Red Dragon Centre outfalls to the pumping station to the south of the Red Dragon Centre, shown in Appendix B. The pumping station takes the surface water flow at low level and pump it high enough to flow by gravity over the top of the Bute Tunnels.

This pumping station is of a significant size. Drawings recovered show that above ground there is a control building, which houses a standby generator, control room, toilets and staff area and potentially an 11kV/400V transformer. The footprint of this building is approximately 12.5m by 9.8m. There is a two storey structure for the pumping station, which reaches approximately 7.9m depth to internal bottom of slab. This contains a series of major pumps, valves and access points. This is believed to be a reinforced concrete structure. The footprint of this structure is believed to be approximately 15.2m by 7.7m.

It is believed that this is a DCWW asset, although confirmation is required.

An easement of 15m around the wet well of the pumping station has been assumed in accordance with Sewers for Adoption 7th Edition. This should be confirmed with DCWW.

3.2 Existing Foul Drainage

DCWW records show a 130mm MDPE foul rising main is located on the north side of Hemingway Road conveying flows from the east and connecting to a break pressure chamber in the footway/cycleway of Lloyd George Avenue. The Red Dragon Centre is also believed to outfall to this DCWW chamber.

A utilities survey undertaken to inform the Cardiff Arena design indicates foul drainage from the western corner of the existing County Hall building conveying flows to the north. This appears to outfall into a pumping station on Schooner Way which pumps flows to the north through a rising main located in Schooner Way.

Foul drainage connections from the commercial units in the east of the Red Dragon Centre site to the public sewer have not been identified.

3.3 Existing Ground Conditions

The historic land use for the Atlantic Wharf is dockland, as part of the wider Cardiff Docks. The British Geological Survey (BGS) Geology of Britain online viewer and geology map (Sheet ST17NE) shows the site to be underlain by superficial deposits of Tidal Flat Deposits (Estuarine Alluvium) and Glaciofluvial Deposits, which overlie the Mercia Mudstone Group bedrock.

Given the historical development of the area as dockland, more recently reclaimed, the natural ground is expected to have been disturbed and overlain by made ground materials.

The thickness of made ground will be variable and heterogenous, with the most significant thicknesses anticipated to be within the infilled dock, reservoir and timber pond features. The made ground is likely to comprise a mixture of natural reworked and man-made materials.

Made ground across the site is considered to be a potential source of contamination, and could potentially provide risks to human health and controlled waters. A geological constraints plan is contained in Appendix C.

There is risk of unexploded ordnance across the site from high-level World War II. Further action to mitigate the risk should be considered as part of the geotechnical reports.

4 Proposed Surface Water Drainage

4.1 S1 – Surface Water Runoff Destination

The masterplan area will require SAB approval; therefore the design will need to be compliant with the Statutory Standards discussed above. Initial discussion have been held with the SAB officer, and a pre-application is to be submitted shortly.

For consideration of discharge, the priority levels outlined in the 'Statutory Standards for Sustainable Drainage Systems' should be considered for the proposed slab.

Disposal of surface water from the site should be considered in the following hierarchy:

- Priority Level 1: Surface water runoff is collected for use
- Priority Level 2: Surface water runoff is infiltrated to ground
- Priority Level 3: Surface water runoff is discharged to a surface water body
- Priority Level 4: Surface water runoff is discharged to a surface water sewer, highway drain, or another drainage system
- Priority Level 5: Surface water runoff is discharged to a combined sewer

The following sections consider in turn the feasibility of achieving each priority level.

4.1.1 Priority Level 1 – Surface water runoff is collected for use

Due to the variety of different building uses proposed in this area, it is possible that some buildings may have use for rainwater harvesting. However, at this stage of the development it is not possible to confirm the likely demand.

In addition, rainwater harvesting requires a secondary outfall which must be designed to cater for the critical storm. As a result, rainwater harvesting has been discounted and other priority levels have been considered at this stage.

4.1.2 Priority Level 2 – Surface water runoff is infiltrated to ground

Prior to the development of Atlantic Wharf, the site formed part of Cardiff's dockland and included building, docks, railways and reservoirs. As shown in Appendix C, the historical development of the site results in high potential for contamination. The historic pre development ground conditions are also unlikely to be suitable as they are Glaciofluvial Deposits and Estuarine Alluvium, which have poor infiltration properties. As a result, infiltration of surface water runoff

generated on the site is not a suitable solution, and all SuDS features will need to be lined.

4.1.3 Priority Level 3 – Surface water runoff is discharged to a surface water body

The closest surface water body to the site is Bute East Dock which is located immediately to the east of the catchment. Other nearby surface water bodies include Roath Basin, located approximately 80m to the south of the site, and Cardiff Bay, approximately 265m to the south of the site.

As the site is relatively flat, it may not be feasible to outfall some of the south and western areas of the site to Bute East Dock. Additional waterbodies are proposed within the site, which will be fed off Bute East Dock, and extend into Atlantic Wharf by approximately 140m. This may enable more of the site to discharge to Bute East Dock.

The Cardiff Arena is currently proposed to outfall to the Bute East Dock. It is proposed that approximately 60% of the wider masterplan site could also outfall to the dock. The remainder would need to outfall to a different source. A catchment plan is shown in Appendix D which shows the proposed catchment split.

4.1.4 Priority Level 4 – Surface water runoff is discharged to a surface water sewer

It is proposed that for the areas of the site which are unable to reach the Bute East Dock by gravity that they should outfall to the existing DCWW surface water sewer in Hemmingway Road to replicate the existing destination. This is to be confirmed with DCWW.

The remaining hierarchy of discharge is not considered further as this is the preferred method of discharge.

4.1.5 Impact on Bute East Dock

A technical note has been produced to assess the impact of outfalling flows from the Arena and Travelodge to Bute East Dock, titled '*Cardiff Arena – Bute East Dock Impact Assessment*, see Appendix E. The principles outlined in the note have been used to assess the impact of areas of the wider masterplan outfalling to the dock, in addition to the flows from the Arena and hotel.

For these calculations, the combined influence of the Atlantic Wharf masterplan and the arena have been considered, to determine the total impact on the dock. Initial calculations undertaken for the wider masterplan surface water drainage strategy indicate that surface water drainage outfalls from East Bute Dock Quarter, Waterfront Quarter, Car Park Quarter and the Red Dragon Centre Building from the Mixed Use Quarter will be able to contribute to Bute East Dock. In addition to the Arena and hotel, this results in a total area of 85,350m^2 which will contribute to the dock.

Plans provided by ABP note that the crest of the weir downstream of the dock is 7.92m AOD. As this weir is understood to control the water level in the dock, it is therefore assumed that the equilibrium water level of Bute East Dock is 7.92m

Assuming the existing area contributing surface water drainage to Bute East Dock is just the area of the dock itself, the existing water level change during a range of return period storm events have been estimated, using the methods detailed in the Bute East Dock Impact Assessment

The additional area contributing to the dock will result in the dock water level increasing to 8.012m AOD in the critical storm, 240 minute 100 year summer storm, with 40% climate change. In the existing case, the maximum water level in the dock during the critical storm without the contributing Atlantic Wharf area has been estimated to be 7.973m. This results in a 39mm rise in water level during the critical storm, compared to existing.

The coping level has been determined from a topographical survey to be 8.37m AOD, which results in a 358mm freeboard in Bute East Dock when the Arena and additional Atlantic Wharf areas are added. The change in water level in the critical storm are shown in Figure 2.

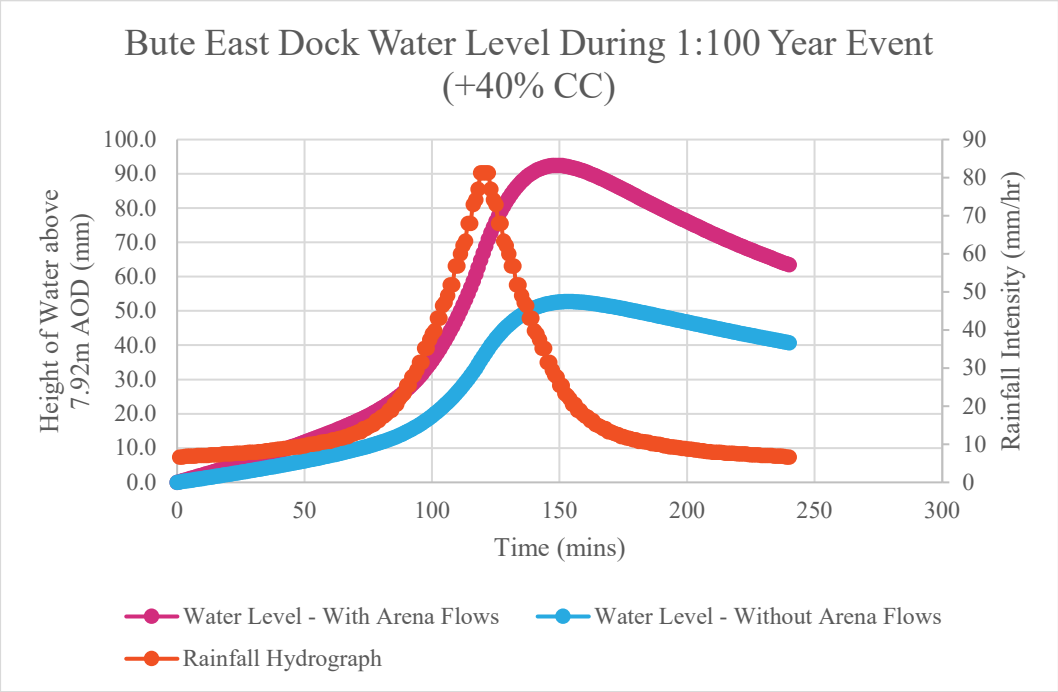


Figure 2 – Bute East Dock Water Level Change

4.2 S2 - Surface water runoff hydraulic control

4.2.1 Interception

The Welsh Government standards for interception encourage the use of green infrastructure in order to intercept the first 5mm of rainfall for 80% of events in summer and 50% in winter. There are a series of recommended ways of providing these. These are considered below:

1. Green roofs – There are green roofs specified for several of the buildings across the site. These are shown in Appendix D and will provide a green roof area of 4,500m^2.
2. Rainwater harvesting – This could potentially be of use on the individual building plots, but it is not believed that a combined rainwater harvesting tank from multiple buildings and public realm areas would have a practical benefit. Therefore it is not recommended further.
3. Soakaway/infiltration systems – As stated above, infiltration is not feasible due to risk of contamination due to the previous of the site as the Cardiff Docks.
4. Permeable surfaces – Several different options for permeable surfaces are discussed below.
    a. Permeable paving blocks – This could be potentially be used in some areas to provide interception. This would need to be agreed with Cardiff Council, and would be excluded from the plaza due to the finishes requirements for this area and also from other areas with utilities congestions. These areas would also be required to be in the public realm and not be subject to regular HGV loading.
    b. Permeable asphalt – This is not considered an appropriate option due to the resilience issues which are commonly associated with this material.
5. Swales – In the Welsh Government Standards swales are used for infiltration as well as conveyance purposes. Conveyance-only swales are not considered acceptable for interception within the Welsh Government standards, and infiltration is not appropriate for the site.
6. Infiltration trenches – Discounted due to infiltration as above.
7. Detention basins – As with swales, these need to be unlined to provide interception benefits. Again, as this is not possible without allowing infiltration, this is discounted.
8. Bioretention areas and rain gardens - As with swales, these need to be unlined to provide interception benefits. Once again, as this is not possible without allowing infiltration, this is discounted.

The discounting of the above options for interception due to their reliance on infiltration does not mean that they will not be considered within the design for their benefits on water quality. This is considered further within the report.

4.2.2 Flood risk mitigation for receiving surface water bodies

In accordance with the Welsh Government Standards, surface water runoff should be limited in both peak runoff rate and total volume.

4.2.2.1 Peak runoff control

As the site has been previously developed, and is therefore classed as Brownfield, it is proposed to reduce the runoff rate by a minimum of 30%. This is appropriate as there is currently an active drainage system which outfalls to the DCWW network, as discussed above.

As outlined in section 3.1.1, with the exception of the residential properties in the north east of the site, surface water runoff generated from existing buildings and hardstandings within the yellow line boundary are assumed to outfall to the 1125-1500mm DCWW sewer which runs down Schooner Way and crosses the Red Dragon Centre. Approximately 10.8ha of impermeable area currently exists within this catchment, which has been modelled to estimate the existing surface water runoff rate to the DCWW sewer. High level modelling of this impermeable area indicates that the existing runoff from the catchment is approximately 2073l/s in the 1 in 100 year return period event.

It is therefore proposed that the post-development flow rate from the catchment to the DCWW sewer is 1451 l/s in the 1 in 100 year return period storm event, with an allowance of 40% for climate change.

To reduce flows to the DCWW sewer, attenuation storage could be provided. Assuming the whole post-development catchment will be impermeable, it is estimated that approximately 2500m^3 of attenuation storage would be required to reduce the flow to the DCWW sewer by 30%. Due to the density of buildings proposed in this area, it is unlikely that this volume of attenuation storage will be achievable within the catchment due to the masterplan requirements for open spaces. It may be possible to provide below ground attenuation cells for this volume, but this would not be desirable as CC may have to adopt these and they would sterilise a significant below ground area for drainage and utilities networks.

The proposed alternative to this is to discharge the flow representing the 30% reduction to Bute East Dock, thus providing betterment to the DCWW sewer and reducing the volume of attenuation storage required on the site. This has been discussed with CC, and requires confirmation from ABP that it is a satisfactory solution.

4.2.2.2 Volumetric control

The requirements for the volumetric storage in the Welsh Government standards states that, where possible, the volume of surface water discharged from the site for the 1 in 100 year, 6 hour storm is kept as close to greenfield conditions as possible.

This is not believed to be practical for the site due to the complex configuration of volumetric storage required. If this is not practicable the standards suggest that the site is restricted to the QMED flows. This is not recommended for the current site as this would require a significant amount of storage, which would be a large cost and a challenge to maintain.

The standards allow the volumetric requirement to be relaxed in agreement with the SAB. It is not considered that the volume of runoff will increase as the area is already mostly impermeable.

4.2.2.3 Exceedance flows

The proposed exceedance flows for the site are shown in the drawing contained in Appendix D. The site currently falls from north to south. It is proposed that the levels are designed to allow exceedance flows to discharge down the boulevard leading to the arena from the existing Millennium Centre. These would then be discharge to the existing highway drainage.

If this is inundated, flows will run down Roald Dahl Plas and into Cardiff Bay.

The eastern residential plots (H1-4 and K1-3) are proposed to fall towards Bute East Dock in an exceedance flow event. Exceedance flows may also flow into the smaller canal elements locally.

The Multi-Storey Car Park (MSCP) exceedance flows will fall towards the south to the proposed landscaping. Flows beyond this may pass onto the highway but this is considered to be low risk and is more acceptable than flooding of properties.

4.3 S3- Water Quality

The current drainage system outfalls directly to the DCWW sewer which outfalls into Cardiff Bay. There are no records of any oil separators as part of the network, and therefore it is assumed that there are currently no systems in place to improve surface water quality.

The proposed development will be mostly pedestrianised, with regular deliveries to the associated plots and car access to the MSCP. There will be a delivery area to the rear of the Arena which will receive articulated lorries delivering music equipment, which is considered within the Arena drainage strategy.

Areas have been identified to improve water quality on the drawing shown in Appendix D.

In order to improve water quality, the following elements are proposed:

1. Green roofs – These are proposed on building A and within the residential blocks of H and K. These will help reduce the peak flows from the surface water drainage and provide beneficial evapotranspiration and water quality treatments
2. Swales – Two conveyance swales are proposed, one between Lloyd George Avenue and buildings M and L, and the other in the existing landscaped strip along the southern boundary of the site. These will provide water quality treatment and reduction in the peak flows from the site, in addition to amenity and biodiversity benefits.

3. Rain gardens – Landscaped areas are proposed across the site totalling approximately 2 Ha, of which a significant area could be used for raingardens. These will provide water quality treatment and also reduce the peak flows, while providing amenity and biodiversity benefits to the area. The areas which drain to these have low vehicular traffic and therefore it is believed that these will provide an appropriate level of treatment.
4. Porous paving – Approximately 2700m^2 of porous paving is proposed in pedestrian or low traffic areas outside of the plaza. Porous paving will provide water quality benefits and peak flow reduction at the source, prior to discharging to the proposed surface water drainage network.

The Simple Index Method from the SuDS manual has been used for the areas with differing surface water treatment trains to confirm that the solutions are appropriate.

In accordance with the Simple Index Method, the access roads to the development and the MSCP will be considered a Medium pollution hazard level. The roof runoff, pedestrianised areas and residential areas are considered a Low pollution hazard level.

It is recommended that additional treatment is required for water quality on the access roads and the MSCP compared to the surrounding areas. This is shown on the proposed water quality treatment plans in Appendix D.

4.4 S4 – Amenity

The proposals for the site are to make use of proposed landscaping areas for SuDS features. The requirement for water quality treatment has meant that significant areas of landscaping are required, which will positively impact on amenity.

The residential areas of H and K also include an extension of the canal area which currently outfalls into Bute East Dock. This will create additional open water, positively impacting on the amenity of the site.

The proposals for the site will significantly benefit the amenity of Cardiff, through providing a venue for music, leisure, employment and residential areas.

4.5 S5 – Biodiversity

The introduction of the additional landscaping as proposed will provide biodiversity benefits.

The introduction of additional open water and the green landscaping is believed to have a positive biodiversity impact. Biodiversity is considered further within the Environmental Statement.

4.6 S6- Maintenance

The proposed solutions are designed to be low maintenance. The use of rain gardens and swales in location will require similar maintenance requirements to landscaping, with regular vegetation cut back.

Porous paving will require regular cleaning to ensure it functions correctly. This maintenance regime would be agreed with the SAB as part of the maintenance document provided for the scheme during the full SAB application.

Green roofs on buildings will be maintained by the asset owner.

A major influence on the proposal to outfall surface water into Bute East Dock is the desire to reduce the amount of attenuation cells within the site. These would be challenging to maintain and expensive to install. The omission of this in favour of outfalling into Bute East Dock means that the maintenance of the surface water drainage across the site is significantly improved.

5 Proposed Foul Drainage

It is proposed to discharge the foul flows generated from the Atlantic Wharf site to the DCWW public sewer networks around the site. To understand the impact of the development on the existing foul infrastructure, calculations have been undertaken to estimate the foul flows which are currently experienced in the existing site.

Foul flows are generated from County Hall, the Red Dragon Centre and the restaurant located within the Red Dragon Centre site, to the south of the Hemingway Road roundabout. The total foul flow from these buildings is estimated to be 41.9 l/s, of which it is believed that 29.0 l/s connects to the DCWW to the north of the site in Schooner Way from County Hall, and the remaining 12.9 l/s outfalls to a DCWW sewer in Hemingway Road or Lloyd George Avenue.

The proposed architectural schedule accommodation dated 13th July 2021 has been used to estimate the foul flows from the development. The total proposed foul flow is estimated to be 80.2 l/s. Foul flow calculations and layouts are contained in Appendix F. The proposed foul flow is to be agreed with DCWW.

During discussions for the Arena and Travelodge hotel site, DCWW indicated that there was no capacity in the Schooner Way sewer pumping station to accommodate flows from that development. However, the existing flows from County Hall to this sewer could be replaced with a portion of foul drainage generated in the Bute East Dock Quarter and the Waterfront Quarter. This will require discussion and agreement with DCWW.

It is proposed that foul drainage which cannot be accepted by the Schooner Way pumping station should outfall to the DCWW public sewers in the south-west of the site, with a possible connection point located in Lloyd George Avenue.

A Pre-Planning Application has been submitted. From previous experience it is believed that DCWW will request a Hydraulic Modelling Assessment is undertaken for the area to determine if there is sufficient capacity, and if not to determine any additional reinforcements which will be required in order to allow for this flow to discharge into their foul or combined network.

6 Summary

Surface water from the existing site is understood to currently drain to the DCWW sewer in Hemmingway Road. There is no treatment of this water prior to discharge to the DCWW sewer. The DCWW sewer outfalls to the existing pumping station to the south of Red Dragon Centre which is proposed to be retained as part of the development.

Foul drainage from the existing site falls to the north for County Hall to an existing foul pumping station. Foul drainage for the Red Dragon Centre falls to the west to an existing foul manhole in the footway of Lloyd George Avenue.

For surface water drainage, it is proposed that the site will outfall to the existing surface water sewers and the Bute East Dock. The proportion split is to be confirmed during further design, with a minimum reduction of 30% on the existing surface water flows that outfall into the existing sewer, in accordance with the guidance for brownfield development.

Water quality will be improved through a variety of different SuDS features used on the site, including rain gardens, swales, permeable paving and green roofs. These will act to improve biodiversity and amenity in the public realm areas across the site.

Foul drainage will need to outfall to the existing DCWW foul sewers in the area. A Pre-Planning Application (PPA) has been applied for with DCWW. It is believed that a Hydraulic Modelling Assessment will be required, but this is to be confirmed by DCWW.

Appendix A

Record Information from ABP

CARDIFF DOCK FEEDER

SLUICES AT BLACKWEIR

WEIR CREST +31.40 FT AOD (CENTRE) [+9.57m AOD]
+32.33 FT AOD (BANKS) [+9.85m AOD]

WEIR TOE +25.00 FT AOD [+7.62m AOD]

BED N FACE +28.4 FT AOD [+8.65 m AOD] in 1967
" D/S TOE +22.5 FT AOD [+6.85 m AOD] " "

W.L. D/S OF SLUICES IN FEEDER V. APPROX +9.20 m AOD.

OPEN WATERWAY

CULVERTS/BRIDGES.

Scale V. approx: 1/10,000 (1 km grid)

AMBULANCE DEPOT – SHORT 3.55M WIDTH RESTRICTION AT BLACKWEIR FARM

TWIN BRICK/CONC CULVERTS 6FT DIAM INT. UNDER NORTH RD

INVERT +6.64m assumed fm old dwg.

1986 CULVERTS TWIN 3M HIGH × 2M MAX – VARIES TO 8FT & 7FT
OVERALL COVERED LENGTH PARK PLACE TO BUTE TERRACE 757m AS HIGHLIGHTED YELLOW.

1M WIDE ACCESS POINT TO GRILLE BY SUBSTATION (CCC HAVE KEY + CLEAN GRILLE)

RESTRICTED WIDTH AT CASTLE BRIDGE (LADY BUTE BR)

ACCESS POINT UNDER MORGAN COLE STEPS

LOW BED LEVEL APPROX +7.12m AOD (LOCAL)

PARK HOTEL CULVERT DIMS AS BELOW MASONRY + APPROX 66m LONG

MASONRY CULVERT UNDER QUEEN ST. 12FT WIDE × (3.65m × 2.90m) — 9'-6" HIGH + 18M LONG

FROM QUEEN ST CHURCHILL WAY 485m [W.L. AT APPROX +8.60m AT S END] WIDTH
FEEDER COVERED BY PCC SLABS OVER ABUTS (20FT)

BUTE TERRACE 43M LONG INVERTED SYPHON TWIN RC BOXES 10FT WIDE × 4FT HIGH INTERNAL

INVERTS
N END +7.42m
CENTRE +6.58m
S END +7.37

20.8m LONG RAIL CROSSING 5 Nº RC BOX CULVERTS 4'-6" SQ INT

BED WHEN CLEAN/ APPROX +6.58m AOD

TILTING WEIR [CREST APPROX +7.68m AOD]

JUNCTION CANAL

START OF 70mgd CULVERT With Penstock. INVERT +6.50m AOD
IMMED BEFORE IN CONC CHANNEL 2.25m × 2.08m DEEP

RC BOX CULVERT 2.25m WIDE × 1.80m HIGH 1357m LONG

BUTE E DOCK COPING AV. LEVEL +8.38m AOD

WATERQUALITY AREA (Q'gate N) 2.4m ϕ ARMCO CULVERT TURBOSIDER/ +6.05m INVERT

FUTURE INNS AREA ASSUMED AS ABOVE FOR PIPE DETAIL

STILLING BASIN WEIR CREST IS AT +7.92m AOD

ARMCO STEEL CULVERT 128m LONG 3.01m DIAM UNDER PDR ROAD.

3m ϕ ARMCO CULVERT UNDER PIERHEAD ST – WATER FLOW EMERGES TO DOCK

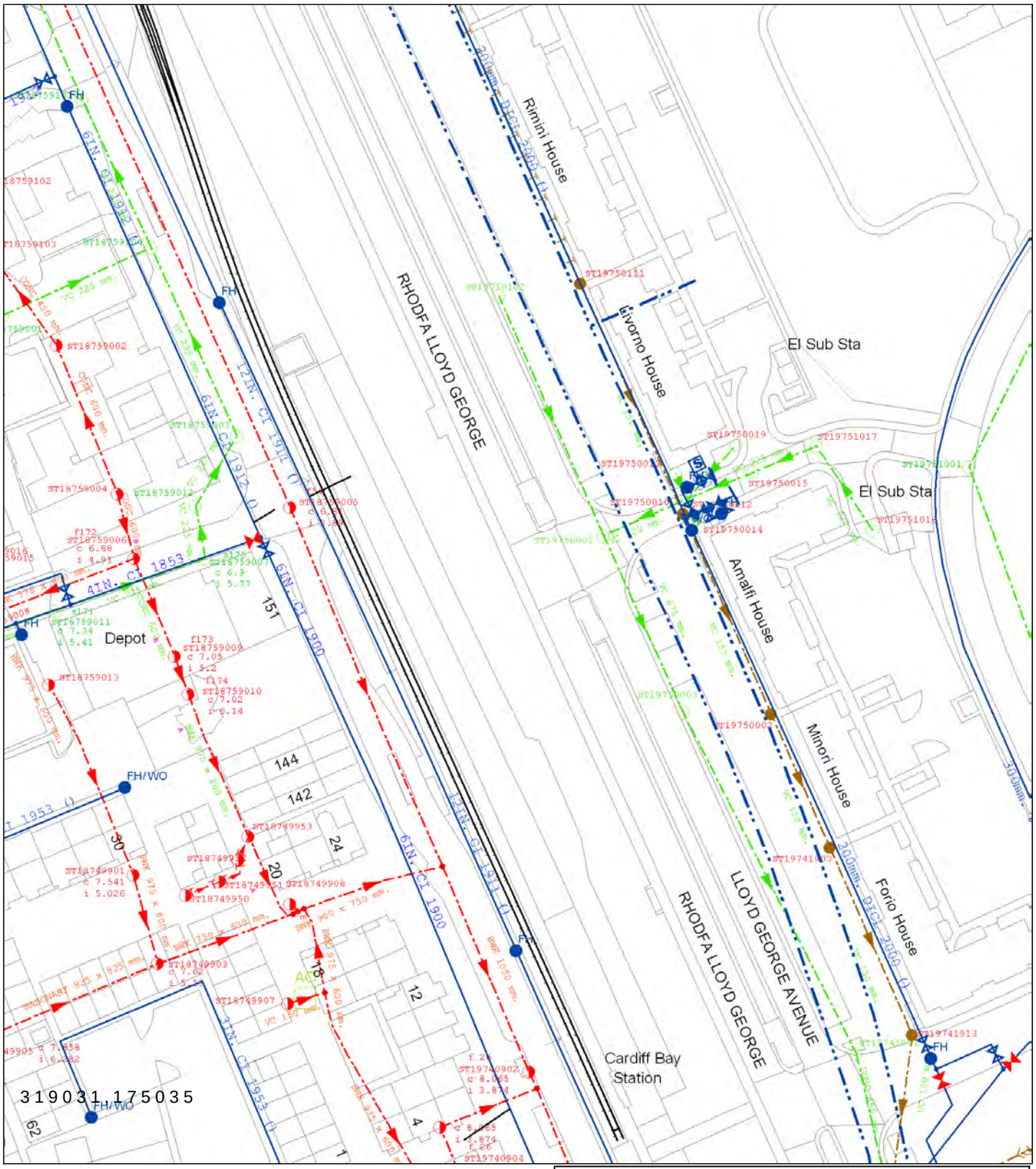
INV +6.0m

ASSOCIATED BRITISH PORTS REGIONAL PROPERTY DEPT. SOUTH WALES 16 JUN 1994 No. 5327 REF

Grangetown

Appendix B

Record Drainage Information



LEGEND

- Sluice Valve
- Air Valve SINGLE
- Tap
- Pressure Reducing Valve
- Meter
- Bulk Meter
- Fire Hydrant
- Cap
- Non Dwr Cymru
- Existing Distribution Main
- Inspection Chamber
- Gravity Sewer
- Rising Main
- Outfall
- Pumping Station
- Lamphole
- Combined Sewer Overflow
- Special Purpose Chamber
- Treatment Works
- Private Sewer Transfer
- Lateral Drain

NB:
Sewer symbol colour indicates the sewer type.

RED - Combined
GREEN - Surface Water
BROWN - Foul

Dŵr Cymru Welsh Water

Scale: 1:1250

13/10/2017

EXACT LOCATION OF ALL APPARATUS TO BE DETERMINED ON SITE

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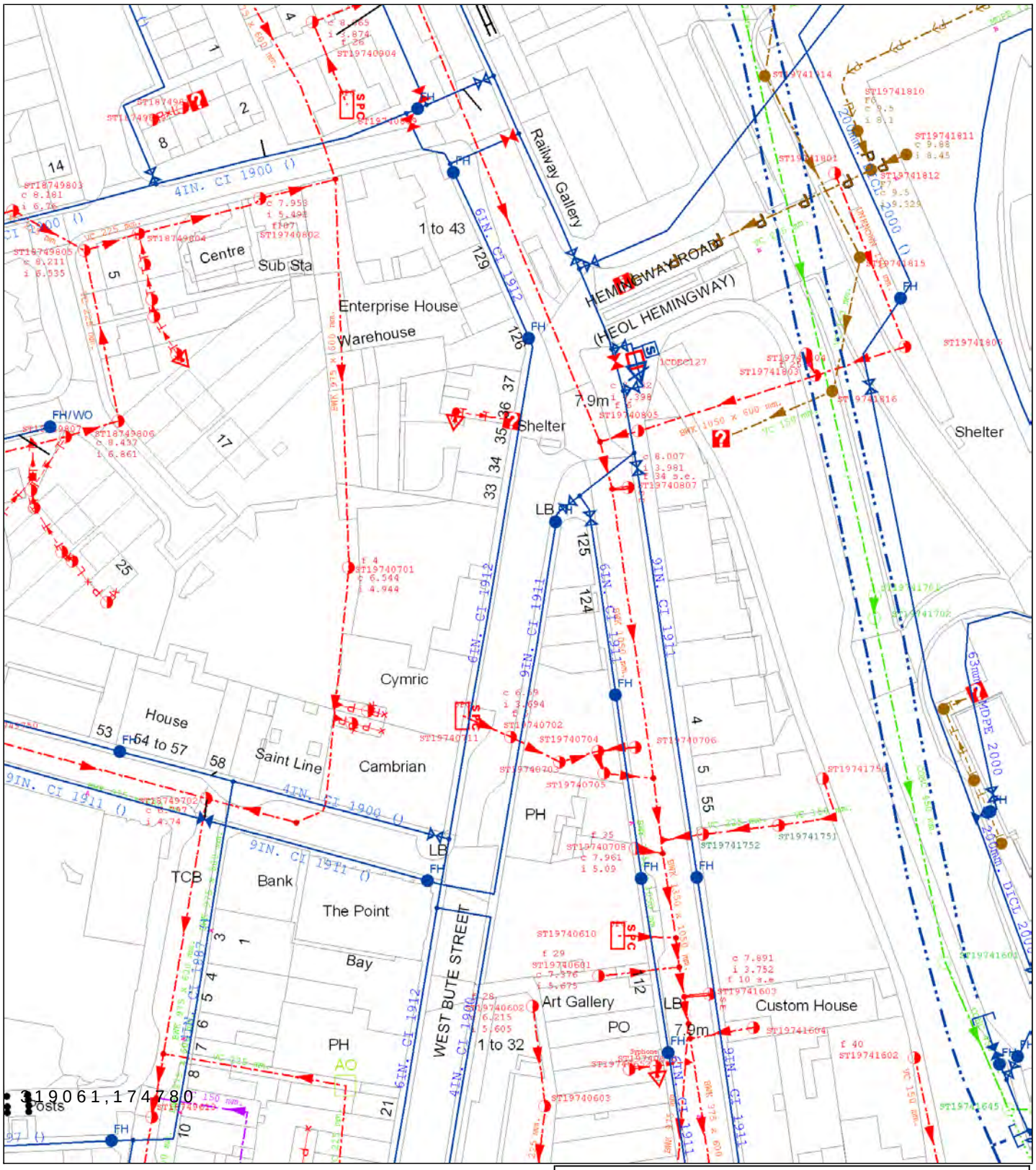

LEGEND

- Sluice Valve
- Air Valve SINGLE
- Tap
- Pressure Reducing Valve
- Meter
- Bulk Meter
- Fire Hydrant
- Cap
- Non Dwr Cymru
- Existing Distribution Main
- Inspection Chamber
- Gravity Sewer
- Rising Main
- Outfall
- Pumping Station
- Lamphole
- Combined Sewer Overflow
- Special Purpose Chamber
- Treatment Works
- Private Sewer Transfer
- Lateral Drain

NB:
Sewer symbol colour indicates the sewer type.

RED - Combined
GREEN - Surface Water
BROWN - Foul

Dŵr Cymru
Welsh Water

Scale: 1:1250
13/10/2017

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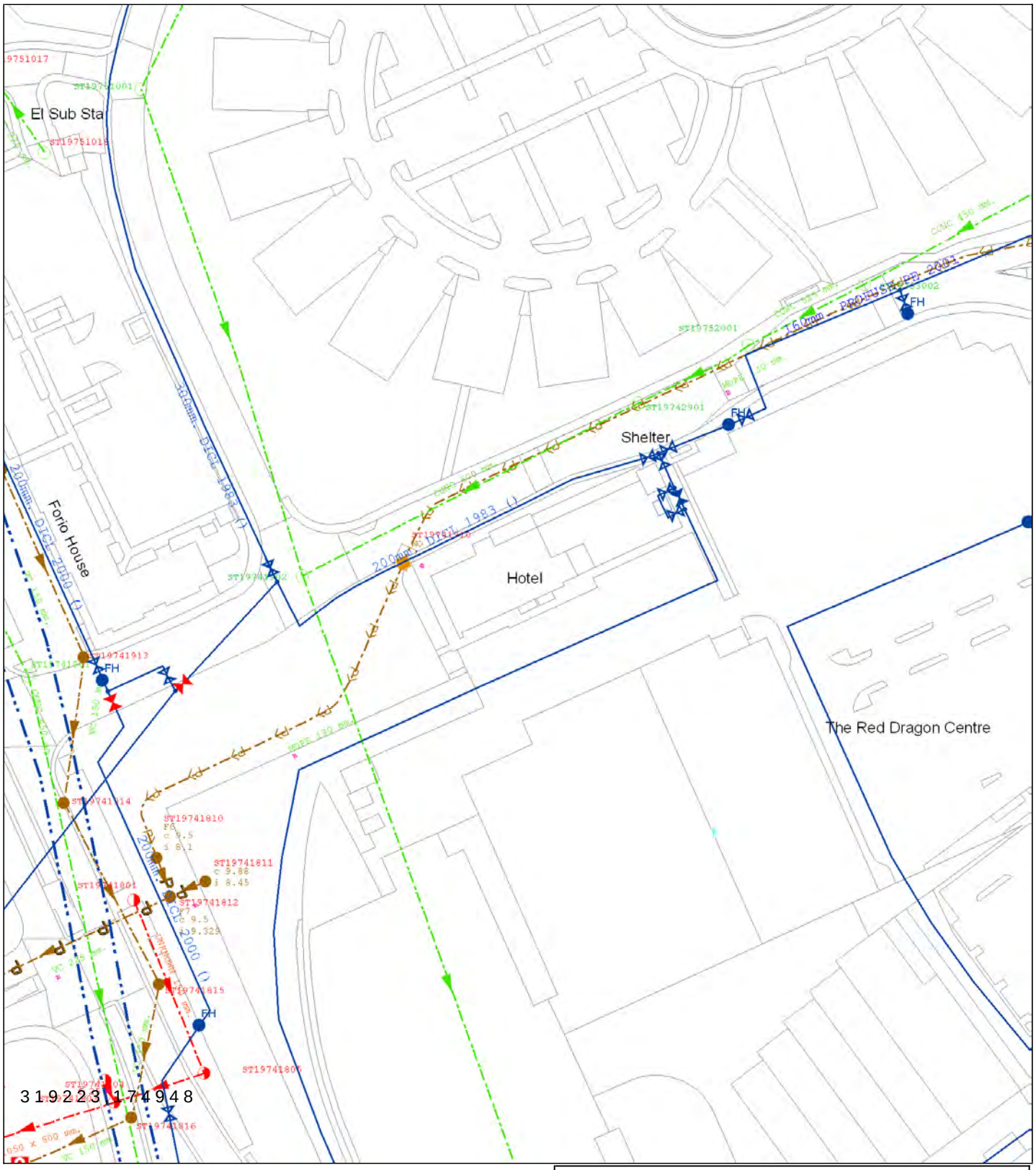

LEGEND

- Sluice Valve
- Air Valve SINGLE
- Tap
- Pressure Reducing Valve
- Meter
- Bulk Meter
- Fire Hydrant
- Cap
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- Existing Distribution Main
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- Gravity Sewer
- Rising Main
- Outfall
- Pumping Station
- Lamphole
- Combined Sewer Overflow
- Special Purpose Chamber
- Treatment Works
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- Lateral Drain

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RED - Combined
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Dŵr Cymru
Welsh Water

Scale: 1:1250
17/10/2017

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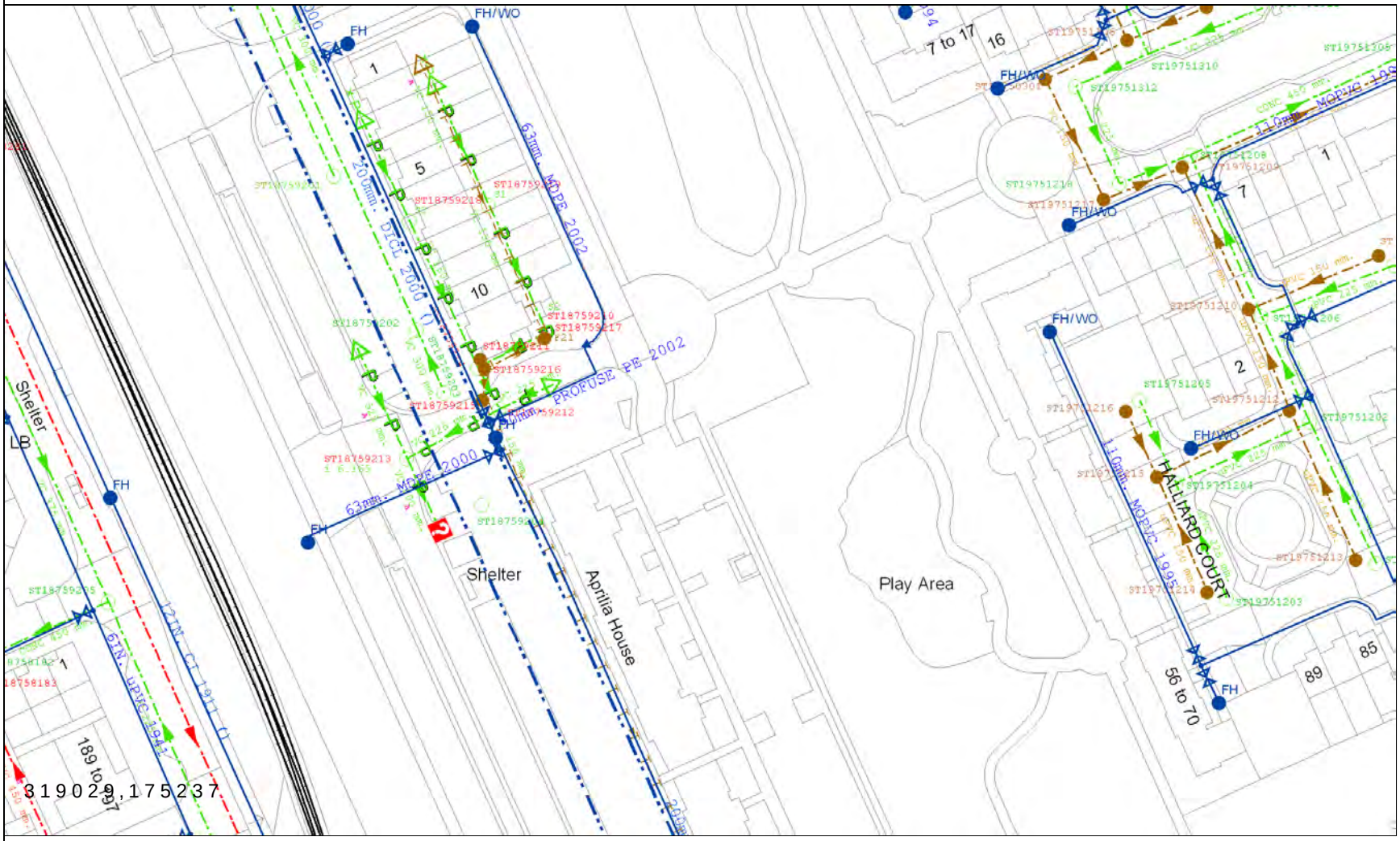
Dŵr Cymru
Welsh Water

17/10/2017

Scale: 1:1250



LEGEND

Clean Water

- Sluice Val
- Air Val, SINGLE
- Tap
- Pressure Reducing Valve
- Meter
- BULK Meter
- FH
- Cap
- Existing Main
- NON COMPANY

Sewerage External

- Foul
- Surface Water
- Combined
- Rising Main
- Private
- Treatment Works
- Pumping Station
- Special Purpose
- Unknown End
- Change, Combined Overflow
- Outfall, FOUL
- Lamp Hole, Foul
- Private Sewer Transfer
- Lateral Drain
- Inspection Chamber

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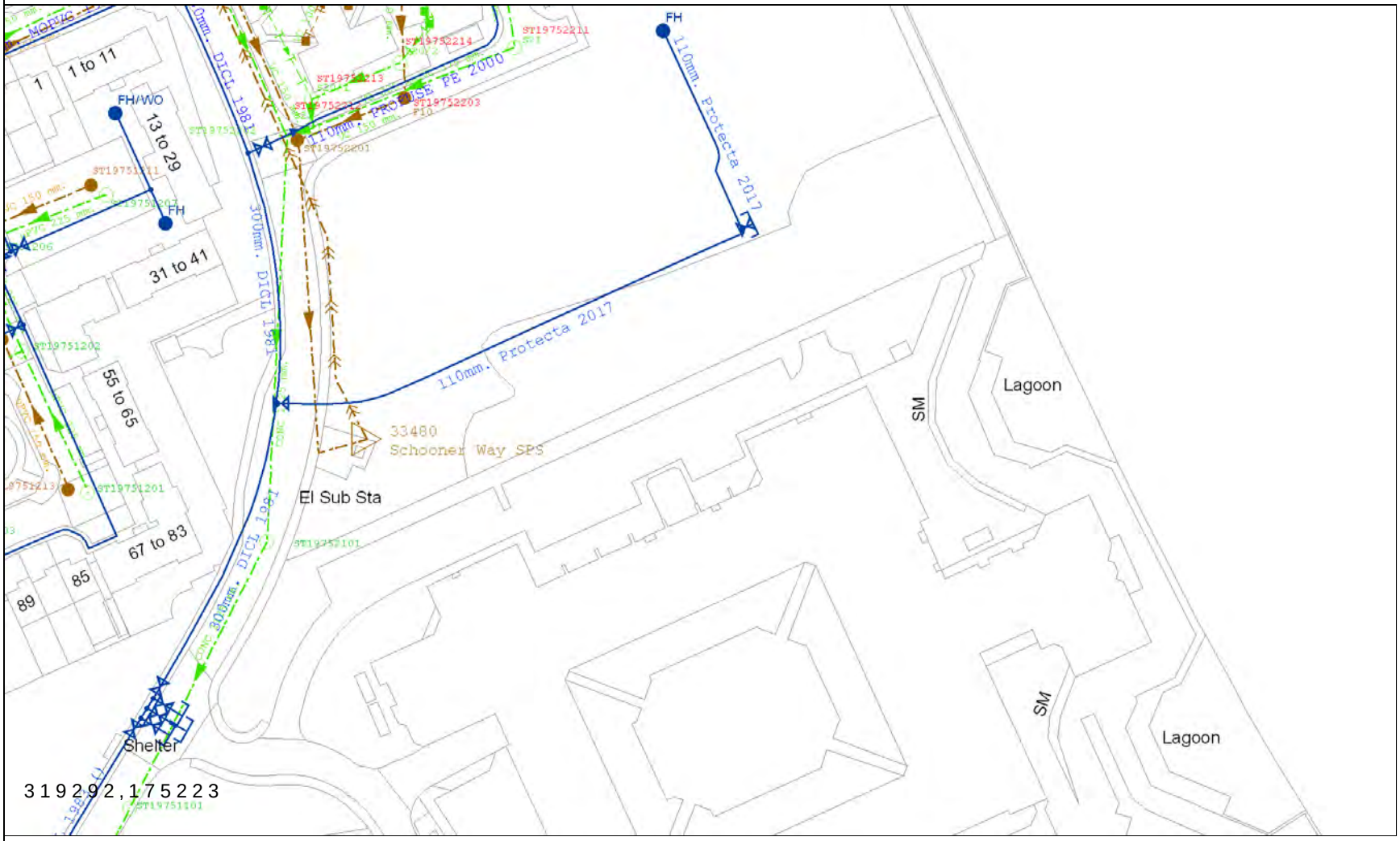
Dŵr Cymru
Welsh Water

17/10/2017

Scale: 1:1250



LEGEND

Clean Water

- Sluice Val
- Air Val, SINGLE
- Tap
- Pressure Reducing Valve
- Meter
- BULK Meter
- FH
- Cap
- Existing Main
- NON COMPANY

Sewerage External

- Foul
- Surface Water
- Combined
- Rising Main
- Private
- Treatment Works
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- Unknown End
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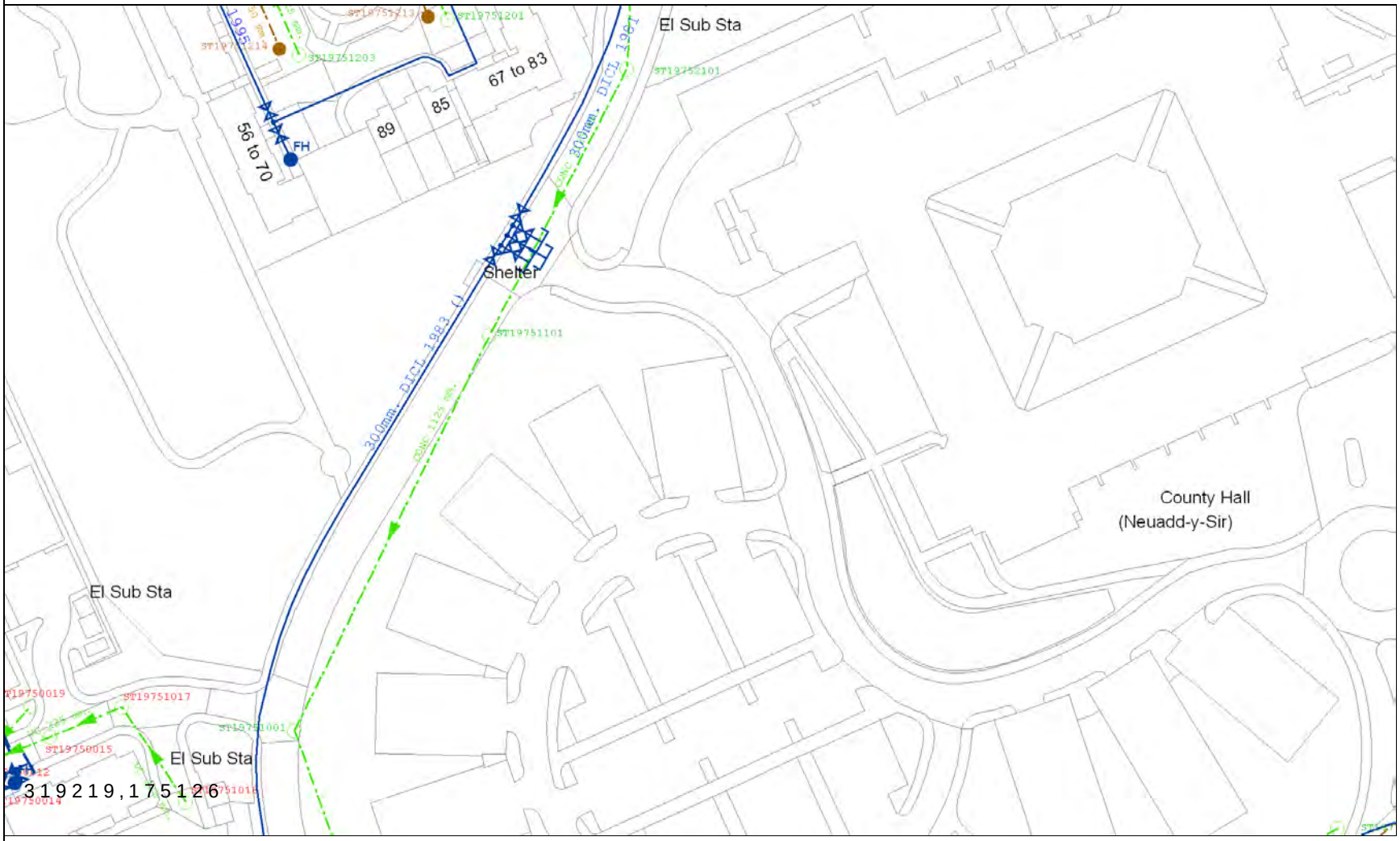
Dŵr Cymru
Welsh Water

17/10/2017

Scale: 1:1250



LEGEND

Clean Water

- Sluice Val
- Air Val, SINGLE
- Tap
- Pressure Reducing Valve
- Meter
- BULK Meter
- FH
- Cap
- Existing Main
- NON COMPANY

Sewerage External

- Foul
- Surface Water
- Combined
- Rising Main
- Private
- Treatment Works
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Appendix C

Geological Constraints Plan

A3

319000 319200 319400 319600

175200 175000 174800 174600

Bute West Dock (infilled)
First input: 31/12/1948
Last input: 31/12/1971

Former buildings associated with ship building and paint factory

Historical oil storage depot and warehouses

Hemingway Road Reservoir / GKN Fragmentiser Waste (infilled)
First input: 31/12/1920
Last input: 31/12/1942

Saw mills

South Wales and Liverpool Steam Packet Warehouse

Junction dry dock
First input: 31/12/1976
Last input: 31/12/1977

Historical engine houses

Bute East Dock (partially infilled)
First input: 31/12/1978
Last input: 31/12/1989

Timber Pond (infilled)
First input: 31/12/1920
Last input: 31/12/1942

Historical engineering works

Union Foundry (Iron & Brass)

Roath Junction Canal (infilled)
First input: 31/12/1960
Last input: 31/12/1979

Bute East Dock Basin (infilled)
First input: 31/12/1948
Last input: 31/12/1979

Legend

- Site boundary
- Tunnel
- Existing Buildings
- Historical Buildings
- Dock Feeder Culvert
- Current Bute East Dock
- Bute West Dock
- Bute East Dock
- Historical railway and dockland
- Reservoir(s)
- Redundant section of Dock Feeder Culvert
- Tunnel approach cutting
- DCWW pumping station
- A Proposed building

*Infilling dates (landfills) sourced from Envirocheck information

Metres
0 30 60 120

Rev	Date	By	Chkd	Appd

ARUP

13 Fitzroy Street
London W1T 4BQ
Tel +44 20 7636 1531 Fax +44 20 7580 3924
www.arup.com

Client
Cardiff City Council

Project Title
Atlantic Wharf Development - High Level Due Diligence Study

Drawing Title
Figure 3: Potential contamination

Scale at A3
1:2,500

Role

Suitability
Issue

Arup Job No **274954** Rev

Name

02/06/2020 11:20:04

I:\CardiffJobs\274000\274957-00\4 Internal Project Data\4-80 GIS\4-84 Map Documents\GEO_Geotechnics\Atlantic_Wharf_Constraints.mxd

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Appendix D

Proposed Surface Water Drainage Drawings

A1

Legend

- Site Boundary
- Catchment 1 - Outfall to Bute East Dock
- Catchment 2 - Outfall to DCWW Surface Water Sewer
- Proposed Route of 1350mm DCWW Sewer Diversion

Notes

1. All dimensions are in metres unless stated otherwise. All levels are in metres above Ordnance Datum (AOD). Do not scale from this drawing.

2. Catchments shown are indicative and subject to agreement with Cardiff Council, DCWW and ABP.

3. Refer to CAH-ARP-RX-XX-DR-C-90-2502 for detail of DCWW sewer diversion.

N

Cardiff Arena and hotel not part of this scope. See separate detailed design.

Outfalls to Bute East Dock via proposed canals. Number of outfalls and locations to be confirmed. Connections to be discussed with ABP.

Indicative location of outfall to proposed diverted 1350mm surface water sewer. To be discussed with DCWW.

J:\281000\281124-00\4 Internal Project Data\4-30 Drawings\4-31 Issue drawings\Atlantic Wharf Masterplan Drawings\CAH-ARP-XX-XX-DR-C-90-2400.dgn

ARUP

4 Pierhead St, Capital Waterside
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www.arup.com

Issue	Date	Revision Description
P01	06/08/21	Issued for Information

Record of Revisions

Client: Cardiff Council

Operators:

Lead Designer: RIO Architects

Project Title: Atlantic Wharf Masterplan

Drawing Title: Proposed Surface Water Drainage Catchment Plan

Disclaimer

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Refer to CDE for current revision.

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If in doubt ask, © Arup

Safety, Health and Environmental (S.H.E.) Information Box

In addition to the hazard/risks normally associated with the types of work detailed on this drawing, take note of the below.
The risks identified below are based on the use of experienced and competent contractors carrying out the work using an approved safe method of working.

Construction Risks | Maintenance Risks

Operational Risks | Demolition / adaptation Risks

Notes

Scale at A1: 1:1000

Role: Civils

Drawn By	Checked By	Approved By
DS	CL	DL

Purpose of Issue: Information

Project No	Rev
281124	P01

ID: CAH-ARP-XX-XX-DR-C-90-2400

Do not scale

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A1

Legend

- Site Boundary
- Medium Pollution Potential
- Low Pollution Potential
- Landscaped Areas

Notes

1. All dimensions are in metres unless stated otherwise. All levels are in metres above Ordnance Datum (AOD). Do not scale from this drawing.

N

Cardiff Arena and hotel not part of this scope. See separate detailed design.

Welsh Water easement

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Construction Risks	Maintenance Risks
Operational Risks	Demolition / adaptation Risks

Notes

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Issue	Date	Revision Description
P01	06/08/21	Issued for Information

Record of Revisions

Client: Cardiff Council

Operators:

Lead Designer: RIO Architects

Project Title: Atlantic Wharf Masterplan

Drawing Title: Proposed Surface Water Drainage Water Quality Zoning Plan

Scale at A1: 1:1000

Role: Civils

Drawn By	Checked By	Approved By
DS	CL	DL

Purpose of Issue: Information

Project No: 281124

Rev: P01

ID: CAH-ARP-XX-XX-DR-C-90-2401

Do not scale

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A1

Legend

- Site Boundary
- Proposed green roof area
- Proposed water features connected to Bute East Dock
- Indicative proposed surface water sewer
- Indicative areas suitable for raingardens
- Indicative swales
- Existing Surface Water drainage
- Existing dock feeder culvert
- Proposed dock feeder culvert diversion

Notes

1. All dimensions are in metres unless stated otherwise. All levels are in metres above Ordnance Datum (AOD). Do not scale from this drawing.

2. Proposed drainage is indicative and subject to change. Proposals are to be agreed with Cardiff Council, DCWW and ABP.

3. Modelling of proposed ground levels will inform drainage design.

N

Cardiff Arena and hotel not part of this scope. See separate detailed design.

Outfalls from Waterfront Quarter and Bute East Dock Quarter to proposed canals

Outfall from proposed Red Dragon Centre to proposed canal

Beginning of surface water sewer diversion

Beginning of dock feeder culvert diversion

Outfalls from Bute East Dock Quarter and Car Park Quarter to proposed canals

Existing Dock Feeder Culvert as surveyed

Existing Dock Feeder Culvert traced from record drawings

End of dock feeder culvert diversion

Indicative location of proposed connection to DCWW sewer

Lloyd George Ave - Bute Street Link

J:\281000\281124-00\4 Internal Project Data\4-30 Drawings\4-31 Issue drawings\Atlantic Wharf Masterplan Drawings\CAH-ARP-XX-XX-DR-C-90-2402.dgn

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Construction Risks	Maintenance Risks
Operational Risks	Demolition / adaptation Risks

Notes

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Issue	Date	Revision Description
P02	24/08/21	Dock feeder amended
P01	30/07/21	Issued for Information

Record of Revisions

Client: Cardiff Council

Operators:

Lead Designer: RIO Architects

Project Title: Atlantic Wharf Masterplan

Drawing Title: Proposed Surface Water Drainage Strategic Layout

Scale at A1: 1:1000

Role: Civils

Drawn By	Checked By	Approved By
DS	CL	DL

Purpose of Issue: Information

Project No	Rev
281124	P02

ID: CAH-ARP-XX-XX-DR-C-90-2402

Do not scale

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A1

Legend

- Site Boundary
- Exceedance flow routes
- Exceedance flow to Bute East Dock
- Exceedance flow to landscaped area to North of A4232
- Exceedance flow to Bute Place

Notes

1. All dimensions are in metres unless stated otherwise. All levels are in metres above Ordnance Datum (AOD). Do not scale from this drawing.

2. Exceedance flows are indicative and subject to modelling in future design stages.

N

Cardiff Arena and hotel not part of this scope. See separate detailed design.

Exceedance flows from residential quarter to be routed towards Bute East Dock, and locally routed towards smaller canal element

Exceedance flows from MSCP to fall towards landscaped area in south of site adjacent to A4232. Risk of flows entering highway to be considered further in future design stages.

Exceedance flows from plaza and surrounding buildings to be routed towards Bute Place and intercepted by existing highway drainage. If no capacity for interception by highway drainage, runoff will flow down Roald Dahl Plas into Cardiff Bay

Welsh Water Easement

J:\281000\281124-00\4 Internal Project Data\4-30 Drawings\4-31 Issue drawings\Atlantic Wharf Masterplan Drawings\CAH-ARP-XX-XX-DR-C-90-2430.dgn

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Operational Risks	Demolition / adaptation Risks

Notes

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Issue	Date	Revision Description
P01	06/08/21	Issued for Information

Record of Revisions

Client: Cardiff Council

Operators:

Lead Designer: RIO Architects

Project Title: Atlantic Wharf Masterplan

Drawing Title: Proposed Surface Water Drainage Exceedance Flow Paths

Scale at A1: 1:1000

Role: Civils

Drawn By	Checked By	Approved By
DS	CL	DL

Purpose of Issue: Information

Project No	Rev
281124	P01

ID: CAH-ARP-XX-XX-DR-C-90-2430

Do not scale

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Appendix E

Bute East Dock Impact Assessment

File Note

ARUP

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Project title	Cardiff Arena	Job number	281124
ccD		File reference	4.70
Prepared by	Rob Varley	Date	20 July 2021
Subject	Bute East Dock and Downstream – Outfall Calculations		

Title: Cardiff Arena – Bute East Dock Impact Assessment	**Rev:** P01
Number: CAH-ARP-AX-XX-RP-C-90-0401	**Reason For Issue:** For Information

1 Introduction

The Cardiff Arena development proposes a 15,000-capacity events space and surrounding public realm area on the site of the car parking area to the west of County Hall. The stormwater drainage for the site is subject to Schedule 3 of the Flood and Water Management Act 2010. The Welsh Governments '*Statutory Standards for Sustainable Drainage Systems',* Standard S1 provides the required discharge hierarchy for outfalling surface water from a development.

Level 1 (Rainwater Harvesting) and Level 2 (Infiltration) do not provide suitable outfalls for the development. Level 3 of the discharge hierarchy is discharging to a water body. As Bute East Dock is located just to the east of the site past County Hall, this would offer the preferred discharge point for the site's stormwater drainage.

However, to outfall to the dock system consideration needs to be given to the impact on the water level in Bute East Dock during a critical rainfall event and potential impact on ABP's assets downstream. This note summarises the information that has been gathered on the Bute East Dock and downstream system, as well as a calculation of the impact of the additional surface water inflow from the Cardiff Arena development into the dock.

2 Bute East Dock and Downstream – Existing Information

2.1 Information from ABP

Information and diagrams of the Cardiff dock feeder system, including the Bute East Dock area have been provided by ABP. These are provided in Appendix A1. A schematic of Bute East Dock and the upstream/downstream conditions has been provided in Figure 1 and further extracts are shown in Figure 2 and 3.

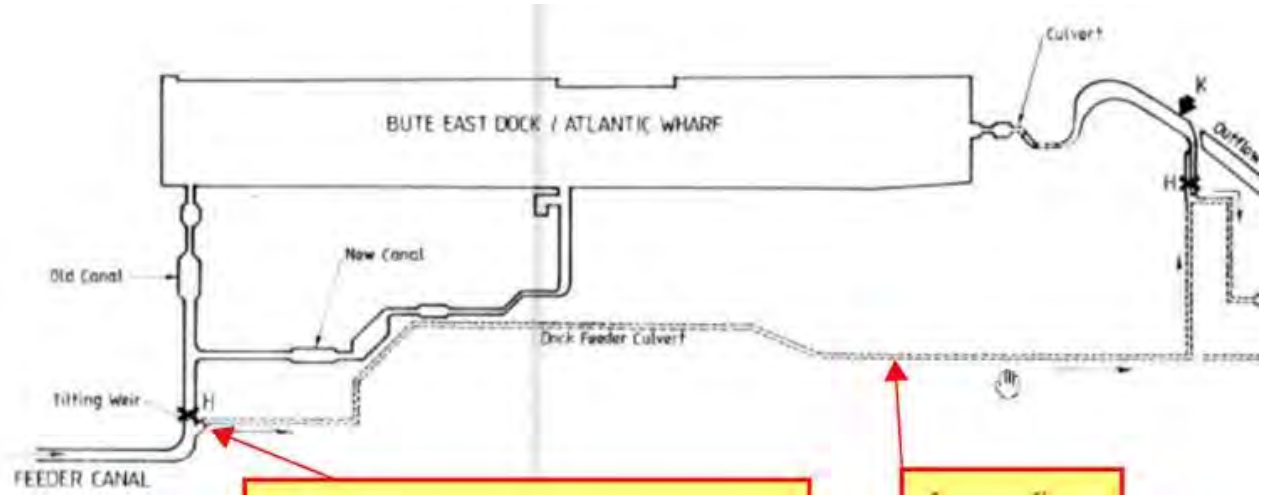


Figure 1 – Schematic of Bute East Dock and dock feeder system, with H representing the incoming and outgoing weir structures.

Bute East Dock receives inflow from the dock feeder at the north western corner, with incoming flows controlled by a tilting weir structure. This tilting weir will generally prevent water entering Bute East Dock, instead conveying it through the dock feeder to the south. However, the tilting weir is periodically opened to allow water inflow, replenishing the water level in Bute East Dock and promoting water circulation.

The top of coping level around Bute East Dock is noted to be 8.37m AOD. This matches the topographical survey information which has been received for the Cardiff Arena site.

The outfall from Bute East Dock is stated as a 2.4m diameter culvert with an invert level of 6.05m AOD. It is noted that the cover level of this culvert would therefore be 8.45m AOD, above the coping level of Bute East Dock. Site inspections described in Section 2.2 indicates that the top of the culvert is around 8.16mAOD. Therefore, it is likely that either the culvert invert is lower than the stated 6.05m or the culvert diameter is smaller than stated (e.g. 2.1m diameter).

File Note

281124 20 July 2021

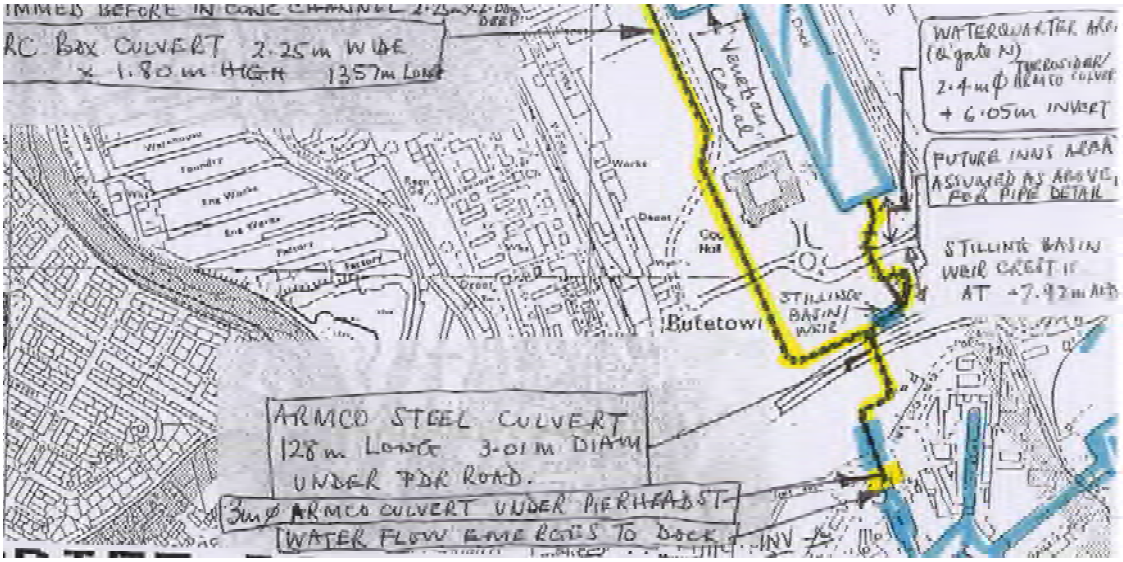


Figure 2 – Extracts from ABP marked up plan

Approximately 250m downstream from the culvert entrance is a stilling basin and weir structure. This stilling basin is used as a water resource in the event of a fire in the A4232 Queensgate Tunnels, with access to the stilling basin compound controlled by Cardiff County Council. The crest of the weir is noted to be at 7.92m AOD, however no further information was provided on the type or width of weir on the drawings received.

This downstream weir is understood to control the water level in Bute East Dock. Therefore, although the water level in Bute East Dock could exceed the weir crest level during rainfall events or whilst receiving inflow from the tilting weir, the water level will naturally fall back down to an equilibrium level of 7.92m AOD.

The outlet from the stilling basin and weir structure is shown on the marked-up plan on Figure 3. The outlet joins the dock feeder culvert south of the stilling basin, before crossing the dual carriageway to the south. The pipe under the dual carriageway and further south is show on Figure 2 as 3m diameter, an open channel section, 9-11m wide, is also present, before it discharges via a further length of culvert into Roath Basin further south.

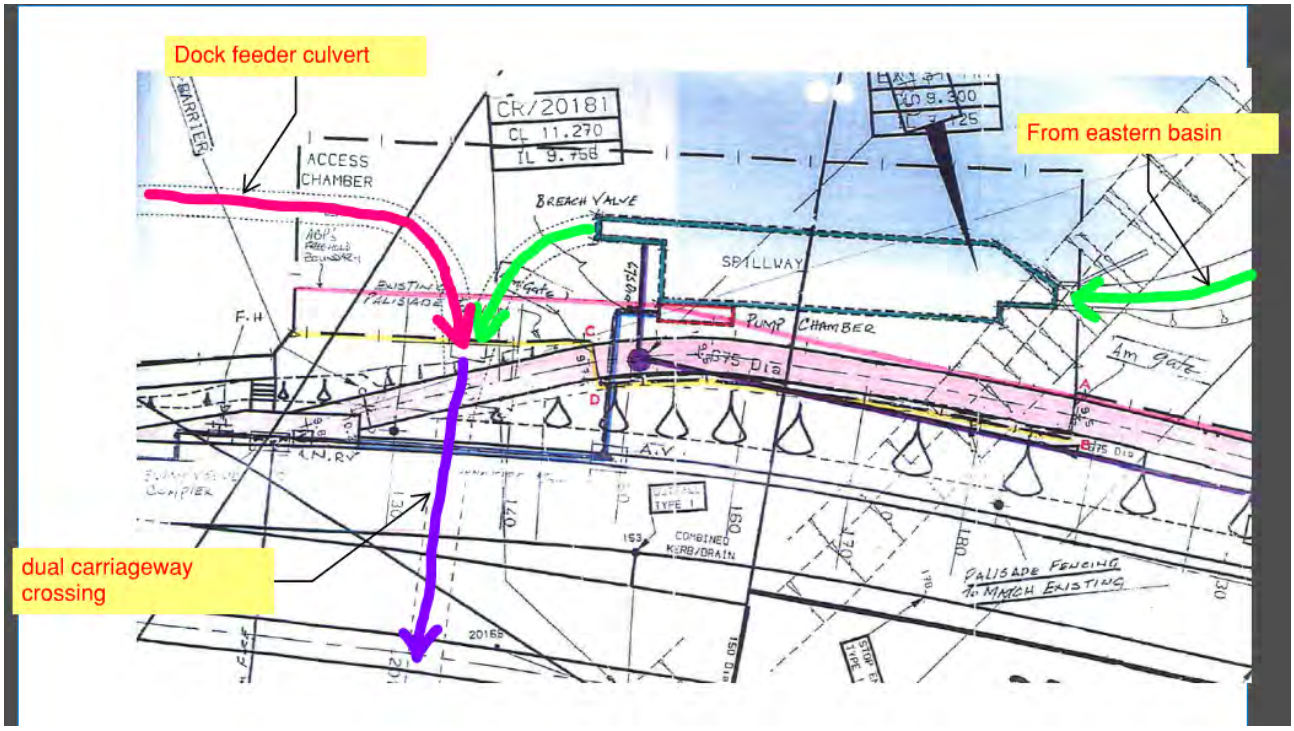


Figure 3 – Marked up plan showing Spillway area and pipes downstream

2.2 Information from Site

Site walkover surveys were undertaken around the culvert outfall to Bute East Dock, the stilling basin and weir, together with outfalls further south. This section records the observations during the surveys.

At the location of the outfall, the water level was measured to be circa. 0.5m below the coping level. Based on the coping level stated above, this results in the water level being at circa. 7.87m AOD, which is slightly less than the 7.92m AOD of the downstream weir crest. This could be due to insufficient inflow to the dock or loss of water through evaporation/seepage. It has also been advised that water is drawn from the dock by the Celsa Steel works for industrial use, which would also lower the water level below the weir crest. The volume and timing of Celsa's use is unknown.

The coping stones around Bute East Dock were noted to be approximately 1.5m wide.

The top of the outgoing culvert from Bute East dock was measured to be 0.29m above the water level, giving an approximate crown level of 8.16m AOD.

- For a 2.4m diameter culvert as highlighted on the ABP plans, this would result in an Invert Level of 5.76m AOD, 0.29m below the suggested invert level on the plans of 6.05m AOD.
- If the culvert diameter was 2.1m diameter, the invert would be circa 6.06m AOD which matches the suggested invert level on the ABP plan.

The other end of the culvert was observed just south of Galleon Way. At this point, the circular culvert transitioned to a box culvert structure crossing beneath the highway to the south. The system could not be observed from the surface beyond this point until the stilling basin.

The stilling basin is further downstream to the west of the Future Inn hotel. During this visit, the weir was identified to be a narrow-crested weir with a trapezoidal nose on the downstream end (see Figure 4). The weir was approximately measured to be 28m wide. A penstock was also observed, which likely allows for the dock/stilling basin to be drained down for repair or maintenance. The inlet and outlet of the stilling basin were observed to be square outlets, suggesting the presence of box culverts.

Figure 4 – Image of the narrow-crested weir and penstock taken from within the Stilling Basin.

The section to the south of the stilling basin, where it joins to the dock feeder culvert, could not be observed, as it is culverted. However, the water level was seen to fall during the visit, while tide mark are also present within the lower section of the stilling basin, indicating that water levels around the outlet changes frequently, by at least 260mm. The flow across the weir was notes as being consistent, indicating that the water level on the lower section is influenced by variations in flow from the dock feeder culvert.

An open channel section, to the south dual carriageway, outside the multi-storey car park was also observed during the visit. Water level was also seen to vary within this area, suggesting some hydraulic continuity with the stilling basin lower section to the north and influenced by variations in flow from the dock feeder culvert.

3 Bute East Dock – Flow Routing Calculation

Based on the available information provided in Section 2, a routing calculation has been undertaken to inform the water level in Bute East Dock during a 1:100-year rainfall event with a 40% allowance for climate change. The calculation has been undertaken for existing case and with the

additional inflows from the Cardiff Arena development to demonstrate the impact of outfalling into Bute East Dock.

These calculations, along with the required assumptions have been detailed in the below subsections.

3.1 Calculation Assumptions and Methodology

3.1.1 Bute East Dock Water Level, Area and Inflow

Within the calculation, the water level within Bute East Dock is assumed to start at the equilibrium level of 7.92m AOD. This is a conservative assumption as if the water level in the dock is lower (as observed on site), the dock will provide additional storage volume.

The area of Bute East dock has been measured from the OS map to be circa. 9.5Ha.

It is assumed that during a 1:100-year (+40% CC) rainfall event there would be no inflow into Bute East Dock via the tilting weir. As no other contributing catchments are known, the only inflow to Bute East Dock is assumed to be via direct rainfall onto the dock.

During the proposed case, the 1 in 100-year rainfall (+40% CC) from the Cardiff Arena drainage network will contribute additional runoff volume.

3.1.2 Downstream Boundary Condition

Based on the information available, there are two downstream boundary conditions which restrict the outflow from Bute East Dock:

1. Flow restriction through the part full culvert as the outfall from Bute East Dock
2. Flow restriction of the narrow-crested weir structure in the downstream spilling basin. It is assumed that the downstream weir is free flowing and not surcharged.

An assessment of the flow through both structures has been undertaken based on an increase in water level of the upstream end to determine which structure provides the most significant restriction in flow.

For the culvert, Bentley Culvertmaster has been used to calculate the flow based on a varying headwater elevation, a tailwater elevation of 7.92m AOD and an almost flat gradient over the culverts 90m length.

For the narrow-crested weir structure, the weir discharge equation was used:

$$Q_{wier} = C_d b g^{\frac{1}{2}} y^{\frac{3}{2}}$$

Where Q_{weir} is the flow over the weir, C_d is the discharge coefficient, b is the weir width, g is the gravitational coefficient (9.81m/s^2) and y is the water depth above the weir (varies).

The narrow-crested weir is approximately 28m wide as determined on site. A discharge co-efficient of 0.544 has been assumed based on the type of weir.

The calculation of flow through both structures is compared graphically in Figure 5. The calculations demonstrate that for up to a water head of 0.16m, the weir will provide a greater restriction for the outflow from Bute East Dock. However, at a water head above this, the culvert would become a greater constraint.

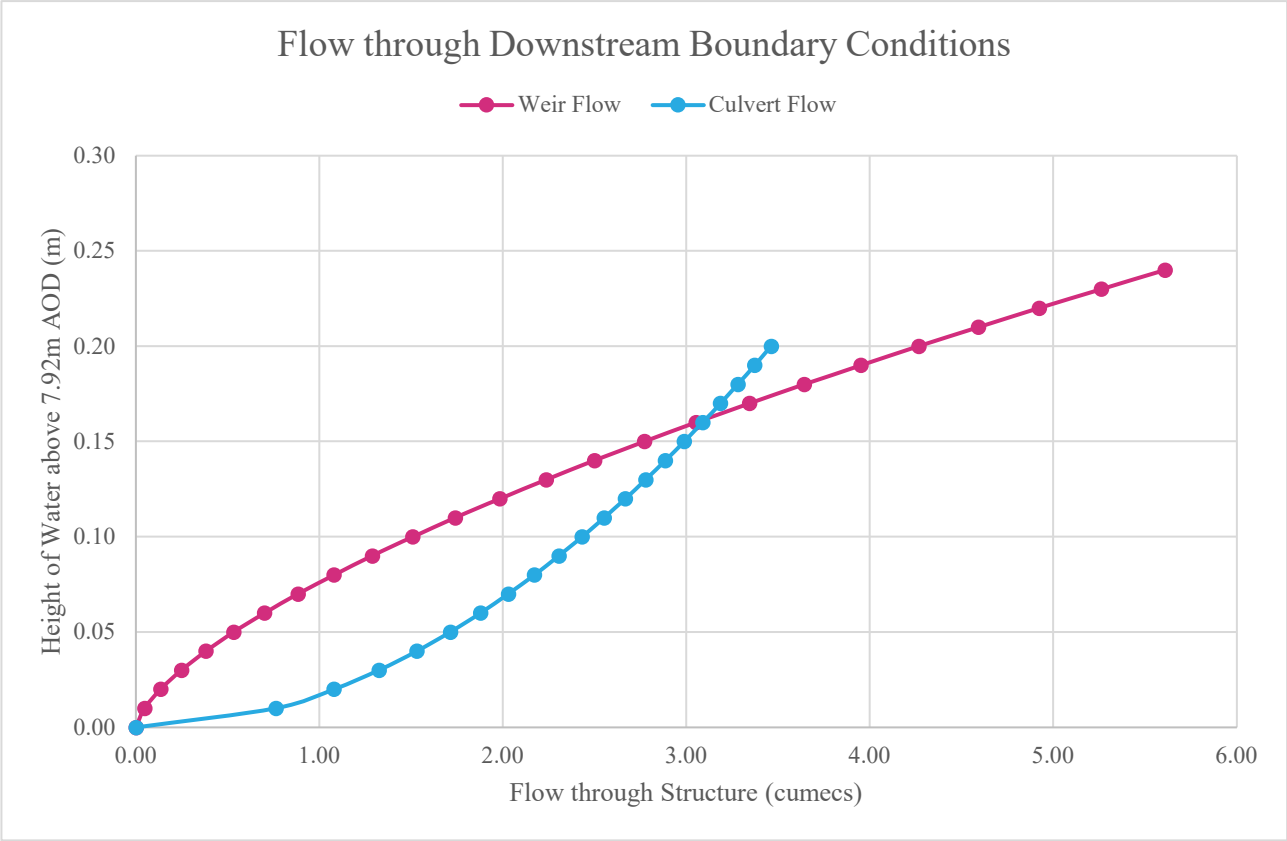


Figure 5 – Graph showing the outflow from the culvert and weir structures with the change in water level of Bute East Dock.

Both structures will have an impact on the water level within Bute East Dock. For example, consider a continuous inflow of 1.5cumecs into the dock system. At equilibrium, the head of water in the stilling basin would need to be 100mm above the weir crest level to provide an outflow of 1.5cumecs. However, the water level in Bute East Dock would need to be 40mm higher to provide a 1.5cumec flow to the downstream stilling basin.

To simplify the routing calculation, the culvert will not be considered and instead the weir will be assumed to be located at the outfall to Bute East Dock. However, to account for the flow through the culvert, an adjustment will be made to the final calculated water level.

For lower values of water head, this offers a reasonable assumption as the flow over the weir is significantly lower. This also excludes the storage volume available in the downstream culvert and stilling basin, providing a conservative approach to the calculation. It also doesn't account for the reduction in water level in Bute East Dock due to the longer time of concentration for water from the dock to reach the weir.

For higher water levels, the culvert and time of concentration would need to be considered within the calculation as the culvert will have a larger impact on water levels.

3.1.3 Routing Equation

In order to determine the water level in Bute East Dock during the 1:100-year storm events, the following flow routing equation has been applied.

$$S_t = S_{t-1} + I_t - O_t$$

Where S is the storage provided by the dock, I is the inflow volume and O is the outflow volume as a particular time step. For the calculation, a 1-minute time step will be applied within the equation.

The inflow volume at each timestep has been calculated by applying the modified rational method, with the rainfall intensity input from FSR rainfall hydrographs for multiple storm durations:

$$I = Ci_tA\Delta t$$

Whilst the outflow volume has be calculated by calculating the flow over the weir and multiplying the flow by the timestep duration.

$$O = Q_{Weir}\Delta t$$

Where the depth of water above the weir is based on the storage volume in the dock calculated for the previous time step.

3.2 Calculated Storage

The routing equation and calculation methodology outlined above has been undertaken for the existing case and the proposed case with the additional contributing area from the Cardiff Arena development.

Hydrographs for the 120, 240, 480, 960 and 1440 minute 1:100-year storm events were derived using the FSR Method, with a 40% allowance for climate change. These were based on an M5-60 value of 19.0mm and a Ratio R of 0.31. The hydrographs for these events were then used in the routing calculation to determine the change in water level on Bute East dock over the various storm events in the existing case.

Of these events, it was found that the 240-minute event was the critical event, providing the largest rise in water level in Bute East Dock. During this event, the water level increased by 53mm to a maximum elevation of 7.973m AOD.

The additional 2.54ha area for the Arena development was subsequently added to the routing calculation for the same storm event. The calculation demonstrated a total water level increase of 65mm to a maximum elevation of 7.985m AOD, a 12mm increase on the existing case. This is shown graphically in Figure 6.

Given the coping level of 8.37m AOD, this demonstrates a freeboard of 385mm for Bute East Dock in the proposed case with the contributing Arena flows.

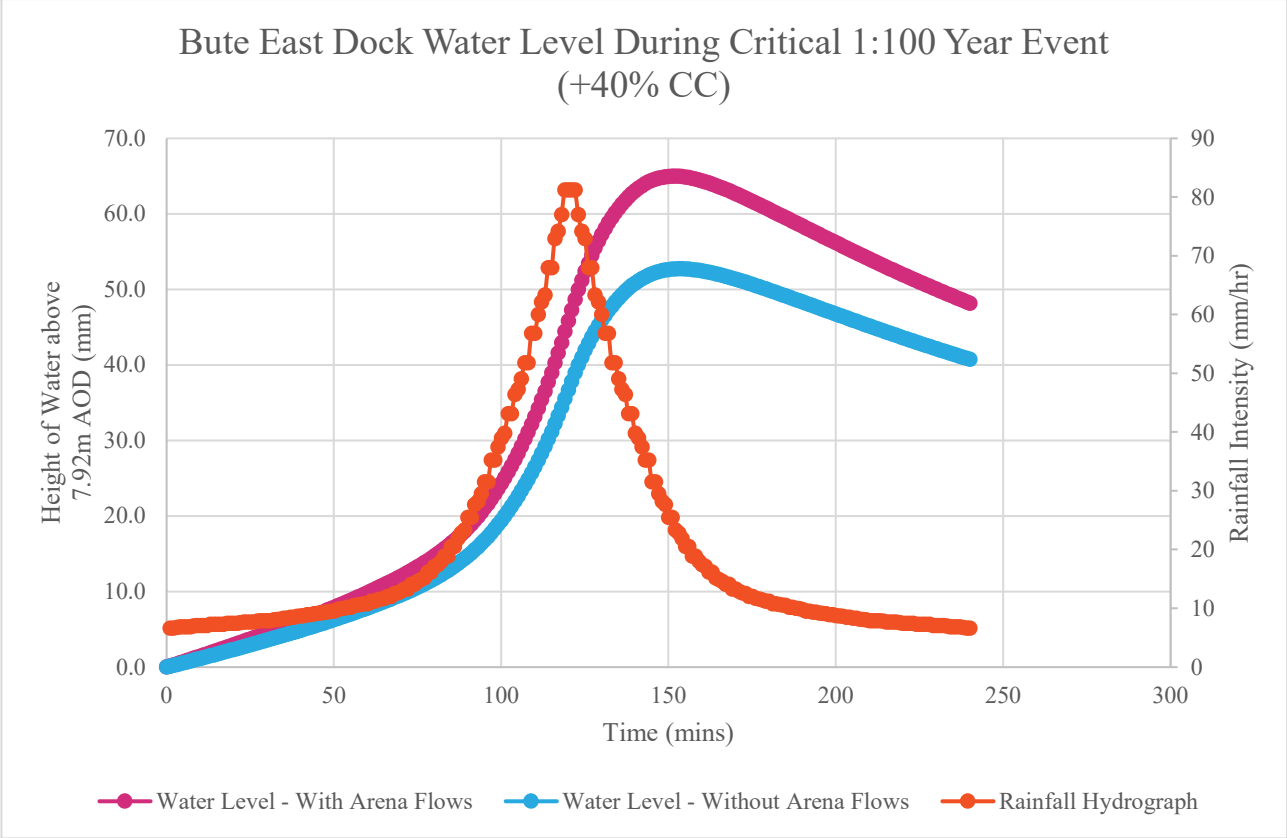


Figure 6 – Calculated water level in Bute East Dock during the 1:100 240 min summer storm event (+40% CC). Water level provided on the left axis, rainfall intensity provided on the right axis.

3.2.1 Adjusting the level to allow for Culvert flow

The calculation assumes the weir is immediately downstream of Bute East Dock. In reality, the weir is located 260m downstream via a circular and box culvert. To make a conservative allowance for this, it is proposed that the calculated water level in Bute East Dock is adjusted by the head required to mimic the outflow over the weir.

At the maximum calculated water level in the existing case, the flow over the weir is 0.58m^3/s. To achieve the same flow through the culvert, a circa. 8mm difference in head is required between the inlet and outlet. Therefore, adjusting the calculated maximum water elevation to accommodate for this would yield a water level of 7.981m AOD in Bute East Dock.

At the maximum calculated water level in the proposed case, the flow over the weir is 0.79m^3/s. To achieve the same flow through the culvert, a circa. 10mm difference in head is required between the inlet and outlet. Therefore, adjusting the calculated maximum water elevation to accommodate for this would yield a water level of 7.995m AOD in Bute East Dock. This reduces the calculated freeboard to 375mm and results in a total increase in water level from the existing case of 14mm.

3.3 Downstream Impact

The above assessment indicates that during high rainfall and storm event, the water level within Bute East Dock will rise slightly and more flow will discharge into the piped and open channel network downstream.

The peak weir overflow rate in the existing and proposed case was estimated to be 0.578 cumecs and 0.790 cumecs respectively. This results in an increase of 0.212 cumecs, however this peak flow is only experienced for a short duration.

The downstream culvert is noted to be an 128m long, 3m diameter steel Armco on the ABP plans, merging with the dock feeder and routed under the A4232 to the downstream open channel. During the site visit, the outfall was observed to be nearly submerged, with tide marks showing that it does get submerged with the increase in water level. As such, for the calculations the downstream water level has been assumed to be at the top of the culvert.

The gradient of this culvert is unknown, however assuming a flat culvert it has been calculated that an upstream increase in water level of 2mm would provide a flow through the culvert of 0.66 cumecs, more than the incoming flows from the weir in the existing case. Increasing the water level by a further 1mm would provide a culvert flow of 0.83 cumecs, which exceeds the weir flows in the proposed case. Therefore, if no flow is being routed through the dock feeder, an increase in water level of 1mm would be anticipated upstream of the culvert due to the development.

The dock feeder is noted as a 2.25m x 1.8m box culvert. Without downstream surcharge conditions, this would have a full-bore capacity of approximately 7 cumecs. Undertaking the same calculation as above, but with an allowance for a 7 cumec incoming flow from the dock feeder results in the following results:

- Existing Case:
    - Combined flow = 7.578 cumecs
    - Upstream head of water required = 260mm
- Proposed Case:
    - Combined flow = 7.790 cumecs
    - Upstream head of water required = 280mm

Therefore, even in the worst-case scenario of the dock feeder running at maximum capacity, the increase in flow over the weir will only result in a 20mm difference in downstream water level. As noted, these peak flows will only be present for a short duration during an extreme rainfall event. It is also considered unlikely that the dock feeder culvert will experience flows of 7 cumecs often.

The downstream network is large and has a wide-open channel section further downstream. Observed water levels already vary with fluctuations in flow along the dock feeder culvert of at least 260mm. An increase in flow across stilling basin weir area will have a negligible impact on the downstream network levels.

3.4 Summary

A simple routing calculation has been undertaken to calculate the increase in water level in Bute East Dock during a number of 1:100-year rainfall events with a 40% allowance for climate change. The calculation initially considered the existing case, with just the rainfall on the dock surface as inflow. A second calculation was subsequently undertaken which considered the additional rainfall contribution from the proposed Cardiff Arena development. The results are summarised in Table 1 below, with the maximum water levels highlighted:

Table 1 - Summary of Maximum Water Levels and Flows from Routing Calculations

Storm Event (+40% Climate Change)	Max Water Level (m AOD)			Max Weir Outflow (cumecs)	
	Existing	Proposed	Difference	Existing	Proposed
60 Minute Winter	7.966	7.977	0.011	0.467	0.649
120 Minute Winter	7.970	7.983	0.013	0.540	0.746
120 Minute Summer	7.970	7.983	0.013	0.541	0.749
240 Minute Winter	7.971	7.983	0.012	0.544	0.752
240 Minute Summer	7.973	7.985	0.012	0.578	0.790
480 Minute Winter	7.968	7.977	0.009	0.494	0.657
480 Minute Summer	7.971	7.982	0.011	0.549	0.738
960 Minute Winter	7.960	7.968	0.008	0.382	0.497
1440 Minute Winter	7.955	7.961	0.006	0.309	0.399

The routing calculation demonstrated a nominal 12mm increase in water level between the existing and proposed cases. By making an adjustment to the calculated water level to allow for a head of flow through the culvert, the maximum water level in the proposed case increases to 7.995m AOD, 14mm above the adjusted existing level value. This adjusted water level provides a freeboard to the dock coping of 375mm, above the 300mm typically provided in surface attenuation features.

4 Conclusion

The impact of connecting drainage from the Arena development into Bute East Dock has been considered as part of this note. Bute East Dock offers significant attenuation capacity and the calculations indicate that the maximum rise of water levels of the dock during an extreme storm event is 14mm. The depth of water below coping level in this event is 375mm, consequently the impact of this rise is considered negligible.

During such events, an increase in flow will occur across the wide stilling basin weir structure and into the downstream network outfalling to Roath Basin. The downstream culverted network is large and also includes a wide, open channel section. Water levels are already observed to fluctuate due to variations in flow from the dock feeder culvert. Compared to the potential flows through the dock feeder, the increase due to communicating the flows from the Arena to Bute East Dock are nominal and will only occur for a short duration during an extreme rainfall event. Consequently, the impact of increased flow from the Arena development through the Bute East Dock, Stilling Basin Weir and downstream system during an extreme storm event is considered to be negligible.

File Note

281124 20 July 2021

A1 Dock Feeder Cardiff Schematic from ABP

CARDIFF DOCK FEEDER

SLUICES AT BLACKWEIR

WEIR CREST +31.40 FT AOD (CENTRE) [+9.57m AOD]
+32.33 FT AOD (BANKS) [+9.85m AOD]

WEIR TOE +25.00 FT AOD [+7.62m AOD]

BED N FACE +28.4 FT AOD [+8.65 m AOD] in 1967
" D/S TOE +22.5 FT AOD [+6.85 m AOD] " "

W.L. D/S OF SLUICES IN FEEDER V. APPROX +9.20 m AOD.

OPEN WATERWAY

CULVERTS/BRIDGES.

Scale V. approx: 1/10,000 (1 km grid)

AMBULANCE DEPOT – SHORT 3.55M WIDTH RESTRICTION AT BLACKWEIR FARM

TWIN BRICK/CONC CULVERTS 6FT DIAM INT. UNDER NORTH RD

INVERT +6.64m assumed fm old dwg.

1986 CULVERTS TWIN 3M HIGH × 2M MAX – VARIES TO 8FT & 7FT
OVERALL COVERED LENGTH PARK PLACE TO BUTE TERRACE 757m AS HIGHLIGHTED YELLOW.

1M WIDE ACCESS POINT TO GRILLE BY SUBSTATION (CCC HAVE KEY + CLEAN GRILLE)

RESTRICTED WIDTH AT CASTLE BRIDGE (LADY BUTE BR)

ACCESS POINT UNDER MORGAN COLE STEPS

LOW BED LEVEL APPROX +7.12m AOD (LOCAL)

PARK HOTEL CULVERT DIMS AS BELOW MASONRY + APPROX 66m LONG

MASONRY CULVERT UNDER QUEEN ST. 12FT WIDE × (3.65m × 2.90m) — 9'-6" HIGH + 18M LONG

FROM QUEEN ST CHURCHILL WAY 485m [W.L. AT APPROX +8.60m AT S END] WIDTH
FEEDER COVERED BY PCC SLABS OVER ABUTS (20FT)

BUTE TERRACE 43M LONG INVERTED SYPHON TWIN RC BOXES 10FT WIDE × 4FT HIGH INTERNAL

INVERTS
N END +7.42m
CENTRE +6.58m
S END +7.37

20.8m LONG RAIL CROSSING 5 Nº RC BOX CULVERTS 4'-6" SQ INT

BED WHEN CLEAN/ APPROX +6.58m AOD

TILTING WEIR [CREST APPROX +7.68m AOD]

JUNCTION CANAL

START OF 70mgd CULVERT With Penstock. INVERT +6.50m AOD
IMMED BEFORE IN CONC CHANNEL 2.25m × 2.08m DEEP

RC BOX CULVERT 2.25m WIDE × 1.80m HIGH 1357m LONG

BUTE E DOCK COPING AV. LEVEL +8.38m AOD

WATERQUALITY AREA (Q'gate N) 2.4m ϕ ARMCO CULVERT TURBOSIDER/ +6.05m INVERT

FUTURE INNS AREA ASSUMED AS ABOVE FOR PIPE DETAIL

STILLING BASIN WEIR CREST IS AT +7.92m AOD

ARMCO STEEL CULVERT 128m LONG 3.01m DIAM UNDER PDR ROAD.

3m ϕ ARMCO CULVERT UNDER PIERHEAD ST – WATER FLOW EMERGES TO DOCK

INV +6.0m

ASSOCIATED BRITISH PORTS REGIONAL PROPERTY DEPT. SOUTH WALES 16 JUN 1994 No. 5327 REF

Grangetown

Appendix F

Proposed Foul Drainage Drawing

A1

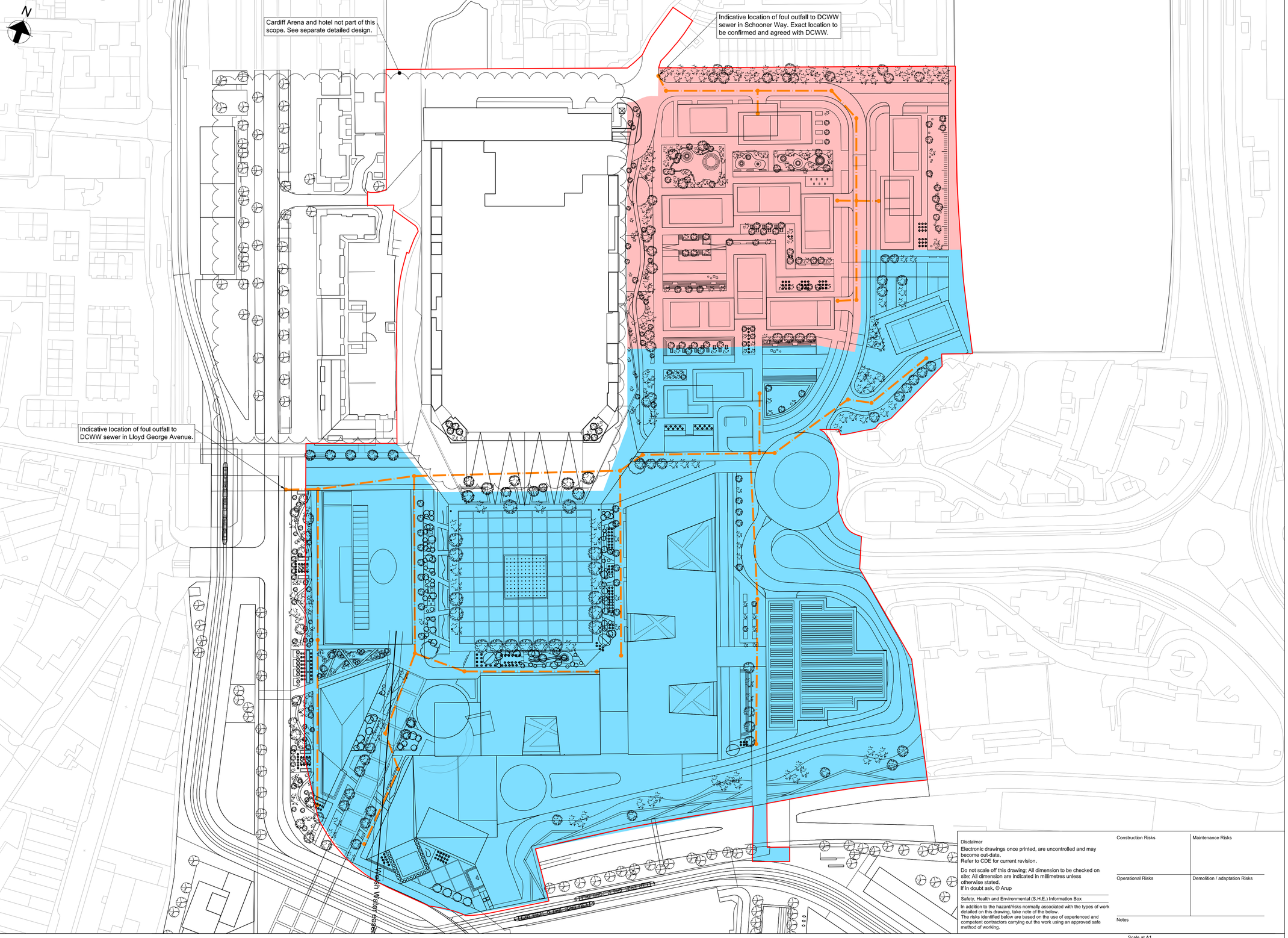
Legend

- Site Boundary
- Indicative proposed foul sewers
- Foul Catchment 1 - Outfall to existing DCWW sewer in Schooner Way
- Foul Catchment 2 - Outfall to existing DCWW sewer in Lloyd George Avenue

Notes

1. All dimensions are in metres unless stated otherwise. All levels are in metres above Ordnance Datum (AOD). Do not scale from this drawing.

2. Foul sewers and catchments are indiciative and subject to discussion with DCWW.



Disclaimer

Electronic drawings once printed, are uncontrolled and may become out-date.
Refer to CDE for current revision.

Do not scale off this drawing: All dimension to be checked on site; All dimension are indicated in millimetres unless otherwise stated.
If in doubt ask, © Arup

Safety, Health and Environmental (S.H.E.) Information Box

In addition to the hazard/risks normally associated with the types of work detailed on this drawing, take note of the below.
The risks identified below are based on the use of experienced and competent contractors carrying out the work using an approved safe method of working.

Construction Risks	Maintenance Risks
Operational Risks	Demolition / adaptation Risks

Notes

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Issue	Date	Revision Description
P01	30/07/21	Issued for Information

Record of Revisions

Client: Cardiff Council

Operators:

Lead Designer: RIO Architects

Project Title: Atlantic Wharf Masterplan

Drawing Title: Proposed Foul Drainage Catchment Plan

Scale at A1: 1:1000

Role: Civils

Drawn By	Checked By	Approved By
DS	CL	DL

Purpose of Issue: Information

Project No: 281124

Rev: P01

ID: CAH-ARP-XX-XX-DR-C-90-2440

J:\281\00\02\81124-00\4 Internal Project Data\4-30 Drawings\4-31 Issue drawings\Atlantic Wharf Masterplan Drawings\CAH-ARP-XX-XX-DR-C-90-2440.dgn

Do not scale

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				Potable Water	Foul Water
Quarter	**Land Use / Use Class**	**Use Class GIA (sqm)**	**Residential Units**	**Peak Consumption (l/s)**	**Peak Foul Flow (l/s)**
Mixed Use Quarter	RDC (A) - D2 Assembly & Leisure	13,500	0	0.47	0.89
	RDC (A) - A3 Food and Drink	2,500	0	5.58	7.07
	RDC (A) - C3 Dwellinghouses	17,000	100	1.33	2.11
	RDC (A) - A1 Shops	175	0	0.00	0.01
	This is Wales (B) - D1 Non-residential Institutions	2,000	0	0.07	0.13
	This is Wales (B) - A1 Shops	100	0	0.00	0.00
	This is Wales (B) - A3 Food and Drink	100	0	0.22	0.28
	Mixed Use (C) - C3 Dwellinghouses	7,500	50	0.67	1.06
	Mixed Use (C) - B1 Business	5,500	0	4.58	5.81
	Mixed Use (C) - A3 Food and Drink	3,000	0	6.70	8.48
	Commercial Office (M) - B1 Business	14,000	0	11.67	14.78
	Commercial Office (M) - A1 Shops	2,000	0	0.03	0.07
Cultural Quarter	WMC Academy (E) - D1 Non-residential Institutions	6,000	0	0.21	0.40
	WMC Academy (E) - A1 Shops	100	0	0.00	0.00
	WMC Academy (E) - A3 Food and Drink	100	0	0.22	0.28
	Cardiff Story Museum (D) - D1 Non-residential Institutions	2,000	0	0.07	0.13
	Cardiff Story Museum (D) - A1 Shops	100	0	0.00	0.00
	Cardiff Story Museum (D) - A3 Food and Drink	100	0	0.22	0.28
	Contemporary Art Museum (L) - D1 Non-residential Institutions	4,000	0	0.14	0.26
Waterfront Quarter	Apart-hotel (K3) - C1 Hotels	16,500	0	1.91	3.63
	Apart-hotel (K3) - A3 Food and Drink	800	0	1.79	2.26
	Residential Plots (H1) - C3 Dwellinghouses	17,500	350	4.67	7.39
	Residential Plots (H1) - A3 Food and Drink	1,500	0	3.35	4.24
Bute East Dock Quarter	Residential Plots (H2-H4) - C3 Dwellinghouses	30,500	550	7.33	11.61
	Residential Plots (H2-H4) - A3 Food and Drink	150	0	0.33	0.42
	Residential Plots (H2-H4) - A1 Shops	175	0	0.00	0.01
	4* Hotel (K1) - C1 Hotels	9,000	0	1.04	1.98
	4* Hotel (K1) - A3 Food & Drink	1000	0	2.23	2.83
	Hotel (K2) - C1 Hotels	10,000	0	1.16	2.20
	Hotel (K2) - A3 Food and Drink	550	0	1.23	1.56
Car Parking Quarter	MSCP (F) - Sui Generis	40,000	0	0.00	0.00
	MSCP (F) - A1 Shops	100	0	0.00	0.00
TOTAL	0	**207,550**	**1,050**	**57.24**	**80.17**

Notes:
Calculations based on 'EIA Parameter Tab;e - 13.07.2021' received 15.07.2021
Max residential units' from parameter plan used for design
Load Assumptions from the UK Maximum Demand Calculations and IDG
Hotel calculations assume 60m2/room on boundary between 'small' and 'business/holiday' in IDG

ARUP

Atlantic Wharf Wider Masterplan - Existing Foul

Date 27/07/2021 Author CL
Job No. 281124 Checked DL

Development Type	GFA (m^2)	No. of units	Population (leave blank if not known)	Electricity			Gas		Estimated Population (use with caution)	Potable Water		Foul	
				Max. Electricity Demand (kW)		Annual Elec. Consumption (kWh/yr)	Max. Gas Demand (kW)	Annual Gas Consumption (kWh/yr)		Average Daily Water Consumption (l/day)	Peak Demand (l/s)	Average Daily Foul Flow(l/day)	Peak Flow (l/s)
				Summer Afternoon	Winter Evening								
Residential													
1 - Bed				0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2- Bed				0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3 - Bed				0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4 - Bed				0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Undefined residential units *(use if split of property size isn't know)*				0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Office													
Air-conditioned	27500			2,255.0	1,488.3	5,500,000.0	2,200.0	4,400,000.0	2,750.0	275,000.0	22.9	261,250.0	29.0
Naturally ventilated				0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Retail													
General Retail				0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Supermarket				0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other													
Hotel				0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Restaurant	3950			395.0	395.0	3,160,000.0	529.3	3,950,000.0	2,821.4	84,642.9	8.8	80,410.7	11.2
Leisure & Culture	26200			1,310.0	262.0	1,834,000.0	3,144.0	5,240,000.0	655.0	16,375.0	0.9	15,556.3	1.7
Education				0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Healthcare				0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Industrial													
General Industry				0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Warehouse				0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Car Park													
Multi-storey				0.0	0.0	0.0	N/A	0.0	N/A	N/A	N/A	N/A	N/A
Surface				0.0	0.0	0.0	N/A	0.0	N/A	N/A	N/A	N/A	N/A
Basement				0.0	0.0	0.0	N/A	0.0	N/A	N/A	N/A	N/A	N/A

Summary		
Max. Electricity Demand	3.96	MW
Annual Electricity Demand	10,494.00	MWh
Max. Gas Demand	5.87	MW
Annual Gas Demand	13,590.00	MWh
Daily Water Demand	376.02	m^3/day
Peak Water Demand	32.64	l/s
Daily Foul Demand	357.22	m^3/day
Peak Foul Flow	41.92	l/s

Assumptions

Office - Existing County Hall Building. Area measured from OS using Google imagery to estimate areas of 1, 3, 4 or 5 storeys. Doesn't account for café/bar areas
Leisure & Culture - Red Dragon Centre cinema, bowling and gym. Area from Electricity demand calcs. Plan area from OS x2 for first floor plant and leisure
Resaturant - 850m2 = Zaika Asian / Chicken House located on Hemingway Road roundabout. Single storey building, measured from OS.
Restaurant - 3100m2 = restaurants inside RDC